APPENDIX A
SILVERDALE PUMP STATIONS
3, 4, 19, AND 31 UPGRADES
PRELIMINARY ENGINEERING
REPORT, BHC, 2020

Kitsap County
Silverdale Lift Stations 3, 4, 19, and 31 Upgrades
Preliminary Engineering Report

January 10, 2020

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CERTIFICATE OF ENGINEER
KITSAP COUNTY
SILVERDALE LIFT STATIONS 3, 4, 19, AND 31 UPGRADES
PRELIMINARY ENGINEERING REPORT

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BHC Consultants, LLC

1/10/2020

January 10, 2020

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ABBREVIATIONS AND ACRONYMS LIST

20-Year CIP	20-year Capital Improvement Plan
6-Year CIP	6-year Capital Improvement Plan
AACE	Advancement of Cost Engineering International
AES	AES Consultants, Inc.
APA	American Wood Association
APE	Area of Potential Effect
ATS	Automatic Transfer Switch
BA	Biological Assessments
bgs	Below-Ground-Surface
BHC	BHC Consultants, LLC
Cascadia	Cascadia Archaeology
Casseday	Casseday Consulting
CDF	Controlled Density Fill
CKTP	Central Kitsap Wastewater Treatment Plant
CIP	Capital Improvement Plan
CMU	Concrete Masonry Unit
County	Kitsap County
DAHP	Department of Archaeology and Historic Preservation
Ecology	Department of Ecology
ESA	Endangered Species Act
fps	Feet per Second
FRP	Fiberglass Reinforced Plastic
ft	Feet
gal	Gallon/s
GIS	Graphical Interface System
gpm	Gallons per Minute
HDPE	High Density Polyethylene
H-O-A	Hand-Off-Auto
hp	Horsepower
HVAC	Heating, Ventilation and Air Conditioning

IBC	International Building Code
in	Inch
IPS	Individual Pump Station
JARPA	Joint Aquatic Resources Permit Application
KCC	Kitsap County Code
kW	Kilowatt
Landau	Landau Associates, Inc.
lf	Linear Feet
LS	Lift Station
LS 3	Lift Station 3
LS 4	Lift Station 4
LS 19	Lift Station 19
LS 31	Lift Station 31
LUV	Land Use Vision
MCC	Motor Control Center
MCP	Main Control Panel
MRO	Mineral Resource Overlay
MPH	Miles per Hour
NC	Neighborhood Commercial
NPDES	National Pollutant Discharge Elimination System
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
OPPC	Opinion of Probable Project Cost
OSB	Oriented Strand Board
pcf	Pounds per Cubic Foot
PER	Preliminary Engineering Report
PLC	Programmable Logic Controller
PSE	Puget Sound Energy
psf	per Square Foot
psi	Pounds per Square Inch

PSRC	Puget Sound Regional Council
PVC	Polyvinyl Chloride
Qgic	Vashon Ice-Contact
Qgof	Vashon Recessional Glacial Lake Deposits
Qgt	Vashon Lodgment Till
Qp	Vashon Peat Deposits
Qve	Vashon Drift Esperance Sand
Qvt	Vashon Till
RCO	Recreation and Conservation Office
ROW	Right-of-Way
RRFB	Rectangular Rapid Flashing Beacon
SCADA	Supervisory Control and Data Acquisition
SDAP	Site Development Activity Permit
SDR	Standard Dimension Ratio
SERP	State Environmental Review Process
SR	State Route
SSMH	Sanitary Sewer Manhole
Station	Lift Station
SWPPP	Storm Water Pollution Prevention Plan
TAZ	Traffic Analysis Zone/s
TDH	Total Dynamic Head
UGA	Urban Growth Area
UL	Urban Low Residential
Update	2019 Hydraulic Model Update
USFWS	U.S. Fish and Wildlife Service
VFD	Variable Frequency Drive
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation
WWTP	Wastewater Treatment Plant

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ES-1. Executive Summary

ES-1.1 Introduction

Kitsap County's Wastewater Division (County) is evaluating alternatives for upgrading Lift Stations 3, 4, 19, and 31, along with portions of the collection and conveyance systems associated with those four stations. These improvements are known as the Silverdale Lift Stations 3, 4, 19, and 31 Upgrades (See Figure ES-1 for the location of these facilities).

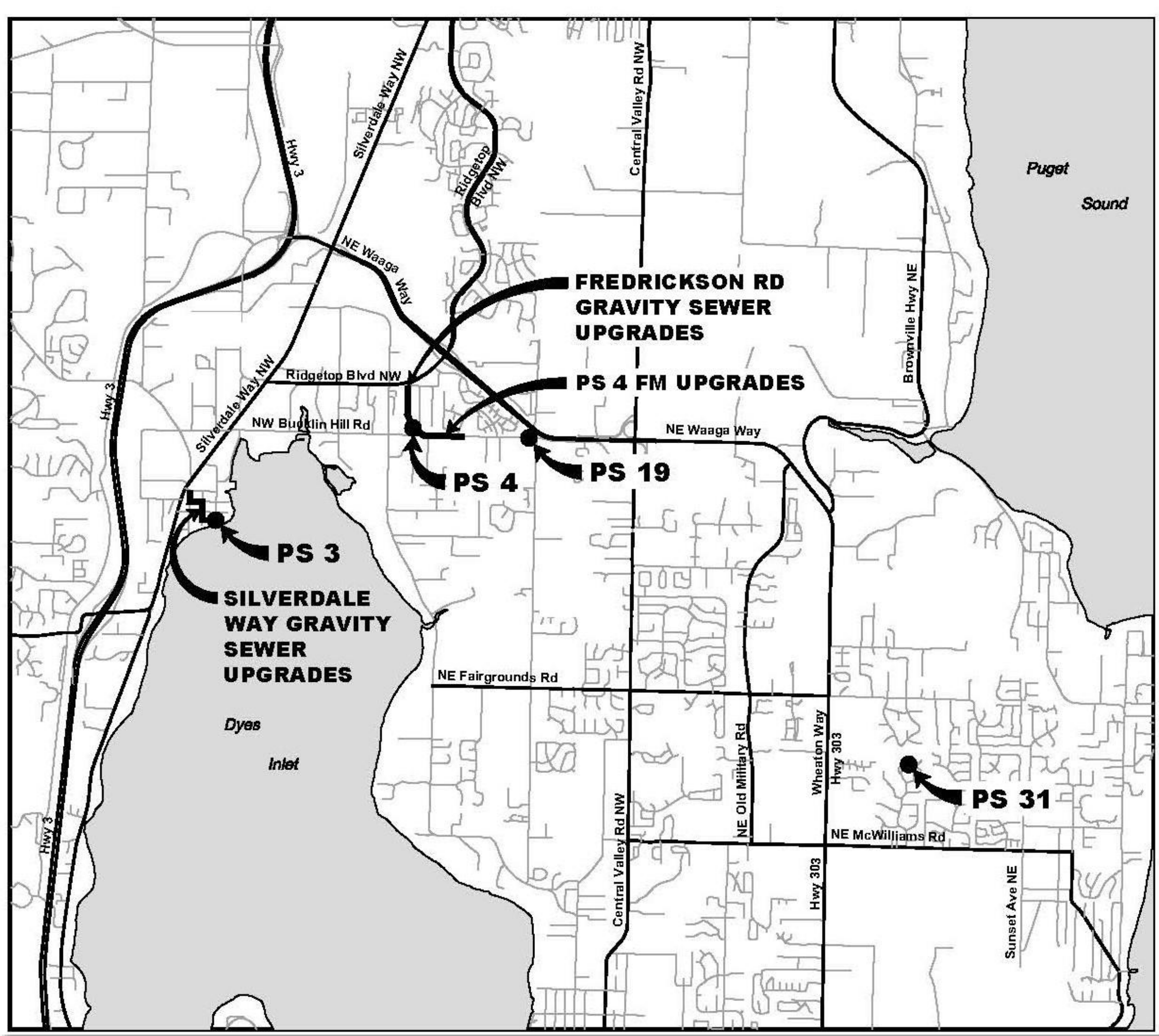

Figure ES-1 – Vicinity Map

ES-1.2 Lift Station 3 and Associated Conveyance System Upgrades

Lift Station 3 is a triplex, wet well/dry well lift station that serves the southern Silverdale service area and pumps wastewater to LS 4 via a 14-inch force main. The lift station is located west of Washington Avenue NW, south of NW Byron Street, and adjacent to the beach associated with Dyes Inlet. The station receives flow from Lift Stations 12 and 40 in addition to the surrounding area that can flow by gravity to the station. Incoming flows are projected to exceed the station's current pumping capacity of 1,800 gallons per minute (gpm). The existing controls, pumps, and pump motors are old, in poor condition, and due to be replaced. Larger pumps will be needed to address the projected flows.

The station currently pumps through approximately 7,400 feet of 14-inch force main before discharging into SSMH K18-4013 located just east of LS 4. Sewage velocities in the existing force main when one of the upgraded pumps is operating will be about 4.1 feet per second (fps) and 5.9 fps when two pumps are operating in parallel. These velocities are reasonable so no upgrades to the force main are required.

The 2019 Hydraulic Model Update identified upgrades to the conveyance system upstream of LS 3 that should be conducted in concert with the upgrades to LS 3 to address surcharging in the system. The existing gravity sewers between Silverdale Way (SSMH L17-1079) and LS 3 surcharge under future and full buildout projected flows. To alleviate the surcharging, a 15-inch interceptor sewer along NW Carlton Street from Pacific Avenue NW to Washington Avenue NW is proposed to redirect flows to the new gravity sewers being installed under the Bayshore and Washington Improvements project. Figure ES-4 (located at the end of this chapter) depicts the proposed upgrades.

ES-1.3 Lift Station 4 and Associated Conveyance System Upgrades

Lift Station 4 is a triplex, wet well/dry well lift station that serves the northern and southern Silverdale service area. The station is located on a lot at the northeast corner of the intersection of Fredrickson Road NW and NW Bucklin Hill Road and is surrounded by residential developments and receives flow from Lift Stations 1, 2, 3, and 39 in addition to the surrounding area that can flow by gravity to the station. Incoming peak flows are approaching the triplex station's pumping capacity of 3,000 gpm and the equipment in the station is old and no longer reliable. Recent upgrades to Lift Station 1 have exacerbated the issue and the proposed upgrades to LS 3 will further challenge the station's pumping capacity. Therefore, a significant upgrade of the station with larger pumps, motors, and a new wet well will be required to handle projected peak flows.

The station currently pumps through approximately 1,570 feet of 14-inch force main before discharging into SSMH J18-3048 near the intersection of Spinnaker Blvd NW and NW Bucklin Hill Road. The sewage exits SSMH J18-3048 via a 20-inch sewer that conveys the flow further east along NW Bucklin Hill Road until it joins with flows from Lift Stations 6 and 7 near the intersection of SR 303 and County Road 15. The pumping capacity upgrades at LS 4 will result in velocities in excess of 9.5 fps in the 14-inch force main when two pumps are operating. Therefore, the 14-inch force main should be upsized to 20-inch pipe concurrently with the lift station upgrades, resulting in velocities in the force main of 2.8 fps (one pump operating) and 4.7 fps (two pumps operating). Consideration should also be given to replacing SSMH J18-3048. SSMH J18-3048 has been converted to air-vacuum station by plating over the existing manhole channel and then filling the remaining structure with sand. Vent piping, an air/vacuum assembly and a carbon canister were then installed to providing venting of the force main at this location. The manhole should be replaced with an air-vacuum valve station as part of the force main upgrades to bring the system into compliance with the County's current standards.

The 2019 Hydraulic Model Update identified conveyance upgrades to the gravity sewers along Fredrickson Road NW between NW Chena Road and LS 4 (Fredrickson Road Gravity Sewer Upgrades) that should be conducted in concert with the upgrades to LS 4 to address surcharging in the system. Replacing the existing 15-inch gravity sewers with 18-inch, 21-inch, and 24-inch gravity sewers would alleviate the surcharging. Figure ES-5 (located at the end of this chapter) depicts the proposed upgrades.

ES-1.4 Lift Station 19 Upgrades

Lift Station 19 (LS 19) is a triplex, wet well/dry well lift station that serves the northeastern portion of the Silverdale service area. he station is located on a lot at the north end of the intersection of NW Bucklin Hill Road and Nels Nelson Road NW and receives flow from Lift Stations 22, 25, and 26 in addition to the surrounding area that can flow by gravity to the station. Flows into the station are not anticipated to increase; however, the equipment in the station is old and no longer functions reliably. Therefore, upgrades to the existing lift station are required.

The station typically pumps north and east through a 14-inch force main before discharging into a 30-inch force main near the intersection of NE Paulson Road and Kelly Court NE. The 30-inch force main then transports the flows in conjunction with flows from LS 4, LS 6, LS 7, and LS 9 to the Central Kitsap Wastewater Treatment Plant. Onsite valving allows the station to also pump directly into LS 4's force main, which conveys the flows east before combining with flows from LS 6 and LS 7 near the intersection of SR 303 and County Road 15. According to discussions with County staff, this second mode of pumping is discouraged, as the existing pumps tend to cavitate when pumping into the LS 4 force main. The County has expressed a desire, however, to maintain the ability to pump into LS 4's force main as a backup option as part of the proposed upgrades.

The 2019 Hydraulic Model Update does not identify a need to increase the pumping capacity of LS 19. Velocities in the 14-inch force main will be 2.3 fps with one pump operating and 3.8 fps with two pumps operating, which are adequate to provide cleansing velocities without undue frictional head loss. Therefore, the existing force main will remain in service and will not be replaced as part of this project. The 2019 Hydraulic Model Update did not identify any needed upgrades to the gravity conveyance system upstream of the station.

ES-1.5 Lift Station 31 Upgrades

Lift Station 31 (LS 31) is a duplex lift station that serves a residential neighborhood in the northern part of the City of Bremerton. The station is located within a cul-de-sac just off Clover Blossom Lane NE. Flows into the station are not anticipated to increase; however, the equipment in the station is old and no longer functions reliably. In addition, the station operates on single-phase power and has experienced multiple issues with breakers tripping, causing the station to be inoperable. Therefore, upgrades to the existing lift station, including a conversion to 3-phase power, are required.

While the station will be designed as a conventional submersible lift station with a separate valve vault, a pre-manufactured submersible lift station, as provided by Romtec or Old Castle, may be a viable consideration and would be evaluated during construction if the Contactor chooses to submit that style of station. The control panels will be located under a canopy-type shelter for some protection from elements. However, no control building is anticipated for this station due to the small nature of the station and a lack of space for a new building. Once the new station has been constructed, the existing valve vault will be demolished or abandoned and the existing wet well converted to a gravity manhole.

ES-1.6 *Purpose of Report*

This Preliminary Engineering Report (PER) includes design criteria and considerations to document the basis of design; preliminary geotechnical investigations and recommendations; permitting requirements; conceptual design layouts; anticipated design and construction schedules; and preliminary opinions of probable construction cost for the Project.

ES-2. 2019 Hydraulic Model Update

To determine the pumping capacities associated with the planned upgrades of the stations, the County's hydraulic models were updated to reflect current population forecasts, zoning changes, and recent flow monitoring data. Updated Current (2017), Future (2038), and Full Buildout Models were developed using MIKE Urban, a hydraulic modeling software package. All models associated with the 2019 Hydraulic Model Update assume 100% of un-sewered properties were converted from septic systems to service by the sanitary sewer system.

These models were then reviewed to determine facilities with inadequate capacity to convey the anticipated flows. The results associated with each model were used to develop a list of capital improvement projects with associated budgetary level opinions of probable project costs. Chapter 2 summarizes the process used to update the County's hydraulic models and the resultant capital improvement plans for the Central Kitsap and Silverdale Service Areas.

ES-2.1 Current Flow Conditions

Current flow conditions were determined by using parcel-based population data. The Central Kitsap Service Area contains two UGAs: Silverdale and Central Kitsap. These two UGAs are further divided into Traffic Analysis Zones (TAZ). Each TAZ contains population data for residential and commercial populations. TAZ data from the Puget Sound Regional Council (PSRC) pertaining to the estimated current (2017) residential and commercial populations within the Central Kitsap and Silverdale UGAs was used to calculate wastewater flows for the Current model.

Current wastewater flow data at the Central Kitsap Wastewater Treatment Plant (CKTP) was then reviewed to determine appropriate per capita flow rates. This review determined 70 gallons per capita per day (gpcd) was more representative of current flows than the 76 gpcd used for the 2012 Remand modeling. Therefore, the populations at each load point were assigned a wastewater load rate of 70 gpcd. The resulting values represent the wastewater loading in gallons per day for the model.

The model then reviewed historical flow data at the CKTP from the years 2012-2018 to obtain the plant's maximum daily inflow. The maximum daily inflow occurred on January 21, 2016. Kitsap County rainfall data showed 3.3 inches of rainfall accumulated during that 24-hour period. According to the Western Washington iso-pluvial maps from the Department of Ecology's Stormwater Management Manual for Western Washington, a 3.3-inch rainfall event corresponds to a 25-year, 24-hour design storm. Discussions with the County determined the 25-year storm would provide a reasonable basis for the wet weather flow calibration.

The County provided 15-minute incremental data for incoming flows at the CKTP for January 21, 2016. This data was graphed and used to determine the average hourly inflow and the maximum peak hour inflow. The maximum peak hour inflow was then divided by the average hourly inflow to determine a peak hour flow multiplier of 1.5, which was then used as the basis for calibrating the Current Model. Model iterations were performed by adjusting the individual multipliers within the peak day diurnal pattern to yield a peak daily flow to peak hourly flow multiplier of 1.5 at the CKTP. The resulting peak day diurnal pattern was then used to complete calibration throughout the Current model. Figure ES-6 (located at the end of this chapter) provides a summary of the current incoming flows at each lift station along with each station's existing pumping capacity.

ES-2.2 Future Flow Conditions

The Future Model was created by updating the Current Model with future population projections. This was done by replacing the current population data at the load points with future population data. The 70 gpcd wastewater load rate used in the Current Model was deemed suitable for future conditions and was applied to the future populations at each load point to represent the wastewater loading for the Future Model. The peak hourly multiplier of 1.5 was also kept as the basis for calibrating the Future Model. Figure ES-7 (located at the end of this chapter) provides a summary of the future incoming flows at each lift station along with each station's existing pumping capacity.

ES-2.3 Buildout Flow Conditions

The full buildout population projections were determined by assuming all zoning capacity is fully utilized. The resultant populations then replaced the future populations contained in the Future Model. The 70 gpcd wastewater load rate used in the Current and Future Model was deemed suitable for buildout conditions and was applied to the buildout populations at each load point to represent the wastewater loading for the Buildout Model. The peak hourly multiplier of 1.5 was also kept as the basis for calibrating the Buildout Model. Figure ES-8 (located at the end of this chapter) provides a summary of the buildout incoming flows at each lift station along with each station's existing pumping capacity.

ES-2.4 Dickey Road Rezone

The County is considering a site-specific Comprehensive Plan amendment with three alternatives for rezoning 138.45 acres just inside the boundary of the Silverdale Urban Growth Area from an Urban Industrial (IND) zone and removing the Mineral Resource Overlay (MRO) designation. The area is located near the Silverdale Elementary School with high-voltage power lines running through the site.

Full buildout models reflecting each alternative zoning proposal were developed to determine the potential impacts to the sanitary sewer conveyance system. The maximum number of dwelling units were calculated for each alternative based on the acreage zoned Urban Low Residential and then translated to a total population by multiplying by 2.5 people per dwelling unit. The resultant population was then multiplied by 70 gpcd to obtain the sanitary sewer service demand. For the acreage proposed to be Neighborhood Commercial, the population projections were based on the number of employees per building square footage. The same methodology described in Appendix A for the Current Model was used to determine the building square footage. Neighborhood Commercial zoning has a density of 500 square feet per employee. The Neighborhood Commercial Zoning population was determined by dividing the building square footage by 500 square feet per employee to obtain the total number of employees, which was then multiplied by

70 gpcd to obtain the sanitary sewer demand. The revised populations were then entered into the models at the appropriate locations similar to the approach previously described for the Full Buildout Flow Conditions.

The resultant flows for all three alternatives create a significant amount of surcharging in the 8-inch gravity sewers between SSMH M18-4005 and SSMH L18-3011 with Alternative 3 being the most significant since it generates the greatest population. In addition, the 8-inch mains between L18-3011 and L18-3004 are flowing near capacity (almost surcharging). To alleviate the surcharging and capacity restrictions, the 8-inch gravity sewers between SSMH M18-4005 and L18-3004 should be replaced with 12-inch diameter pipe. These improvements would discharge into the upgraded 12-inch gravity sewers installed as part of the Anderson Hill Road Gravity Sewer Upgrades. Figure ES-9 (located at the end of this chapter) summarizes the necessary upgrades. The hydraulic model results associated with this area may be found in Appendix B.

ES-2.5 2024 Comprehensive Plan Update

The County is currently updating its comprehensive plan, which will include new growth assumptions and population projections. This plan is anticipated to include three scenarios, one of which will be there preferred scenario and will include associated Traffic Analysis Zones for the new zoning and population assumptions through 2044. If the new zoning and population assumptions differ substantially from the growth projections included in the model updates associated with this report, then the Wastewater Division may need to update the models in the future to comply with the Growth Management Act.

ES-2.6 Capital Facility Plan

Recognizing that funding needs are generally set for six-year planning windows, upgrades needed to address capacity issues identified in the Current Model are included in the 6-Year Capital Improvement Plan (6-Year CIP). Upgrades needed to address severe capacity issues found in the Future Model may also warrant inclusion in the 6-Year CIP. Longer term projects needed to address minor capacity issues identified in the Future Model as well as capacity issues found in the Full Buildout Model are included in the 20-year CIP. Projects included in the 20-year CIP should be re-evaluated periodically to reflect changes in growth patterns, regulations affecting waster infrastructure construction, alternative means of funding, changes in project costs and advances in wastewater technologies. For this reason, projects included on the 20-Year CIP should be viewed as the most likely scenario, given the parameters known at this time.

The 2019 Hydraulic Model Update identified capacity or age-related issues with nine existing lift stations within the Central Kitsap and Silverdale Service Areas. Four of the pump stations were included on the 6-year CIP as incoming flows into those stations are approaching the firm pumping capacities of the station or the station's equipment has or is reaching the end of its useful life. The other five pump stations were placed on the 20-year CIP as full buildout peak hour flow projections are expected to approach or exceed the firm pumping capacities of those stations.

In addition, ten collection and conveyance projects, totaling approximately 53,500 feet of pipe, were identified as needed improvements to the existing collection and conveyance piping system. Six of these projects will address problems identified in the Current and Future models and should be included in the 6-Year CIP. Three projects are associated with capacity issues identified in the Full Buildout model and should be included in the 20-Year CIP. The tenth project is needed to address severe corrosion in the existing system and has been added to the 6-year CIP.

Figure ES-2 and Figure ES-3 provide a summary of the proposed 6-Year and 20-Year CIP, respectively and all nine stations are shown on Figure ES-10, Figure ES-11, and Figure ES-12 (located at the end of this chapter).

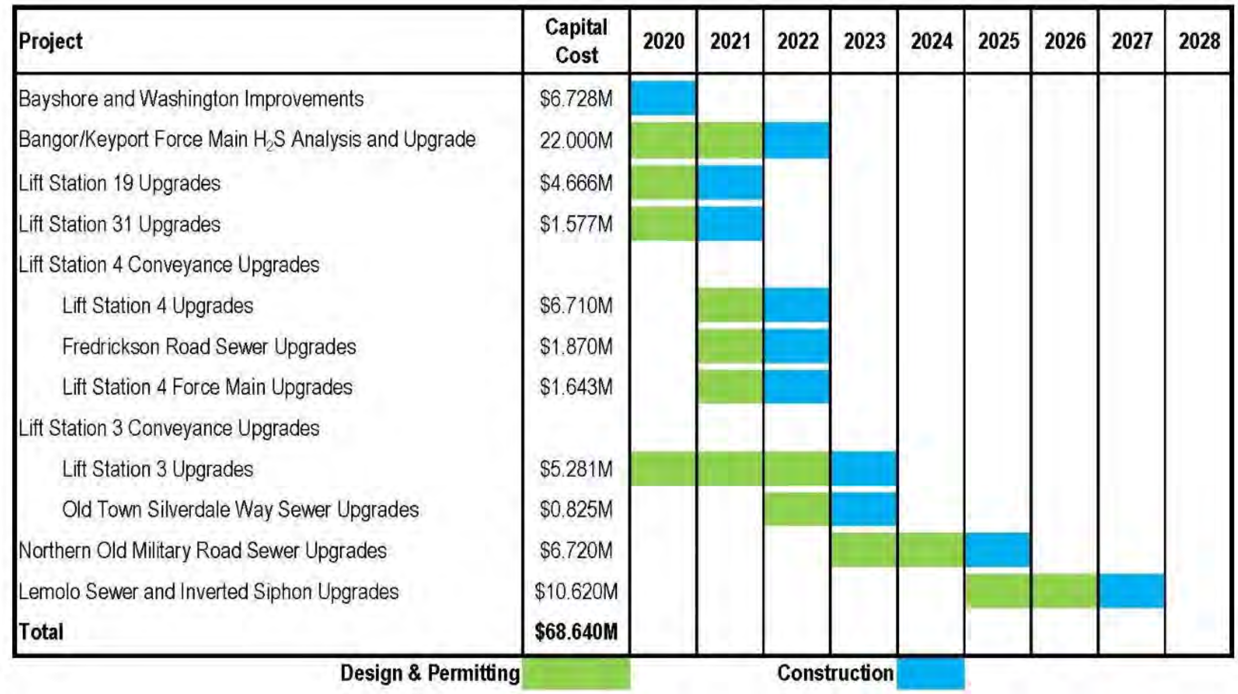

Figure ES-2 – 6 Year CIP

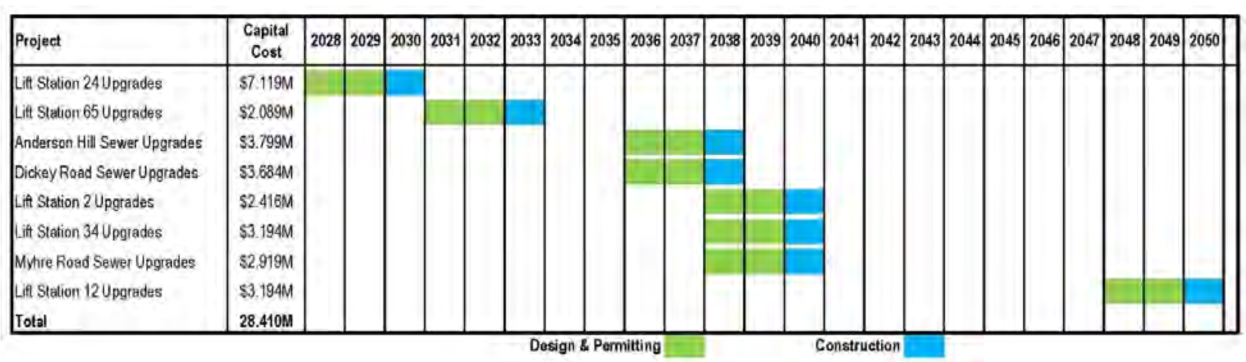

Figure ES-3 – 20 Year CIP

The full buildout model also identified flows to be within 10 to 20 gpm of the pumping capacities of four more lift stations. All four stations are small with pumping capacities ranging from 150 gpm to 270 gpm. Due to the number of assumptions being made during the development of the full buildout model, these stations should be monitored but not necessarily included on the 20-year CIP. If growth occurs as anticipated, upgrades to these stations will likely be triggered by aging equipment before their pumping capacities are exceeded. Table ES-1 identifies the four stations along with their firm pumping capacities and expected buildout peak flows. Figure ES-13 and Figure ES-14 (located at the end of this chapter) provide summaries of the incoming flows for the Future and Full Buildout Models at each lift station along with each station's pumping capacity after the proposed capital improvements have been completed.

Table ES-1
Lift Stations to Monitor

Lift Station	Ex. Firm Capacity (gpm)	Buildout Peak Hourly Inflow (gpm)	Year Installed
LS 10	270	280	1980
LS 32	165	175	1983
LS 36	150	170	1979/1999
LS 69	160	165	1998

ES-3. General Design Criteria and Constraints

All facilities will be designed and constructed in accordance with the current requirements of the following sources:

- Department of Ecology's Criteria for Sewage Works Design (Orange Book)
- Kitsap County Standards
- Washington State Department of Transportation's (WSDOT) 2020 Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications)
- Design consultant expertise and standard industry practices

The lift stations will include submersible type sewage pumps with capacity to accommodate the projected peak hour flow into each station with the largest pump out of service. The pumps will be controlled in an alternating lead-lag configuration. All four lift stations will include magnetic meter flow measurement, force main pressure monitors, pigging ports, and radio telemetry systems with provisions for future upgrades to fiber optic telemetry systems. In addition, LS 3, LS 4, and LS 19 will include standby generators or backup diesel pumps located within the control buildings.

Gravity sewers and force mains will be designed to maintain Orange Book recommended minimum velocities to promote self-scouring and prevent solids accumulation. In addition, force mains will be sized so that fluid velocities within the force main do not exceed 8 feet per second to avoid unnecessary energy consumption.

The County has standardized on the following equipment and manufacturers. Other manufacturers for the following equipment are not anticipated to be allowed at the time of this PER.

- Submersible Wastewater Pumps: Flygt
- Programmable Logic Controllers (PLCs):
    - Allen Bradley Compact Logix PLC (for all equipment control, monitoring and alarming)

- Allen Bradley 1400 PLC (telemetry panel)
- Telemetry: Viper CAL-Amp SC-100 Ethernet 173.3125 MHZ (radio)
- Flow Meters: Siemens 5000 series or Krohne Enviromag 2000 series
- Submersible Pressure Transducers: Siemens A1000
- Standby Generator: Cummins Power Generation or Caterpillar Energy Systems.

The 2019 Hydraulic Model Updates were used to determine the design flows for each station. Table ES-2 summarizes the design flows entering LS 3, LS 4, LS 19, and LS 31.

Table ES-2
Design Inflow

Lift Station	Current Flows (gpm)		2038 Flows (gpm)		Full Build-Out Flows (gpm)	
	Average	*Peak*	*Average*	*Peak*	*Average*	*Peak*
3	340	580	760	1,200	2,095	2,340
4	1,170	1,965	2,340	3,825	3,910	4,950
19	200	480	385	780	610	1,075
31	15	20	20	30	55	80

For the triplex lift stations (LS 3, LS 4, and LS 19), the pumps will be sized to meet the peak full buildout flows with two pumps operating. Each station's pumping capacity with one pump operating will then be reviewed against the current and 2038 peak and average flows and the full build-out average flows to evaluate pump cycling times. For the duplex station (LS 31), the pumps will be sized to meet the peak full build-out flows with one pump operating. The station's pumping capacity with one pump operating will then be reviewed against the current and 2038 peak and average flows and the full build-out average flows to evaluate pump cycling times. Table ES-3 summarizes the resultant target pumping capacities for each lift station and the anticipated pump cycles per hour at peak flows.

Table ES-3
Target Pumping Capacity

Lift Station	One Pump		Two Pumps	
	Q (gpm)	*Cycles/Hr*	*Q (gpm)*	*Cycles/Hr*
3	2,200	2 to 4	3,200	4 to 6
4	3,040	2 to 3	5,030	3 to 5
19	1,240	2 to 4	2,040	3 to 6
31	170	1 to 2	N/A	N/A

ES-3.1 Lift Stations 3, 4, 19 and 31 Preliminary Design Elements

The preliminary design of the gravity sewer and force main upgrades are based on the following engineering principles:

- The 2019 Hydraulic Model Update – 2038 Flow Conditions and Full-Buildout Flow Conditions are used to establish the design flows.
- Gravity sewer pipe shall convey the design flows without surcharging the system while maintaining a velocity of at least 2 feet per second (fps).
- Velocities in force mains shall be greater than 2 fps and less than 8 fps. Velocities between 3.5 and 5.0 fps are targeted to reduce maintenance costs and prevent the accumulation of solids.
- Pipeline materials are expected to have a design life of 50-75 years.

All gravity conveyance piping that is installed via open trench construction methods will use PVC gravity sewer main. If a trenchless construction method such as pipe reaming or pipe bursting is used, the new pipe will be HDPE with a minimum SDR of 17. For LS 4's force main, C905 PVC pipe will be installed using open trench construction methods. Lift Station 31's force main will be constructed of C905 PVC or HDPE pipe. Ductile iron pipe and fittings, lined with Protecto 401 Ceramic Epoxy or accepted equal, will be used between the pumps and the pig launch or downstream end of the valve vault or easier assembly.

Manholes along the upgraded alignment will be replaced with new standard sized manholes coated on the inside with a 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide. Manholes will be installed in accordance with the requirements of Section 7-05.3 of the Standard Specifications. If the excavation for the bottom of the manhole becomes disturbed, the disturbed soil will be over-excavated to expose undisturbed native soil and backfilled with suitable foundation material to provide a firm base. Foundation material should meet the requirements for Foundation Material Class A in Section 9-03.17 of the Standard Specifications. Foundation material will be placed in 6-inch lifts and thoroughly compacted to provide a firm excavation bottom. Manholes will be backfilled in accordance with the requirements of Section 2-09.3(1)E of the Standard Specifications. Parcels that are connected to the existing gravity sewer will be reconnected to the new gravity sewer with new laterals from the main to the edge of the right-of-way. Cleanouts will be installed on the laterals at the right-of-way (ROW)/property line.

ES-3.1.1 Old Town Silverdale Gravity Sewer Upgrades

The existing 8-inch gravity sewers along Pacific Avenue NW, the alley between NW Carlton Street and NW Lowell Street, and along McConnell Avenue NW (north of NW Byron Street) experience minor surcharging under current conditions and significant surcharging under future conditions. The surcharging can be addressed by intercepting the flows at SSMH L17-1079 near the intersection of Pacific Avenue NW and NW Carlton Street and conveying them via about 700 feet of new 15-inch gravity sewer east along NW Carlton Street to the new gravity sewers being installed in Washington Avenue NW under the Bayshore and Washington Improvements. Figure ES-15 (located at the end of this chapter) shows the proposed improvements for the Old Town Silverdale Gravity Sewer Upgrades.

ES-3.1.2 Fredrickson Road Gravity Sewer Upgrades

The existing 15-inch gravity sewers along Fredrickson Road NW from NW Chena Road to Lift Station 4 need to be upsized to 18-inch, 21-inch, and 24-inch gravity pipe. The proposed Fredrickson Road Gravity Sewer Upgrades are shown on Figure ES-16 (located at the end of this chapter).

ES-3.1.3 Lift Station 4 Force Main Upgrades

Upgrades to LS 4 will result in velocities in the existing 14-inch force main of 5.7 fps with one pump operating and 9.5 fps with two pumps running in parallel. Force mains are deemed to be at or above capacity if velocities exceeded 8 fps. Based on that criteria, LS 4's 14-inch force main needs to be upgraded to 20-inch force main from LS 4 to SSMH J18-3048, which is located approximately 250 feet east of Spinnaker Boulevard. Sewage velocities in a 20-inch force main would be approximately 2.8 fps with one pump operating and 4.7 fps with two pumps running in parallel. The proposed upgrades are shown on Figure ES-17 (located at the end of this chapter).

ES-3.1.4 Lift Station Upgrades

Based on the pump rates shown in Table ES-3 and the age of the existing infrastructure, the necessary upgrades to address the projected flows and to bring LS 3, LS 4, LS 19, and LS 31 into compliance with the County's current standards were identified. These upgrades include new wet wells, valve vaults, flow meters, pumps, control panels, telemetry panels, generators, control buildings, odor control facilities, onsite lighting where appropriate, and overflow storage. Table ES-4 summarizes the proposed upgrades.

Table ES-4
Summary of Lift Station Upgrades

Criteria	LS 3	LS 4	LS 19	LS 31
Pumping Capacity	3,200 gpm	5,030 gpm	2,040 gpm	170 gpm
No. of Pumps & HP	3 @ 160 HP	3 @ 250 HP	3 @ 70 HP	2 @ 3.2 HP
Wet Well Upgrades	New 20' x 16' rectangular wet well	New 34' x 20' rectangular wet well	Re-use existing wet well	New 8' diameter wet well
Flow Meter	Magnetic flow meter located in control building	Magnetic flow meter located in control building	Magnetic flow meter located in control building	Magnetic flow meter located in underground vault
Pig Launch	New underground vault	New underground vault	New underground vault	New underground vault
Building Upgrades	New control building	New control building	New control building	Canopy shelter for control panels
Generator	New 400 kW	New 600 kW	New 200 kW	Pig tail for portable
Control Panels	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, motor controller, ATS, and telemetry panels; new antenna
Odor Control	Carbon scrubber	Carbon scrubber/ biofiltration bed	Room allotted for future odor control	Goose-necked vent with carbon canister
Overflow Storage	157,200 gallons	267,000 gallons	53,850 gallons	N/A

The recommended configuration and County standard for these lift stations is a submersible type lift station including non-clog, submersible wastewater pumps affixed to a guiderail system in a wet well. The County has standardized on Flygt submersible wastewater pumps to ease maintenance complexities. Therefore, the proposed lift station layouts are based on the respective Flygt pump sizes and configurations.

Providing adequate response time for maintenance crews to troubleshoot and address issues at the stations is a paramount consideration. Additional response time may be gained by constructing additional overflow storage via an underground vault or piping. Table ES-4 identifies the overflow storage required to achieve a one-hour response time at full buildout peak flows.

New control buildings will be constructed for LS 3, LS 4, and LS 19 to house the standby generators, electrical equipment, and odor control equipment. The buildings will be designed in accordance with the 2015 or 2018 edition of the Washington State Building Code (IBC 2015). Permit applications made after July 2020 will need to comply with the 2018 edition. The Occupancy Group of all three rooms is U. The control buildings will be classified as Construction Type V-A, which allows both combustible and non-combustible materials. The exterior walls of each structure will be 1-hour rated. A 1-hour separation between each room will be provided by Concrete Masonry Unit (CMU) partitions and a gypsum board ceiling applied to the underside of the roof trusses. The roof assembly does not need to be fire rated construction.

The proposed construction anticipates using CMU walls with a wood truss framed roof topped by APA (The American Wood Association) rated sheathing (plywood or Oriented Strand Board (OSB)) and a standing seam metal roofing. CMU is selected for its durability and low maintenance. The CMU will be 8 inches thick, fully grouted and reinforced, supported on 8-inch thick reinforced concrete stem walls that bear on reinforced concrete strip footings. All floors will be at least 6 inches thick reinforced concrete, except where thickened at free edges around generator foundations. The CMU walls may have a split faced surface with integral color that does not need painting. Interior walls may need to be insulated to comply with energy codes. Exterior fascia, soffits, and trim may be pre-finished metal to minimize painted surfaces. The generators will be supported on isolated concrete foundations sized to minimize resonance and isolated from the surrounding floor to minimize transmission of vibration that would occur with direct contact between the foundation and the surrounding slab. The architectural appearance details for each building will be determined during final design. For LS 3, the architectural details will also need to be coordinated with the Port of Silverdale due to the station's location within the Silverdale Waterfront Park.

Each room within each control building has different HVAC requirements. The generator rooms will have electric unit heaters to be utilized in the winter months for freeze protection purposes. Sound lined ductwork will be connected to the discharge of each generator's radiator and terminated at acoustical exhaust louvers. Acoustical intake louvers with motorized control dampers will be installed to provide make-up air for when each generator is in operation. Exhaust piping with critical grade silencers will be attached to the generators and routed to the roof above to discharge engine exhaust. The electrical rooms and odor control rooms will use a split-system heat pump; protecting the equipment against overheating and potential freezing. The walls and ceiling will need to be insulated to comply with energy codes.

Each room will contain a floor drain with a P-trap piped to the wet well. The P-traps will be supplied by a trap primer to prevent sewer gas from the wet wells from entering the building.

Lift Station 3

Lift Station 3 is located within the Silverdale Waterfront Park and as such the Port of Silverdale is a significant stakeholder with concerns on how the station will be integrated into the surrounding park. To begin addressing their concerns, four alternative layouts were evaluated for the upgraded station and presented in a design memorandum dated September 24, 2018 (see Appendix E for a copy of the memorandum). The main difference between the options was the physical location of the proposed station. After much discussion between the County and the Port, the decision was made to proceed with Option 4 where the proposed station is located adjacent to the parking lot on property owned by the Port of Silverdale.

The Silverdale Waterfront was acquired in 1977 using Federal Land and Water Conservation Funds. This funding source contains restrictions on land use. In 2008, the County underwent a mitigation process to bring the existing lift station into compliance with the funding requirements. Based on recent discussions between the County and the Washington State recreation and Conservation Office (RCO) and the National Parks Services, the County was informed that shifting the lift station towards the parking lot on property owned by the Port of Silverdale would likely not require further mitigation by the County or the Port of Silverdale. However, the RCO and National Parks will need the final location and footprint of the upgraded station before that determination can be finalized.

Lift Station 3's proximity to Dyes Inlet raises concerns regarding long-term impacts due to rising tidal concerns associated with global warming. To address those concerns, a waterproof membrane will be installed behind the wainscoting and fully integrated with the supporting footings. All windows and exhaust/supply ducts will be installed at least 3'-6" above the finished floor, and heavy-duty jambs and doors that can resist up to 3 feet of flooding will be used. In addition, electrical equipment will be installed on elevated pads and drains and/or sump pumps will be considered to minimize potential flood damage. The landscaping design may consider berms that could act as levees to protect the building. To address the volumes of overflow storage identified in Table ES-4, an additional underground vault, located south of the proposed station is proposed. The County should note that the overflow storage required to provide a one-hour response time at peak buildout flows is about three times the amount of storage required for peak future flows. Given the volume difference, further discussion during the design phase of the project is warranted to determined how much storage is needed given the County's available response time and risk tolerance.

The isolation and check valves along with the flow meter and pig launch will be located in the generator room in the new building. Separate rooms will be provided for the electrical control panels and odor control facilities. The proposed upgrades are shown on Figure ES-18, Figure ES-19, and Figure ES-20 (all three figures are located at the end of this chapter) represents a conceptual elevation view of what the station might look like in the park. The County recognizes the building will likely be a joint use facility with the Port of Silverdale and the intent of Figure ES-20 is to show how the station could be worked into the park setting. The final configuration, appearance, and location of the station will be determined via subsequent discussions between the County and the Port of Silverdale.

Lift Station 4

The existing above grade building is in poor condition with extensive rusting of the metal roof and deterioration of the concrete block walls. Therefore, a full replacement of the control building is needed. The below ground wet well and dry well structures are in reasonably good condition and may be reused. With that in mind, the preliminary design utilized the existing dry well to house the isolation and check valves, and the flow meter will be located in a utilidor just north of the existing dry well and under the new building. Access to the utilidor is via the generator room.

The existing wet well will be rehabilitated and then connected to the new wet well to provide additional overflow storage. Given the volumes of overflow storage shown in Table ES-4, additional overflow storage via an underground vault is anticipated. Note that that the peak buildout flows require about 50% more storage than the peak future flows and hence consideration should be given during the design phase of the project to determined how much storage is needed given the County's available response time and risk tolerance. Finally, a below ground pig launch will be installed near the northwest corner of the new building. Figure ES-21 and Figure ES-22 (located at the end of this chapter) show the proposed layout of the station and the control building.

Lift Station 19

The existing wet well at LS 19 is in good condition and the County indicated a preference to use it to house the new submersible pumps. The existing control building, however, has reached the end of its useful life and would cost more to rehabilitate to current codes than to just replace it with a new building. With that in mind, the new building was laid out to house isolation and check valves, flow meter, and pig launch above ground in the generator room. Separate rooms are provided for the electrical control panels and odor control facilities. Provisions have been maintained the ability to pump into the northern force main or into Lift Station 4's force main. The proposed upgrades are shown on Figure ES-23 and Figure ES-24 (located at the end of this chapter).

Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is also consideration at this station, given the volume of incoming flow shown in Table ES-4. Additional response time may be gained by constructing an underground vault to the south of the existing wet well and new control building. Note that that the peak buildout flows require about 75% more storage than the peak future flows. Given the volumes being considered, this report recommends designing around the volumes associated with full buildout peak flows. Further discussion during the design phase of the project may be warranted to determined how much storage is needed given the County's available response time and risk tolerance.

Finally, Kitsap County's Roads Division is designing improvements to the intersection of Nels Nelson Road NW and NW Bucklin Hill Road which fronts LS 19. The proposed improvements include new signal lights, new sidewalks, and a revised driveway to the storm water detention pond located immediately west of the lift station. The Roads Division has indicated the intersection upgrades may be delayed until after the LS 19 upgrades, but close coordination between the Roads Division and the Wastewater Division will still be required as the design proceeds to avoid future rework and/or utility conflicts.

Lift Station 31

Lift Station 31 is old, and the equipment no longer operates reliably. To address the necessary upgrades to the station, a new duplex submersible lift station inside a new wet well and a new valve vault adjacent to the existing wet well with a 4-inch force main from the new lift station to the 12-inch force main from LS 8 located in NE Clover Blossom Lane is proposed. The existing wet well would be converted to a conveyance manhole after the existing station is removed from service.

The design will need to upgrade the power source to 240V or 480V three-phase power as the current power is only 240V single phase. Constructing a control building for this station would require the acquisition of additional land via a purchase or an expansion of the existing easement. Due to the relatively small size of the station, a control building isn't necessary as the control panels can be located under a canopy-type structure to provide protection from the weather. In addition, a permanent onsite generator is unnecessary due to the limited flows seen by the station. Instead, a generator receptacle will be provided to allow a portable generator to operate the station during a power outage. Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is not a significant issue, as an 8-foot diameter wet well would provide reasonable response times at the projected peak flow rates.

A pre-manufactured lift station, like ones provide by Romtec or One-Lift, may be good candidates for LS 31. A pre-manufactured lift station would minimize the onsite construction time with resultant impacts to the surrounding neighborhood. Figure ES-25 and Figure ES-26 (located at the end of this chapter) provide a preliminary site plan and a plan view layout for the submersible lift station.

ES-3.1.5 Surge Analysis

A preliminary surge analysis was performed for the proposed pumps at LS 3, LS 4, LS 19, and LS 31. The purpose of this analysis was to investigate and identify potential surge conditions that could occur at each lift station. Surge pressures, also referred to as pressure transients or water hammer, occur when steady state flow conditions are changed in a pipeline. Examples of such conditions include pump startup, sudden closure of a valve or loss of power to the pumps. The impacts of these conditions are usually insignificant for most potential transients and specific surge control facilities or modifications are typically unnecessary for protection. In some specific cases however, pressure surges may occur that could result in damage to pipelines and appurtenances if protection is not provided. Damaging surge events may occur when pressures in the pipe fall below the vapor pressure of the sewage. Rather than continuing to decrease in pressure, the fluid will vaporize to stabilize the negative pressure. This may cause cavitation to occur, which can lead to loss of pipe material and very high pressures when the vapor cavity subsequently collapses, and the two water columns reunite. The extreme pressures could burst the pipe if they exceed the capacity of the pipe material.

The most critical surge condition associated with lift stations typically results from a total station power failure (pump trip) when the largest flow is occurring. This condition was analyzed for all four lift stations. Table ES-5 summarizes the results of this investigation and Appendix G contains a memorandum summarizing the results of the surge analysis.

Table ES-5
Surge Analysis Results

Lift Station	Surge Analysis Results
LS 3	Rapid shut down conditions during a pump trip may result in a maximum pressure of about 75 psi and a minimum pressure of approximately -15 psi, which is the fluid's vapor pressure. This would indicate that surge protection may be needed at LS 3. The surges may be controlled by adding a surge tank at the station, an air-vacuum valve on the force main near the point where the LS 2 force main connects to the LS 3 force main, or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 4	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 75 psi and a minimum pressure of proximately -15 psi, which is the fluid's vapor pressure. This would indicate that surge protection may be needed at LS 4. The surges may be controlled by adding a surge tank at the station or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 19	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 44 psi and minimum pressures were at vapor pressure (cavitation) for an extended length of the force main. This would indicate that surge protection is needed at LS 19. The surges may be controlled by adding a surge tank at the station or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 31	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 22 psi and minimum pressures of about a negative 5 psi. The LS 31 force main discharges into the LS 8 force main system. Therefore, the maximum pressures along the LS 31 force main occur when the LS 8 force main system is experiencing maximum head conditions of approximately 55 feet. During these maximum head conditions, however, pressures at LS 31 do not change significantly during a pump trip because the pressurized LS 8 force main buffers the pressures. The minimum pressure of negative 5 psi occurs when the LS 8 force main is not surcharge (when the LS 8 pump are off). The negative pressure is not low enough to cause cavitation, so surge mitigation measures appear to be unnecessary at LS 31. However, the analysis should be refined during the final design stages to verify the preliminary analysis results.

ES-3.1.6 Electrical, Instrumentation, and Controls

The new pumps at LS 3, LS 4, and LS 19 will have variable frequency drives (VFD), while the pumps at LS 31 will have constant speed drives. Oversized junction boxes with cable splice kits (aluminum with rubber gasket covers) adjacent to each wet well will provide easy disconnection and removal of the pumps. Table ES-6 identifies the rated horsepower (hp) for each pump as well as the fuel storage requirements.

Table ES-6
Rated Motor Horsepower

Lift Station	Rated Horsepower	Generator Size	Fuel Storage
LS 3	160 hp	400 kW	700 gal
LS 4	250 hp	600 kW	1,200 gal
LS 19	70 hp	200 kW	400 gal
LS 31	3.2 hp	N/A	N/A

Lift Stations 3, 4, and 19 will be equipped with standby generators to power the stations during utility service outages. Per County request, the generators are sized to power each lift station in a buildout condition with the largest pump out of service. Since these stations are triplex stations, the generators are sized to operate two pumps during an outage. The generators will share a room within control building with the check valves, isolation valves, and flow meters, but isolated from the electrical distribution panels. The generator and automatic transfer switch will include alarms, status monitoring, windings heaters, engine block heater, and battery charger. Due to their size, all three generators will likely be diesel driven generators. The fuel storage systems should be designed to provide 24 hours of operation at full engine generator load with fuel monitoring and leak detection systems.

Storing more than 667 gallons (2,500 liters) of fuel indoors triggers additional fire suppression requirements. Therefore, fire suppression equipment for an indoor tank or an outdoor fuel storage tank would be needed at Lift Stations 3 and 4. An underground outdoor fuel tank would be typical with public use spaces such as Lift Stations 3 and 4 and would need fuel transfer and fuel monitoring systems. The cost of the fire suppression equipment or an outdoor fuel storage tank with associated transfer and monitoring systems exceeds the benefits of 37 gallons of additional fuel storage at LS 3. Therefore, this report recommends using a subbase tank under the generator with a fuel storage capacity of 660 gallons, even though this would not provide a full 24 hours of operation at full engine generator load. A subbase tank located beneath the generator would be sufficient at LS 19.

Natural gas generators could be used at LS 3 and LS 19, but they would be more expensive at the anticipated capacities. The County will need to consider the additional costs versus the benefits of not accessing the lift stations with diesel trucks for refueling. Natural gas generators also tend to be less noisy, which would be a benefit for community enjoyment of the public space around LS 3.

Another option involves installing backup diesel driven pumps at LS 3, 4, and 19 instead of standby generators. Backup diesel pumps would have their own mechanical and controls, providing additional redundancy. Further redundancy could be provided by including a receptacle for a portable generator in addition to the diesel pump. Table ES-7 provides a summary of the advantages and disadvantages of a diesel backup pumps, diesel generators, and natural gas generators.

Table ES-7
Standby Power Source Comparison

	Diesel Pumps	Diesel Generators	Natural Gas Generators
Advantages	▪ Redundant mechanical and control systems ▪ Generator receptacle in addition to diesel pump provides further redundancy ▪ Diesel engine not required to meet Tier 4 emission standards (Tier 3 is acceptable due to pumps emergency use designation) ▪ May be used for bypass pumping during routine maintenance of electrical driven pumps	▪ Generator may be tested without affecting station operation ▪ Successfully implemented at other County lift stations leading to maintenance crew familiarity	▪ Generator may be tested without affecting station operation ▪ Successfully implemented at other County lift stations leading to maintenance crew familiarity ▪ Does not require refilling of fuel source ▪ Often requires less noise attenuation as natural gas generators are quieter than diesel generators
Disadvantages	▪ Additional pump and control system to maintain ▪ Suction lift considerations can complicate design ▪ Requires additional piping and valves ▪ Requires time to prime the pump ▪ Requires a diesel storage tank, which could trigger additional fire suppression requirements ▪ Requires diesel truck to refill diesel tank	▪ May require larger footprint in building ▪ Does not provide contingency in event of a pump or pump control failure ▪ Requires a diesel storage tank, which could trigger additional fire suppression requirements ▪ Requires diesel truck to refill diesel tank ▪ Requires an automatic transfer switch	▪ May require larger footprint in building ▪ Does not provide contingency in event of a pump or pump control failure. ▪ Requires natural gas service, which could be subject to interruption during an earthquake.
Equipment Cost	▪ LS3 = $238,500 ▪ LS4 = $244,000 ▪ LS19 =$89,500	▪ LS3 = $99,500 ▪ LS4 = $171,500 ▪ LS19 =$67,500	▪ LS3 = $209,000 ▪ LS4 = $356,500 ▪ LS19 =$122,500

In accordance with the Kitsap County Code 10.28.080, "Sounds created by emergency equipment and work necessary in the interests of law enforcement or for health, safety or welfare of the community" are exempt from all provisions of Section 10.28.040 and 10.28.145, sections which define permissible noise levels. The Kitsap County Department of Community Development Planning and Environmental Programs Division has indicated that the standby generators are not required to meet permissible noise levels set forth in the Kitsap County Code, during emergency operation, as well as routine testing. However, as the generators at each lift station site are close to residences or within a park that is heavily used by the general public, the engine generator rooms will feature sound attenuation to reduce the sound levels of the engine at full loading to approximately 68 decibels at the closest property line. In addition, routine testing of the generators will be conducted by the County during daytime hours as much as possible. The routine testing of each engine generator may not require the engine to operate at full loading, so the actual noise generated may be less. The standby generators will be Cummins Power Generation or Caterpillar Energy Systems.

Service power for all four lift stations will be 480/277Y volt, 3-phase, 60 Hertz as available from the electrical utility for electrical loads at each station. This will require an upgrade to the service power at LS 31, since the station is currently operating on 240 single phase power. The control panel equipment cabinets at LS 3, LS 4, and LS 19 will be approximately 90"L x 48"W x 2'D and installed on housekeeping pads inside the electrical rooms to elevate the free-standing electrical equipment. All wall mounted electrical equipment will be at least 12 inches above the slab to promote usability and maintenance access. For LS 31, the control panel and telemetry panels will be pedestal mounted under the proposed canopy.

The control panels will contain the County's standard Allen-Bradley CompactLogix programmable logic controllers (PLC) to control the pumps and interface with the telemetry system. The control panels will also contain hand-off-auto (H-O-A) switches, speed potentiometers, operator interface graphical terminals, elapsed time meters, pilot lights, wet well level monitoring equipment, pump monitoring relays, power supplies, and relays. The motors are powered through variable frequency drives (VFDs). The VFDs at Lift Stations 3, 4, and 19 will be free standing, MCC style drives. The motor controllers at Lift Station 31 will be enclosed in an electrical panel but separate from the PLC control panel.

The PLC and Supervisory Control and Data Acquisition (SCADA) systems will store historical data including flow, totalized flow, and alarms. This data will be periodically transmitted through the telemetry system to the County.

Telemetry at each lift stations will be communicated via radio to match existing communications. An antenna will extend approximately 20 feet above the ground using a mast supported by the control building or attached to a light pole. At LS 31, the mast will be free standing. Spare conduits will route to the right-of-way for future fiber optic telemetry system upgrades. Each telemetry panel will be the County's standard arrangement comprised of an Allen Bradley 1400 PLC with Viper CAL-Amp SC-100, 173.3125 MHZ Ethernet radio unit.

Each lift station will be equipped with a magnetic flow meter. For LS 3 and LS 19, the flow meters will be above ground in the generator/valve/meter room. At LS 4, the flow meter will be in a below ground utilidor in the generator room. Lift Station 31's flow meter will be in the valve vault. The flow meters for LS 3, LS 4, and LS 19 will have piping and valves that can be manipulated to bypass flows around the flow meter in the event the meter needs to be removed for servicing. At LS 31, a fabricated flanged spool piece (the same length as the flow meter) will be provided, which can be installed in place of the meter should the flow meter require servicing. All four flow meters will be County standard Siemens 5000 series or Krohne Enviromag 2000 series.

Wet well levels will be measured with submersible pressure transducers. The transducers will be mounted in removable fiberglass stilling wells to allow wet well cleaning. Backup level measurement and pump control will be implemented using float switches. The float switches will also be mounted on removable cables to permit cleaning. Transducers will be the County's standard Evoqua (formerly Siemens) A1000.

Door open switches and occupancy sensors will monitor for unauthorized access to the station. The wet well and in-ground utility structures will not have hatch monitoring switches. Additionally, the PLC will monitor the control room temperature and small particulate matter, such as smoke.

ES-3.2 Easement Requirements

Temporary or permanent easements may need to be acquired to facilitate the upgrades. Table ES-8 summarizes the easement needs for each station. The contractor should be responsible for acquiring any additional staging areas beyond the temporary or permanent easement limits.

Table ES-8
Easement Requirements

Lift Station	Temporary Easement Requirements	Permanent Easement Requirements
LS 3	Temporary easements from the Port of Silverdale may be required to facilitate construction of the prosed improvements.	Permanent easement from the Port of Silverdale for the new location of the lift station will be required.
LS 4	Temporary easements may be needed from the properties to the north and east of the station to facilitate construction of the retaining walls. The size and extents of those temporary easements will be determined once the grading plan and the associated retaining walls for the proposed upgrades are determined.	No new permanent easements are anticipated.
LS 19	No temporary easements are anticipated	No new permanent easements are anticipated
LS 31	Temporary construction easements may be required to facilitate construction of the proposed upgrades.	No new permanent easements are anticipated

ES-3.3 Permit Requirements

The following permitting requirements have been compiled based on preliminary project descriptions for each station, a review of Kitsap County permit requirements, and experience with similar projects. As the design is finalized, the permitting and regulatory requirements should be confirmed with County and Agency staff.

ES-3.3.1 Site Development Activity Permit

Kitsap County's Site Development Activity Permit (SDAP) provides a mechanism to ensure storm water quality and quantity concerns are addressed prior to site development. An SDAP permit will be required for each lift station. The application is processed by Kitsap County's Department of Community Development and will require temporary erosion and sedimentation control plans for construction activities. In addition, the County's permitting agency will review drainage construction plans and other storm water documents for improvements. If additional storm water facilities are required, County personnel will need to inspect them for compliance with the County codes after the facilities have been constructed. This permit would be obtained for each site using the final (100 percent design) contract documents.

ES-3.3.2 Building Permit

All four lift stations will need building permits to address the new control building at LS 3, LS 4, and LS 19 as well as the canopy at LS 31. In addition, the retaining walls at LS 4 will require a separate building permit. Separate permit applications for each site will be made to the Kitsap County Department of Community Development and will need to include final construction design drawings and supporting documents. The County's permitting agency will then review the documents for compliance with the County's codes. These permits will not be issued by the County until the SDAP for each site has been approved and issued.

ES-3.3.3 PSE Application

All four lift stations will need separate applications to Puget Sound Energy (PSE) for revised electrical services. The applications will be made using the 60% design drawings. Once the applications are received, PSE typically takes about two to three months to process them.

ES-3.3.4 Environmental Permits

Landau Associates conducted a preliminary investigation into the environmental permits that will be needed for each station. Their findings are summarized in Table ES-9 through Table ES-12. The need for some of these permits will depend on whether the Project financing includes any funds from federal or state sources.

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Table ES-9
Lift Station 3 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Pump station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Shoreline Management Act	Kitsap County Department of Community Development	"Development" within shoreline jurisdiction (below ordinary high water and extending 200 ft landward).	Project activities within 200 ft of the ordinary high-water line of Dyes Inlet.	▪ Joint Aquatic Resources Permit Application ▪ SEPA Checklist ▪ Shoreline Master Program Consistency Evaluation Narrative ▪ Project plans	Up to 120 days	Depending on the proposed configuration, the project may be considered for "exemption" as normal maintenance or repair of existing structures/developments or would otherwise be considered a "substantial development." Utilities are permitted in the Urban Conservancy shoreline environment; landscaping may be required to satisfy wetland/vegetation conservation buffer requirements. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland buffer and shoreline master program jurisdiction location.
Section 404 Clean Water Act (Waters of the U.S.)	U.S. Army Corps of Engineers	Dredge and/or fill in wetlands, below ordinary high-water line (streams), or mean higher high-water line (tidal waters).	Fill or dredge activity in wetlands. Installation of utility lines using directional drill techniques under wetlands does not require permit.	▪ Joint Aquatic Resources Permit Application ▪ Wetland/Waterways Critical Areas Report	3 to 6 months	Installation of utility lines using directional drill techniques does not require permit. However, if unavoidable wetland impacts occur as a result of utility line installation, authorization under the Nationwide Permit program is likely. The USACE will also require documentation of consultations under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act as part of the State Environmental Review Process (SERP). If SERP does not apply, the application to the USACE would require a no effect determination or a biological assessment and cultural resources investigation report. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland locations.
Critical Areas Ordinance – Wetlands	Kitsap County Department of Community Development	Development in wetlands or associated buffers.	Development in wetland and/or associated buffers.	▪ Wetland/Waterways Critical Areas Report	Concurrent with SEPA review	Installation of utilities using directional drill techniques does not require compensatory mitigation, which would be presented in the critical areas report. Landscaping may be necessary to satisfy wetland/shoreline vegetation conservation buffer mitigation requirements. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland locations.
Critical Areas Ordinance – Frequently Flooded Areas	Kitsap County Department of Community Development	Development in 100-year floodplains.	Pump station improvements.	▪ Evaluation of cut/fill in the floodplain ▪ No effect determination or biological assessment	Concurrent with SEPA review	Any fill above base flood elevation would require mitigation to compensate for volume of flood storage removed. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for mapped floodplain locations.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA.	Hydrogeology report (if needed)	Concurrent with SEPA review	Category II CARA mapped in the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Cross cutter report	Varies, and is contingent on consultations with other agencies.	SERP compliance requires supporting documentation as detailed below, and compliance with Section 404 Clean Water Act and Floodplain Management (i.e., Critical Areas – Frequently Flooded Areas) as identified above.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historic buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance areas occur in the project area.	Completed with SERP	No air quality non-attainment or maintenance areas occur in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act (Essential Fish Habitat)	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and US Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment.	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance.		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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Table ES-10
Lift Station 4 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Pump station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA.	Hydrogeology report (if needed)	Concurrent with SEPA review	Category I CARA mapped in segment of the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)[A]		Cross cutter report	Varies, and is contingent on consultations with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s)	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historic buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Section 404 Clean Water Act/ Executive Order 11990 (Wetlands Protection)	Ecology Water Quality Program (and U.S. Army Corps of Engineers [USACE] if unavoidable wetland/waterway impacts)	Projects with federal assistance. (USACE – Dredge and/or fill in wetlands, below ordinary high-water line of streams, or mean higher high-water line of tidal waters).	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Not applicable, no wetlands/waterways occur in the project area.	Completed with SERP	No wetlands/waterways occur in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and US Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment.	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program			Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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Table ES-11
LS 19 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Pump station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Section 404 Clean Water Act (Waters of the U.S.)	U.S. Army Corps of Engineers	Dredge and/or fill in wetlands, below ordinary high-water line (streams), or mean higher high-water line (tidal waters).	Fill or dredge activity in wetlands. Installation of utility lines using directional drill techniques under wetlands does not require permit.	▪ Joint Aquatic Resources Permit Application ▪ Wetland/Waterways Critical Areas Report	3 to 6 months	Site design may avoid wetland and/or stream impacts and permitting may not be necessary. However, if unavoidable wetland/stream impacts occur, authorization under the Nationwide Permit program is likely. The USACE will also require documentation of consultations under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act as part of the SERP process. If SERP does not apply, application to the USACE would require a no effect determination or biological assessment and cultural resources investigation report. Refer to Figure 5-3 Pump Station No. 19 Environmental Features for wetland/stream locations.
Critical Areas Ordinance – Wetlands	Kitsap County Department of Community Development	Development in wetlands or associated buffers.	Development in wetland and/or associated buffers.	▪ Wetland/Waterways Critical Areas Report	Concurrent with SEPA review	Site design may avoid wetland and/or stream impacts, and permitting may not be necessary, or may be limited to unavoidable impacts to buffers. Landscaping may be required to satisfy wetland/stream buffer mitigation requirements. Refer to Figure 5-3 Lift Station No. 19 Environmental Features for wetland location.
Critical Areas Ordinance – Fish and Wildlife Habitat Conservation Areas	Kitsap County Department of Community Development	Development in protected habitats (including streams and associated buffers).	Development in streams and/or associated buffers.			
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Cross cutter report	Varies, and is contingent on consultation with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below, and compliance with Section 404 of the Clean Water Act as identified above.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historical buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act (Essential Fish Habitat)	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and U.S. Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance.		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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Table ES-12
LS 31 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Pump station construction ▪ Utility lines with diameters greater than 12 inches	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA	Hydrogeology report (if needed)	Concurrent with SEPA review.	Category I and II CARA mapped in the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)	Cross cutter report	Varies, and is contingent on consultation with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historical buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Section 404 Clean Water Act/ Executive Order 11990. (Wetlands Protection)	Ecology Water Quality Program (and U.S. Army Corps of Engineers [USACE] if unavoidable wetland/waterway impacts)	Projects with federal assistance. (USACE – Dredge and/or fill in wetlands, below ordinary high-water line of streams, or mean higher high water line of tidal waters).		Not applicable, no wetlands/waterways occur in the project area.	Completed with SERP	No wetlands/waterways occur in the project area.
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries, and U.S. Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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Joint Aquatic Resource Permit Application (JARPA)

To streamline the environmental permitting process, multiple regulatory agencies joined together to create one application that can be used to apply for more than one permit at a time (the Joint Aquatic Resources Permit Application (JARPA) permit). The JARPA is a master form used by federal, state, and local agencies for environmental review and issuance of permits on projects that have water-related impacts (e.g. wetlands, streams, and shorelines). Information for the JARPA will be derived from design information, wetland delineation reports, wildlife and fish habitat survey, and other available information obtained from the County and other agencies. The JARPA application will include a copy of the Wetland and Waterway Delineation Report and the necessary restoration plans compiled to address Critical Areas Mitigation requirements. Additional supporting documentation includes the Biological Assessment and Cultural Resources Assessment. The Wetland Delineation, Critical Areas Mitigation, Biological Assessment and Cultural Resources Assessment are described below.

Wetland Delineation/Critical Areas Mitigation

A wetland reconnaissance was completed by Landau as part of the preliminary design process to identify wetlands, waterways and associated buffers in the Project areas. Based on the findings of the wetland reconnaissance, wetlands will need to be delineated near LS 3, LS 19, and LS 31 during the design phase. No wetlands were identified within the Project limits associated with LS 4. Landau will complete the delineation and AES will locate the wetland flags to produce a survey record of the wetland boundaries. This information will then be used to establish the wetland buffer limits, which will dictate some of the restoration requirements and permitting needs.

Biological Assessment (BA)

Biological Assessments (BA) for compliance with the Endangered Species Act (ESA) are required for projects that are on federal property, require approval by a federal agency, or receive federal funding. Review of BAs by NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) is known as "consultation with the services." Concurrence must be received by both services for other federal agencies to issue permits or approvals. A BA is filed under JARPA when submitted to a federal agency and/or the State Environmental Review Process (SERP) process.

BAs are evaluations of impacts caused by project construction and the completed project on listed species/critical habitat within the Project action area. BA results are used to determine whether conditions in the Project action area support listed species and critical habitats and severity of impacts (both beneficial and adverse), if present. None of the Project areas are on federal property. However, if federal funding is obtained, then a BA would need to be prepared to identify the effects of the Project on any endangered species and critical habitat and to recommend mitigation measures to offset impacts. The BA would also include an assessment of impacts to 100-year floodplains, if necessary.

Cultural Resources Assessment

Cultural resources investigation, including archaeological resources, for compliance with Section 106 of the National Historic Preservation Act (NHPA) is required for projects seeking approval by a federal agency or funding from federal or state sources. Section 106 NHPA requires defining the Project Area of Potential Effect (APE), which represents the limit of the cultural resource investigation. Consultation on the cultural resources assessment is completed with the Department of Archaeology and Historic Preservation (DAHP) and affected Tribes and is coordinated through the lead federal agency. Governor Executive Order 05-05 requires cultural/archaeological resources review for capital projects not undergoing Section 106 NHPA review.

Phase I cultural resources investigations have been performed by Cascadia Archaeology (Cascadia) along the Project limits. The Phase I Assessment is included as Appendix GError! Reference source not found.. The Suquamish Tribe has requested a Phase 2 Cultural Resources assessment be conducted at all four proposed lift station sites during the design phase of the project when more information pertaining to ground disturbance limits is known.

National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Storm Water Discharges Associated with Construction Activities

BHC will prepare a Storm Water Pollution Prevention Plan (SWPPP) that will be included as part of the construction documents. The SWPPP will be reviewed and approved by the County's construction manager prior to submittal to the Department of Ecology (DOE). Once the County has approved the SWPPP, the document will be submitted to DOE along with a Notice of Intent (NOI) to obtain coverage under DOE's Construction Storm Water General Permit. The County will be listed as the responsible agency on the NOI. However, once the contractor has been selected, an application will be made to transfer responsibility for compliance to the contractor.

Other Permits Considered

The County will be responsible for applying for and obtaining the permits described above. The contractor will be responsible for obtaining all required permits for construction that are not obtained by the County. These are anticipated to include, but not be limited to the following:

- Encroachment/ROW/Roadway Permit
- Demolition Permit
- Electrical Permit

ES-3.4 Project Costs and Schedules

The opinions of probable project cost (OPPC) are considered Class 3 estimates, as defined by the Association for the Advancement of Cost Engineering International (AACE). The associated level of project definition is 10 to 40 percent (a 30% contingency was included in the OPPC). The accuracy of Class 3 estimates ranges from -20 to +30 percent due to the preliminary nature of project data and engineering. The opinions of probable project costs were developed based on 2019 dollars and detailed breakdowns for the conveyance piping and lift station are presented in Appendix I. The OPPC for each project is as follows:

Lift Station 3 and Associated Conveyance Piping Improvements	
Silverdale Way Gravity Sewer Upgrades	$825,500
Lift Station 3 Upgrades	$5,280,000
Total	$6,005,500

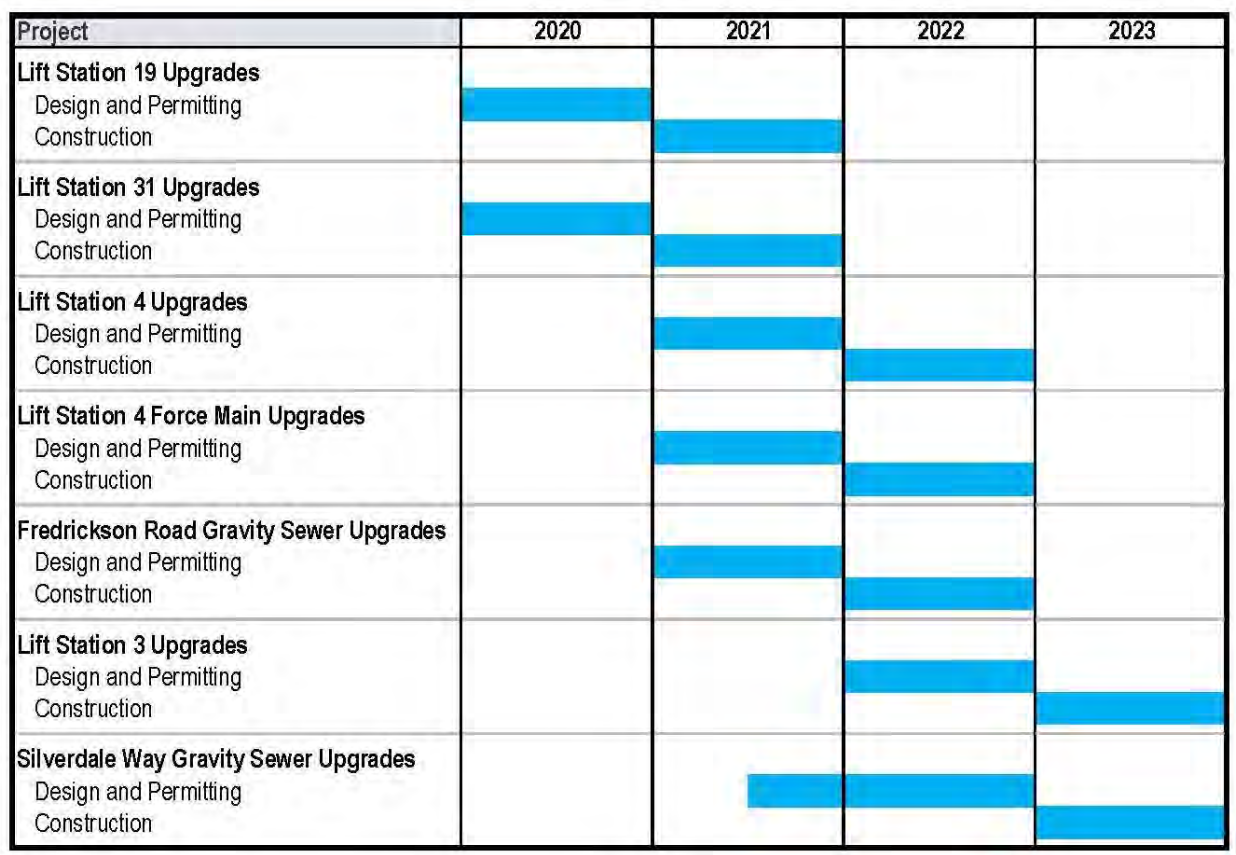
Lift Station 4 and Associated Conveyance Piping Improvements	
Fredrickson Road Sewer Upgrades	$1,870,000
Lift Station 4 Force Main Upgrades	$1,643,500
Lift Station 4 Upgrades	$6,710,000
Total	$10,223,500

Lift Station 19 and Associated Conveyance Piping Improvements	
Conveyance Pipe Upgrades	N/A
Lift Station 19 Upgrades	$4,465,500
Total	$4,465,500

Lift Station 31 and Associated Conveyance Piping Improvements	
Conveyance Pipe Upgrades	N/A
Lift Station 19 Upgrades	$1,576,500
Total	$1,576,500

Final design and construction of the four projects will be staggered over the next several years. Based on discussions with the County, the upgrades to Lift Station 19 and Lift Station 31 and their associated conveyance systems will occur first, followed by the upgrades to Lift Station 4 and its associate conveyance systems. The upgrades to Lift Station 3 and the Silverdale Way Gravity Sewer Upgrades will be the last improvements made under this project, primarily because Lift Station 4 must be upgraded prior to Lift Station 3 in order to handle the upgraded flows from Lift Station 3. The ongoing negotiations with the Port of Silverdale, which will continue through the final design stage of the project, are anticipated to increase the project time required to complete the upgrades. Table ES-13 summarizes the anticipated schedules for the upgrades to each lift station and associated conveyance systems.

Table ES-13
Project Schedule



The estimated final design period for each lift station and its associated conveyance upgrades is 300 working days, including 10 days of County review time for each of the 60 and 90 percent and Final Bid Document deliverables. The final design period includes developing bid documents, permitting, bid period, and notification of award to the low bid contractor. The design period for each project may run concurrently, depending on how the County wants to package the contracts. Currently, the County has authorized BHC to proceed with the final design of the upgrades for LS 19 and LS 31. The bid opening for these lift station upgrades is anticipated to occur in January 2021. The estimated construction duration for the Project is 240 working days.

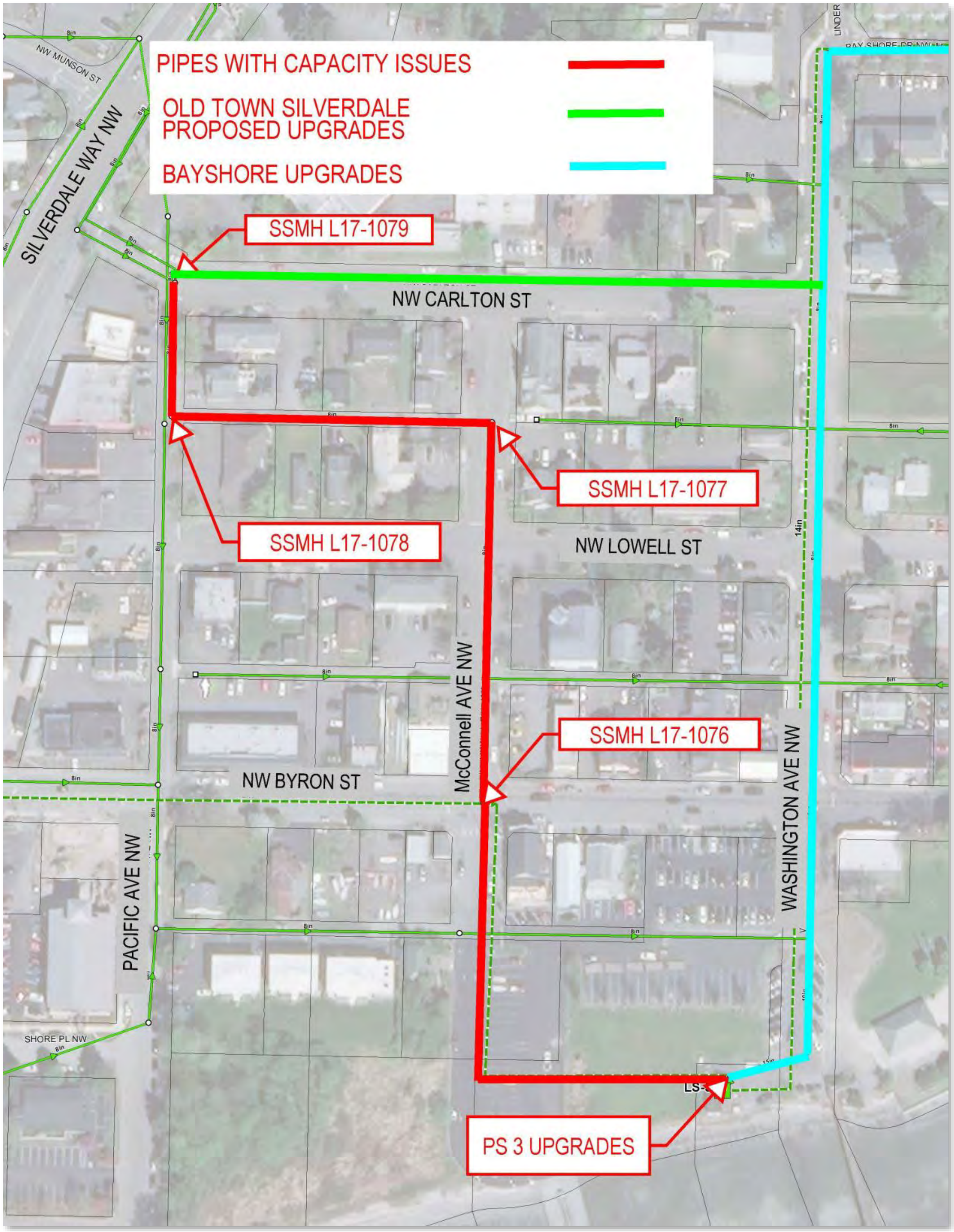


Figure ES-4 – Old Town Silverdale Gravity Sewer Upgrades

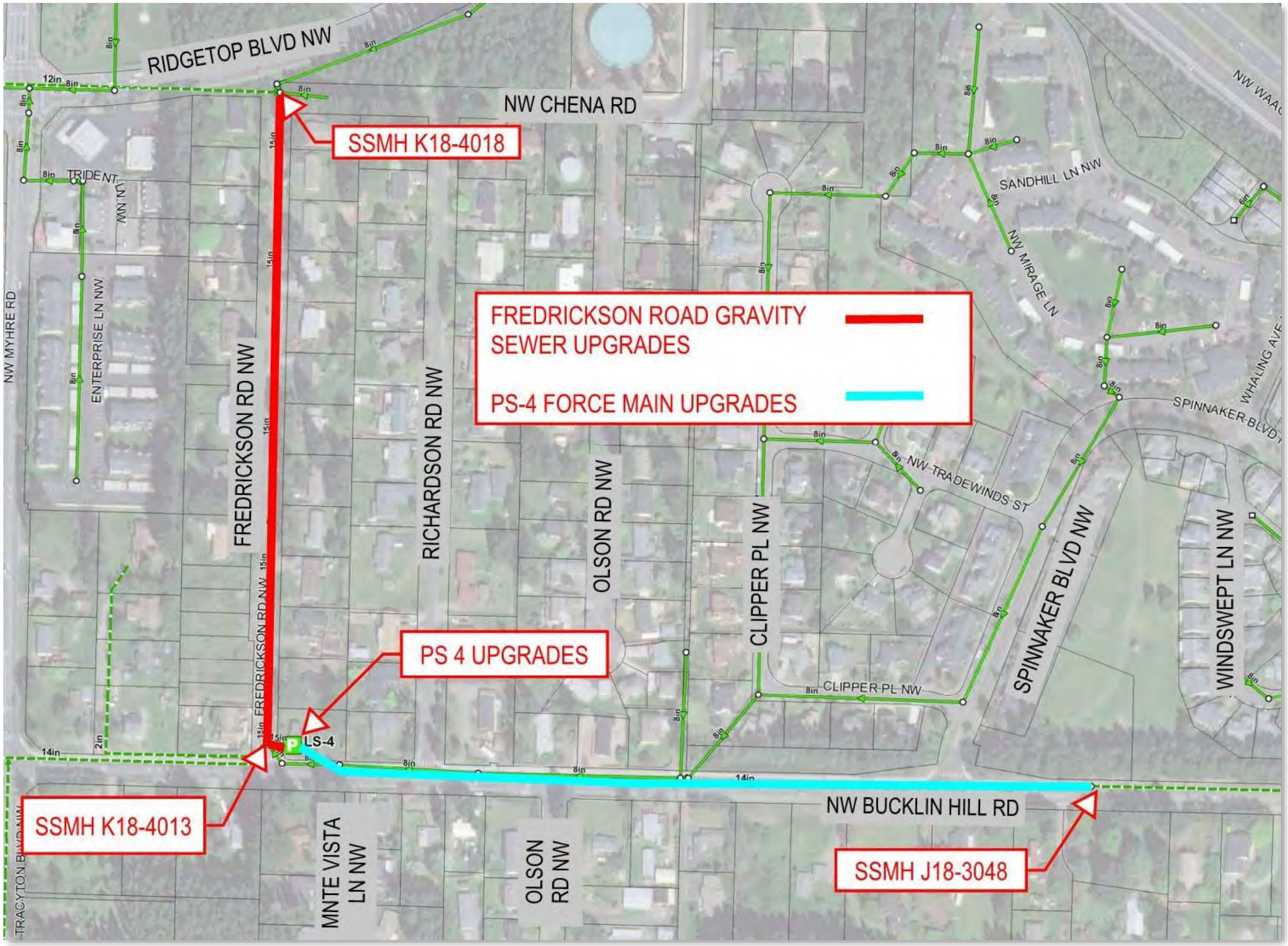
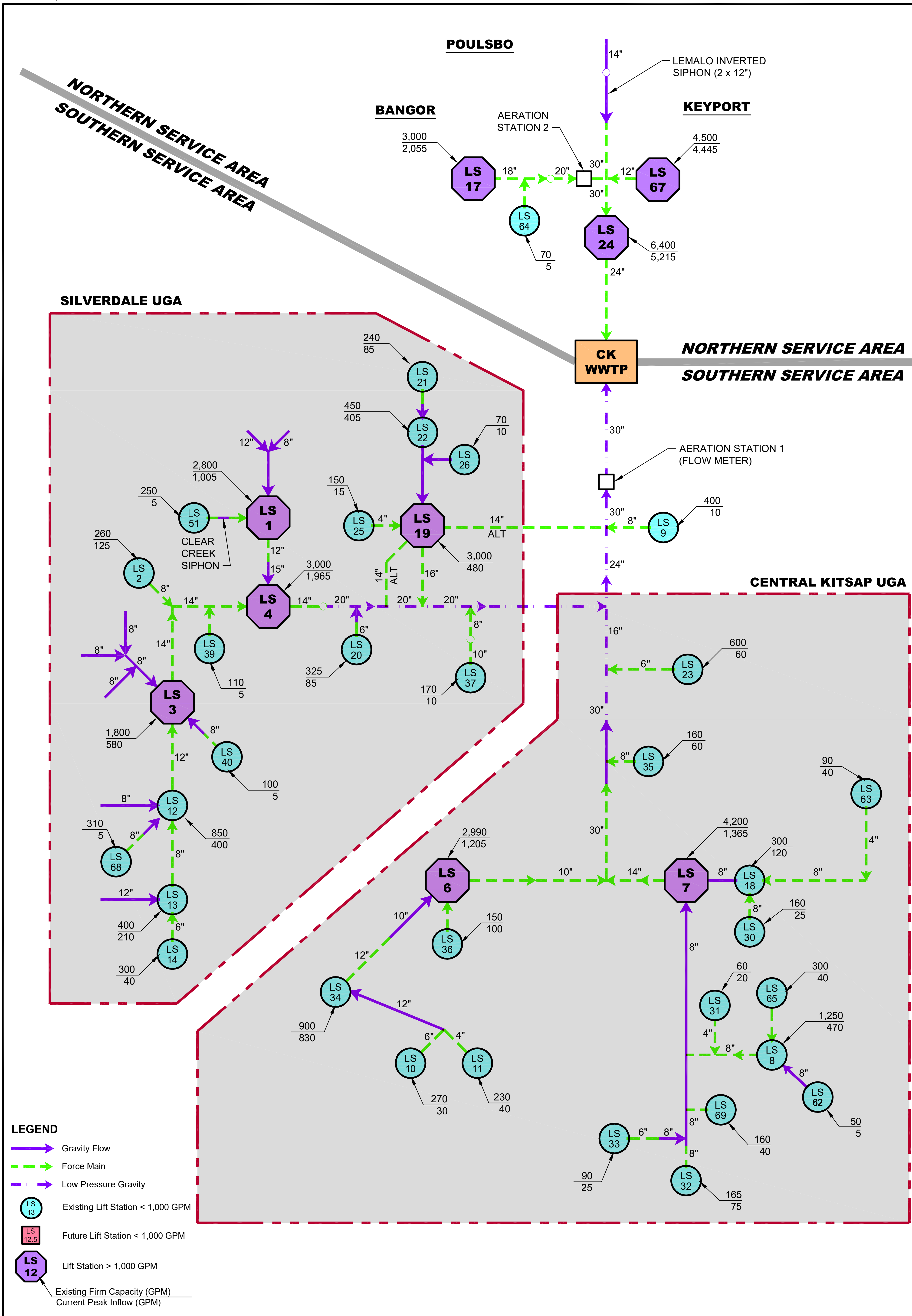


Figure ES-5 – LS 4 Conveyance System Upgrades



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Existing Lift Station Capacity and Existing Peak Flows
Kitsap County Public Works
November 2019

Figure
ES-6

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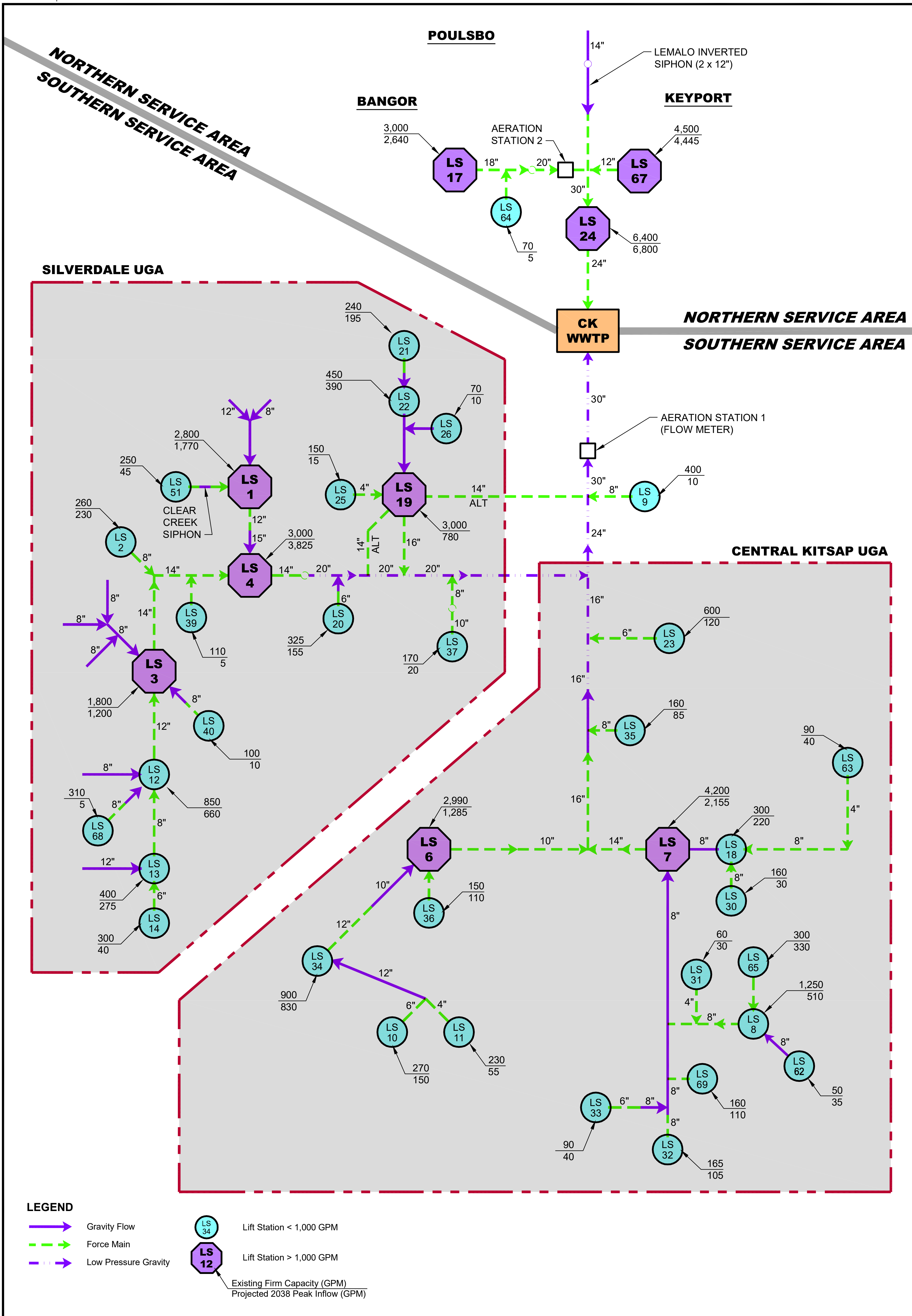

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Existing Lift Station Capacity and Future 2038 Peak Flow

Kitsap County Public Works

November 2019

Figure ES-7

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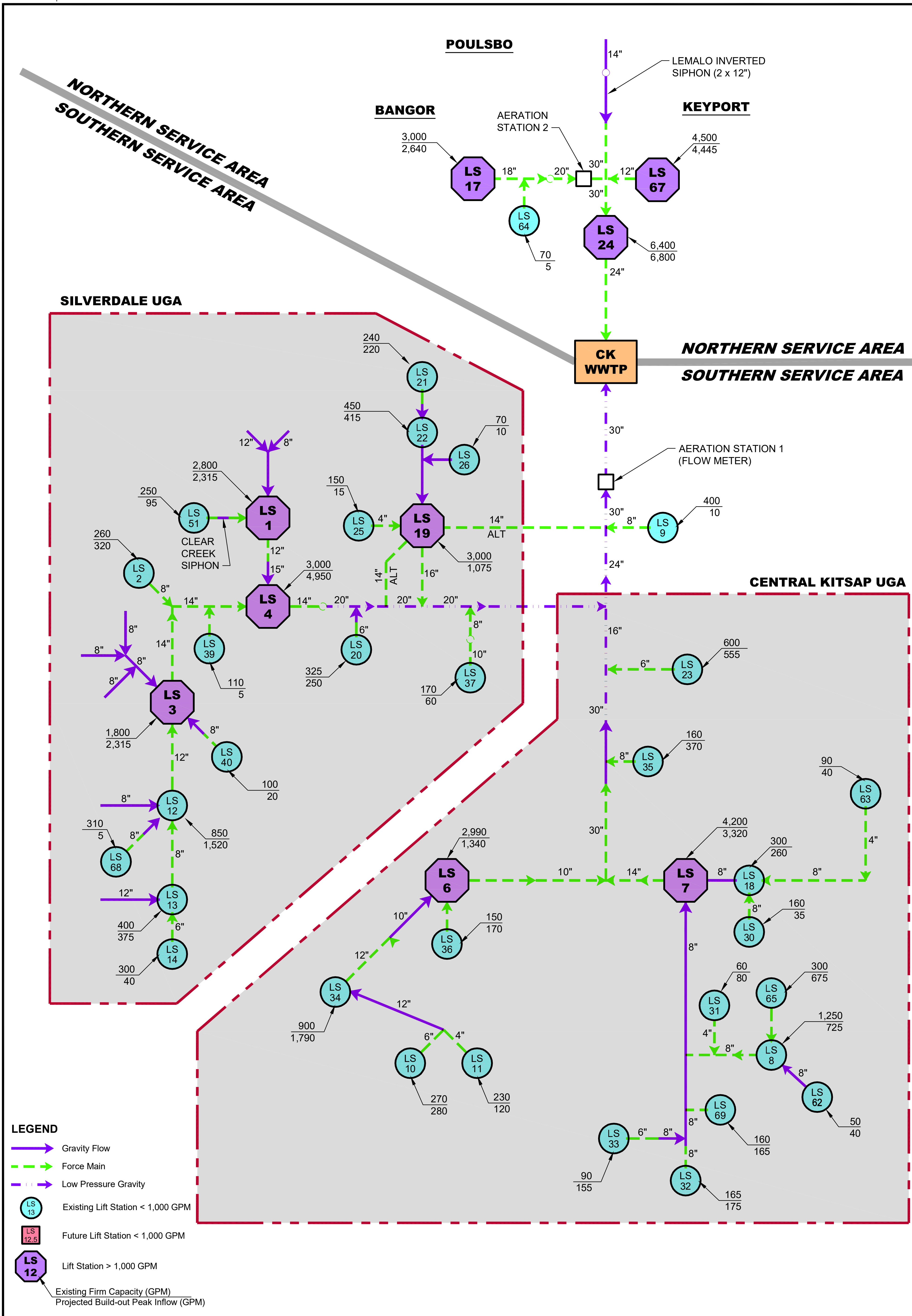

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Existing Lift Station Capacity and Future Build-out Peak Flows

Kitsap County Public Works

November 2019

Figure ES-8

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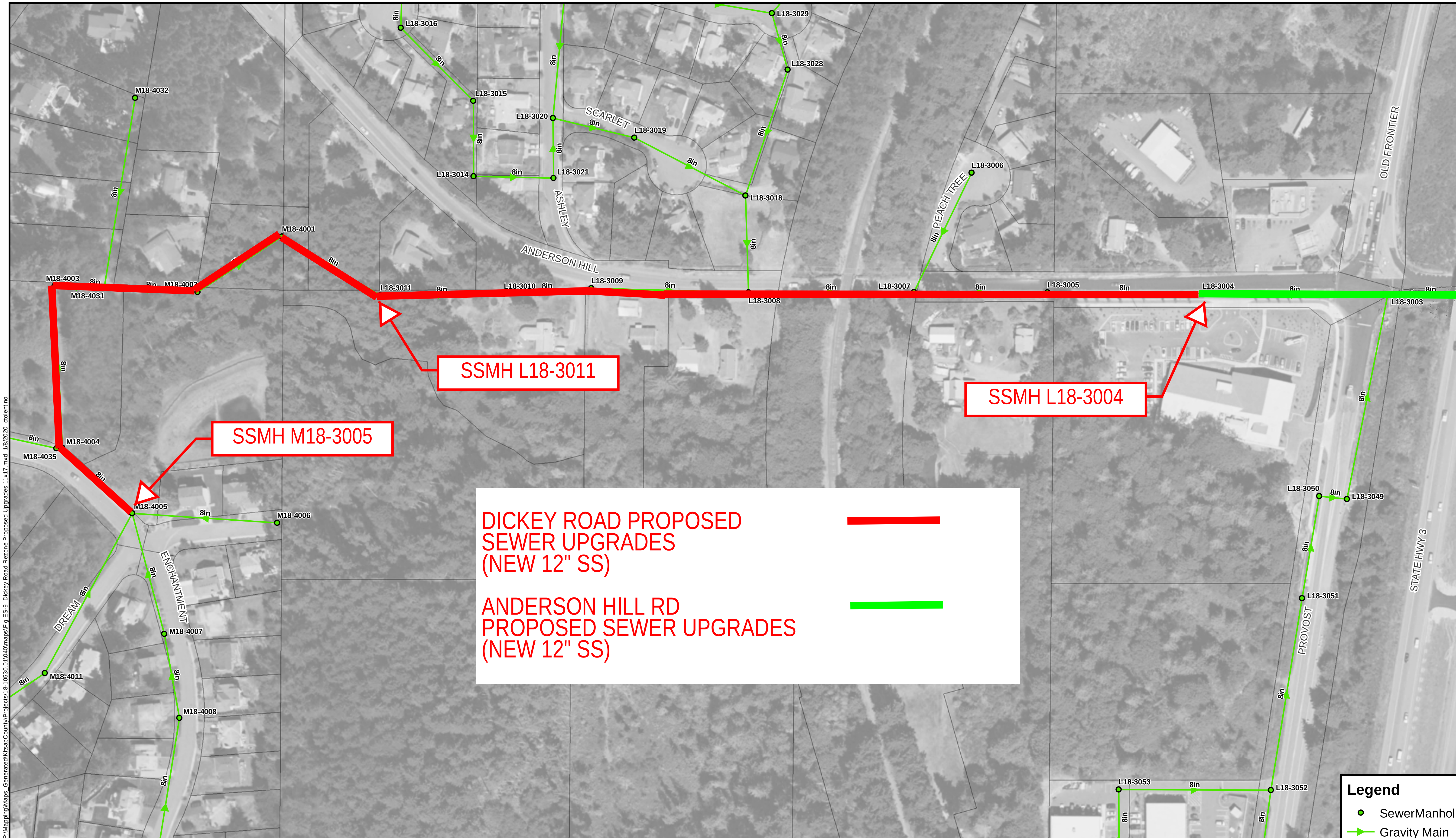

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Sewer System: Kitsap County.
GIS Base data: Kitsap County.
Data sources supplied may not reflect current or actual conditions. This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.
BHC Consultants LLC., assumes no responsibility for the validity of any information presented herein, nor any responsibility for the use or misuse of the data.

KITSAP COUNTY 18 57 WASHINGTON

Dickey Road Rezone Proposed Upgrades
Kitsap PS 3, 4,19 & 31 Upgrades
Kitsap County, Washington
December 2019

Figure
ES-9

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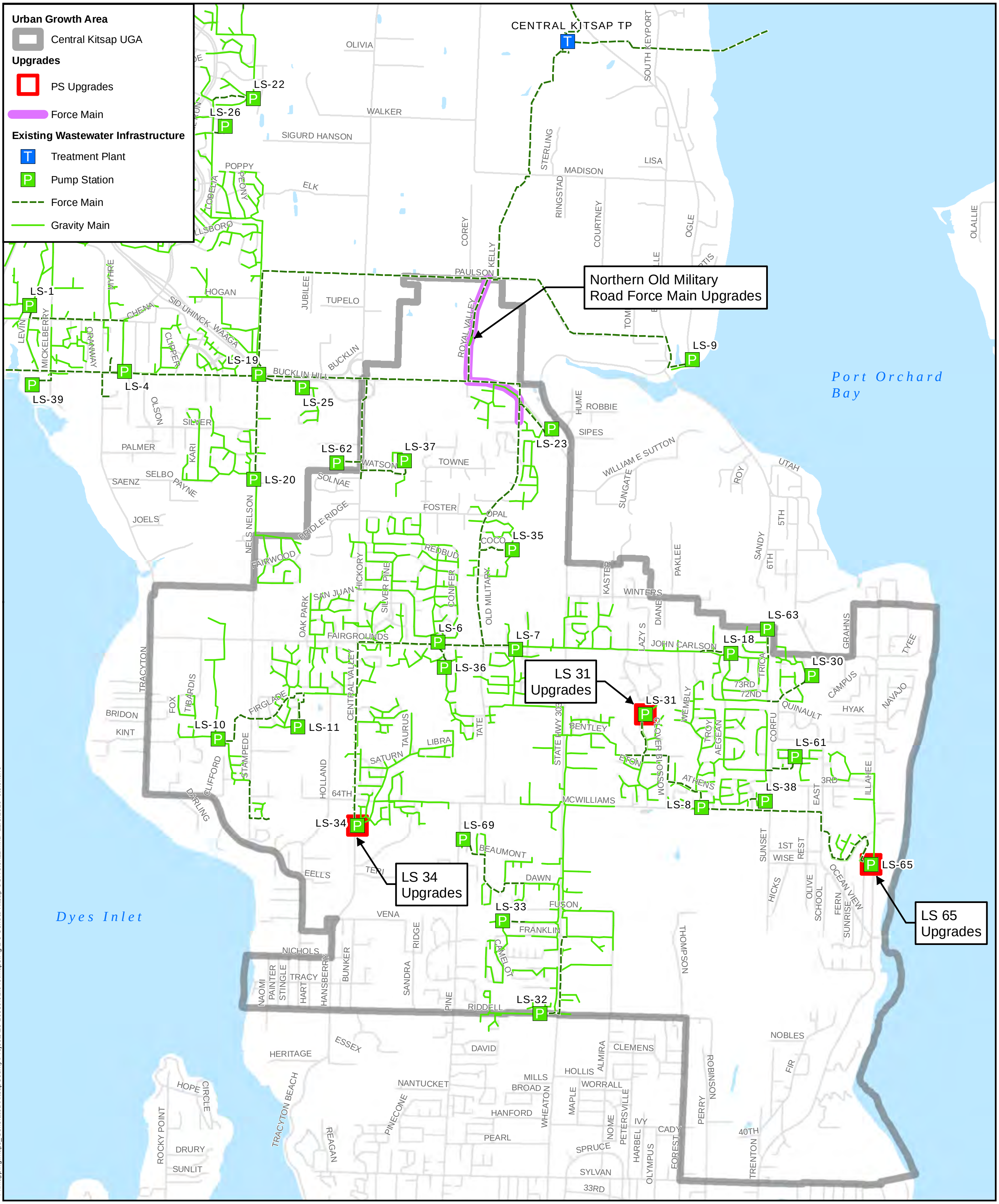

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This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

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Central Kitsap UGA
Kitsap County Public Works
December 2019

Figure
ES-10

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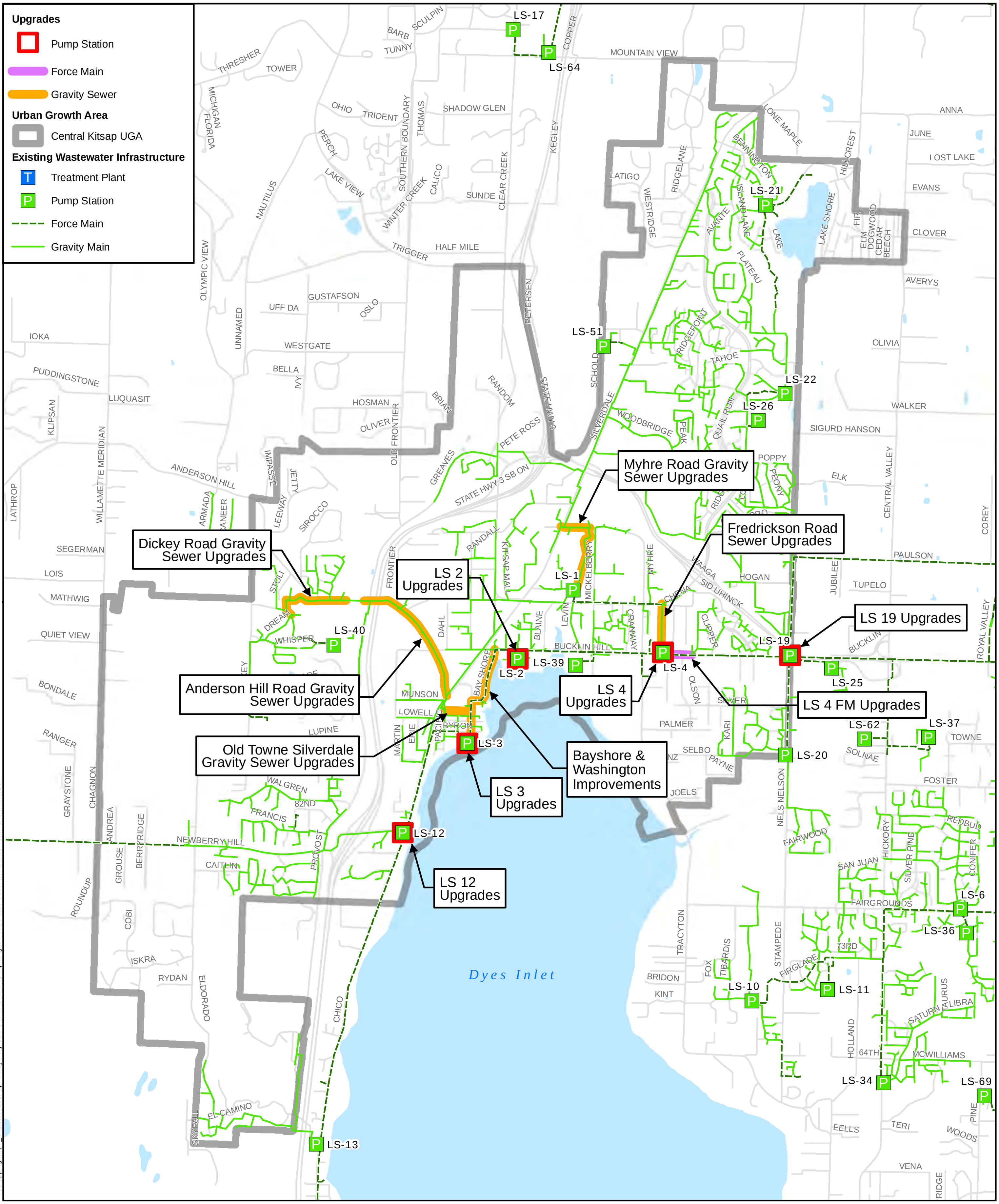

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Silverdale UGA

Kitsap County Public Works

December 2019

Figure

ES-11

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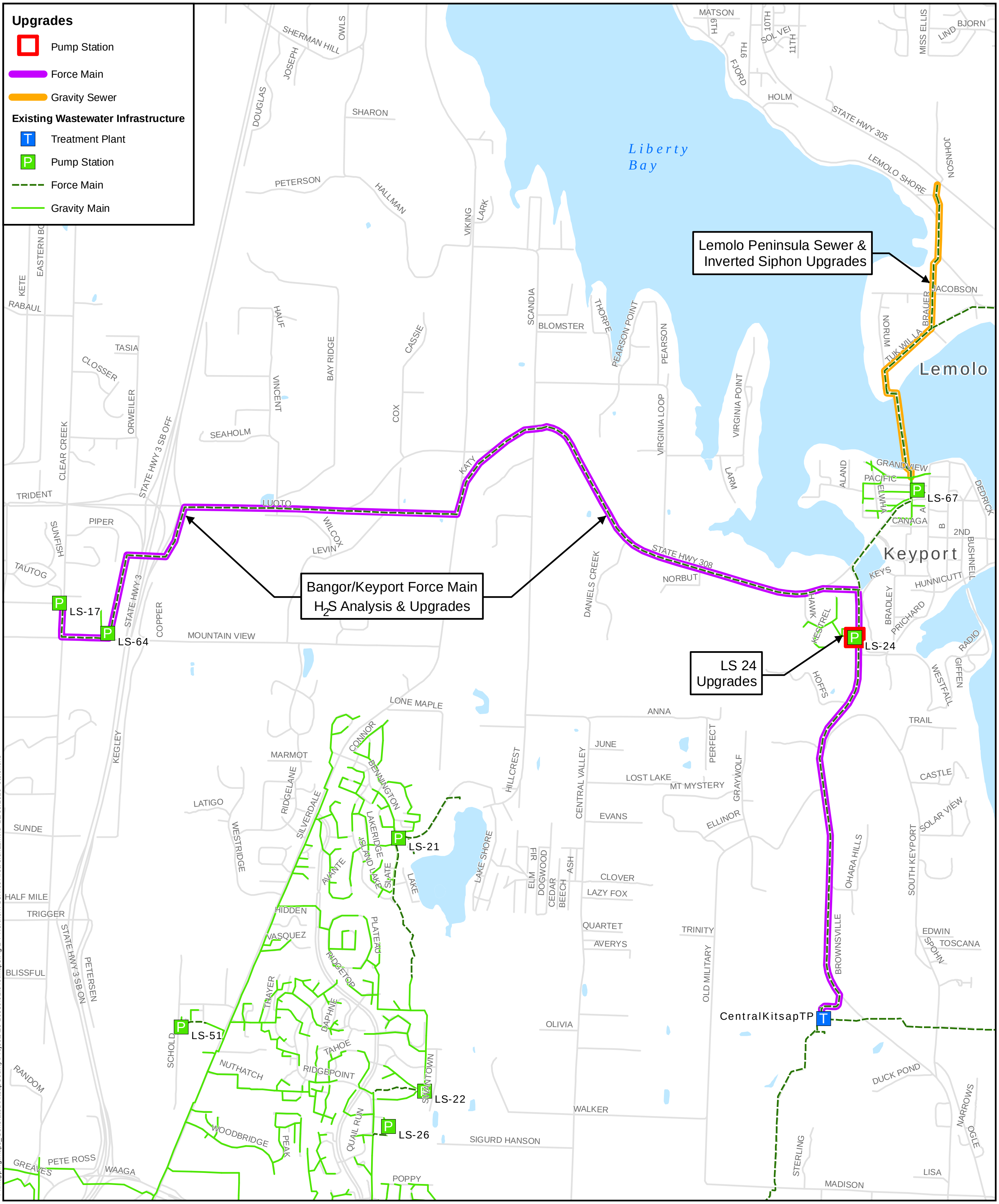

P:\Mapping\Maps_Generated\KitsapCounty\Projects\18-10530.01\040\maps\Fig 2-7 Northern Service Area 8.5x11.mxd 12/30/2019 ctolentino

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Northern Service Area
Kitsap County Public Works
December 2019

Figure
ES-12

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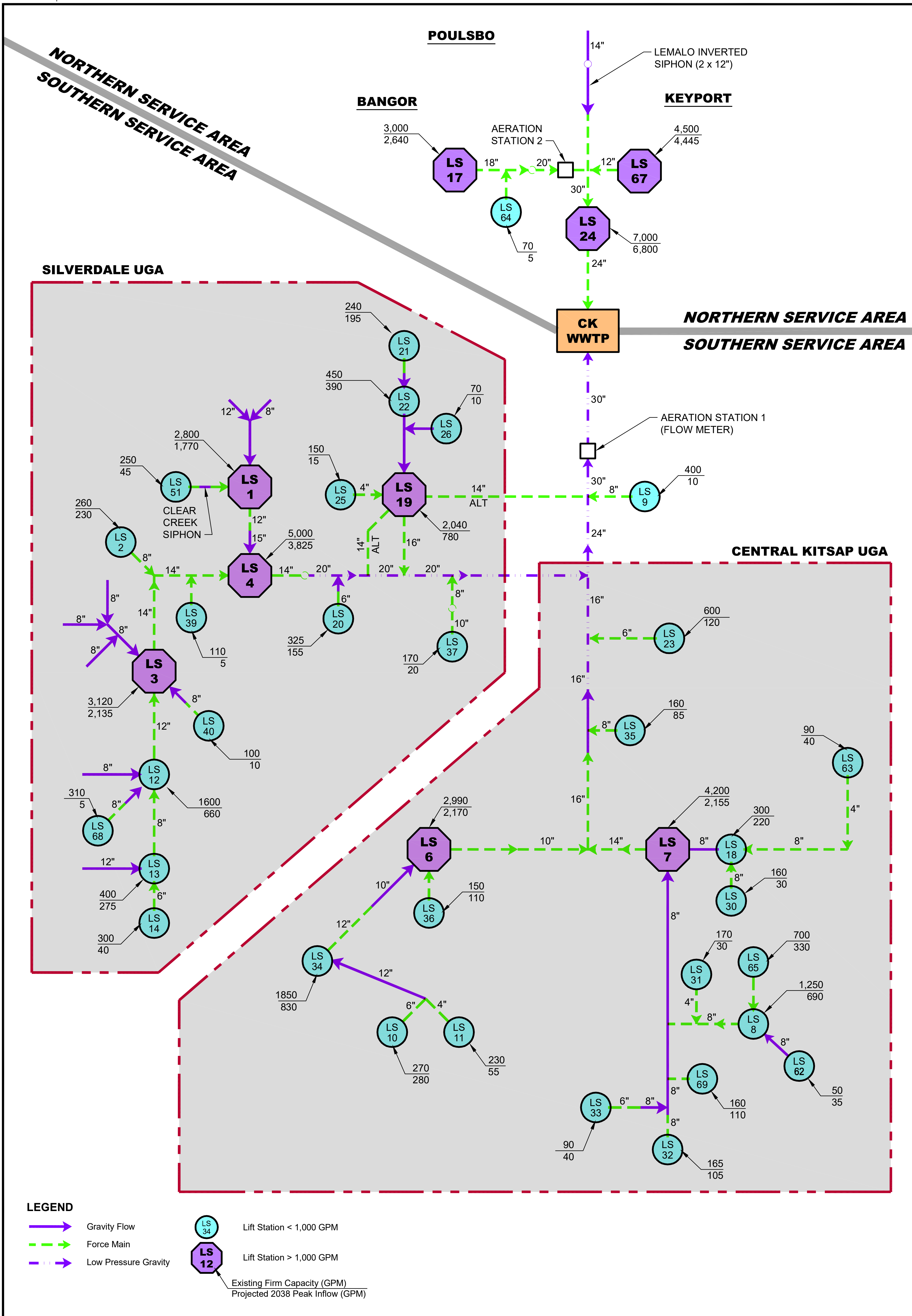

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Future Lift Station Capacity for Future 2038 Peak Flow

Kitsap County Public Works

November 2019

Figure ES-13

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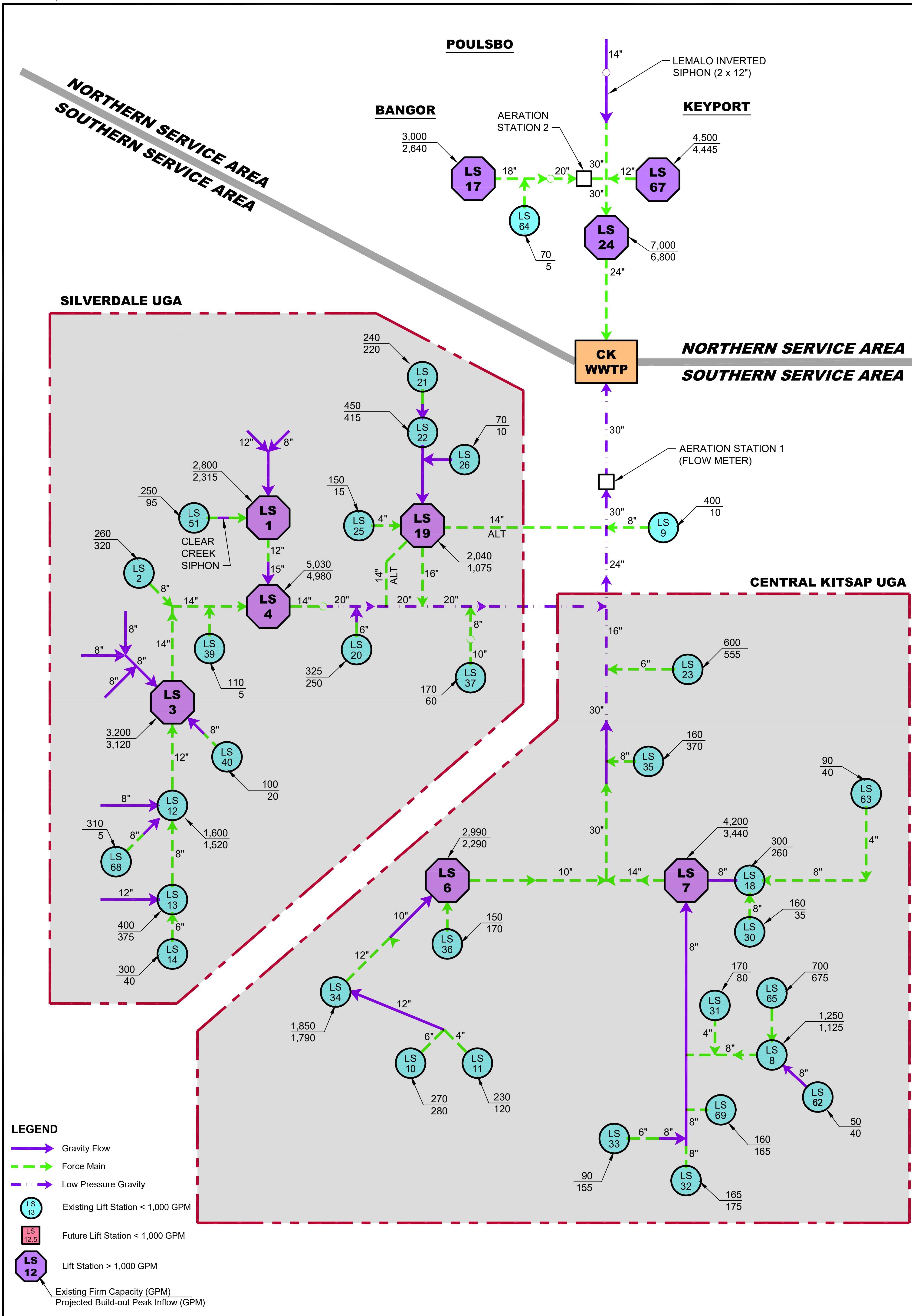

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Future Lift Station Capacity For Future Build-out Peak Flows

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Figure ES-14

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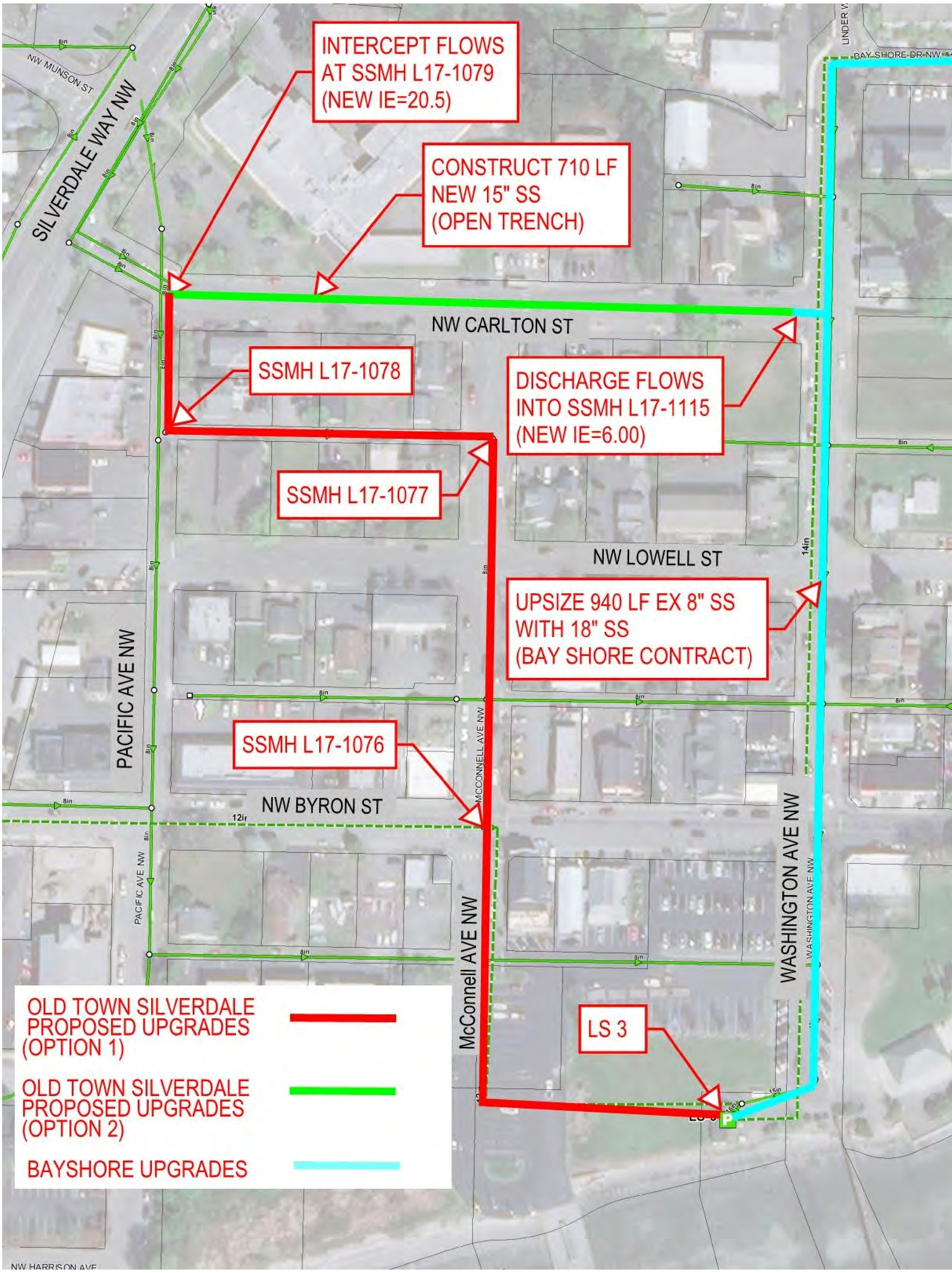

Figure ES-15 – Old Town Silverdale Gravity Sewer Upgrades

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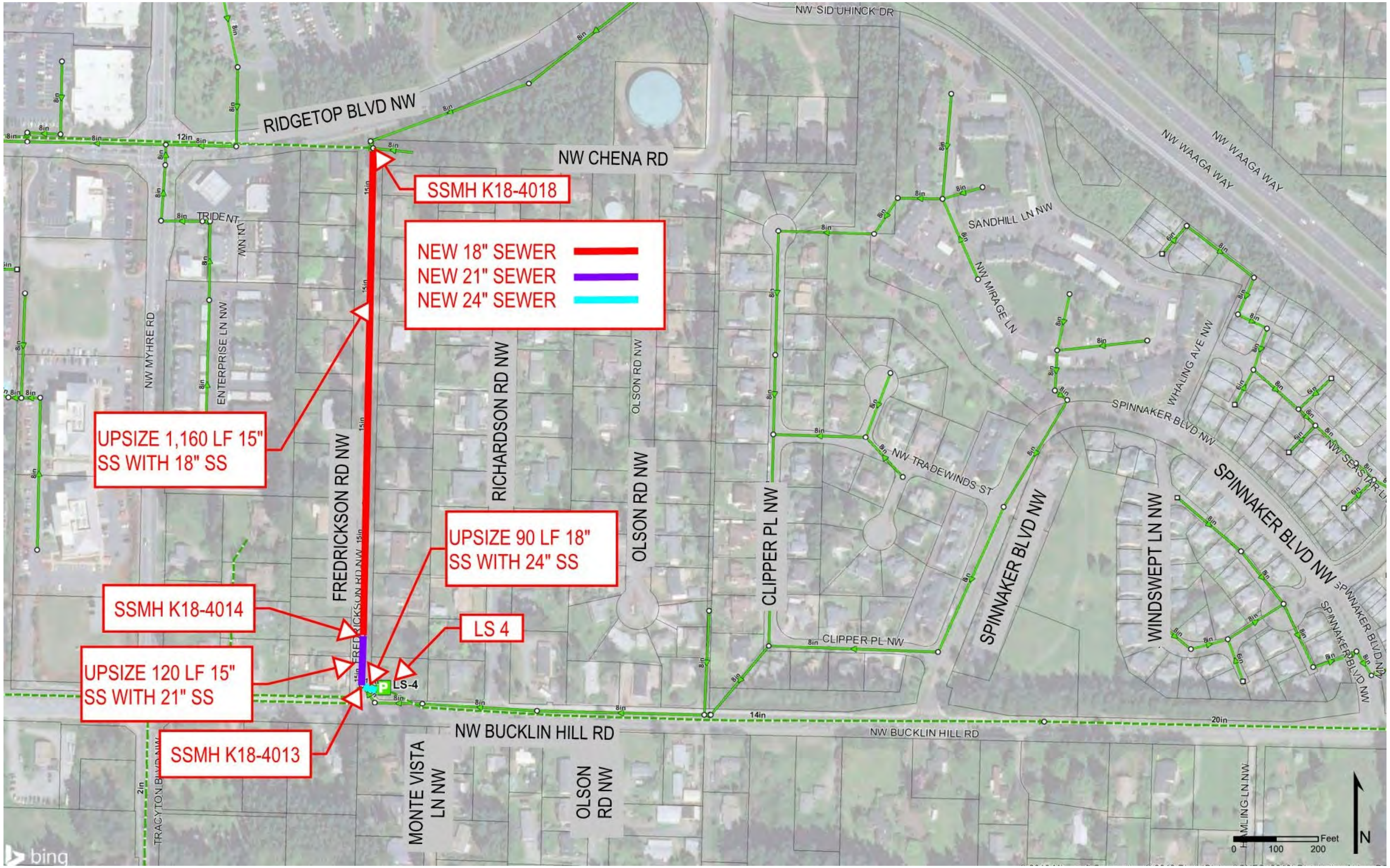

Figure ES-16 – Fredrickson Road Gravity Sewer Upgrades

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Figure ES-17 – Lift Station 4 Force Main Upgrades

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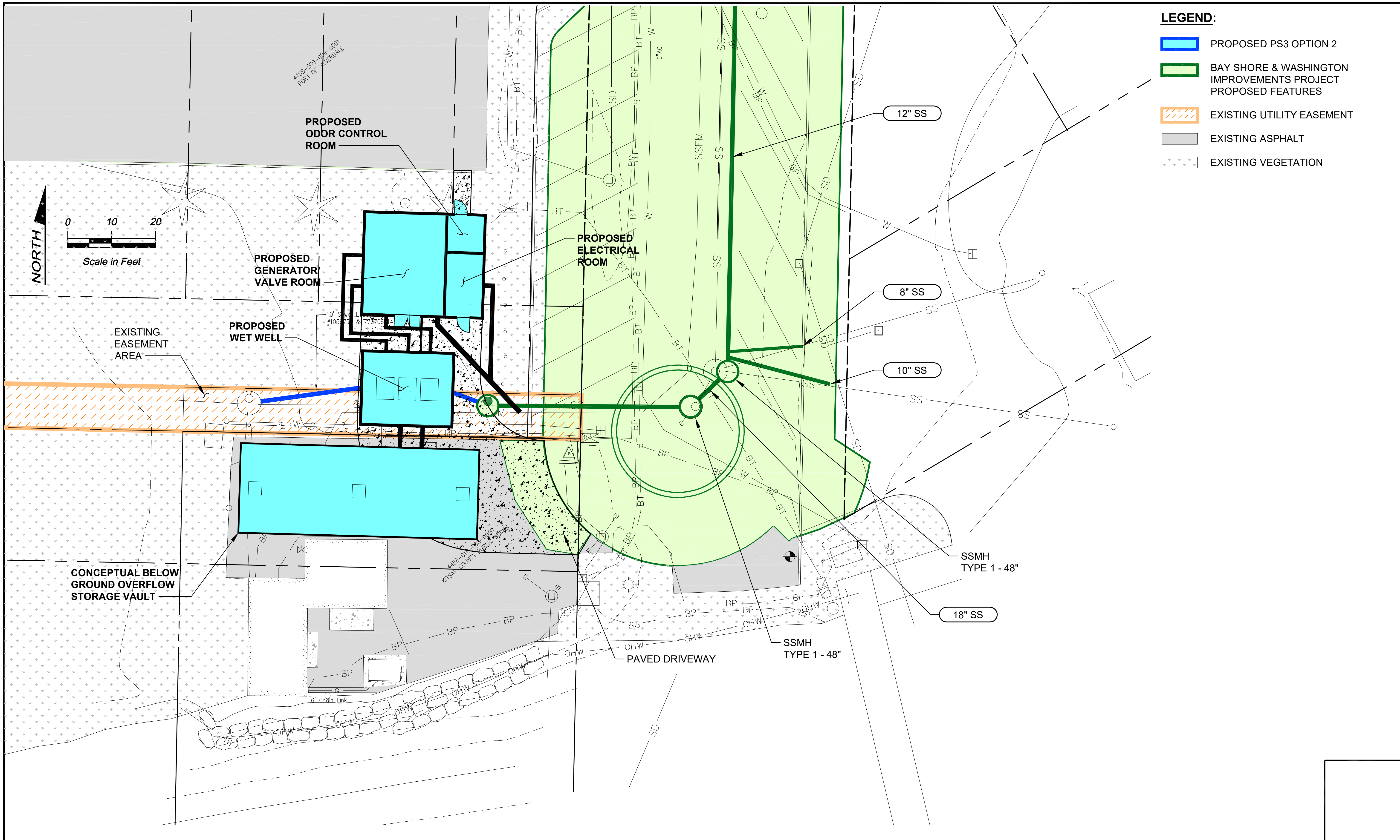

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE ES-18
LIFT STATION 3
SITE PLAN

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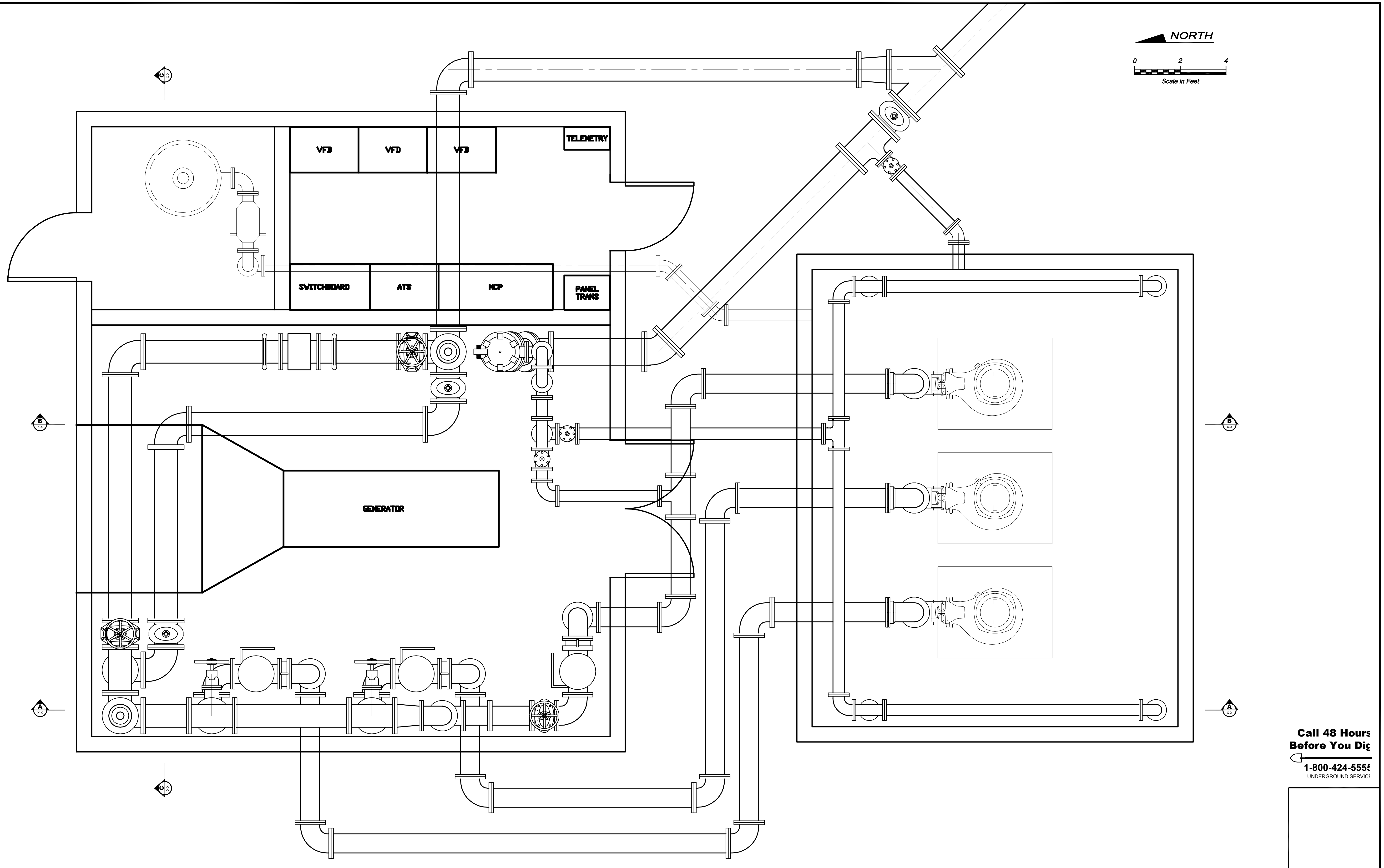

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE ES-19
LIFT STATION 3
DETAILED PLAN VIEW

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-20
LIFT STATION 3
STATION RENDERING

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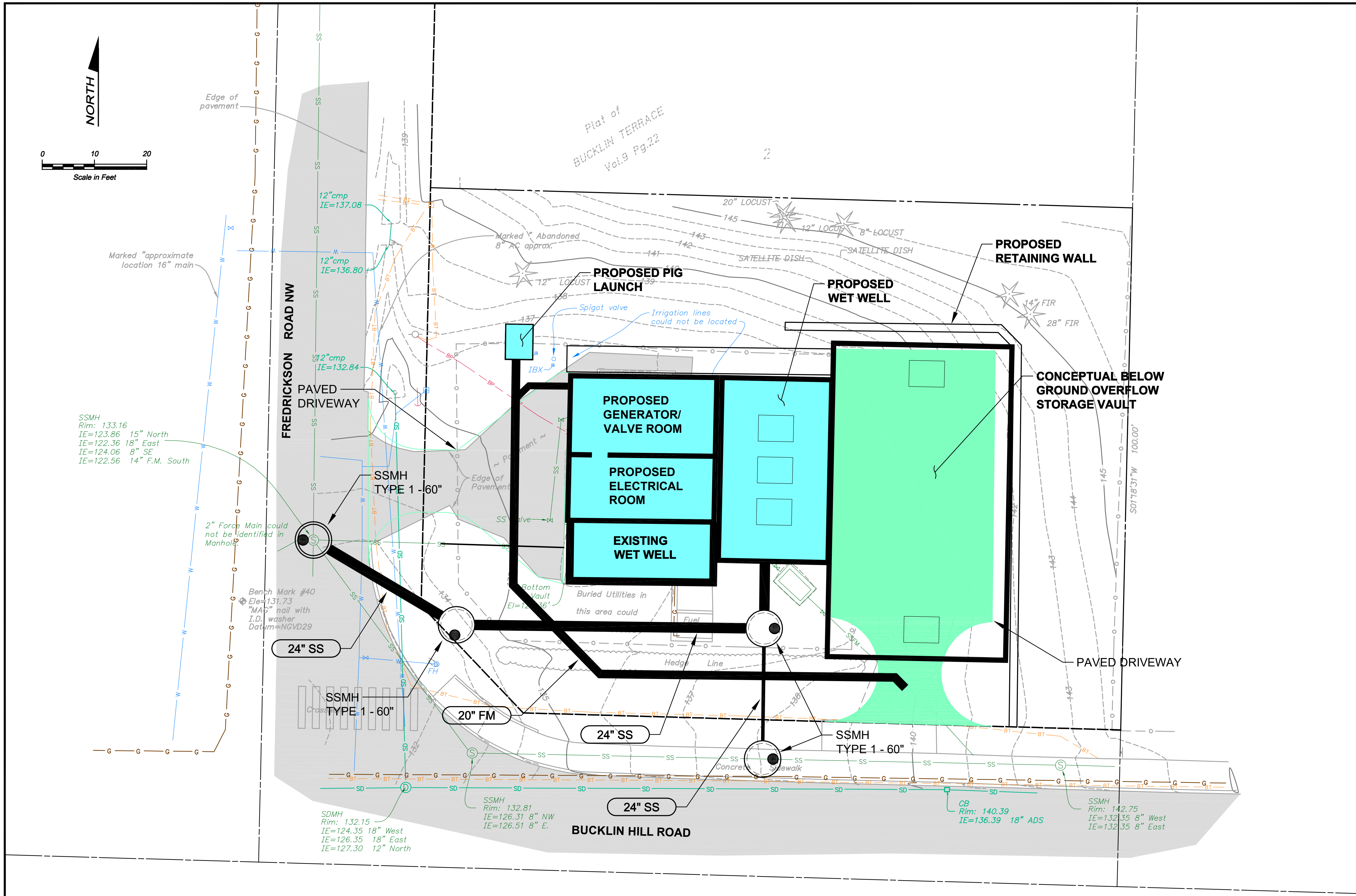

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-21
LIFT STATION 4
SITE PLAN

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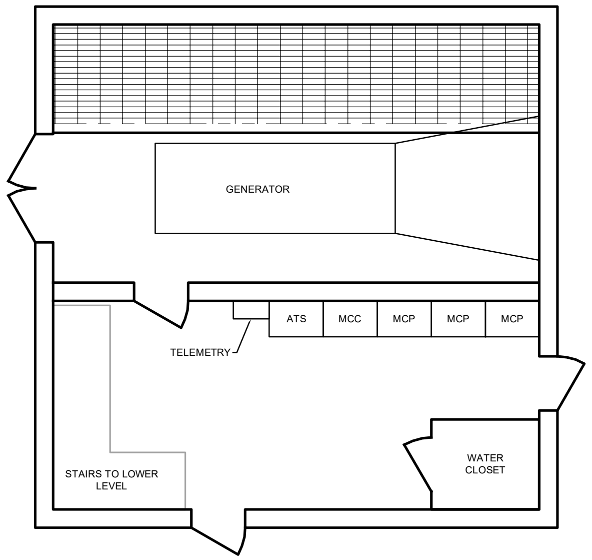
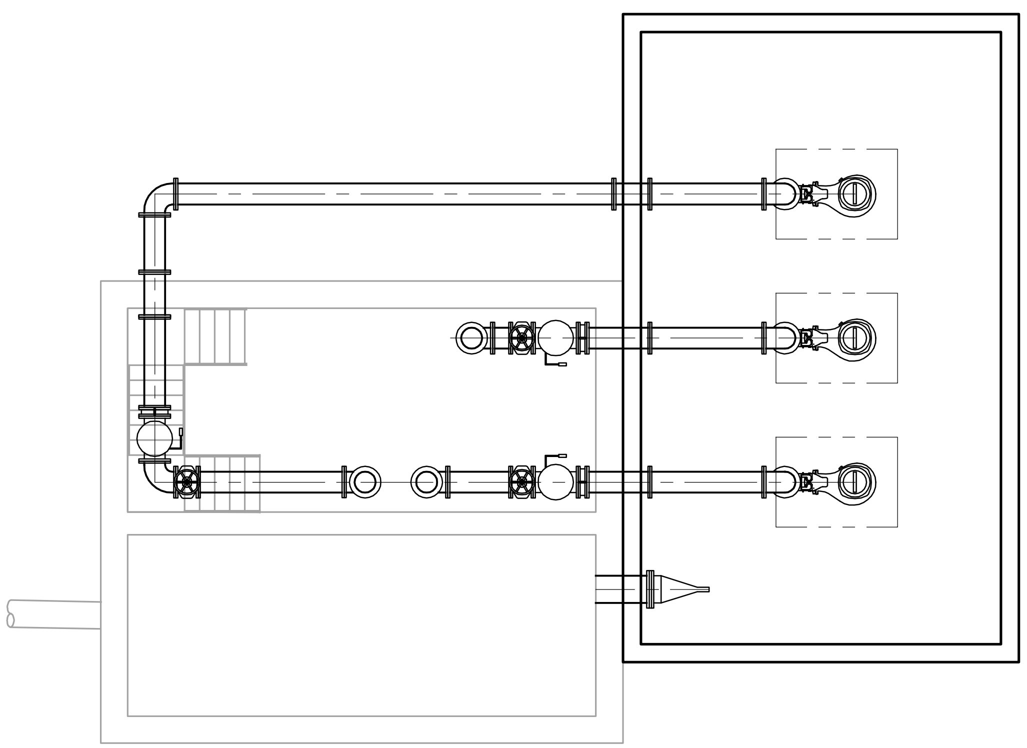


CONTROL BUILDING



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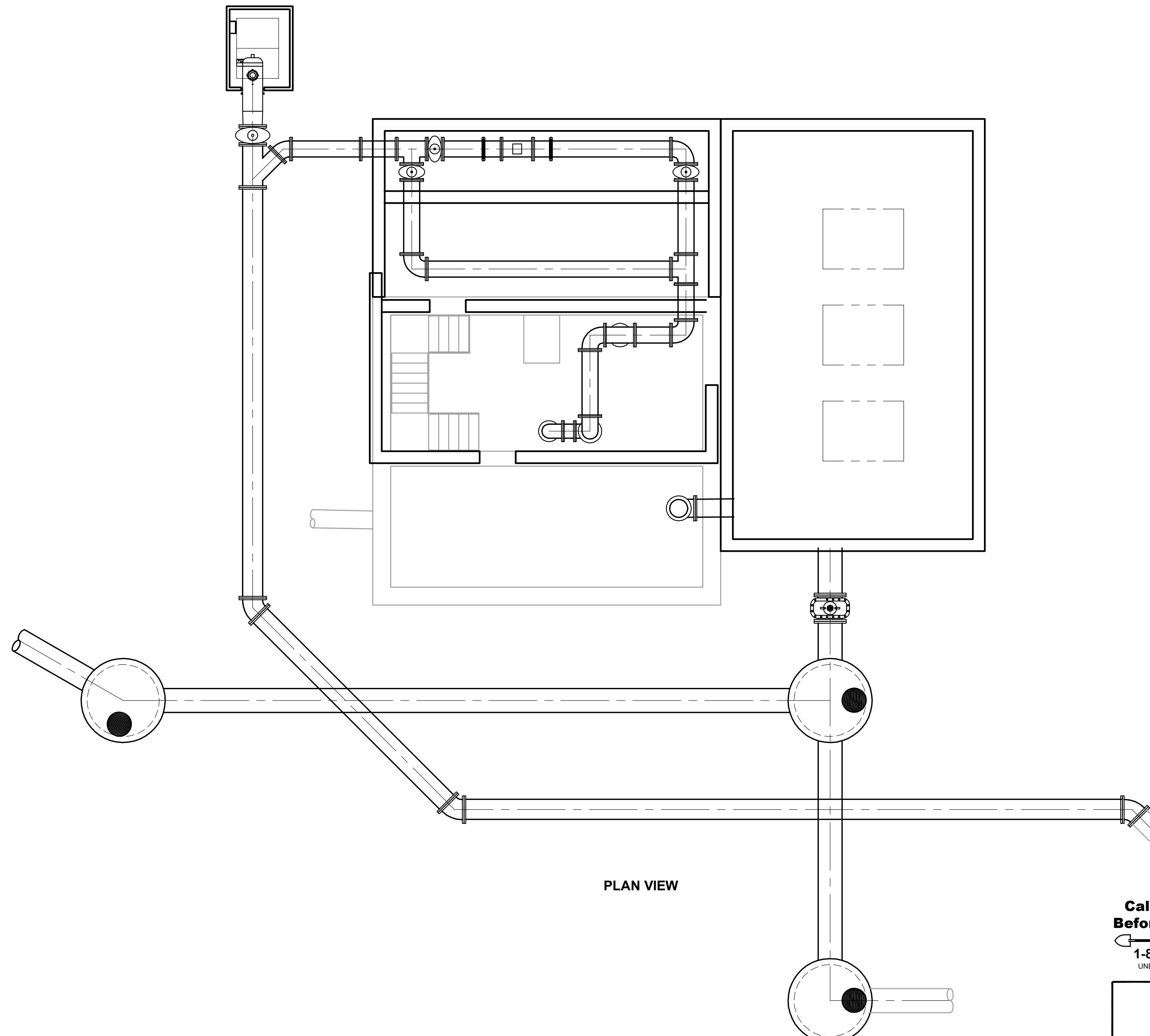

PLAN VIEW

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE ES-22
LIFT STATION 4
DETAILED PLAN VIEW

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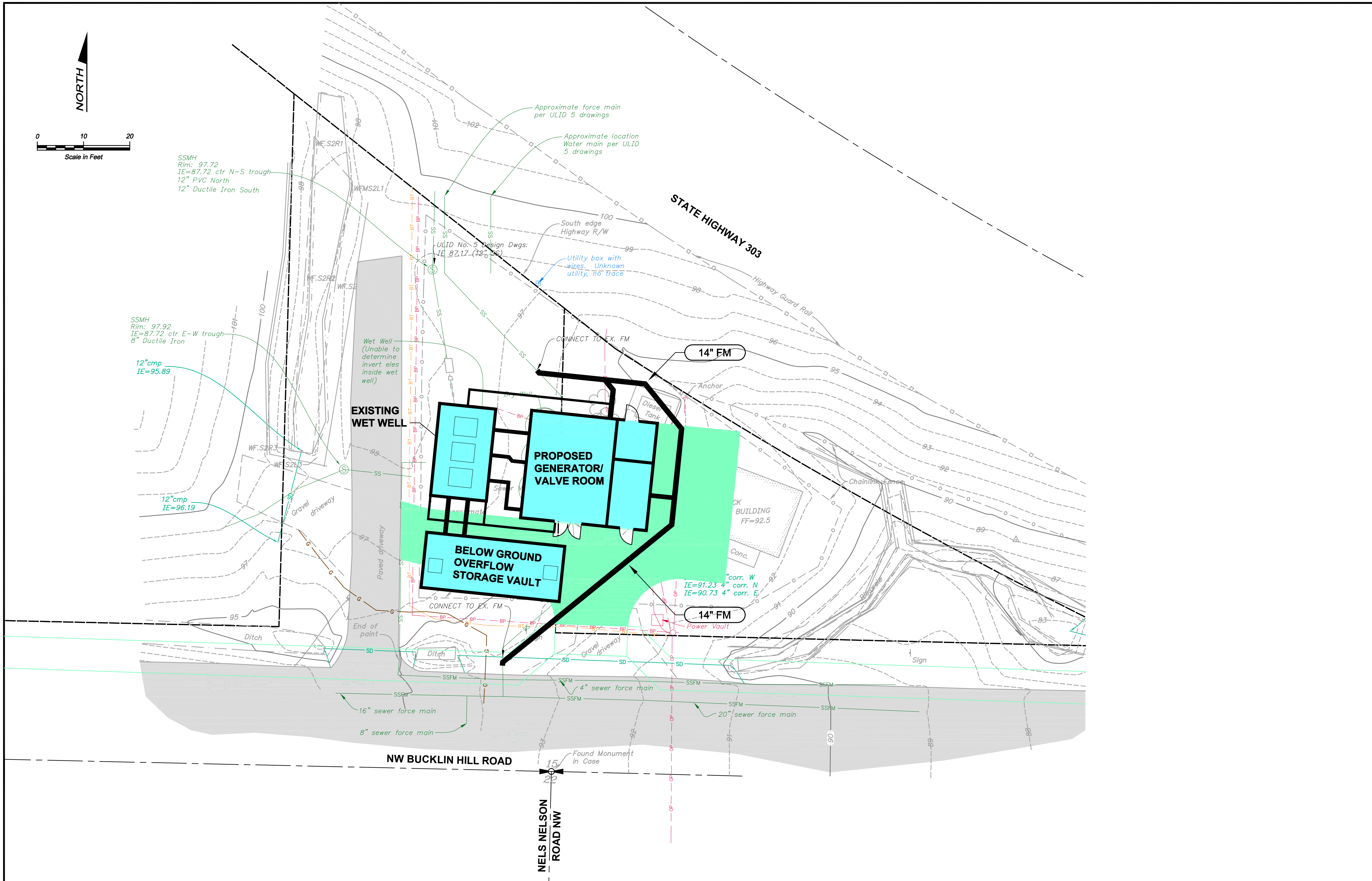

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-23
LIFT STATION 19
SITE PLAN

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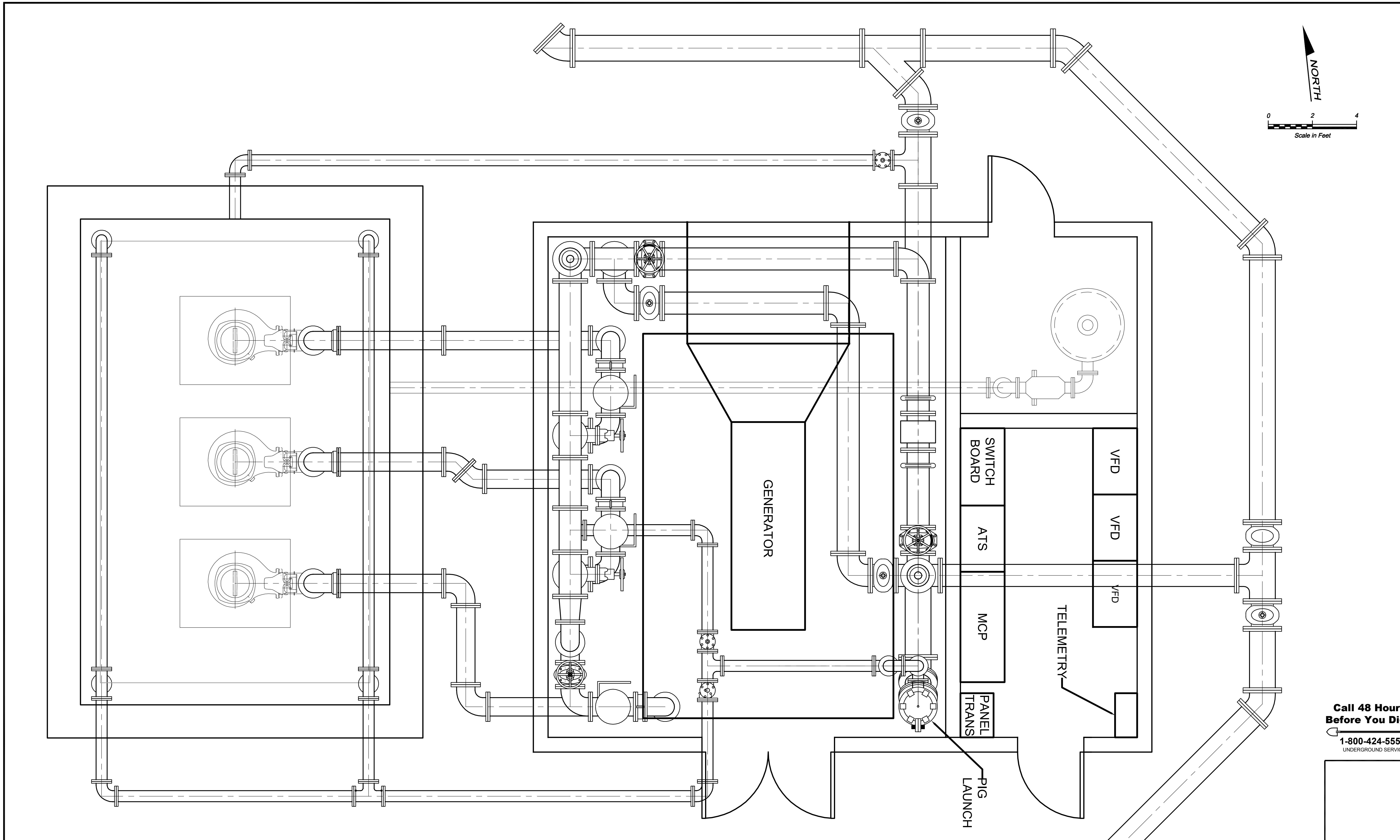

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-24
LIFT STATION 19
DETAILED PLAN VIEW

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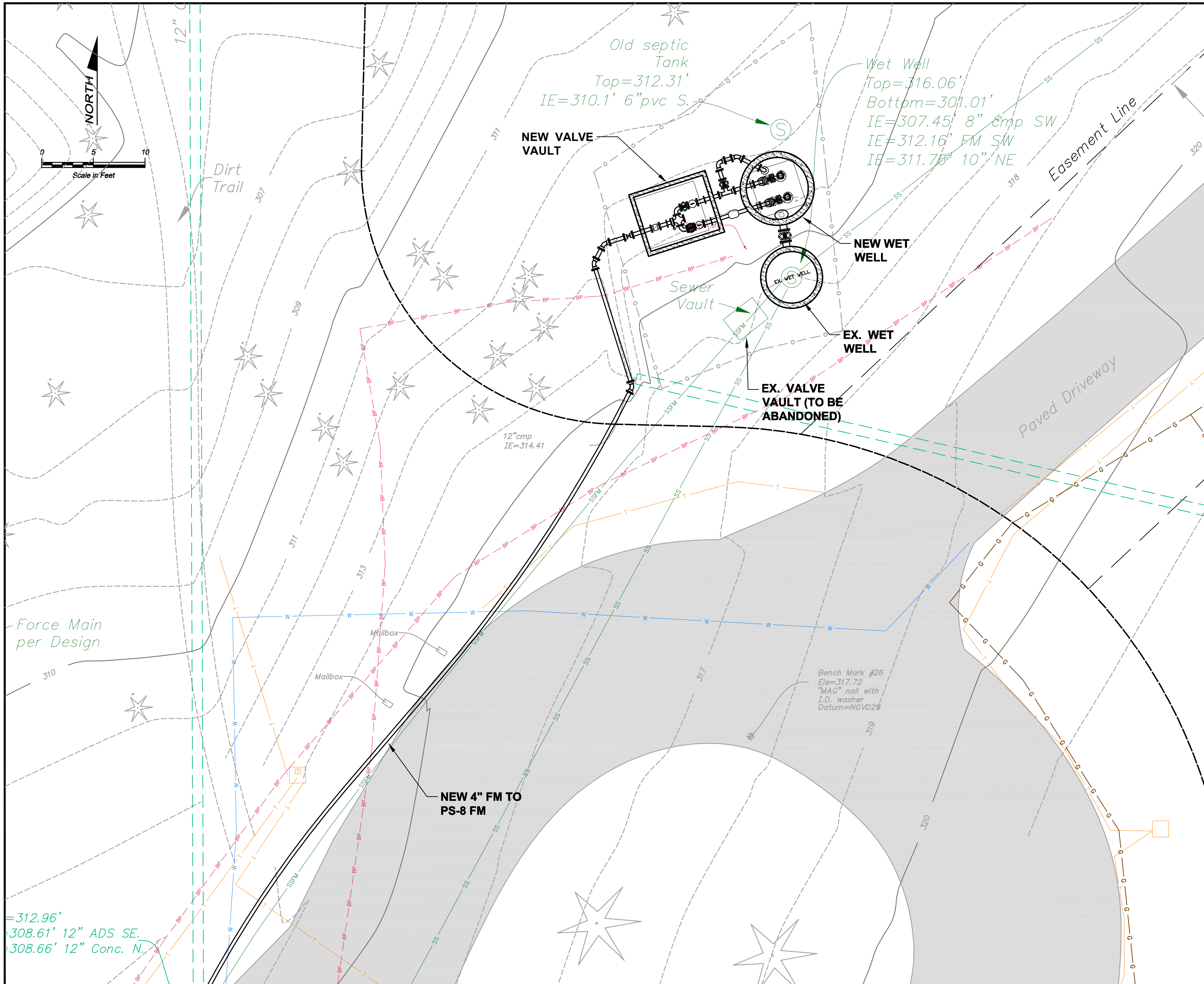

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-25
LIFT STATION 31
SITE PLAN

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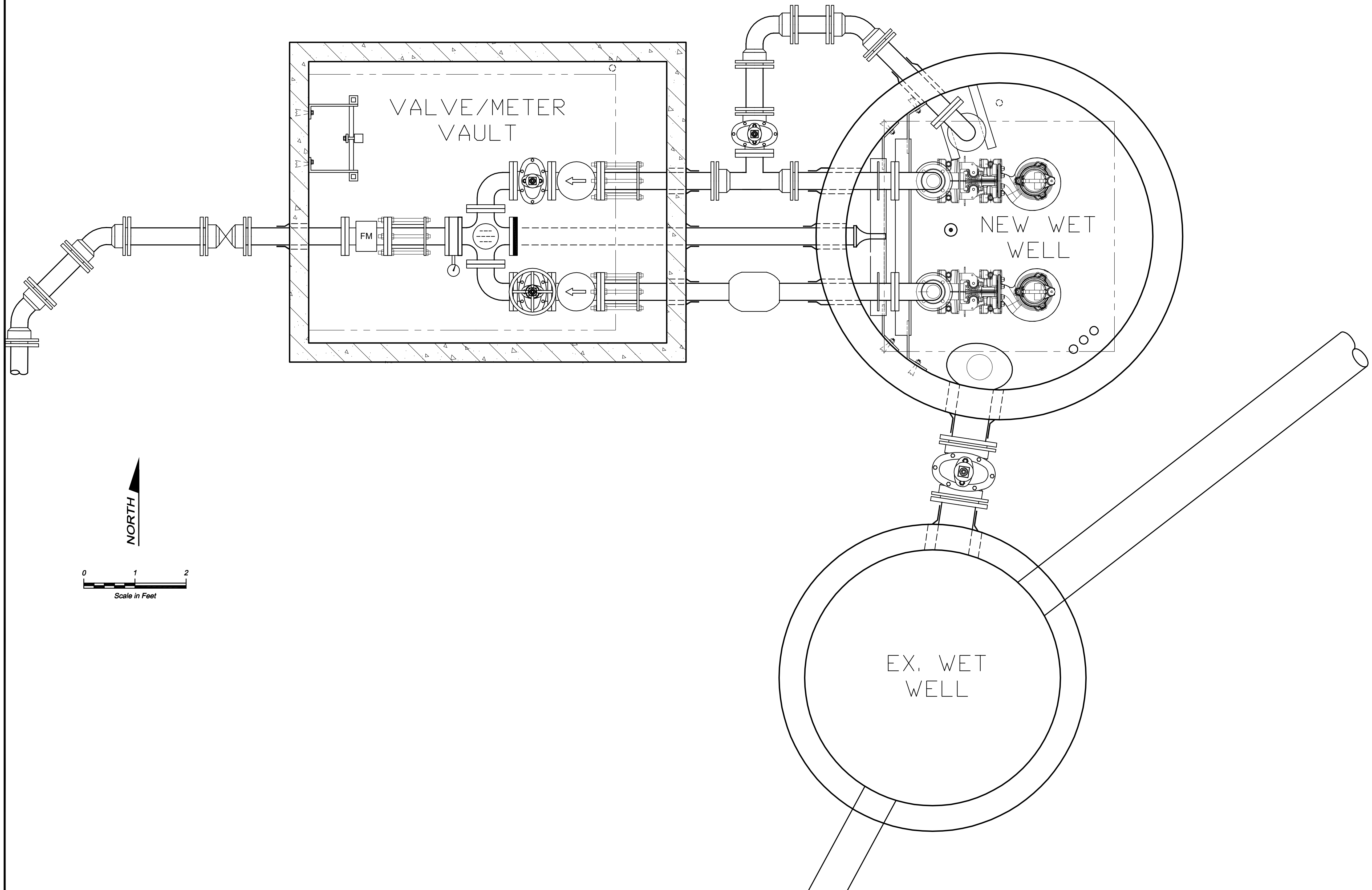

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE ES-26
LIFT STATION 31
DETAILED PLAN VIEW

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Chapter 1. Introduction

1.1 Background

Kitsap County's (County) Wastewater Division is evaluating alternatives for upgrading and/or replacing Lift Stations 3, 4, 19, and 31, along with portions of the collection and conveyance systems associated with those four stations. These improvements are known as the Silverdale Lift Stations 3, 4, 19, and 31 Upgrades.

This Preliminary Engineering Report (PER) includes preliminary design criteria and considerations to document the basis of design; preliminary geotechnical investigations and recommendations; permitting requirements; conceptual design layouts; anticipated design and construction schedules; and preliminary opinions of probable construction cost for the Project. The PER evaluates the Project's major construction improvements including upgrades to LS 3, LS 4, LS 19, and LS 31, as well as conveyance piping upgrades through Old Town Silverdale, along Fredrickson Road NW, and LS 4's force main along NW Bucklin Hill Road.

All four lift stations have aging equipment that is no longer operating efficiently or reliably. In addition, current incoming flows are approaching the pumping capacities at Lift Station 3 (LS 3) and Lift Station 4 (LS 4) and future projected flows are anticipated to exceed the pumping capacities at the two stations. Upgrades to all four lift stations will bring the stations into compliance with the County's current design standards for lift stations.

Portions of the conveyance systems upstream and/or downstream of these facilities also need to be replaced or upgraded to handle projected flows. The preliminary design phase of this project confirmed the projected flows through these systems and evaluated upgrades to address capacity issues. Alternative alignments for necessary improvements were reviewed to identify routes with the least overall impacts to the environment, the public, and the County's budget.

The preliminary design phase of the Project considered several configurations for each station to address the needed upgrades. The preliminary design level drawings included with this PER represent the recommended and preferred lift station configurations as discussed with the County on June 27, 2019.

While many aspects of each lift station and associated conveyance system improvements are similar, each facility has its own unique issues, considerations, and requirements. Therefore, each station's background and characteristics are outlined in the following section. The Silverdale Lift Station 3, 4, 19, and 31 Upgrades are identified in the 2011 Central Kitsap Wastewater Facility Plan and shown on Figure 1-1.

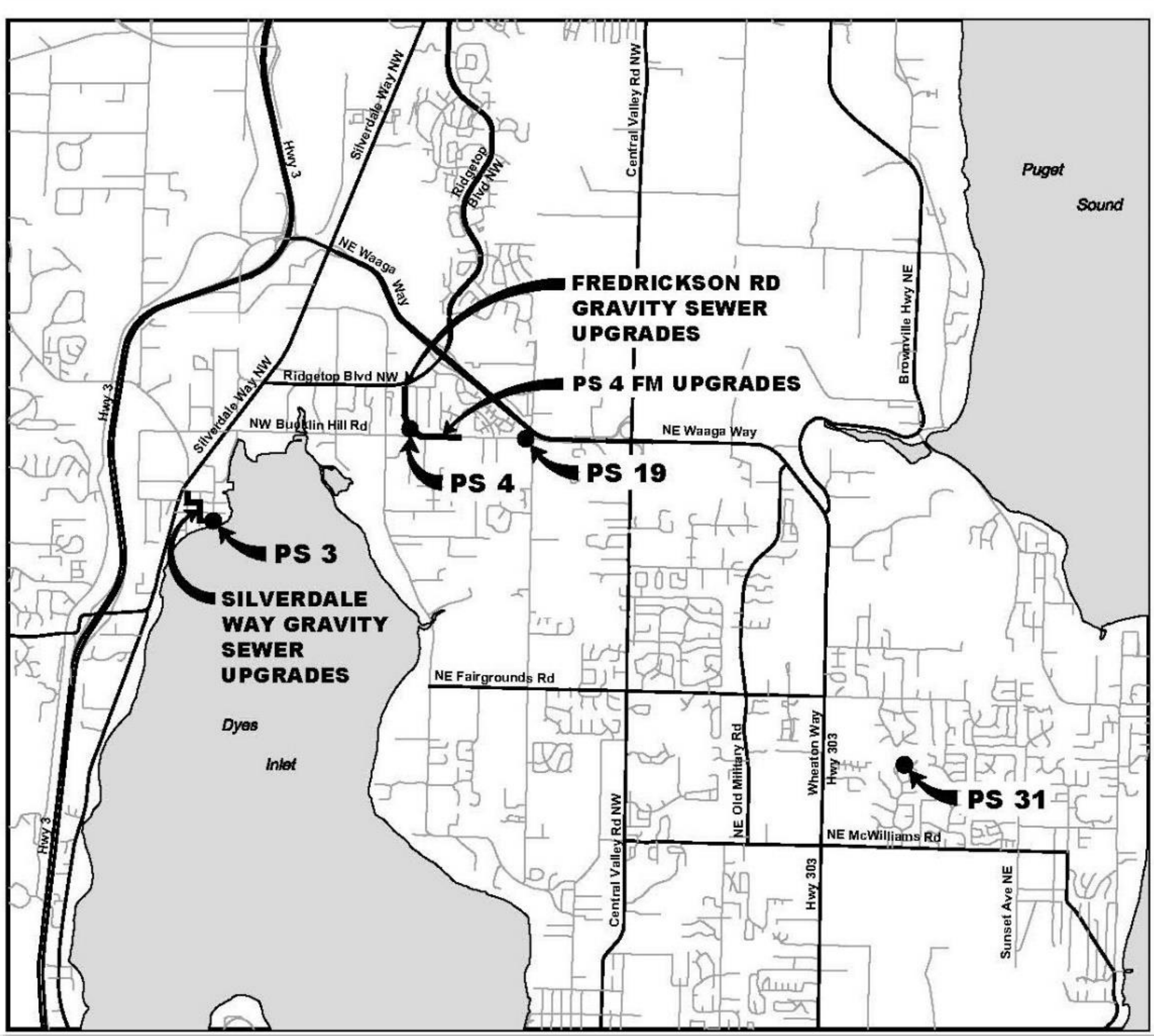

Figure 1-1 – Vicinity Map

1.2 Lift Station 3 and Associated Upstream Conveyance System Upgrades

Lift Station 3 is a major lift station that serves the southern Silverdale service area and pumps wastewater to LS 4 via a 14-inch force main. The lift station is located west of Washington Avenue NW, south of NW Byron Street, and adjacent to the beach associated with Dyes Inlet. The station receives flow from Lift Stations 12 and 40 in addition to the surrounding area that can flow by gravity to the station. Incoming flows are projected to exceed the station's current pumping capacity of 1,800 gallons per minute (gpm). The existing controls, pumps, and pump motors are old, in poor condition, and due to be replaced. Larger pumps will be needed to address the projected flows.

The existing station is a triplex, wet well/dry well station with a separate control building that houses the electrical control panels and backup generator with a separate room that is used to add odor control chemicals. To bring the station into compliance with the County's current design standards, the wet well and dry well will be removed or abandoned in place and a new wet well will be constructed to house the new submersible pumps. In addition, the existing concrete masonry unit (CMU) building will be demolished and replaced with a new CMU building to house the isolation valves, check valves, pressure gauges, flow meter, and generator. Separate rooms will be added for the control panels and odor control facilities. Isolation valves will also be installed on all incoming gravity sewer mains to facilitate isolation of the wet well in the future, if necessary. Finally, a new pig launch will be added to allow County maintenance personnel to clean the station's force main.

Figure 1-2 – Existing Lift Station 3

The station currently pumps through approximately 7,400 feet of 14-inch force main before discharging into a manhole located just east of LS 4 (SSMH K18-4013). Sewage velocities in the existing force main when one of the upgraded pumps is operating will be about 4.1 feet per second (fps) and 5.9 fps when two pumps are operating in parallel. These velocities are reasonable so no upgrades to the force main are required.

The 2019 Hydraulic Model Update identified upgrades to the conveyance system upstream of LS 3 that should be conducted in concert with the upgrades to LS 3 to address surcharging in the system. These upgrades are referred to as the Old Town Silverdale Gravity Sewer Upgrades (see Figure 1-3). The Old Town Silverdale Gravity Sewer Upgrades call for improving approximately 1,500 feet of 8-inch and 12-inch gravity sewer mains between Silverdale Way (SSMH L17-1079) and LS 3 with 15-inch and 18-inch sewer main. The 2019 Hydraulic Model Update anticipates these improvements being constructed under the County's 6-Year Capital Improvement Plan (6-Year CIP) in conjunction with the upgrades to LS 3.

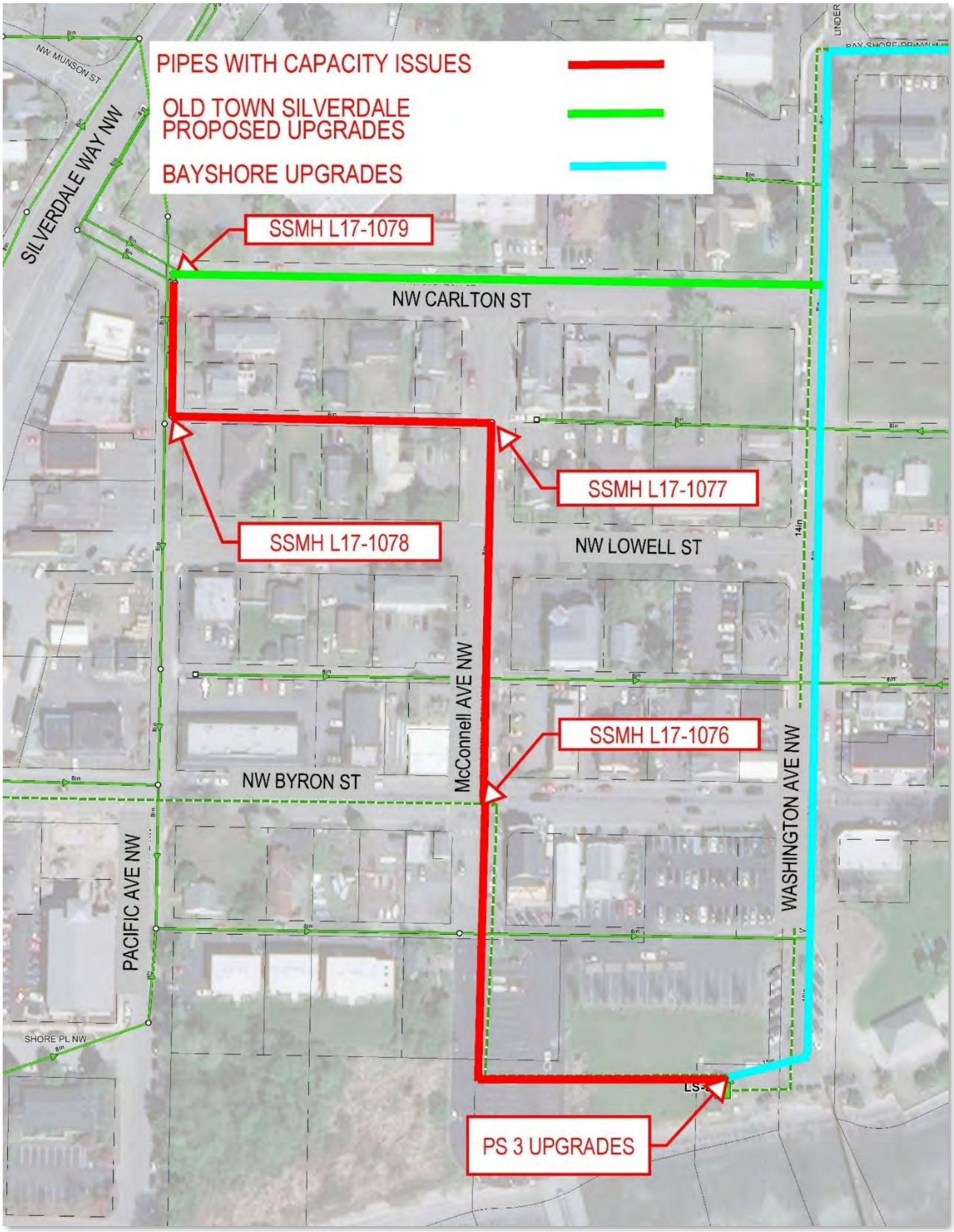

Figure 1-3 – Old Town Silverdale Gravity Sewer Upgrades

1.3 Lift Station 4 and Associated Conveyance System Upgrades

Lift Station 4 is a major lift station that serves the northern and southern Silverdale service area. The station receives flow from Lift Stations 1, 2, 3, and 39 in addition to the surrounding area that can flow by gravity to the station. The station is on a lot at the northeast corner of the intersection of Fredrickson Road NW and NW Bucklin Hill Road and is surrounded by residential developments. Incoming peak flows are approaching the triplex station's pumping capacity of 3,000 gpm and the equipment in the station is old and no longer reliable. Recent upgrades to Lift Station 1 have exacerbated the issue and the proposed upgrades to LS 3 will further challenge the station's pumping capacity. Therefore, a significant upgrade of the station with larger pumps, motors, and a new wet well will be required to handle projected peak flows.

The existing station is a triplex, wet well/dry well station with a separate control building that houses the electrical control panels and backup generator with a separate room that used to contain odor control equipment, but is now vacant. Odors are currently treated via an onsite biofiltration bed. To bring the station into compliance with the County's current design standards, a new wet well will be constructed adjacent to the east side of the existing station (where the current biofiltration bed is located). New submersible pumps will be installed in the wet well and piping routed to the mezzanine level of the existing dry well. The mezzanine level will house the isolation valves, check valves, and pressure gauges. A new utilidor will be constructed adjacent to the north side of the existing dry well to house the flow meter. In addition, a pig launch will be installed along the west side of the site to allow County maintenance personnel to pig the station's force main. Isolation valves will also be installed on all incoming gravity sewer mains to facilitate isolation of the wet well in the future, if necessary.

Figure 1-4 – Existing Lift Station 4

The above grade portions of the existing building are old with portions of the CMU walls flaking away. In addition, the metal roof is rusting and needs to be replaced. Due to the extensive nature of improvements that would be necessary to bring the building into compliance with current building codes, the County will be better served to demolish and replace the above grade structure with a new CMU control building located within the same general footprint. Rooms in the control building would then house the control panels and backup generator. A third room could be added for odor control facilities or the biofiltration bed can be replaced in a different location. As part of the construction, the existing wet well will be rehabilitated to provide additional storage to increase response time should there be an equipment failure that prevents the station from operating. The lower level of the dry well, where the existing pumps are currently located, will be filled with sand or controlled density fill (CDF) and abandoned.

The station currently pumps through approximately 1,570 feet of 14-inch force main before discharging into SSMH J18-3048 near the intersection of Spinnaker Blvd NW and NW Bucklin Hill Road. Sewer manhole J18-3048 has been converted to an air-vacuum station by plating over the existing manhole channel and then filling the remaining structure with sand. Vent piping, an air/vacuum assembly and a carbon canister were then installed to providing venting of the force main at this location. The sewage exits SSMH J18-3048 via a 20-inch sewer that conveys the flow further east along NW Bucklin Hill Road until it joins with flows from Lift Stations 6 and 7 near the intersection of SR 303 and County Road 15. The pumping capacity upgrades at LS 4 needed to address the projected peak flows will result in velocities in excess of 9.5 fps in the 14-inch force main when two pumps are operating. Therefore, the 14-inch force main should be upsized to 20-inch pipe concurrently with the lift station upgrades, which would result in velocities in the force main of 2.8 fps (one pump operating) and 4.7 fps (two pumps operating). Consideration should also be given to replacing SSMH J18-3048 with a more conventional air-vacuum valve assembly as part of the upgrades to the 14-inch force main. This project, known as the Lift Station (LS) 4 Force Main Replacement, should be included in the County's 6-year CIP.

The 2019 Hydraulic Model Update also identified conveyance upgrades to the gravity sewers along Fredrickson Road NW between NW Chena Road and LS 4. This project is referred to as the Fredrickson Road Gravity Sewer Upgrades. The Fredrickson Road Gravity Sewer Upgrades include the replacement of approximately 1,350 feet 15-inch gravity sewer main with new 18-inch, 21-inch, and 24-inch gravity sewers as part of the County's 6-year CIP. The LS 4 Force Main Upgrades and the Fredrickson Road Gravity Sewer Upgrades are shown on Figure 1-5.

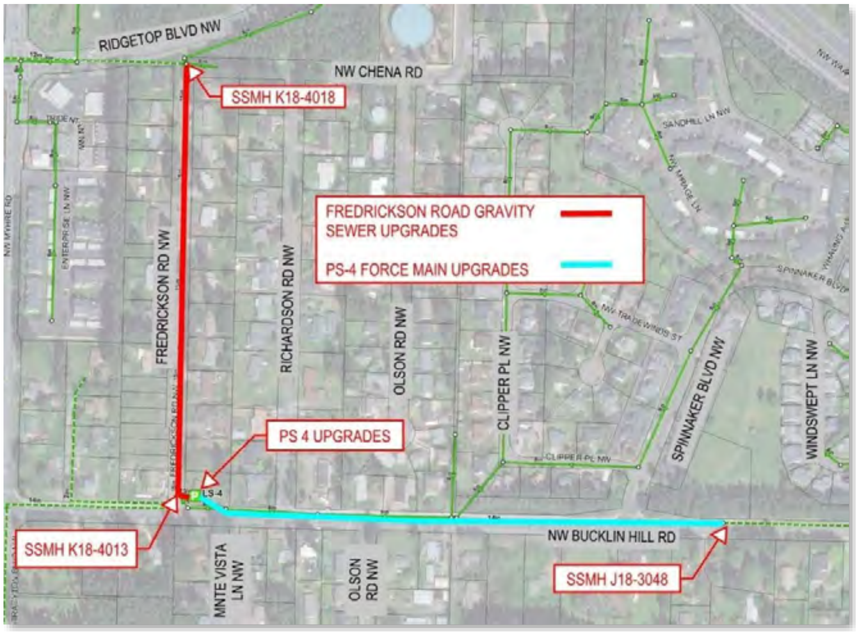

Figure 1-5 **–** LS 4 Conveyance System Upgrades

1.4 Lift Station 19 and Associated Conveyance System Upgrades

Lift Station 19 (LS 19) is a major lift station that serves the northeastern portion of the Silverdale service area. The station receives flow from Lift Stations 22, 25, and 26 in addition to the surrounding area that can flow by gravity to the station. The station is located on a lot at the north end of the intersection of NW Bucklin Hill Road and Nels Nelson Road NW. Flows into the station are not anticipated to increase; however, the equipment in the station is old and no longer functions reliably. Therefore, upgrades to the existing lift station are required.

Figure 1-6 **–** Existing Lift Station 19

The existing station is a triplex, wet well/dry well station with a separate brick control building that houses the electrical control panels and backup generator. To bring the station into compliance with the County's current design standards, the dry well will be removed or abandoned in place and the existing wet well will be modified to house new submersible pumps. In addition, the existing brick building will be demolished and replaced with a new CMU building to house the isolation valves, check valves, pressure gauges, flow meter, and generator. Separate rooms will be added for the control panels and future odor control facilities. Isolation valves will also be installed on all incoming gravity sewer mains to facilitate isolation of the wet well in the future, if necessary. Finally, a new pig launch will be added to allow County maintenance personnel to pig the station's force main.

The station typically pumps north and east through a 14-inch force main before discharging into a 30-inch force main near the intersection of NE Paulson Road and Kelly Court NE. The 30-inch force main then transports the flows in conjunction with flows from LS 4, LS 6, LS 7, and LS 9 to the Central Kitsap Wastewater Treatment Plant. Onsite valving allows the station to also pump directly into LS 4's force main, which conveys the flows east before combining with flows from LS 6 and LS 7 near the intersection of SR 303 and County Road 15. According to discussions with County staff, this second mode of pumping is discouraged, as the pumps tend to cavitate when pumping into the LS 4 force main. The County has expressed a desire, however, to maintain the ability to pump into LS 4's force main as a backup option as part of the proposed upgrades.

The 2019 Hydraulic Model Update does not identify a need to increase the pumping capacity of LS 19. Velocities in the 14-inch force main will be 2.3 fps with one pump operating and 3.8 fps with two pumps operating, which are adequate to provide cleansing velocities without undue frictional head loss. Therefore, the existing force main will remain in service and will not be replaced as part of this project. The 2019 Hydraulic Model Update did not identify any needed upgrades to the gravity conveyance system upstream of the station.

1.5 Lift Station 31 and Associated Conveyance System Upgrades

Lift Station 31 (LS 31) is a small duplex lift station that serves a residential neighborhood in the northern part of the City of Bremerton. The station is located within a cul-de-sac just off Clover Blossom Lane NE. Flows into the station are not anticipated to increase; however, the equipment in the station is old and no longer functions reliably. In addition, the station operates on single phase power and has experienced multiple issues with breakers tripping, causing the station to be inoperable. Therefore, upgrades to the existing lift station, including a conversion to 3-phase power, are required.

Figure 1-7 – Existing Lift Station 31

The existing station is an old Smith and Loveless lift station and consists of a wet well, two above ground centrifugal pumps housed in a doghouse type structure, and a below ground valve vault. The doghouse type structure also contains the control panels for the station. To bring the station into compliance with the County's current design standards, a new wet well will be installed to house two submersible pumps and a new valve vault will be constructed for the isolation valves, check valves, pressure gauges, and flow meter. Provisions will be provided in the valve vault to allow County maintenance personnel to pig the station's force main.

While the station will be designed as a conventional submersible lift station with a separate valve vault, a pre-manufactured submersible lift station, as provided by Romtec or Old Castle, may be a viable consideration and would be evaluated during construction if the Contactor chooses to submit that style of station. The control panels will be located under a canopy-type shelter for some protection from elements. However, no control building is anticipated for this station due to the small nature of the station and a lack of space for a new building. Once the new station has been constructed, the existing valve vault will be demolished or abandoned and the existing wet well converted to a gravity manhole.

Discussions with County staff indicated chlorine residuals were found in the groundwater. This may be an indication that North Perry's water main is leaking somewhere in the vicinity of the station. A leaking water main may be contributing to elevated groundwater tables in the area and may be contributing to some of the erosion that is occurring. Preliminary discussions with the Water District indicate the existing main consists of asbestos cement pipe that the District may be interested in replacing. Further discussions with the Water District are warranted regarding this topic.

1.6 Purpose of Report

This Preliminary Engineering Report (PER) includes preliminary design criteria and considerations to document the basis of design; preliminary geotechnical investigations and recommendations; permitting requirements; conceptual design layouts; anticipated design and construction schedules; and preliminary opinions of probable construction cost for the Project. The PER evaluates the Project's major construction improvements including upgrades to LS 3, LS 4, LS 19, and LS 31, as well as conveyance piping upgrades through Old Town Silverdale, along Fredrickson Road NW, and LS 4's force main along NW Bucklin Hill Road.

The preliminary design phase of the Project considered several configurations for each station to address the needed upgrades. The preliminary design level drawings included with this PER represent the recommended and preferred lift station configurations as discussed with the County on June 27, 2019.

Chapter 2. 2019 Hydraulic Model Update

2.1 Background

In order to determine the pumping capacities associated with the planned upgrades of the stations, the County's hydraulic models were updated to reflect current population forecasts, zoning changes, and recent flow monitoring data. Updated Current (2017), Future (2038), and Full Buildout Models were developed. These models were then reviewed and analyzed to determine facilities with inadequate capacity to convey the anticipated flows. The results associated with each model were used to develop a list of capital improvement projects with associated budgetary level opinions of probable project costs. This chapter summarizes the process used to update the County's hydraulic models and the resultant capital improvement plans for the Central Kitsap and Silverdale Service Areas.

The 2019 Hydraulic Model Update used MIKE Urban to model the Current, Future, and Full Buildout flows. All models associated with the 2019 Hydraulic Model Update assume 100% of un-sewered properties were converted from septic systems to service by the sanitary sewer system. Appendix A contains memoranda that summarize the methods used to update the population projections, load the models with sanitary flows, and then calibrate for wet weather flows. The modeled flow projections are peak hour flows during wet weather conditions.

2.2 Current Flow Conditions

Current flow conditions were determined by using parcel-based population data. The Central Kitsap Service Area contains two UGAs: Silverdale and Central Kitsap. These two UGAs are further divided into Traffic Analysis Zones (TAZ). Each TAZ contains population data for residential and commercial populations. GIS shapefiles containing the TAZ boundaries were provided by the County in 2010 as part of the Remand Study and were checked for consistency as part of the 2019 Hydraulic Model Update. No significant discrepancies were found.

Data from the Puget Sound Regional Council (PSRC) pertaining to the estimated current (2017) residential and commercial populations within the Central Kitsap and Silverdale UGAs was used to calculate wastewater flows for the Current model by assigning the populations to load points. Load points are geographical point features that input wastewater flows generated from residential and commercial demand into the model. The 2019 Hydraulic Model Update used the load points developed for the 2012 Remand Analysis as the basis for the model updates.

A review of current wastewater flow data at the Central Kitsap Wastewater Treatment Plant (CKTP) determined 70 gallons per day per capita (gpcd) was more representative of current per capita wastewater flows than the 76 gpcd used for the 2012 Remand modeling. Therefore, the populations at each load point were assigned a wastewater load rate of 70 gpcd. The resulting values represent the wastewater loading in gallons per day for the model.

The model then reviewed historical flow data at the CKTP from the years 2012-2018 to obtain the plant's maximum daily inflow. The maximum daily inflow occurred on January 21, 2016. Kitsap County rainfall data showed 3.3 inches of rainfall accumulated during that 24-hour period. According to the Western Washington iso-pluvial maps from the Department of Ecology's Stormwater Management Manual for

Western Washington, a 3.3-inch rainfall event corresponds to a 25-year, 24-hour design storm. Discussions with the County determined the 25-year storm would provide a reasonable basis for the wet weather flow calibration.

The County provided 15-minute incremental data for incoming flows at the CKTP for January 21, 2016. This data was graphed and used to determine the average hourly inflow and the maximum peak hour inflow. The maximum peak hour inflow was then divided by the average hourly inflow to determine a peak hour flow multiplier of 1.5, which was then used as the basis for calibrating the Current Model. Model iterations were then performed by adjusting the individual multipliers within the peak day diurnal pattern to yield a peak daily flow to peak hourly flow multiplier of 1.5 at the CKTP. The resulting peak day diurnal pattern was then used to complete calibration throughout the Current model. Figure 2-1 provides a summary of the current incoming flows at each lift station along with each station’s existing pumping capacity.

2.3 Future Flow Conditions

The Future Model was created by updating the Current Model with future population projections. This was done by replacing the current population data at the load points with future population data. The 70 gpcd wastewater load rate used in the Current Model was deemed suitable for future conditions and was applied to the future populations at each load point to represent the wastewater loading for the Future Model. The peak hourly multiplier of 1.5 was also kept as the basis for calibrating the Future Model. Figure 2-2 provides a summary of the future incoming flows at each lift station along with each station’s existing pumping capacity.

2.4 Full Buildout Flow Conditions

The full buildout population projections were determined by assuming all zoning capacity is fully utilized. The resultant populations then replaced the future populations contained in the Future Model. The 70 gpcd wastewater load rate used in the Current and Future Model was deemed suitable for buildout conditions and was applied to the buildout populations at each load point to represent the wastewater loading for the Buildout Model. The peak hourly multiplier of 1.5 was also kept as the basis for calibrating the Buildout Model. Figure 2-3 provides a summary of the buildout incoming flows at each lift station along with each station’s existing pumping capacity.

Because the Future and Full Buildout models used two different methods for developing population projections, some discrepancies between the population forecasts became apparent. Specifically, the projections for the Future model were based on population forecast data generated by the PSRC’s Land Use Vision (LUV) long-range model while the population projections for the full buildout model were generated by analyzing zoning requirements and underdeveloped land use within the UGAs. Due to these distinct differences, the commercial population for a TAZ in the Future model was sometimes greater than the commercial population for a TAZ in the full buildout model.

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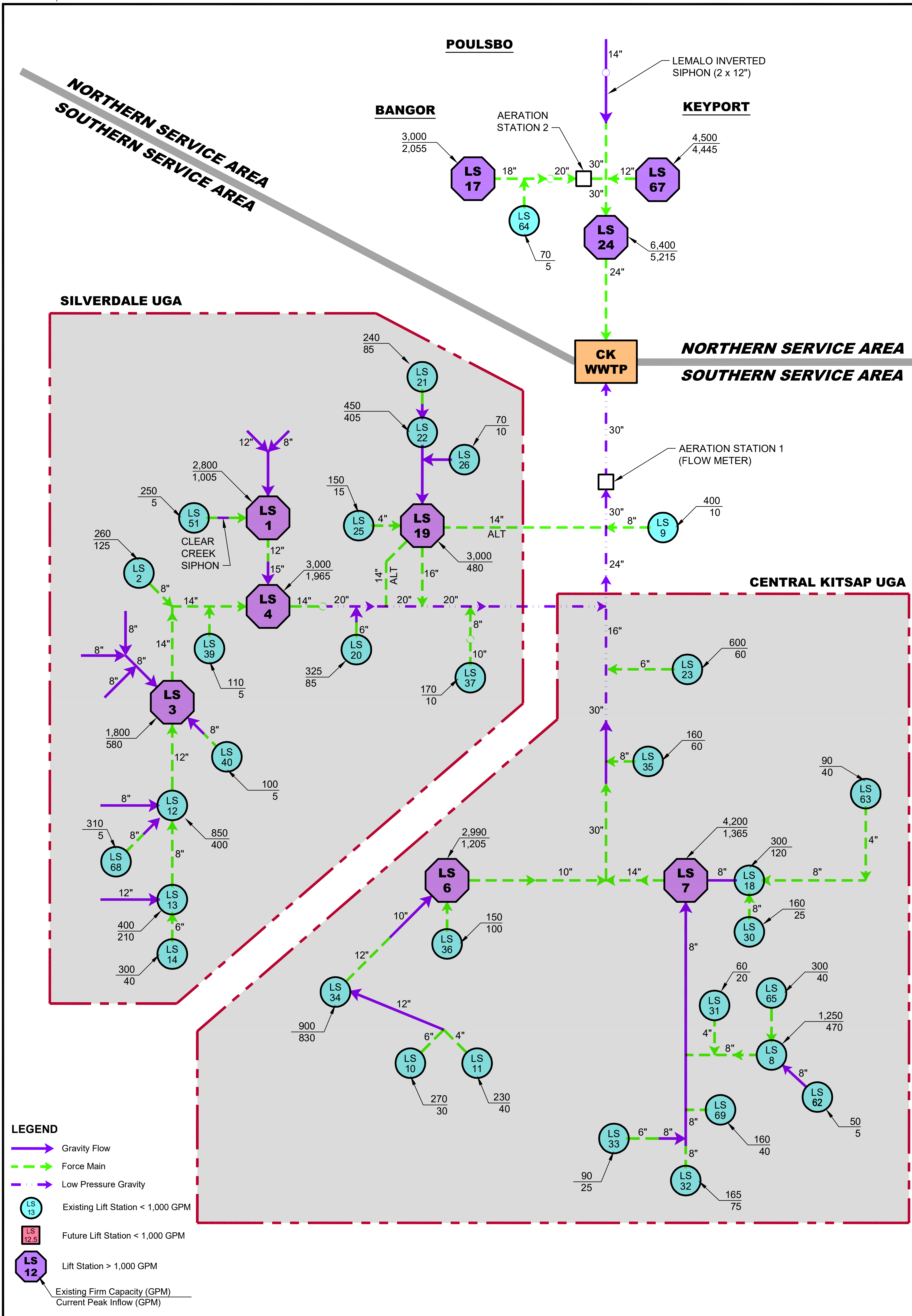

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Existing Lift Station Capacity and Existing Peak Flows

Kitsap County Public Works

November 2019

Figure **2-1**

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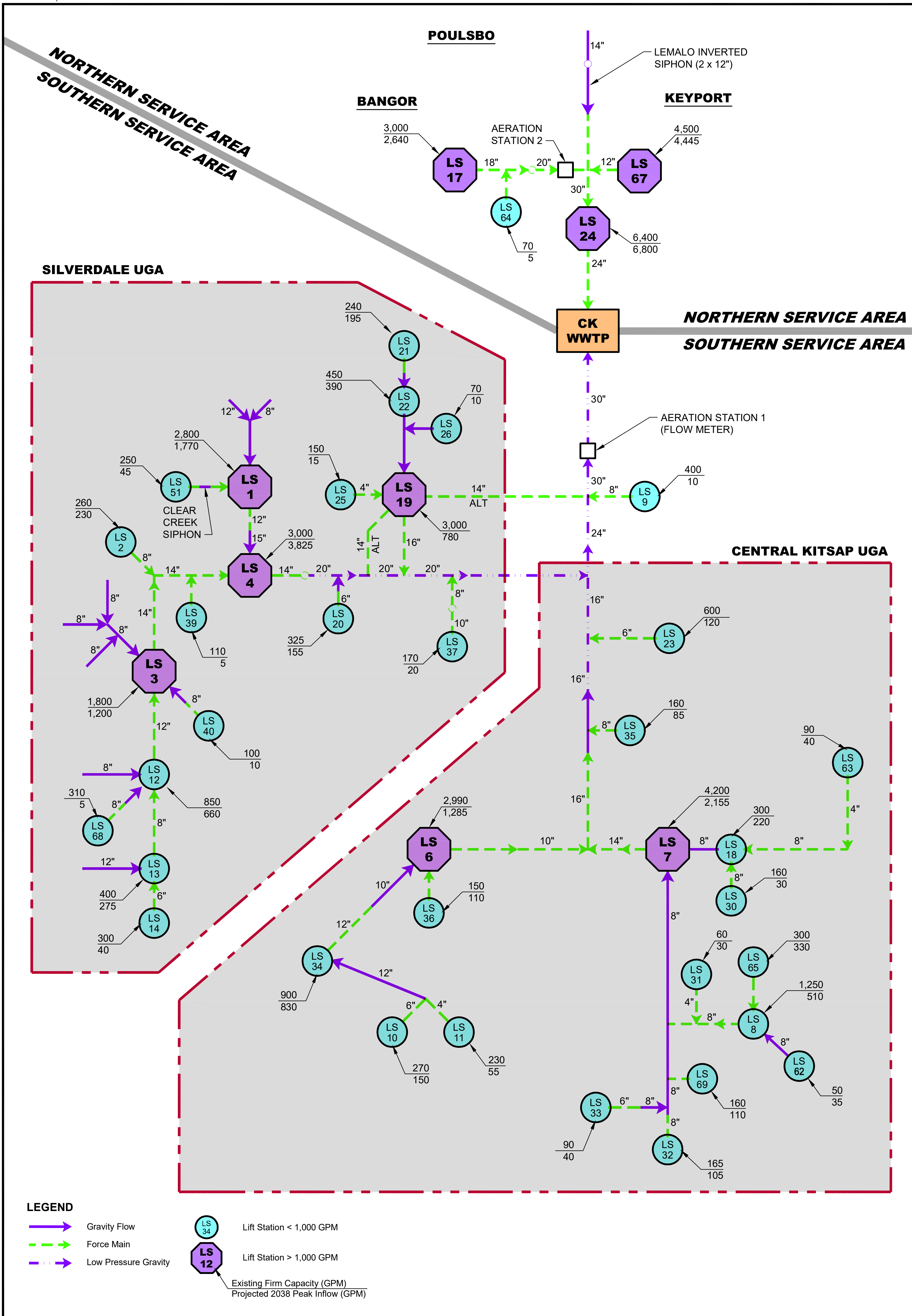

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Existing Lift Station Capacity and Future 2038 Peak Flow
Kitsap County Public Works
November 2019

Figure
2-2

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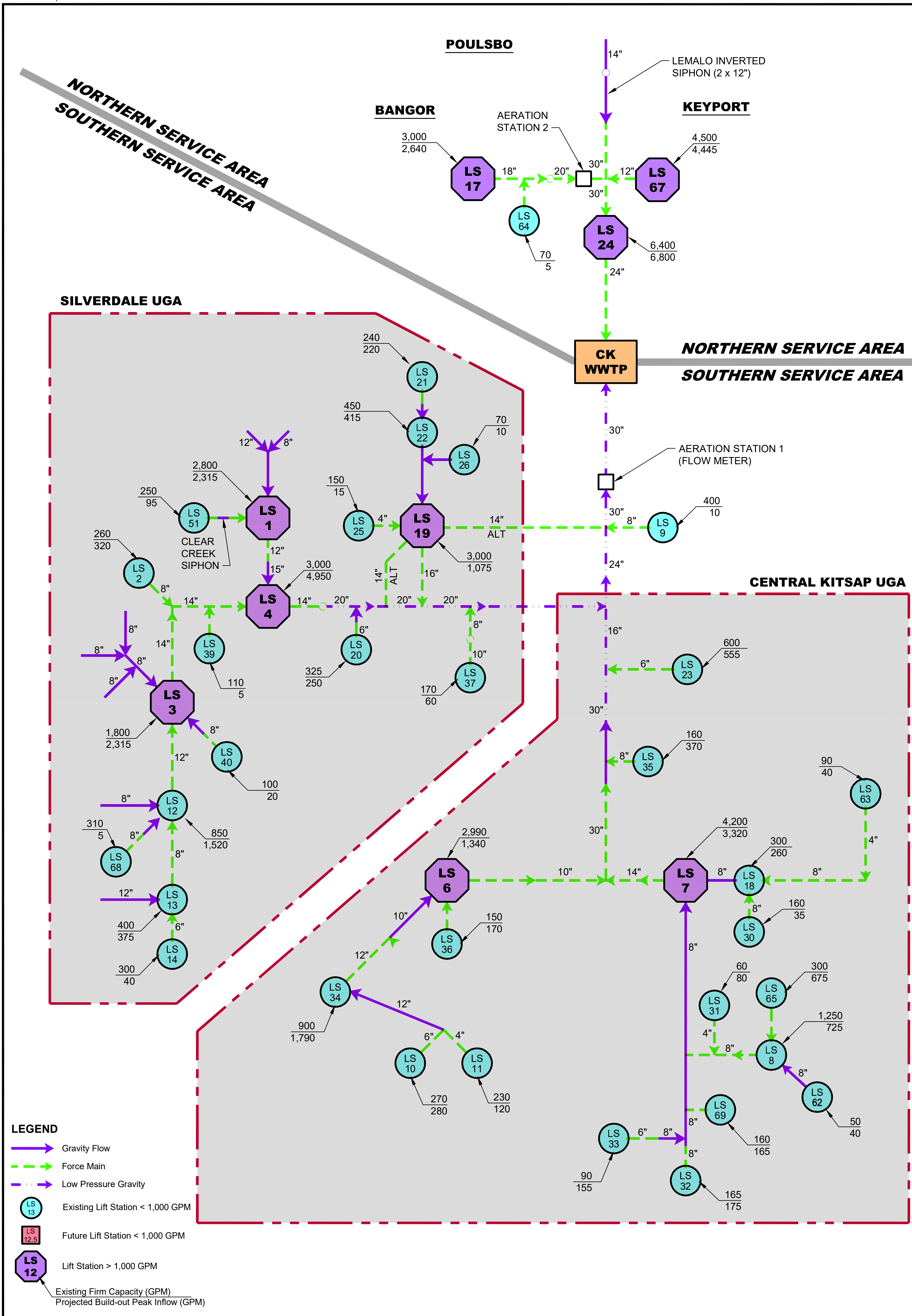

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Existing Lift Station Capacity and Future Build-out Peak Flows

Kitsap County Public Works

November 2019

Figure 2-3

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This trend is non-intuitive as the commercial population would be expected to increase as the zoning capacity is fully utilized in the build-out model, thus resulting in a greater population per TAZ. Therefore, the population projection discrepancies were analyzed further, and the differences were reconciled. Although the commercial population for some TAZ's decreased from the Future model to the Full Buildout model, the overall commercial population increased. An increase in total commercial population in the Silverdale and Central Kitsap UGA's translates to an increase in total wastewater demand derived from commercial populations within these UGAs. Since the overall wastewater demand increased from the Future model to the Full Buildout model, the differences in commercial population projections were deemed acceptable.

2.5 Dickey Road Rezone

The County is considering a site-specific Comprehensive Plan amendment with three alternatives for rezoning 138.45 acres just inside the boundary of the Silverdale Urban Growth Area from an Urban Industrial (IND) zone and removing the Mineral Resource Overlay (MRO) designation. The proposed zoning alternatives are shown in Table 2-1. The site is near Silverdale Elementary School with high-voltage power lines running through the site.

Table 2-1
Dickey Road Proposed Zoning Alternatives

Alternative	Proposed Zone	Acres	Estimated Dwellings	Max Dwellings
1	Urban Low Residential (UL, 5-9 DU/Ac) Neighborhood Commercial (NC, 10-30 DU/Ac)	108 30	630 to 1,074	1,872
2	Urban Low Residential (UL, 5-9 DU/Ac) Neighborhood Commercial (NC, 10-30 DU/Ac)	126 12	435 to 843	1,494
3	Urban Low Residential (UL, 5-9 DU/Ac)	138	410 to 738	1,242

The future developments would include:

- A new residential neighborhood with single-family and potentially a mix of multi-family and commercial buildings.
- A new road connecting to Dickey Road NW and Willamette-Meridian Rd NW.
- Non-motorized connections to three surrounding roads.

Full buildout models reflecting each alternative zoning proposal were developed to determine the potential impacts to the sanitary sewer conveyance system. The maximum number of dwelling units were calculated for each alternative based on the acreage zoned Urban Low Residential and then translated to a total population by multiplying by 2.5 people per dwelling unit. The resultant population was then multiplied by 70 gpcd to obtain the sanitary sewer service demand. For the acreage proposed to be Neighborhood Commercial, the population projections were based on the number of employees per building square footage. The same methodology described in Appendix A for the Current Model was used to determine the building square footage. Neighborhood Commercial zoning has a density of 500 square feet per employee. The Neighborhood Commercial Zoning population was determined by dividing the building square footage by 500 square feet per employee to obtain the total number of employees, which was then multiplied by 70 gpcd to obtain the sanitary sewer demand. The revised populations were then entered into the models at the appropriate locations similar to the approach previously described for the Full Buildout Flow Conditions. Table 2-2 summarizes the population forecasts for each alternative.

Table 2-2
Dickey Road Proposed Zoning Populations

Alternative	Proposed Zone	Population
1	Urban Low Residential (UL, 5-9 DU/Ac) Neighborhood Commercial (NC, 10-30 DU/Ac)	2,430 503
2	Urban Low Residential (UL, 5-9 DU/Ac) Neighborhood Commercial (NC, 10-30 DU/Ac)	2,835 201
3	Urban Low Residential (UL, 5-9 DU/Ac)	3,105

The resultant flows for all three alternatives create a significant amount of surcharging in the 8-inch gravity sewers between SSMH M18-4005 and SSMH L18-3011 with Alternative 3 being the most significant since it generates the greatest population. In addition, the 8-inch mains between L18-3011 and L18-3004 are flowing near capacity (almost surcharging). To alleviate the surcharging and capacity restrictions, the 8-inch gravity sewers between SSMH M18-4005 and L18-3004 should be replaced with 12-inch diameter pipe. These improvements would discharge into the upgraded 12-inch gravity sewers installed as part of the Anderson Hill Road Gravity Sewer Upgrades. Figure 2-4 summarizes the necessary upgrades. The hydraulic model results associated with this area may be found in Appendix B.

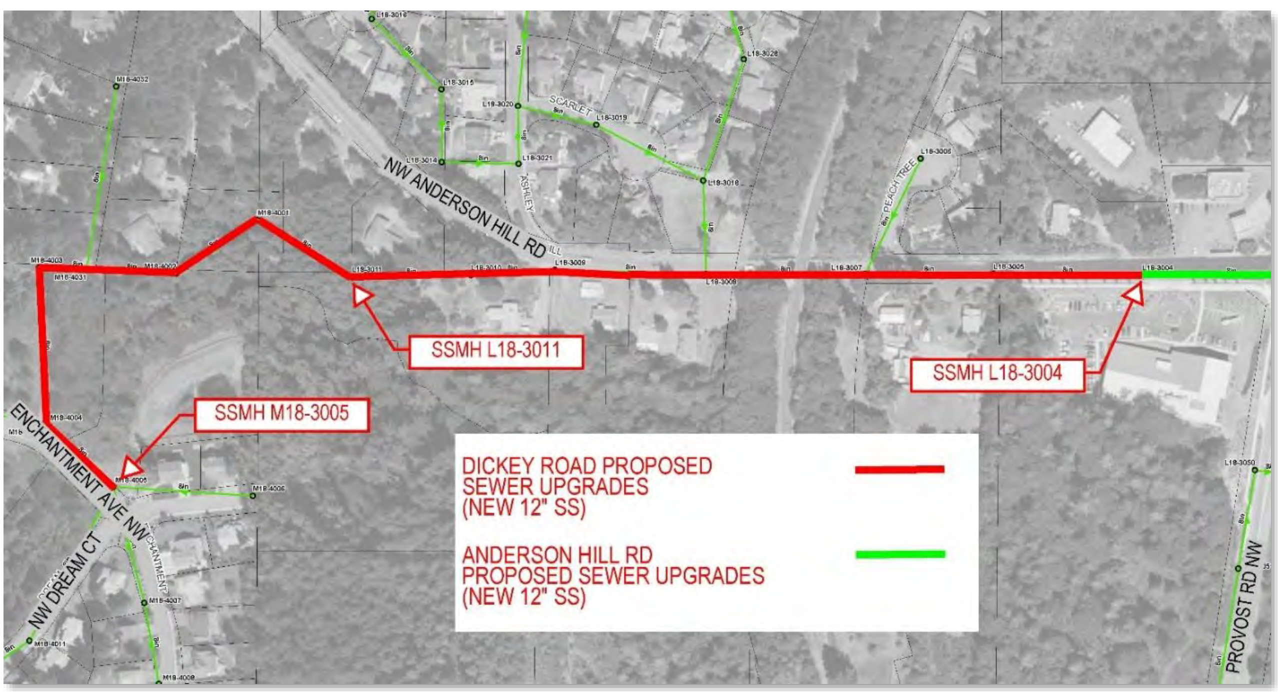


Figure 2-4 – Dickey Road Rezone Proposed Sewer Upgrades

2.6 2024 Comprehensive Plan Update

The County is currently updating its comprehensive plan, which will include new growth assumptions and population projections. This plan is anticipated to include three scenarios, one of which will be there preferred scenario and will include associated Traffic Analysis Zones for the new zoning and population assumptions through 2044. If the new zoning and population assumptions differ substantially from the growth projections included in the model updates associated with this report, then the Wastewater Division may need to update the models in the future to comply with the Growth Management Act.

2.7 Capital Facilities Plan

Recognizing that funding needs are generally set for six-year planning windows, upgrades needed to address capacity issues identified in the Current Model should be included in the 6-Year Capital Improvement Plan (6-Year CIP). Upgrades needed to address severe capacity issues found in the Future Model may also warrant inclusion in the 6-Year CIP. Longer term projects needed to address minor capacity issues identified in the Future Model as well as capacity issues found in the Full Buildout Model should be included on the 20-year CIP. Projects included in the 20-year CIP should be re-evaluated periodically to reflect changes in growth patterns, regulations affecting waster infrastructure construction, alternative means of funding, changes in project costs and advances in wastewater technologies. For this reason, projects included on the 20-Year CIP should be viewed as the most likely scenario, given the parameters known at this time.

2.7.1 Lift Station Projects

The 2019 Hydraulic Model Update identified capacity related issues with seven existing lift stations within the Central Kitsap and Silverdale Service Areas. Two of these projects (LS 3 and LS 4) are included on the 6-Year CIP as incoming flows into each station are approaching the firm pumping capacities of the station under Current and/or Future Model conditions. Five more pump stations are identified as having future capacity issues when comparing each station’s pumping capacity with full buildout peak hour flow projections. As such, they have been included on the 20-Year CIP. In addition, conversations with the County resulted in two more stations (LS 19 and 31) being added to the 6-Year CIP due to aging equipment that has or is reaching the end of its useful service life. Table 2-3 provides a summary of these projects as well as their anticipated year of construction. The locations of these projects are shown on Figure 2-5, Figure 2-6, and Figure 2-7.

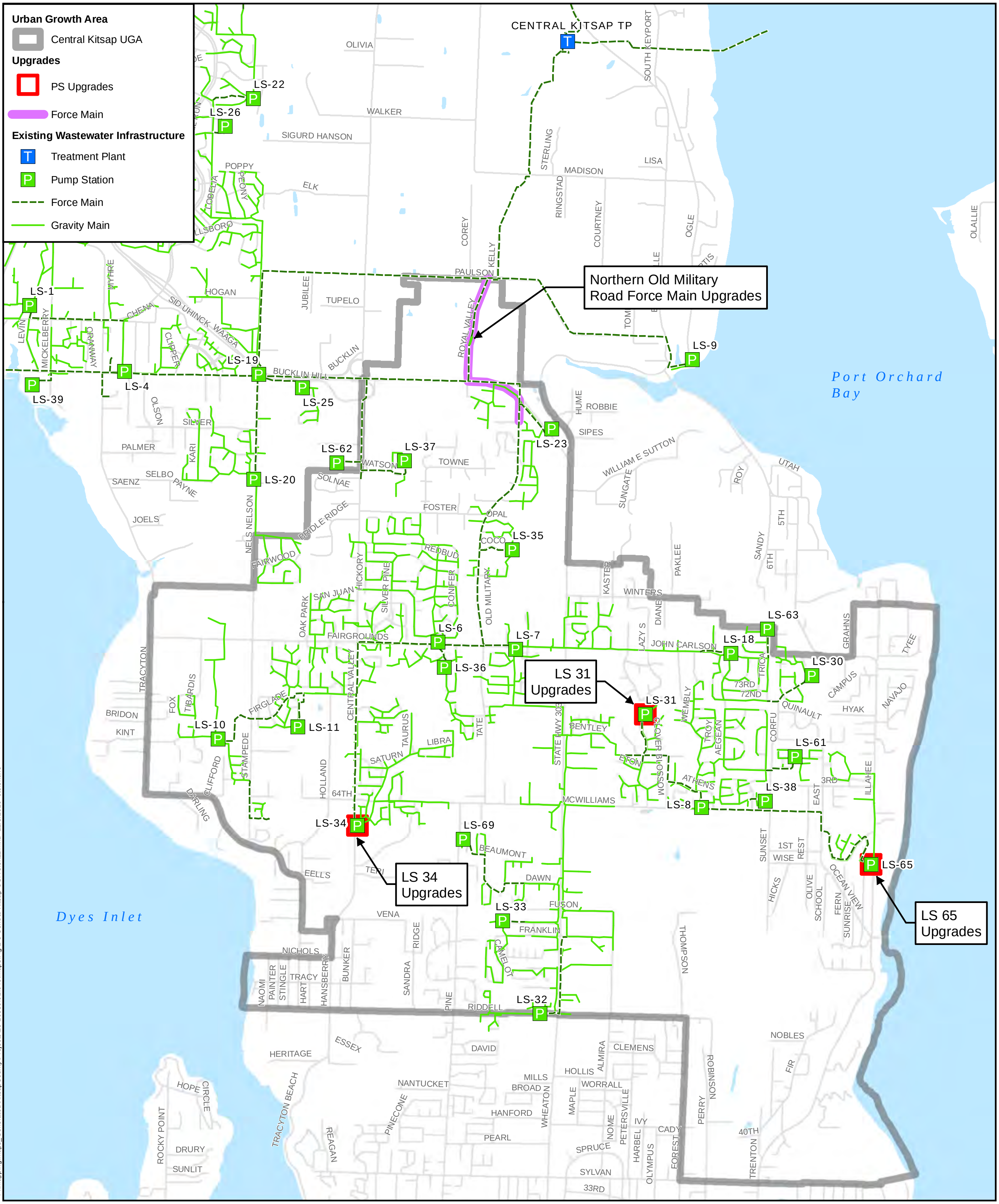
Table 2-3
Lift Station Projects

Lift Station	Ex. Firm Capacity (gpm)	Future Peak Hourly Inflow (gpm)	Buildout Peak Hourly Inflow (gpm)	Future Firm Capacity (gpm)	Project Cost	Year of Construction
LS 2	260	230	320	350	$2.416M	2040
LS 3	1,800	1,200	2,315	2,500	$5.281M	2022/2023
LS 4	3,000	3,825	4,950	5,000	$6.710M	2021/2022
LS 12	850	660	1,520	1,600	$3.194M	2050
LS 19	3,000	780	1,075	1,240	$4.666M	2020/2021
LS 24	6,400	6,800	6,800	7,000	$7.119M	2030
LS 31	60	30	80	170	$1.577M	2020/2021
LS 34	900	830	1,790	1,850	$3.194M	2040
LS 65	300	330	675	700	$2.089M	2033
Total					$36.246M	

In addition to the lift station projects identified above, the Full Buildout model identified flows to be within 10 to 20 gpm of the pumping capacities of four more lift stations. All four stations are small with pumping capacities ranging from 150 gpm to 270 gpm. Due to the number of assumptions being made during the development of the full buildout model, this report recommends these stations be monitored but not necessarily included on the 20-year CIP. If growth occurs as anticipated, upgrades to these stations will likely be triggered by aging equipment before their pumping capacities are exceeded. Table 2-4 identifies the four stations. Figure 2-8 and Figure 2-9 provides summaries of the incoming flows for the Future and Full Buildout Models at each lift station along with each station's pumping capacity after the proposed capital improvements have been completed.

Table 2-4
Lift Stations to Monitor

Lift Station	Ex. Firm Capacity (gpm)	Buildout Peak Hourly Inflow (gpm)	Year Installed
LS 10	270	280	1980
LS 32	165	175	1983
LS 36	150	170	1979/1999
LS 69	160	165	1998



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This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

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KITSAP COUNTY 1857 WASHINGTON

Central Kitsap UGA
Kitsap County Public Works
December 2019

Figure
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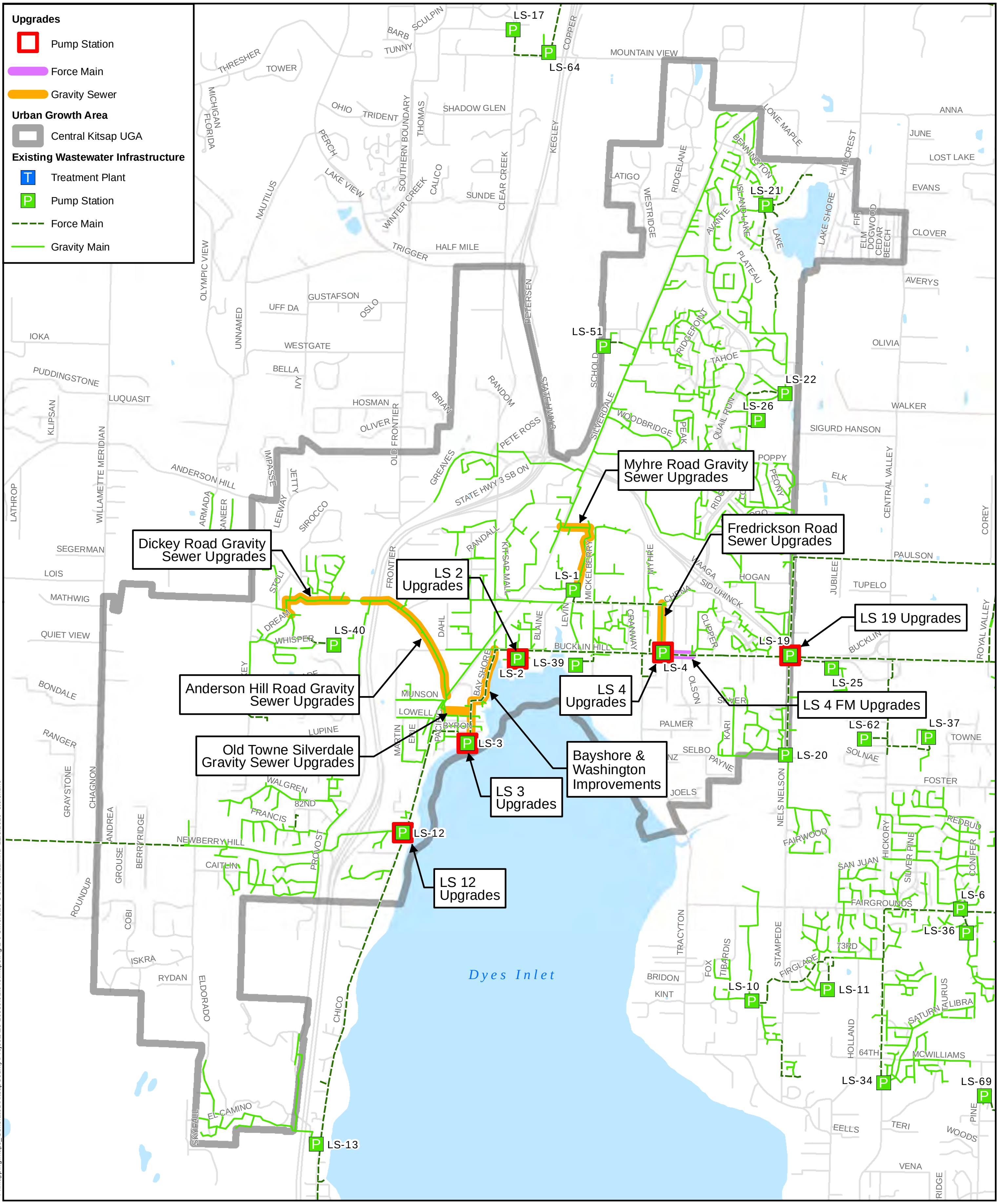

P:\Mapping\Maps_Generated\KitsapCounty\Projects\18-10530.01\040\maps\Fig 2-6 Silverdale UGA 8.5x11.mxd 12/3/2019 ctolentino

This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

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Silverdale UGA
Kitsap County Public Works
December 2019

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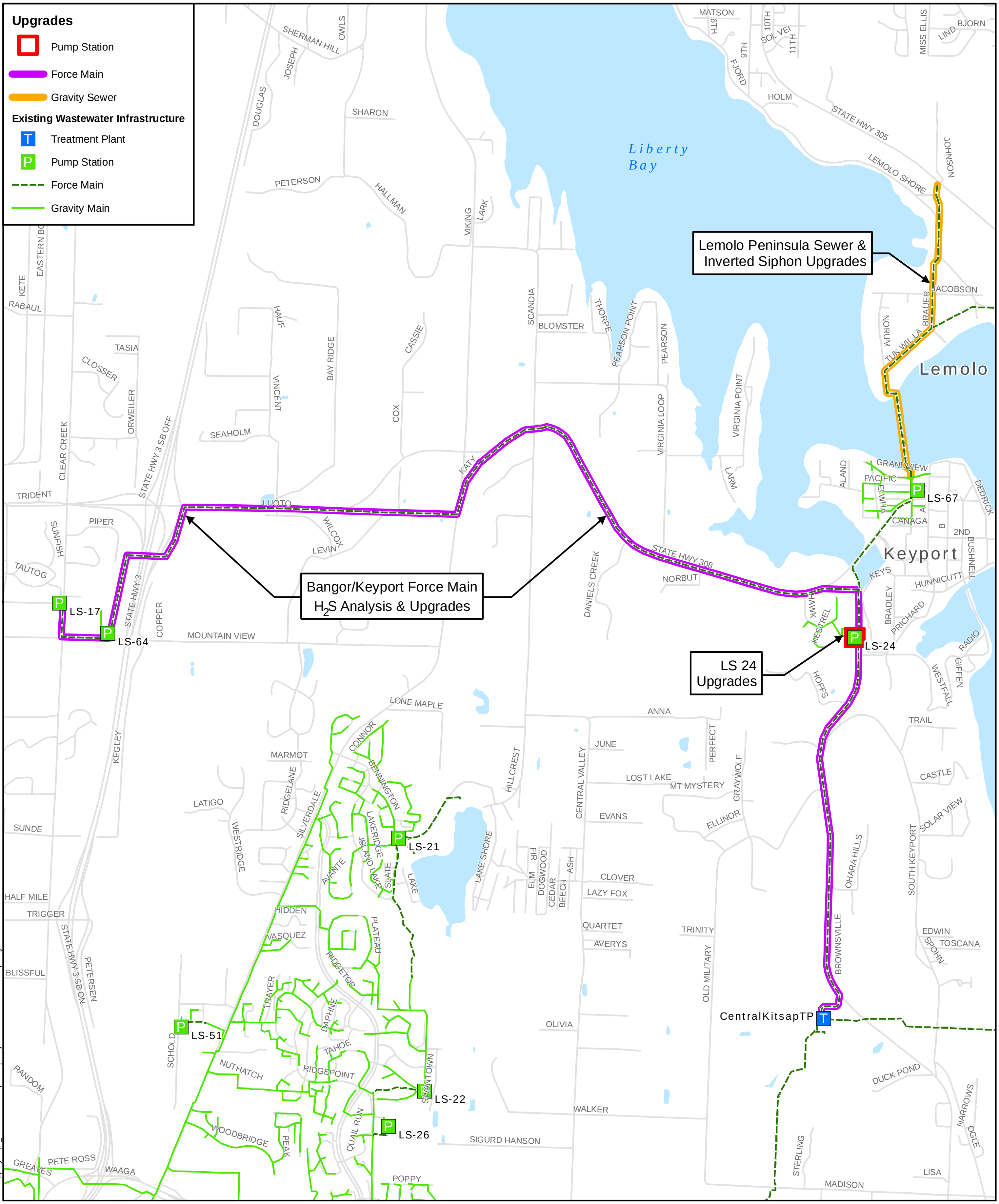

This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

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Northern Service Area
Kitsap County Public Works
December 2019

Figure
2-7

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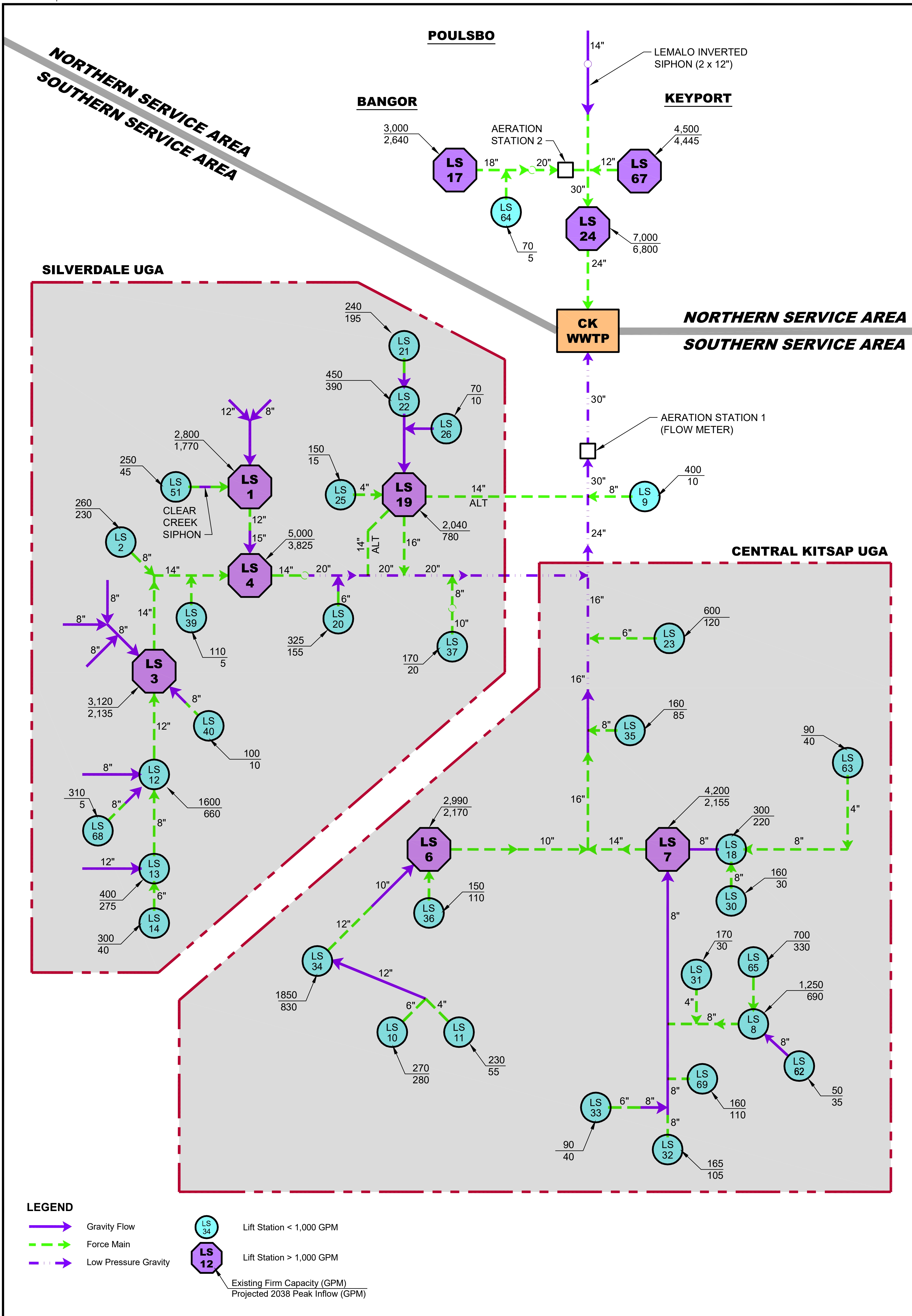

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Future Lift Station Capacity for Future 2038 Peak Flow
Kitsap County Public Works
November 2019

Figure
2-8

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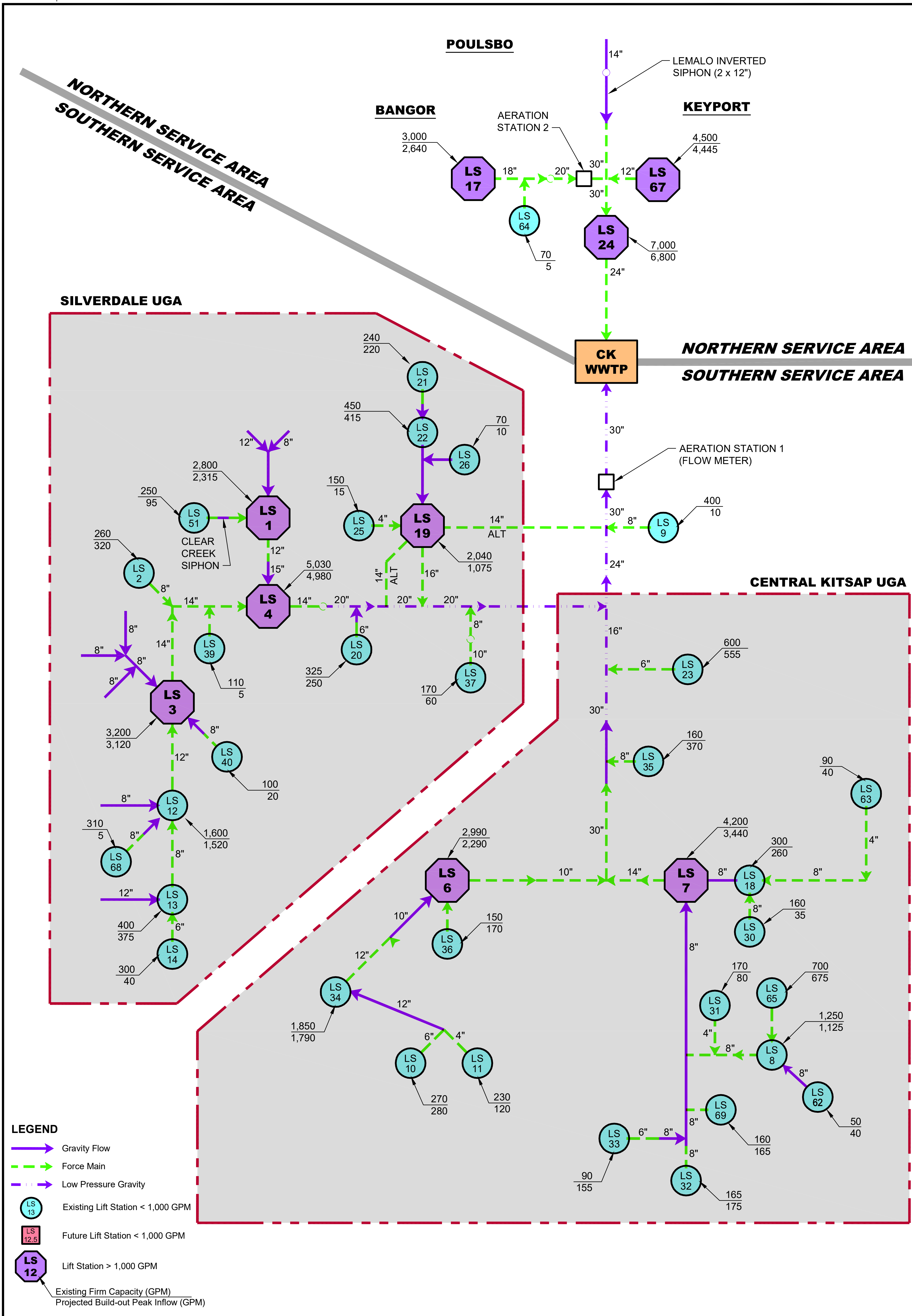

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Future Lift Station Capacity For Future Build-out Peak Flows
Kitsap County Public Works
November 2019

Figure **2-9**

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2.7.2 Collection and Conveyance Projects

Nine collection and conveyance projects, totaling approximately 27,100 feet of pipe, were identified as needed capacity upgrades to the existing collection and conveyance piping system. Six of these projects, listed in Table 2-5, will address problems identified in the Current and Future models and should be included in the 6-Year CIP. The remaining three projects are associated with capacity issues identified in the Full Buildout model and should be included in the 20-Year CIP. In addition, one project has been identified as necessary to address severe corrosion in the existing system and has been included in the 6-year CIP. All ten projects are shown on Figure 2-5, Figure 2-6, and Figure 2-7. The hydraulic modeling results for each identified project may be found in Appendix B.

Table 2-5
Conveyance System Projects

Project Name	Project Scope	Justification	Benefit	OPPC	Construction Year
Northern Old Military Road Sewer Upgrades	Replace 6,180 LF of 14” and 24” SS with 30” SS from Old Military Rd NE to NE Paulson Rd	Excessive surcharging creates backwater effects in surrounding conveyance system	Increase operating efficiency; reduce potential for spills	$6.720M	2024/2025
Bayshore and Washington Improvements	Replace 2,860 LF of 12” SS Along Washington Ave NW and Bay Shore Dr NW from LS 3 to NW Bucklin Hill Rd	Capacity and Maintenance	Reduce potential for spills into Dyes Inlet; reduce maintenance costs	$6.728M	2020
Bangor/Keyport Force Main H_2S Analysis and Upgrade	Replace/rehabilitate about 5 miles of 18-inch to 24-inch sewer main from Lift Station 17 to the CKTP	Severe corrosion in portions of the system have led to pipe failures and continued corrosion is anticipated	Reduce potential for spills associated with pipe failures	22.000M	2022
Old Town Silverdale Sewer Upgrades	Install 700 LF of 15” SS along NW Carlton Street from Pacific Ave NW to Washington Ave NW to redirect flows from Silverdale Way NW to Washington Ave NW	Projected future peak flows cause surcharging in existing sewers between Pacific Ave NW and LS 3	Reduce potential for spills into Dyes Inlet	$0.825M	2022/2023
Anderson Hill Sewer Upgrades	Replace 3,900 LF of 8” SS with 12” SS along NW Anderson Hill Rd from Peach Tree Pl NW to Silverdale Way NW	Projected full buildout peak flows cause surcharging in existing sewers	Reduce potential for spills	$3.799M	2038
Myhre Road Sewer Upgrades	Replace 2,260 LF of 15” and 18” SS with 21” SS from Silverdale Way along NW Myhre Rd and Levin Rd NW to LS 1	Projected full buildout peak flows cause surcharging in existing sewers	Reduce potential for spills	$2.919M	2040

Table 2-5
Conveyance System Projects

Project Name	Project Scope	Justification	Benefit	OPPC	Construction Year
Dickey Road Sewer Upgrades	Replace 2,420 LF of 8" SS with 12" SS as part of the Dickey Road Rezoning	Projected full buildout peak flows cause surcharging in existing sewers under the proposed rezoning	Reduce potential for spills	$3.684M	2038[1]
Fredrickson Road Sewer Upgrades	Replace 1,340 LF of 15" SS with 18", 21", and 24" SS along Fredrickson Rd NW from NW Chena Rd to NW Bucklin Hill Rd	Projected future peak flows cause surcharging in existing sewers	Reduce potential for spills	$1.870M	2021/2022
LS 4 Force Main Upgrades	Replace 1,570 LF of 14" force main with 20" force main along NW Bucklin Hill Rd from LS 4 to Spinnaker Blvd NW	Upgrades to pumping capacity as LS 4 results in excessive velocities in the existing 14" force main	Reduce pumping costs; lower risk of pressure surges	$1.643M	2021/2022
Lemolo Peninsula Sewer and Inverted Siphon Upgrades	Install a 24" inverted siphon parallel to the two existing 12" inverted siphons via 2,200 LF of HDD; Replace 3,660 LF 14" SS with 24" SS	Excessive surcharging in existing 12" inverted siphons creates significant backwater effects in upstream system; existing siphons cannot adequately convey projected flows from the City of Poulsbo	Reduce surcharging; increase operational efficiency; improve maintenance access	$10.620M	2026/2027
Total				$60,808M	

Notes:

1) The timing depends on how development occurs after the area is rezoned.

2.7.2.1 Northern Old Military Road Sewer Upgrades

This project, which replaces about 6,180 feet of pipe for increased flow capacity, will be required after the upgrades to LS 4 and LS 19 are completed and wastewater flows generated in the service area increase due to growth. Upsizing the pipe to 30 inches will reduce backwater effects on the upstream tributary areas. The project extends from about the intersection of NE Old Military Road and NE Steele Creek Drive along NE Old Military Road to SR 303 and then along SR 303 to about NE Royal Valley Road. The improvement will then continue north along Royal Valley Road to NE Paulson Road where it will connect to the existing 30-inch pipe installed under the Central Kitsap Schedule 2 Force Main Improvements Contract.

2.7.2.2 Bayshore and Washington Improvements

This project replaces approximately 2,860 feet of gravity sewer along Washington Avenue NW from about LS 3 to Bayshore Drive NW and then along Bayshore Drive NW to NW Bucklin Hill Road. The project is needed to address excessive cleaning requirements in the existing mains.

2.7.2.3 Bangor/Keyport Force Main H_2S Analysis and Upgrade

This project replaces or upgrades approximately 26,400 feet of force main that is experiencing severe corrosion in substantial portions of the main. The project extends from Lift Station 17 near the Bangor Naval Base east along SR 308 to the Brownsville Highway and then south along the Brownsville Highway to the CKTP and will include connections to existing Individual Pump Stations (IPS), existing lift stations, and the evaluation/replacement of air vacuum structures along the alignment. Appendix K contains a memorandum that provides additional information regarding this project.

2.7.2.4 Old Town Silverdale Sewer Upgrades

This project diverts flow from about 1,470 feet of 8-inch gravity sewer though the Old Town Silverdale area by installing approximately 700 feet of 15-inch gravity sewer along NW Carlton Street from Pacific Avenue NW to Washington Avenue NW. The project is needed to address surcharging within the existing 8-inch gravity sewers between the intersection of NW Carlton Street and Pacific Avenue NW to LS 3.

2.7.2.5 Anderson Hill Sewer Upgrades

This project replaces about 3,900 feet of 8-inch gravity sewer with new 12-inch sewer to alleviate pipe and manhole surcharging that is anticipated to occur under full buildout conditions. The project extends along NW Anderson Hill Road from Silverdale Way NW to about Peach Tree Place NW.

2.7.2.6 Myhre Road Sewer Upgrades

This project (previously known as the Mickelberry Road Pipe Replacement in the 2011 Central Kitsap County Wastewater Facility Plan) replaces 2,260 feet of 15-inch and 18-inch gravity sewer with 21-inch sewers from Silverdale Way, along NW Myhre Road and Levin Road NW to LS 1. The project is needed to alleviate surcharging in the existing pipes and manholes associated with Full Buildout flow conditions.

2.7.2.7 Dickey Road Sewer Upgrades

This project replaces about 2,420 feet of 8-inch gravity sewer with new 12-inch sewer to alleviate pipe and manhole surcharging that will occur under full buildout conditions associated with the proposed zoning alternatives described in Section 2.5 above. The project extends along NW Anderson Hill Road from Peach Tree Place NW to Ashley Drive NW and then across easements to about Stoli Lane NW. The improvements will then extend south along Stoli Lane NW and along easements to Enchantment Avenue NW where the pipe upgrades will turn east and follow Enchantment Avenue NW to NW Dream Court.

2.7.2.8 Fredrickson Road Sewer Upgrades

This project replaces about 1,340 feet of 15-inch gravity sewer with 18-inch, 21-inch, and 24-inch sewer along Fredrickson Road NW from LS 4 to NW Chena Road. The project is needed to alleviate surcharging in the existing pipes and manholes that is predicted by the Future Model.

2.7.2.9 LS 4 Force Main Upgrades

This project replaces 1,570 feet of 14-inch force main with 20-inch force main along NW Bucklin Hill Road from LS 4 to about Spinnaker Blvd NW. The project is needed to address excessive velocities in the existing force main that will occur after LS 4 is upgraded.

2.7.2.10 Lemolo Peninsula Sewer and Inverted Siphon Upgrades

This project installs a new inverted siphon under Liberty Bay from the Lemolo Peninsula to Keyport and replaces about 3,660 feet of 14-inch gravity sewer with 24-inch sewer main along Norum Road NE, Tuk Wil La Road NE, and Braur Road NE. The existing 12-inch inverted siphons have insufficient capacity to convey the projected flows from the City of Poulsbo without excessive surcharging predicted in the Current and Future Models. The gravity sewer upgrades are also needed to address surcharging.

2.7.3 6-Year and 20-Year Capital Improvement Plan

The nineteen (19) lift station and conveyance projects described in the previous section were grouped into logical combined projects based on discussions with the County and a review of which projects should be constructed concurrently to minimize impacts. Conceptual schedules were then developed for each project. These schedules are reflected in Figure 2-10 and Figure 2-11 for the 6-Year and 20-Year CIP, respectively.

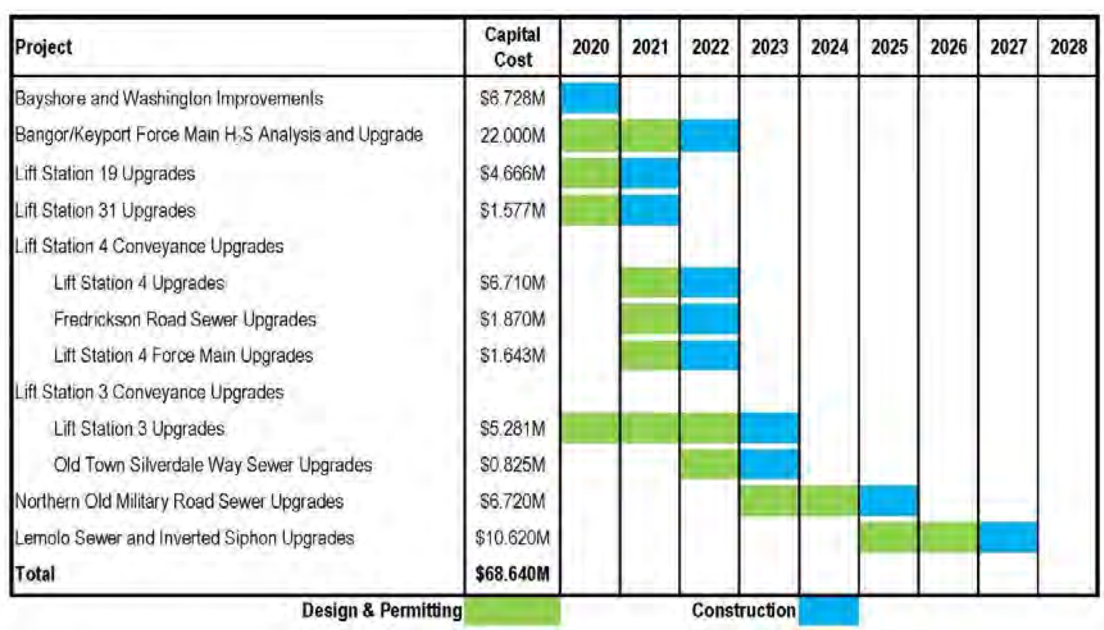

Figure 2-10 – 6-Year CIP

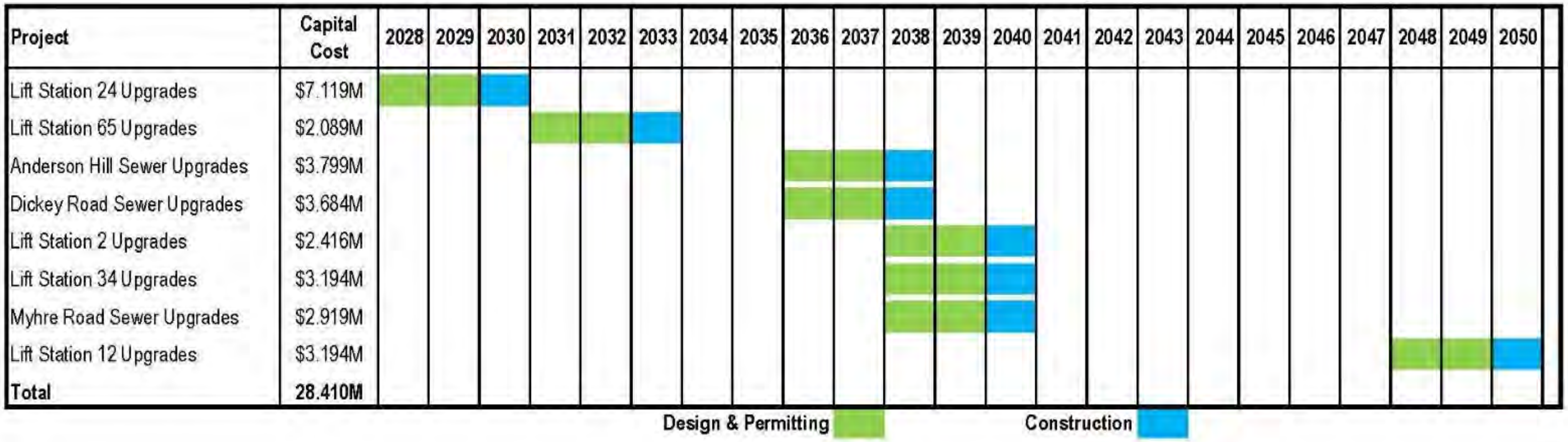

Figure 2-11 – 20-Year CIP

Chapter 3. General Design Criteria and Constraints

3.1 Project Datum and Survey

The Project will be designed using the County's vertical datum, NGVD29. The horizontal control datum is NAD 83 (1991). The topographic survey used for design was conducted by AES Consultants, Inc. (AES).

3.2 Design Standards

All facilities will be designed and constructed in accordance with the current requirements of the following sources:

- Department of Ecology's Criteria for Sewage Works Design (Orange Book)
- Kitsap County standards
- Washington State Department of Transportation's (WSDOT) 2020 Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications)
- Design consultant expertise and standard industry practices

The lift stations will include submersible type sewage pumps with capacity to accommodate the projected peak hour flow into each station with the largest pump out of service. The pumps will be controlled in an alternating lead-lag configuration. All four lift stations will include magnetic meter flow measurement, force main pressure monitors, pigging ports, and radio telemetry systems with provisions for future upgrades to fiber optic telemetry systems. In addition, LS 3, LS 4, and LS 19 will include standby generators or backup diesel pumps located within the control buildings.

Gravity sewers and force mains will be designed to maintain Orange Book recommended minimum velocities to promote self-scouring and prevent solids accumulation. In addition, force mains will be sized so that fluid velocities within the force main do not exceed 8 feet per second to avoid unnecessary energy consumption.

3.3 Equipment Standards

The County has standardized on the following equipment and manufacturers. Other manufacturers for the following equipment are not anticipated to be allowed at the time of this PER.

- Submersible Wastewater Pumps: Flygt
- Programmable Logic Controllers (PLCs):
  - Allen Bradley Compact Logix PLC (for all equipment control, monitoring and alarming)
  - Allen Bradley 1400 PLC (telemetry panel)
- Telemetry: Viper CAL-Amp SC-100 Ethernet 173.3125 MHZ (radio)
- Flow Meters: Siemens 5000 series or Krohne Enviromag 2000 series
- Submersible Pressure Transducers: Siemens A1000
- Standby Generator: Cummins Power Generation or Caterpillar Energy Systems.

3.4 Modeled Flows

The 2019 Hydraulic Model Updates described in Chapter 2 were used to determine the design flows for each station. The Update used MIKE Urban to hydraulically model Current flows, Future (2038) flows, and Full Buildout flows based on maximizing the current zoning. Table 3-1 summarizes the design flows entering LS 3, LS 4, LS 19, and LS 31.

Table 3-1
Design Inflow

Lift Station	Current Flows (gpm)		2038 Flows (gpm)		Full Build-Out Flows (gpm)	
	Average	*Peak*	*Average*	*Peak*	*Average*	*Peak*
3	340	580	760	1,200	2,095	2,340
4	1,170	1,965	2,340	3,825	3,910	4,950
19	200	480	385	780	610	1,075
31	15	20	20	30	55	80

For the triplex lift stations (LS 3, LS 4, and LS 19), the pumps will be sized to meet the peak full build-out flows with two pumps operating. Each station's pumping capacity with one pump operating will then be reviewed against the current and 2038 peak and average flows and the full build-out average flows to evaluate pump cycling times. For the duplex station (LS 31), the pumps will be sized to meet the peak full build-out flows with one pump operating. The station's pumping capacity with one pump operating will then be reviewed against the current and 2038 peak and average flows and the full build-out average flows to evaluate pump cycling times. Table 3-2 summarizes the resultant target pumping capacities for each lift station and the anticipated pump cycles per hour at peak flows.

Table 3-2
Target Pumping Capacity

Lift Station	One Pump		Two Pumps	
	Q (gpm)	*Cycles/Hr*	*Q (gpm)*	*Cycles/Hr*
3	2,200	2 to 4	3,200	4 to 6
4	3,040	2 to 3	5,030	3 to 5
19	1,240	2 to 4	2,040	3 to 6
31	170	1 to 2	N/A	N/A

3.5 Geotechnical Investigations

Preliminary geotechnical assessments were performed by Landau Associates, Inc. (Landau) at all four lift station sites in March 2019 and April 2019 and summaries of the assessments were prepared in April 2019. As part of the geotechnical assessments, Landau reviewed existing records, conducted site visits to verify surface information, and explored subsurface conditions at LS 31 by advancing one hollow-stem auger boring. The records review revealed historic borings near LS 3 and LS 19 that were used to assist in evaluating subsurface conditions at those two stations. A summary of the key findings and recommendations are discussed below and the preliminary geotechnical assessments for each lift station are included in Appendix C.

3.5.1 Lift Station 3

Geologic information was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5 -minute Quadrangles, Kitsap and Jefferson Counties, Washington*. The map indicates surficial deposits in the vicinity of the site consist of artificial fill that is highly variable and may consist of cobbles, pebbles, boulders, silt, clay, organic matter, riprap, concrete, and other debris. Additionally, Vashon recessional alluvial and delta fan deposits are mapped adjacent to the site. Vashon recessional alluvial fan deposits typically consist of moderately to poorly sorted, stratified pebble gravel, sand, silt, and boulders in a loose condition. Alluvium is deposited in river deltas or where streams emerge from valleys.

Organic silt, peat, and wood fragments were documented in historical borings and may be encountered at the proposed foundation elevations. These compressible soils extended to approximately 15 feet below ground surface (bgs) in historical boring B-1W and could contribute to long-term settlement of structures. Other soils documented in historical borings B-1W through B-7 are generally consistent with the mapped geology for the site.

Public use of the Project area, risk of settlement-related damage to nearby infrastructure, and limitations imposed by site soil and groundwater conditions should be considered when selecting shoring and dewatering methods. Compressible soils are present throughout the site, and conventional dewatering (well points, etc.) is likely to cause settlement within approximately 50 feet of the excavation areas. Vibrations associated with sheet pile installation could also cause settlement within 50 to 100 feet of the excavations. Additionally, the proximity of the site to Puget Sound could make conventional dewatering difficult.

Landau's preliminary assessment of geotechnical and project elements for LS 3 is provided below along with recommendations for further investigations during the design phase of the Project:

- Shoring and Dewatering. Ground freezing is proposed to shore and dewater similar soils at the nearby Bay Shore Drive site. Ground freezing technology provides neat shoring and groundwater cutoff (dewatering). This construction method would limit the risk for dewatering- and vibration-induced settlement of adjacent infrastructure and could reduce noise and other impacts to public use. Compared with other shoring and dewatering methods, ground freezing limits use of heavy construction equipment and minimizes laydown requirements. Landau considers ground freezing the preferred method for installation of the wet well and gravity sewers. Other potential shoring/dewatering options include:

  <u>Wet well:</u>

  - Sunken caisson, or drill and advance casing, with a tremie seal. This method may be more economical than ground freezing but is likely to encounter obstructions that could delay construction.
  - Secant piling. This method is not cost competitive with ground freezing.
  - Sheet pile walls with internal dewatering or tremie seal. This method may be more economical than ground freezing but carries a significant risk for vibration related damage and impact to public-use areas.

Gravity sewers:

- o Dewatering with well points plus sheet pile walls or trench box shoring. This method is more economical than ground freezing, but risks damage to nearby infrastructure. Additionally, the noise and vibration caused by sheet pile installation could be considered a public nuisance.

- Foundation Support: Artificial fill and alluvial deposits are likely present within the excavation depths required for the proposed improvements. These soils are typically considered unsuitable as foundation material. The proposed 30-feet-deep wet well is anticipated to extend below the unsuitable soils; however, a boring should be advanced during final design to obtain site-specific soil and groundwater data. Ancillary structures may need to be designed using a zero-net increase in bearing pressure (with lightweight fill below), local over-excavation and replacement of unsuitable soils, and/or small-diameter pile foundations (pin piles).
- Gravity Sewers: During preliminary design of new gravity sewers, the use of lightweight backfill should be assumed. Lightweight backfill will mitigate potential settlement caused by heavier backfill placed over compressible soils.
- Seismic Conditions: Critical areas maps on the County's graphical interface system (GIS) website indicate that the site is in a geologically hazardous area and could be severely impacted by seismic events. In Landau's opinion, the site is at risk for seismic-induced settlement or subsidence and soil liquefaction. Liquefaction could also result in lateral spreading, given the site's proximity to the Puget Sound shoreline. Areas with moderate potential for seismic-induced differential settlement may be present along the Project alignment.
- Groundwater: The tidal cycles of the nearby Puget Sound are likely to influence groundwater levels at the site, and granular fill and/or alluvial deposits could be highly permeable, and readily transmit groundwater. Groundwater was encountered at 1.4 feet bgs in historical boring B-1W (located approximately 170 feet north of the site).
- Onsite Soils: Onsite soils are moisture sensitive and include debris-laden fill. Imported soils should be used for structure and utility backfill.
- Oversized Material: Cobbles, boulders, and debris are often found in artificial fill, and may be encountered during excavation. The contractor should be prepared to handle such oversized material.
- Recommendations: Subsurface explorations should be performed prior to final design and should include at least one soil boring advanced 50 feet bgs at the proposed wet well location. Given the variability of site soils/fills, borings should be advanced at 200-feet intervals along the gravity sewer alignment to Silverdale Way (if applicable). Data gathered during subsurface explorations can be used to address the following:
  - o Confirm the extent, depth, and composition of artificial fill.
  - o Determine bearing characteristics and settlement behavior of underlying deposits.
  - o Determine the probable extent of seismically induced liquefaction settlement and lateral spreading.

- Finalize shoring and dewatering assessments and collect detailed soil gradations for ground freezing and dewatering design considerations.

3.5.2 Lift Station 4

Geologic information was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5 -minute Quadrangles, Kitsap and Jefferson Counties, Washington*. The map indicates surficial deposits in the vicinity of the site consist of Vashon lodgment till, a mixture of clay, silt sand, pebbles, cobbles, and isolated boulders. Lodgment till (glacial till) is typically unsorted, unstratified, and exhibits high sheer strength and little to no permeability. This unit is highly compacted as it was overridden and deposited directly by glacial ice. Cobles and boulders are often present in glacial deposits and may be encountered throughout the site.

Glacial till is mapped at the site and is likely present within the excavation depths required for the proposed improvements. The till is anticipated to provide adequate support for the wet well replacement and ancillary, on-grade structures. Boulders and cobbles are often present in glacially derived soils and may be encountered throughout the site.

Landau's preliminary assessment of geotechnical and project elements for LS 4 is provided below along with recommendations for further investigations during the design phase of the Project:

- Onsite Soils: Glacial till typically has a high fines content and may be moisture sensitive. Earthwork should be avoided during heavy and/or extended periods of precipitation. If reused as structural fill, onsite soils should be moisture conditioned and screened for constituents greater than 6 inches in diameter.
- Seismic Conditions: Medium dense to very dense, glacially consolidated soil is mapped at the site. Site soil likely has a low risk of seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.
- Foundation Support: Medium dense to very dense glacial till will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered.
- Subgrade Preparation: After vegetation has been stripped and subgrade has been excavated to the proposed elevation, the upper 1 foot of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be over-excavated and replaced with structural fill.
- Construction Dewatering: Dewatering may be necessary if shallow, perched groundwater is encountered in excavations. Excavations may cross existing utility trenches that contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations, where minor groundwater seepage is encountered.

- Temporary Excavations: The soil likely to be exposed in the excavations (glacial till) should be considered Type B with a maximum allowable excavation inclination of 1 horizontal to 1 vertical. Depending on the wet well location and adjacent infrastructure, open cut, temporary excavations could be feasible. Temporary excavations should be completed in accordance with Section 2-09 of the Washington State Department of Transportation's 2018 Standard Specifications for Road, Bridge, and Municipal Construction. Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor.
- Recommendations: Subsurface explorations should be performed prior to final design and should include at least one soil boring advanced 50 feet bgs at the proposed wet well location and along the deep gravity sewer extension along Fredrickson Road NW. The purpose of these borings will be to identify subsurface conditions as a basis for contract bidding and to ensure that unusual quantities of groundwater are not present.

3.5.3 Lift Station 19

Geologic information was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5 -minute Quadrangles, Kitsap and Jefferson Counties, Washington*. The map indicates surficial deposits in the vicinity of the site consist of Vashon lodgment till (Qgt), a mixture of clay, silt sand, pebbles, cobbles, and isolated boulders. Lodgment till (glacial till) is typically unsorted, unstratified, and exhibits high sheer strength and little to no permeability. This unit is highly compacted as it was overridden and deposited directly by glacial ice. Additionally, Vashon ice-contact (Qgic), Vashon recessional glacial lake deposits (Qgof), and peat deposits (Qp) are mapped adjacent to the site. Peat generally contains significant organic quantities as well as muck, silt, and clay deposited in wetland areas. Glacial ice-contact deposits are highly variable, and consist of poorly to well-sorted cobble, gravel, sand, and lacustrine material in a loose to dense condition with discontinuous deposits of ablation, flow, and lodgment till. Recessional glacial lake deposits generally consist of loose to moderately stiff, moderately to well-sorted silt, sand, and clay.

Fill was observed in historical boring B-2. Fill is highly variable, and consists of cobbles, pebbles, boulders, silt, clay, organic matter, riprap, concrete, and other debris. The soils observed underlying the fill in historical boring B-2 were generally consistent with the mapped geology for the site. Although not observed in the historical boring, cobbles and boulders are often present in glacial deposits, and may be encountered throughout the site. Additionally, cobbles, boulders, and construction debris may be present in fill. The contractor should be prepared to handle such oversized materials.

During the April 2019 field investigation, groundwater was observed at 5 feet bgs in historical boring B-2. The groundwater conditions on the exploration log are for the specific location and date indicated and may not be representative of other locations and/or times. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring.

Landau's preliminary assessment of geotechnical and project elements for LS 19 is provided below along with recommendations for further investigations during the design phase of the Project:

- Onsite Soils: Onsite soils have a high fines content and are considered moisture sensitive. Earthwork should be avoided during heavy and/or extended periods of precipitation. The soils underlying existing surface conditions were categorized into two general units:
  - Fill: This unit typically consisted of sandy gravel with silt in a medium dense, moist condition. Fill was observed to approximately 3 feet bgs.
  - Ice-contact deposits: This unit generally consisted of sandy gravel or very silty sand with gravel. Ice-contact deposits ranged from medium dense to very dense and moist to wet. Historical boring B-2 terminated in this unit.
- Seismic Conditions: Medium dense to very dense, glacially consolidated soil was observed in historical boring B-2. Based on that observation, the site soil has a low risk for seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.
- Foundation Support: Medium dense to very dense ice-contact deposits will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered. A net allowable bearing pressure of 3,000 pounds per square foot (psf) is recommended for on-grade structures. This net allowable bearing pressure includes a factor of safety of at least 3.0 on the calculated ultimate bearing capacity. Less than ½ inch of total settlement is expected to occur as loads are applied. Post-construction settlement is expected to be negligible. The maximum allowable bearing pressure can be increased by one-third for short-term transient loads. An allowable coefficient of sliding resistance of 0.35, which includes a factor of safety of 1.5 on the calculated ultimate value, may be used to compute the frictional resistance acting on the base of footings, if applied to vertical dead loads only. The passive resistance of properly compacted structural fill placed against the sides of the foundations can be considered equivalent to a fluid with a density of 300 pounds per cubic foot (pcf). A buoyant value of 140 pcf should be used along portions of structures that extend more than 5 ft bgs. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded from the calculation, unless the foundation perimeter is covered by a slab-on-grade or pavement.
- Lateral Earth Pressures: For design of below-grade walls, a design groundwater elevation equal to the ground surface is recommended. Below-grade walls are expected to be restrained against rotation during backfilling and should be designed for an equivalent fluid unit weight of 90 pcf. This assumes level backfill and at-rest, undrained soil conditions. Design of subsurface walls should include appropriate lateral pressures exerted by adjacent surcharge loads. To achieve uniform surcharge pressures and uniformly distributed lateral pressures, 0.44 times the surcharge pressure, should be added to non-yielding walls. Given their size, wet wells are expected to move with the ground during a seismic event, and unbalanced, dynamic lateral earth pressures need not be incorporated into the lift station design.

- Uplift Resistance: A design groundwater elevation equal to the ground surface when evaluating tank-like structures, such as new vaults is recommended. The design should also account for the fact that utilities could experience uplift pressure.
- Subgrade Preparation: After vegetation has been stripped and the subgrade has been excavated to the proposed elevation, the upper 1 foot of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be over-excavated and replaced with structural fill.
- Construction Dewatering: Shallow, perched groundwater should be anticipated in excavations; the storm water pond at the western site boundary likely contributes to perched groundwater. Excavations may also cross existing utility trenches that contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations, where minor groundwater seepage is encountered. The site also has the advantage of topographic relief and nearby ditches, which could allow shallow excavations to drain via open channel.
- Temporary Excavations: Temporary excavations should be completed in accordance with Section 2-09 of *the Washington State Department of Transportation's 2018 Standard Specifications for Road, Bridge, and Municipal Construction*. Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor. Temporary excavations in excess of 4 feet shall be shored or sloped in accordance with the requirements outlined in *Safety Standards for Construction Work, Part N (Chapter 296-155 of the Washington Administrative Code)*. The soil likely to be exposed in the excavations should be considered Type C with a maximum allowable excavation inclination of 1½ horizontal to 1 vertical. All applicable local, state, and federal safety codes shall be followed. If excavation instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater seepage is present and the excavation is not properly dewatered, the soil may be prone to caving, channeling, and running. Temporary shoring systems should be designed in accordance with the soil parameters presented in Table 3 of the Preliminary Site Assessment for LS 19, which is included in Appendix C.

3.5.4 Lift Station 31

Geologic information for the Project area was obtained from the *Geologic Map of the Suquamish 7.5-minute Quadrangle and Part of the Seattle North 7.5'x 15' Quadrangle, Kitsap County, Washington.* The map indicates surficial deposits in the vicinity of the site consist of Vashon till (Qvt), a material composed of clay, silt, sand, pebbles, cobbles, and isolated boulders. Glacial till is also mapped in this area, and typically consists of pebbles in a sandy matrix. The till is unsorted, unstratified, and exhibits high shear strength and little to no permeability. This unit is highly compacted, as it was overridden and deposited directly by glacial ice. Additionally, Vashon Drift Esperance Sand (Qve) is mapped adjacent to the site. This material typically consists of sand with small amounts of gravel or silt in a loose condition.

Site subsurface conditions were explored on March 8, 2019 by advancing one hollow-stem auger boring (B-1). Holocene Drilling, Inc., subcontracted by Landau, used a track-mounted drill rig to advance the boring 31.5 feet bgs. The field investigation was coordinated and monitored by Landau personnel, who also obtained representative soil samples, maintained a detailed record of the subsurface soil and groundwater conditions observed, and used visual and textural examination to describe soils.

The soils observed underlying existing surface conditions (i.e., topsoil) can be categorized as Esperance sand. This unit typically consists of medium dense to very dense sand with occasional cobles, gravel, and variable silt content. The Esperance sand observed in boring B-1 extended to the maximum depth explored (31.5 feet bgs). Soil in the upper 5 to 10 feet of the exploration was in a medium dense condition and then transitioned to dense to very dense. Mottling was observed at approximately 13 feet bgs. Cobbles were observed in boring B-1 and could be present throughout the site. The contractor should be prepared to handle such oversized material.

During the March 2019 field investigation, perched groundwater was observed between 4.5 and 16 feet bgs in Boring B-1. The groundwater conditions reported on the exploration log are for the specific location and date indicated and may not be representative of other locations and/or times. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, groundwater levels in the Project area are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring.

- Seismic Conditions: Medium dense to very dense, glacially consolidated soil was observed in Boring B-1. Based on that observation, the site soil has a low risk for seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.
- Foundation Support: Medium dense to very dense Esperance sand will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered. A net allowable bearing pressure of 3,000 psf is recommended for on-grade structures. This net allowable bearing pressure includes a factor of safety of at least 3.0 on the calculated ultimate bearing capacity. Less than ½ inch of total settlement is expected to occur as loads are applied. Post-construction settlement is expected to be negligible. The maximum allowable bearing pressure can be increased by one-third for short-term transient loads. An allowable coefficient of sliding resistance of 0.35, which includes a factor of safety of 1.5 on the calculated ultimate value, may be used to compute the frictional resistance acting on the base of footings, if applied to vertical dead loads only. The passive resistance of properly compacted structural fill placed against the sides of the foundations can be considered equivalent to a fluid with a density of 300 pcf. A buoyant value of 140 pcf should be used along portions of structures that extend more than 5 feet bgs. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded from the calculation, unless the foundation perimeter is covered by a slab-on-grade or pavement.

- Lateral Earth Pressures: For design of below-grade walls, a design groundwater elevation equal to the ground surface is recommended. Below-grade walls are expected to be restrained against rotation during backfilling and should be designed for an equivalent fluid unit weight of 90 pcf. This assumes level backfill and at-rest, undrained soil conditions. Design of subsurface walls should include appropriate lateral pressures exerted by adjacent surcharge loads. To achieve uniform surcharge pressures and uniformly distributed lateral pressures, 0.44 times the surcharge pressure, should be added to non-yielding walls. Given their size, wet wells are expected to move with the ground during a seismic event, and unbalanced, dynamic lateral earth pressures need not be incorporated into the lift station design.
- Uplift Resistance: A design groundwater elevation equal to the ground surface when evaluating tank-like structures, such as new vaults is recommended. The design should also account for the fact that utilities could experience uplift pressure.
- Subgrade Preparation: After vegetation has been stripped and subgrade has been excavated to the proposed elevation, the upper 1 ft of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be over-excavated and replaced with structural fill.
- Construction Dewatering: Perched groundwater, between approximately 4.5 and 16 feet bgs, should be anticipated in excavations and managed with dewatering. Excavations may also cross existing utility trenches that contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations, where minor groundwater seepage is encountered. For the wet well, dewatering will likely require well points, or an appreciably sized pump placed at the bottom of the excavation. Sheet piling could be used to seal the wet well excavation from perched groundwater.
- Temporary Excavations: Temporary excavations should be completed in accordance with Section 2-09 of the Washington State Department of Transportation's *2018 Standard Specifications for Road, Bridge, and Municipal Construction*. Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor. Temporary excavations in excess of 4 feet should be shored or sloped in accordance with the requirements outlined in *Safety Standards for Construction Work, Part N (Chapter 296-155 of the Washington Administrative Code)*. The soil likely to be exposed in the excavations should be considered Type C with a maximum allowable excavation inclination of 1½ horizontal to 1 vertical. All applicable local, state, and federal safety codes should be followed. If excavation instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater seepage is present and the excavation is not properly dewatered, the soil may be prone to caving, channeling, and running. Given the relatively rural location of the lift station and the presence of glacially consolidated soils, open cutting (with dewatering) will likely be used for the wet well if the site layout permits. A steel casing may be used as temporary shoring and placed in an open cut or open drilled excavation. Temporary shoring systems should be designed in accordance with the soil parameters presented in Table 3 of the Preliminary Site Assessment for LS 31, which is included in Appendix C.

3.6 Traffic Control

Casseday Consulting (Casseday) performed preliminary assessments of the traffic patterns within the Project limits. Construction is anticipated to occur during the daytime between 7 AM and 7 PM on weekdays with all roadways restored for local access and circulation each weekday evening and on weekends. Where possible, streets will remain open to traffic with at least one 11-foot travel lane available for alternating traffic throughout the workday. Property access will be maintained by the contractor with continued access for pedestrian travel, bikes, deliveries, and emergency vehicles. A memorandum describing the recommended strategy for traffic control is presented in Appendix D and summarized below.

3.6.1 Lift Station 3

The gravity sewers feeding into LS 3 travel along roadways within Old Town Silverdale which is a small residential and commercial district east of Silverdale Way NW. The speed limit for the streets is 25 miles per hour (MPH). Pacific Ave NW is a 2-lane local street with 11-foot lanes, a sidewalk along the east side of the street, and parking immediately adjacent to the street on the west side. The alley south of Carlton Street is a one lane street with access to both residences and businesses. McConnell Ave NW is a 2-lane street approximately 40 feet wide with parking and sidewalks on both sides of the street.

The south end of McConnell Ave NW leads to the Silverdale Waterfront Park and feeds a boat launch and parking lot. The parking lot has spaces for 38 vehicle-plus-trailer combinations and 54 vehicles without trailers. A portion of the park parking lot is used for the Central Kitsap Farmers Market on Tuesday afternoons between May and October. An additional entrance and exit to the parking lot is located off Washington Ave NW, but this access may not be feasible for vehicles with trailers.

Traffic Control Recommendations

Construction of the sewer upgrades through Old Town Silverdale will likely block at least one travel lane. If feasible, at least one 11-foot lane for flagger controlled alternating traffic should be maintained. In areas where at least one 11-foot cannot be maintained, the contractor may be allowed to close one block at a time for daytime construction. The active work zone shall not impede more than one block or intersection and the roadway must be restored and the block re-opened for travel and access every evening and night. If a block must be closed due to construction, traffic shall be detoured around the closed block. The contractor shall identify the shortest detour route around the active work zone with signage, utilizing the regular grid of roadways in the area. In addition, the contractor shall always maintain safe pedestrian and bicycle travel through the work zone as well as access to all properties and businesses for deliveries, school buses, and emergency vehicles.

Construction along McDowell Avenue may require parking along that street to be closed to allow one lane to remain open for alternating traffic with flagger control. Otherwise, daytime closures of full blocks may be necessary. Traffic control for the work zone will need to manage construction through intersections as well as along blocks – with the goal to maintain local circulation and access.

Construction of the gravity line through the park will displace or close some of the vehicle-plus-trailer parking spaces. Access to the boat launch will also be affected and the County may want to consider limiting the number of construction days that can directly impact the boat ramp and trailer parking.

3.6.2 Lift Station 4

Fredrickson Road NW is a two-lane street serving residential land uses from NW Chena Road to NW Bucklin Hill Road. The pavement width along Fredrickson Road NW is approximately 22 feet with limited shoulders and no curb. Fredrickson Road NW provides access to 22 single family homes adjacent to the street. Traffic on Fredrickson Road NW has a stop-controlled intersection with NW Bucklin Hill Road. At north end of Fredrickson Road NW, the roadway turns east and becomes NW Chena Road. The speed limit along Fredrickson Road NW and NW Chena Road is 25 MPH.

NW Bucklin Hill Road is an urban minor arterial roadway with one travel lane in each direction and a two-way left turn lane. The Project area extends from Fredrickson Road NW to approximately 250 feet east of Spinnaker Boulevard. The speed limit along NW Bucklin Hill Road is 35 MPH. Daily traffic volumes in the Project area range from approximately 6,000 to 8,000 vehicles per day. Three signed bus stops, serving the eastbound Kitsap Transit Route 37 Fairgrounds Shuttle, are located on the south side of the roadway within the Project area. Driveways serving from one home to multiple homes and larger neighborhoods are located on either side of this roadway segment. Lighting along this section is extremely limited. NW Bucklin Hill Road has a sidewalk on the north side of the roadway and a 3-foot wide striped shoulder signed for pedestrian access along the south side of the roadway. The westbound travel lane is 12 feet wide; the two-way left turn lane is 12 feet wide, and the eastbound travel lane is 10 feet wide. A marked crosswalk with Rectangular Rapid Flashing Beacon (RRFB) display is located near the bus stop at Olson Road NW.

Traffic Control Recommendations

Construction along Fredrickson Road NW will close at least one travel lane and construction activities may block the entire roadway in the active work zone. The contractor shall always maintain access to homes by providing safe access through the work zone or by directing traffic around the active work zone via NW Chena Road and Richardson Road NW to the north, or via NW Bucklin Hill Road and Richardson Road NW to the south. The local streets are not set up for turn-around movements.

Force main construction is anticipated in the westbound travel lane or the north shoulder of NW Bucklin Hills Road. The contractor should be able to maintain two-way traffic by directing westbound traffic into the two-way left turn lane. Occasionally, flagger controlled, alternating one-way traffic around an active work zone may be required. Closure of the entire roadway should not be allowed. Access to local properties, Kitsap Transit, deliveries, and emergency vehicles should always be maintained with provisions for safe pedestrian and bicycle traffic through the work zone. No detours are envisioned for traffic, and construction across roadways and driveways will need to be coordinated with local residents.

3.6.3 Lift Station 19

The upgrades to LS 19 will require access from NW Bucklin Hill Road for material deliveries. Construction activities should be contained onsite with no impact to passing traffic.

Traffic Control Recommendations

Construction of a new traffic signal at this intersection is planned for 2019 or 2020 but may be delayed until after the lift station upgrades are complete. If the intersection improvements are completed prior to the lift station upgrades, then construction activities at LS 19 will need to maintain access through the traffic signal at all times.

3.6.4 Lift Station 31

The upgrades to LS 31 will impact a cul-de-sac located east NE Clover Blossom Lane. The cul-de-sac provides access to three residential properties. NE Clover Blossom Lane is a dead-end street that terminates at the cul-de-sac. Traffic along NE Clover Blossom Lane is limited.

Traffic Control Recommendations

Construction of the upgrades to LS 31 and the new force main from the lift station to the existing force main in NE Clover Blossom Lane will impact access to the three homes located off the cul-de-sac and coordination with those homes will be necessary. Material deliveries will be made via NE Clover Blossom Lane but should not adversely impact traffic along that street.

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Chapter 4. Lift Stations 3, 4, 19 and 31 Preliminary Design

4.1 Gravity Sewer Conveyance and Force Main Upgrades

The preliminary design of the gravity sewer and force main upgrades are based on the following engineering principles:

- The 2019 Hydraulic Model Update – 2038 Flow Conditions and Full-Buildout Flow Conditions are used to establish the design flows.
- Gravity sewer pipe shall convey the design flows without surcharging the system while maintaining a velocity of at least 2 feet per second (fps).
- Velocities in force mains shall be greater than 2 fps and less than 8 fps. Velocities between 3.5 and 5.0 fps are targeted to reduce maintenance costs and prevent the accumulation of solids.
- Pipeline materials are expected to have a design life of 50-75 years.

As described in Chapter 2, Section 2.7.2, the hydraulic model identified several necessary upgrades to the conveyance systems associated with LS 3, LS4, LS19, and LS31. The following sections provide preliminary design information on the Old Town Silverdale Upgrades, the Fredrickson Road Gravity Sewer Upgrades, and the Lift Station 4 Force Main Upgrades.

4.1.1 Old Town Silverdale Gravity Sewer Upgrades

The existing 8-inch gravity sewers along Pacific Avenue NW, the alley between NW Carlton Street and NW Lowell Street, and along McConnell Avenue NW (north of NW Byron Street) experience minor surcharging under current conditions and significant surcharging under future conditions. The surcharging can be addressed by upsizing the existing 8-inch pipe to 15-inch pipe via a combination of open trench construction and pipe reaming. In addition, a new 18-inch gravity sewer would be needed to convey flows from SSMH L17-1076 near the intersection of NW Byron Street and McConnell Avenue to the upgraded LS 3. Table 4-1 summarizes this option.

Table 4-1
Proposed Old Town Silverdale Gravity Sewer Upgrades

Street	From	To	Length (ft)	Existing Diameter (in)	Proposed Diameter (in)
Pacific Avenue NW	SSMH L17-1079	SSMH L17-1078	145	8	15
Alley	SSMH L17-1078	SSMH L17-1077	340	8	15
McConnell Avenue NW	SSMH L17-1077	SSMH L17-1076	415	8	15
McConnell Avenue NW	SSMH L17-1076	LS 3	570	8	18

A cheaper and less disruptive option involves intercepting the flows at SSMH L17-1079 near the intersection of Pacific Avenue NW and NW Carlton Street and conveying them via about 700 feet of new 15-inch gravity sewer east along NW Carlton Street to the new gravity sewers being installed in Washington Avenue NW under the Bayshore and Washington Improvements. Figure 4-1 shows the proposed improvements for the Old Town Silverdale Gravity Sewer Upgrades. The hydraulic model results with the upgraded pipe sizes are contained in Appendix B.

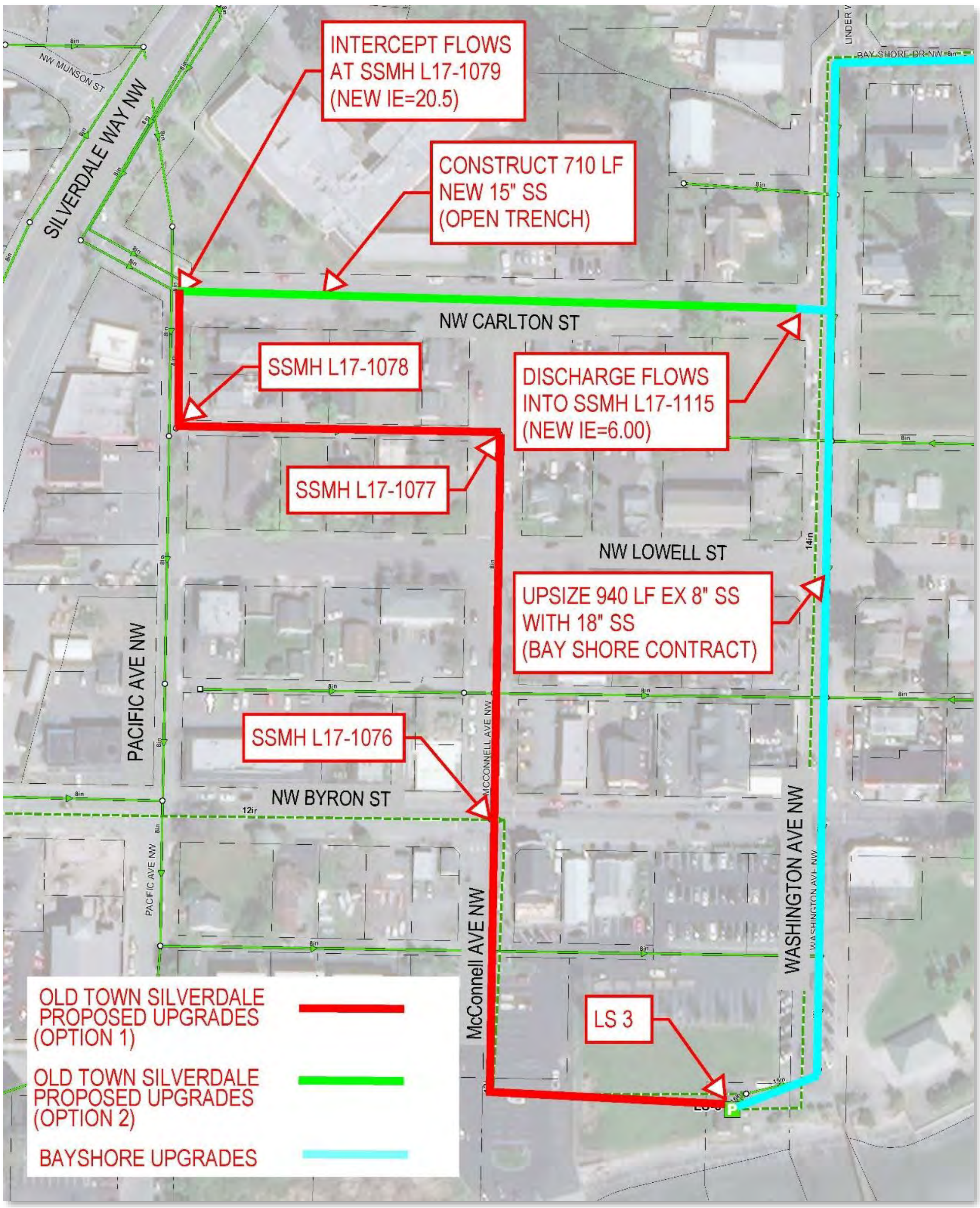


Figure 4-1 – Old Town Silverdale Gravity Sewer Upgrades

4.1.2 Fredrickson Road Gravity Sewer Upgrades

The 2019 Hydraulic Model Update also indicated conveyance upgrades are necessary along Fredrickson Road NW from NW Chena Road to LS 4. The existing 15-inch gravity sewers need to be upsized to 18-inch, 21-inch, and 24-inch gravity pipe. The proposed Fredrickson Road Gravity Sewer Upgrades are summarized in Table 4-2 and shown on Figure 4-2. The hydraulic model results with the upgraded pipe sizes are contained in Appendix B.

Table 4-2
Proposed Fredrickson Road Gravity Sewer Upgrades

Street	From	To	Length (ft)	Existing Diameter (in)	Proposed Diameter (in)
Fredrickson Road NW	SSMH K18-4018	SSMH K18-4014	1,160	15	18
Fredrickson Road NW	SSMH K18-4014	SSMH K18-4013	120	15	21
Fredrickson Road NW	SSMH K18-4013	LS 4	90	18	24

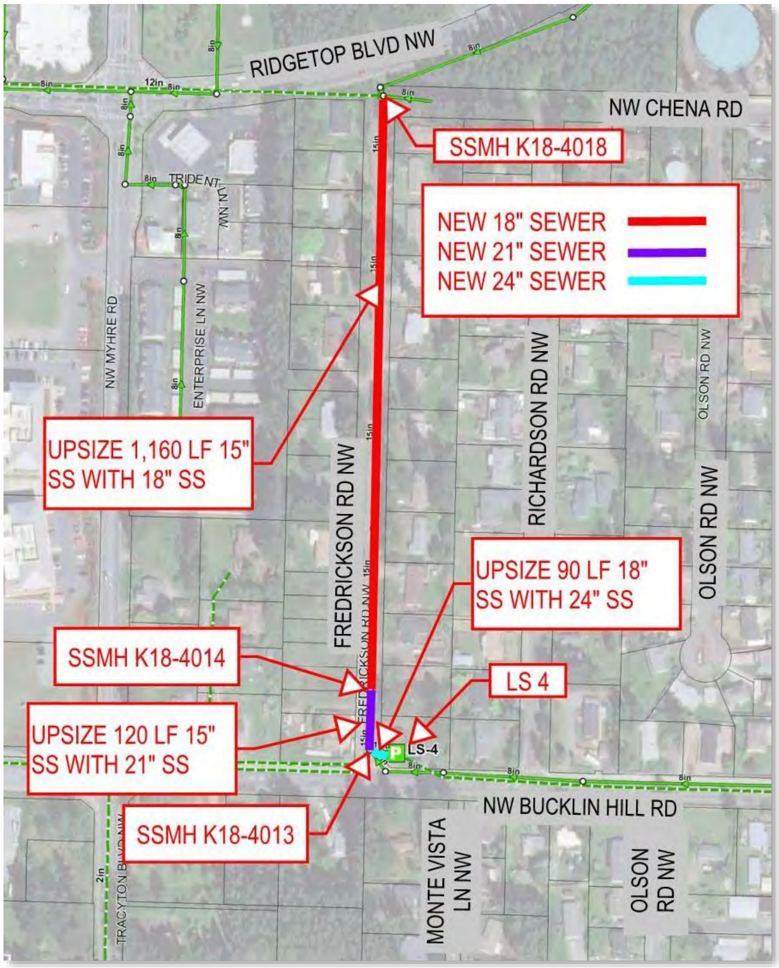


Figure 4-2 – Fredrickson Road Gravity Sewer Upgrades

The new pipe material will depend on the construction method that is used to install the larger pipe. All gravity conveyance piping that is installed via open trench construction methods will use PVC gravity sewer main. If a trenchless construction method such as pipe reaming or pipe bursting is used, the new pipe will be HDPE with a minimum SDR of 17. Manholes along the upgraded alignment will be replaced with new standard sized manholes coated on the inside with a 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide. Manholes will be installed in accordance with the requirements of Section 7-05.3 of the Standard Specifications. If the excavation for the bottom of the manhole becomes disturbed, the disturbed soil will be over-excavated to expose undisturbed native soil and backfilled with suitable foundation material to provide a firm base. Foundation material should meet the requirements for Foundation Material Class A in Section 9-03.17 of the Standard Specifications. Foundation material will be placed in 6-inch lifts and thoroughly compacted to provide a firm excavation bottom. Manholes will be backfilled in accordance with the requirements of Section 2-09.3(1)E of the Standard Specifications. Parcels that are connected to the existing gravity sewer will be reconnected to the new gravity sewer with new laterals from the main to the edge of the right-of-way. Cleanouts will be installed on the laterals at the right-of-way (ROW)/property line.

4.1.3 Lift Station 4 Force Main Upgrades

Upgrades to LS 4 will result in velocities in the existing 14-inch force main of 5.7 fps with one pump operating and 9.5 fps with two pumps running in parallel. Force mains were deemed to be at or above capacity if velocities exceeded 8 fps. Based on that criteria, LS 4's 14-inch force main needs to be upgraded to 20-inch force main from LS 4 to SSMH J18-3048, which is located approximately 250 feet east of Spinnaker Boulevard. Sewage velocities in a 20-inch force main would be approximately 2.8 fps with one pump operating and 4.7 fps with two pumps running in parallel. The proposed upgrades are shown on Figure 4-3.

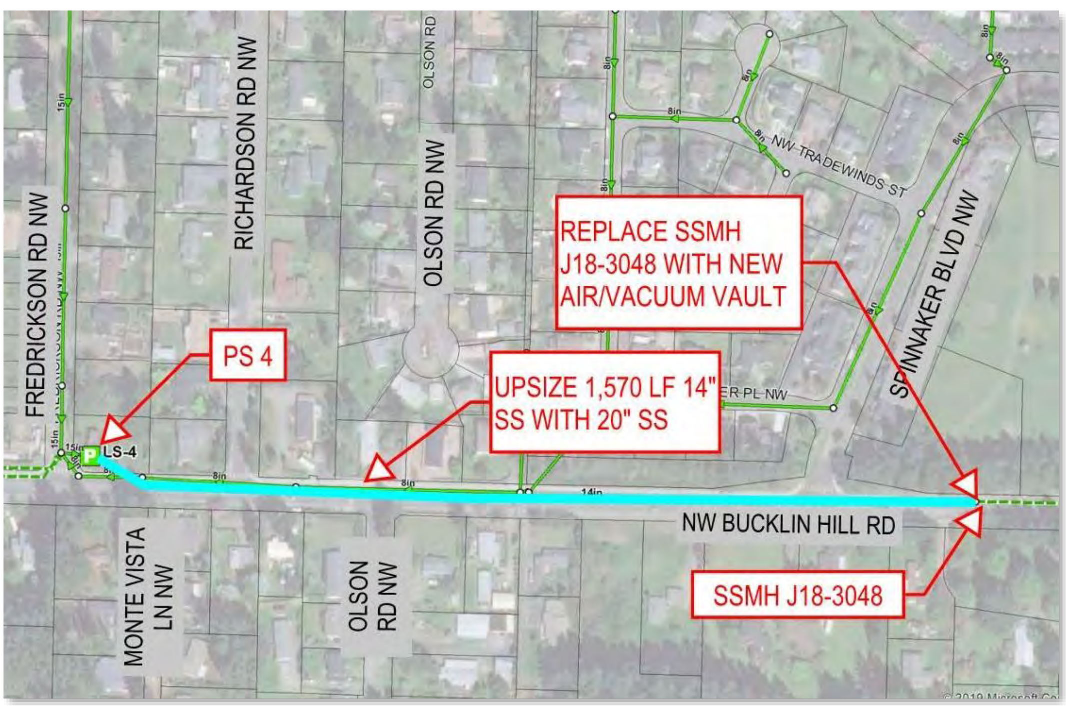


Figure 4-3 – LS 4 Force Main Upgrades

For LS 4's force main, C905 PVC pipe will be installed using open trench construction methods. Ductile iron pipe and fittings, lined with Protecto 401 Ceramic Epoxy or accepted equal, will be used between the pumps and the pig launch for easier assembly.

4.2 Lift Station Design and Construction Components

The following sub-sections summarize key lift station design and construction components/ recommendations. These items should be reviewed and confirmed by the County to document the basis of design prior to entering the final design phase of the Project.

Based on the pump rates shown in Table 3-2 and the age of the existing infrastructure, the necessary upgrades to address the projected flows and to bring each station into compliance with the County's current standards were identified. These upgrades include new wet wells, valve vaults, flow meters, pumps, control panels, telemetry panels, generators, control buildings, odor control facilities, and onsite lighting where appropriate. Table 4-3 summarizes the proposed upgrades.

Table 4-3
Summary of Lift Station Upgrades

Criteria	LS 3	LS 4	LS 19	LS 31
Pumping Capacity	3,200 gpm	5,030 gpm	2,040 gpm	170 gpm
No. of Pumps & HP	3 @ 160 HP	3 @ 250 HP	3 @ 70 HP	2 @ 3.2 HP
Wet Well Upgrades	New 20' x 16' rectangular wet well	New 34' x 20' rectangular wet well	Re-use existing wet well	New 8' diameter wet well
Flow Meter	Magnetic flow meter located in control building	Magnetic flow meter located in control building	Magnetic flow meter located in control building	Magnetic flow meter located in underground vault
Pig Launch	New underground vault	New underground vault	New underground vault	New underground vault
Building Upgrades	New control building	New control building	New control building	Canopy shelter for control panels
Control Panels	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, MCC, ATS, and telemetry panels; new antenna	New MCP, motor controller, ATS, and telemetry panels; new antenna
Generator	New 400 kW	New 600 kW	New 200 kW	Pig tail for portable
Odor Control	Carbon scrubber	Carbon scrubber/ biofiltration bed	Room allotted for future odor control	Goose-necked vent with carbon canister

The recommended configuration and County standard for these lift stations is a submersible type lift station including non-clog, submersible wastewater pumps affixed to a guiderail system in a wet well. While other submersible options, including Hidrostal's screw centrifugal wastewater pump and patented pre-rotation basin, could work for the proposed upgrades, the County has standardized on Flygt submersible wastewater pumps to ease maintenance complexities. Therefore, the proposed lift station layouts are based on the respective Flygt pump sizes and configurations.

4.2.1 Lift Station 3

Because the lift station is located within the Silverdale Waterfront Park, the Port of Silverdale is a significant stakeholder with concerns on how the lift station will be integrated into the surrounding park. To begin addressing their concerns, four alternative layouts were evaluated for the upgraded station and presented in a design memorandum dated September 24, 2018. A copy of this memorandum may be found in Appendix E. These options are identified as:

- Option 1 – Upgrade LS 3 at its current location on property owned by the County.
- Option 2 – Upgrade LS 3 north of its current location, straddling property currently owned by the County and the Port of Silverdale.
- Option 3 – Upgrade LS 3 slightly north of its current location but remaining on property owned by the County, as well as within an existing sewer easement over property owned by the Port of Silverdale.
- Option 4 – Upgrade LS 3 north of its current location, adjacent to the parking lot on property owned by the Port of Silverdale.

Each option includes a new below ground wet well; new valves, fittings, flow metering equipment, pig launch, and associated piping to connect the new facilities to the existing gravity sewers and force main; a new generator; new telemetry and electrical control panels; and new odor control facilities such as chemical addition equipment or an activated carbon air scrubber.

To address rising tidal concerns associated with global warming, a waterproof membrane will be installed behind the wainscoting around the exterior perimeter of the new building and fully integrated with the supporting footings below. All windows and exhaust/supply vents will be installed at least 3'-6" above the finished floor, and heavy-duty jambs and doors will be added that can resist up to 3 feet of flooding. In addition, consideration will be given during design to installing the electrical equipment on elevated pads to protect the equipment from flood leakage. Drains and sump pumps will also be considered to minimize potential flood damage. The landscaping design may consider berms that act as levees to protect the building. The final finished floor elevation of the building and the surrounding landscaping will be determined during the design stage as more information is obtained regarding potential tide increases and their resultant impacts/risks on infrastructure.

All four options assume construction would occur north of the existing rip rap wall to the south of the existing control building. Consequently, the rip rap wall would remain in place with no upgrades, shoreline armoring, or restoration work on the beach. In addition, since all four alternative options are located within the shoreline buffer zone, modifications to the impervious surface area will require mitigation measures.

Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is a paramount consideration at this station, given the volume of incoming flow and the station's proximity to Dyes Inlet. Additional response time may be gained by oversizing the new wet well or constructing additional overflow storage via an underground vault or piping or a combination of both options. Based on conversations with the County, a target response time of 60 minutes at full buildout peak flows was deemed reasonable. To achieve a one-hour response time at full buildout peak flows, about 121,200 gallons of additional overflow storage would be required. This amount of storage would require the construction of an underground vault that is about 54'L x 20'W x 15' deep. Table 4-4 shows the response times at current, future, and full buildout peak flows associated with adding 121,200 gallons of overflow storage.

Table 4-4
LS 3 Storage/Response Times

Structure	Current Peak Flows (580 gpm)		Future Peak Flows (1,220 gpm)		Full Build-Out Peak Flows (2,630 gpm)	
	Volume	*Time*	*Volume*	*Time*	*Volume*	*Time*
New Wet Well (20'L x 16'W x 15'D[1])	35,900 gal	62 min	35,900 gal	29 min	35,900 gal	14 min
Overflow Storage ((54'L x 20'W x 15'D[1])	121,200 gal	209 min	121,200 gal	99 min	121,200 gal	46 min
Total Storage/Time	157,100 gal	271 min	157,200 gal	128 min	157,100 gal	61 min

Notes:
1) Depth from lag pump off elevation to overflow elevation.

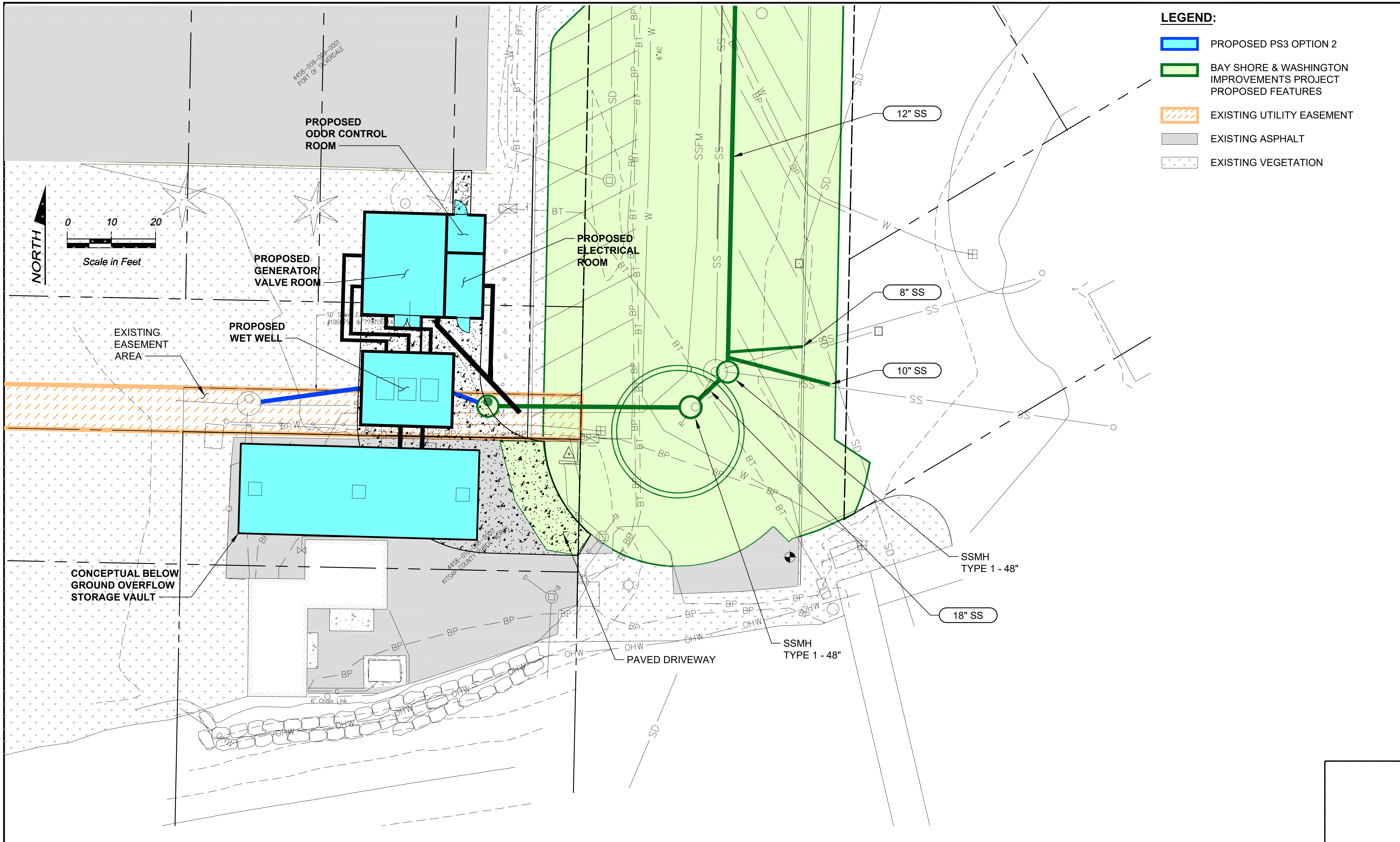
As mentioned above, full build-out flows were used to determine the required overflow storage. Peak flows under future flow conditions would only require about 40,400 gallons of storage to provide a one-hour response time. This means the full buildout peak flows would require about three times as much overflow storage as the future peak flows. Given the volume difference, further discussion during the design phase of the project is warranted to determined how much storage is needed given the County's available response time and risk tolerance.

Providing overflow storage will require additional space on the Project site. Determining a reasonable location for this storage may be a challenge given the other improvements in the area and the potential limitations imposed by the grant funding that was used to originally purchase the land. Another issue associated with overflow storage is how to clean the storage after its been utilized. One option would be to use the lift station's submersible pumps in conjunction with piping and valves to provide an initial flush of the storage and then use clean water via a fire hydrant for a final rinse. This approach would require adequate backflow prevention on the clean water source and potentially a new fire hydrant onsite.

The Silverdale Waterfront was acquired in 1977 using Federal Land and Water Conservation Funds. This funding source contains restrictions on land use. In 2008, the County underwent a mitigation process to bring the existing lift station into compliance with the funding requirements. Based on recent discussions between the County and the Washington State Recreation and Conservation Office (RCO) and the National

Parks Services, the County was informed that shifting the lift station towards the parking lot on property owned by the Port of Silverdale would likely not require further mitigation by the County or the Port of Silverdale. However, the RCO and National Parks will need the final location and footprint of the upgraded station before that determination can be finalized.

After reviewing the options presented in the memorandum, and in consideration of ongoing discussions with the Port or Silverdale, the County directed BHC to refine the layout associated with Option 4 while negotiations with the Port of Silverdale continue regarding the final location and configuration of the station. Figure 4-4 and Figure 4-5 show the proposed layout of the station and the control building for Option 4, including a conceptual layout of additional underground overflow storage. Figure 4-6 represents a conceptual elevation view of what the station might look like in the park. The County recognizes the building will likely be a joint use facility with the Port of Silverdale and the intent of Figure 4-6 is to show how the station could be worked into the park setting. The final configuration, appearance, and location of the station will be determined via subsequent discussions between the County and the Port of Silverdale.



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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE 4-4
LIFT STATION 3
SITE PLAN

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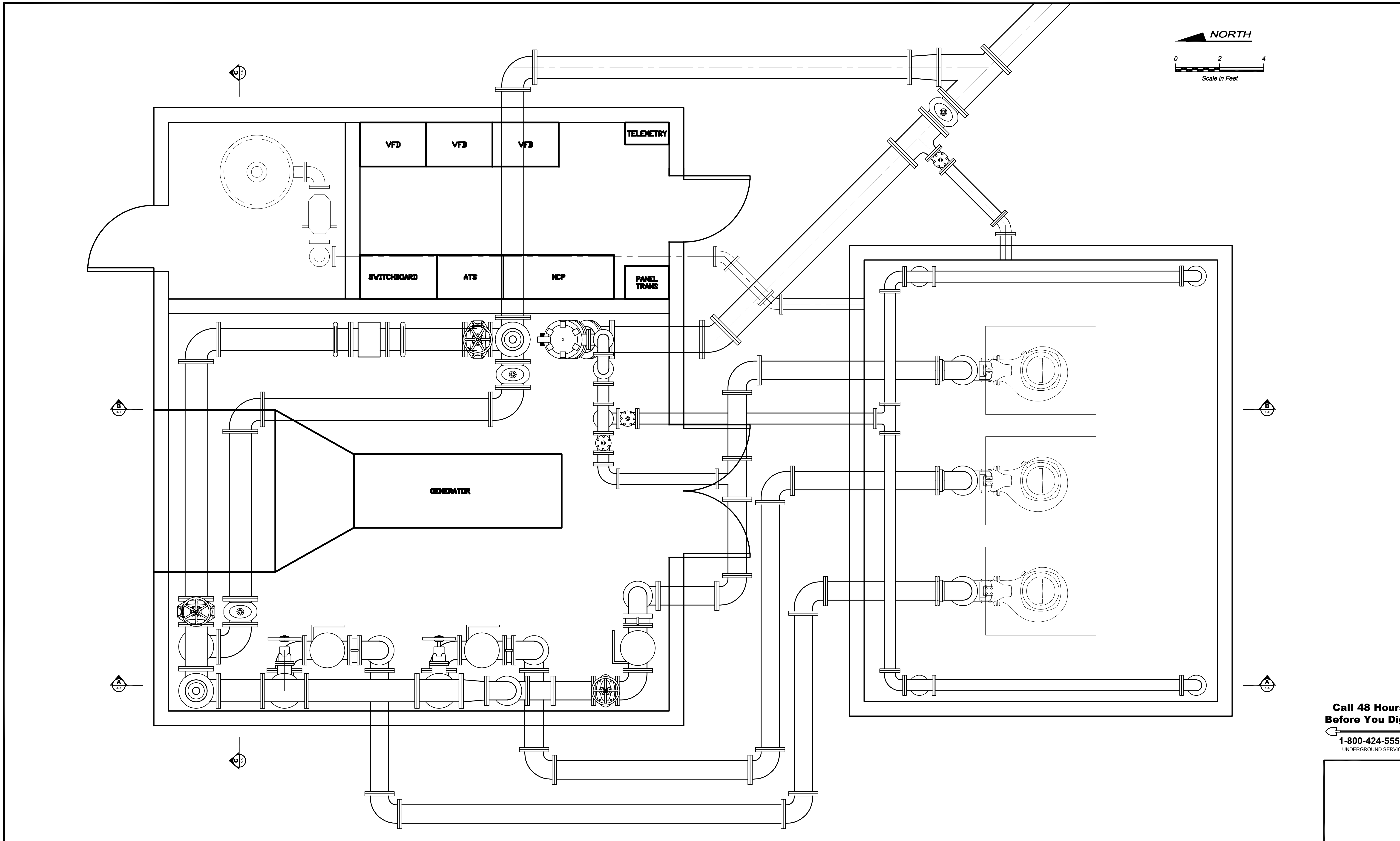

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE 4-5
LIFT STATION 3
DETAILED PLAN VIEW

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Figure 4-6 – Lift Station 3 Conceptual Rendering

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4.2.2 Lift Station 4

The existing above grade building is in poor condition with extensive rusting of the metal roof and deterioration of the concrete block walls. Therefore, upgrades to LS 4 will need to include a full replacement of the control building. The below ground wet well and dry well structures are in reasonably good condition and may be reused, depending on which alternative the County elects to choose. Three alternative layouts were evaluated for LS 4 and presented to the County in an email dated January 10, 2019. These options are identified as:

- Option 1 – Reuse the existing wet well to house the submersible pumps and the existing dry well for the valves and flow meter. The existing building would be replaced with a new building for the generator and control panels.
- Option 2 – Construct a new wet well for the submersible pumps; reuse the existing dry well for the valves and flow meter. The existing building would be replaced with a new building for the generator and control panels. Convert the existing wet well into overflow storage to provide additional response time should a lift station failure occur.
- Option 3 – Construct a new wet well for the submersible pumps and new below ground valve vault for the isolation valves and check valves; reuse the existing dry well for the flow meter. The existing building would be replaced with a new building for the generator and control panels. Convert the existing wet well into overflow storage to provide additional response time should a lift station failure occur.

While Option 1 would maximize the use of existing structures and involve the least amount of new excavation, it would require the most bypass pumping as the existing station would need to be removed from service until the new station is operational. Conversely, constructing a new wet well and valve vault under Option 3 would minimize bypass requirements as these facilities could be constructed while the existing station remains in service. However, shoring and dewatering costs would be higher due to the more extensive excavations and use of the existing structures would be minimal. Option 2 represents a compromise between Options 1 and 3, balancing excavation costs against bypass risks.

Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is a paramount consideration at this station given the volume of incoming flow. Additional response time may be gained by utilizing the existing wet well, oversizing the new wet well, constructing additional overflow storage via a new underground vault or piping or a combination of these options. Based on conversations with the County, a target response time of 60 minutes at full buildout flows was deemed reasonable. To achieve a one-hour response time at full buildout peak flows, about 206,500 gallons of additional overflow storage would be required. The existing wet well would provide about 23,350 gallons of storage leaving an additional 183,100 gallons of needed storage. Achieving this volume of storage would be most effectively achieved via an overflow storage vault. The overflow storage vault would need to be about 60'L x 34'W x 12'D. The final configuration of the overflow vault will be determined during the design phase of the project. Table 4-5 shows the response times at current, future and full buildout peak flows associated with adding 206,500 gallons of overflow storage via the existing wet well and new overflow storage vault.

Table 4-5
LS 4 Storage/Response Times

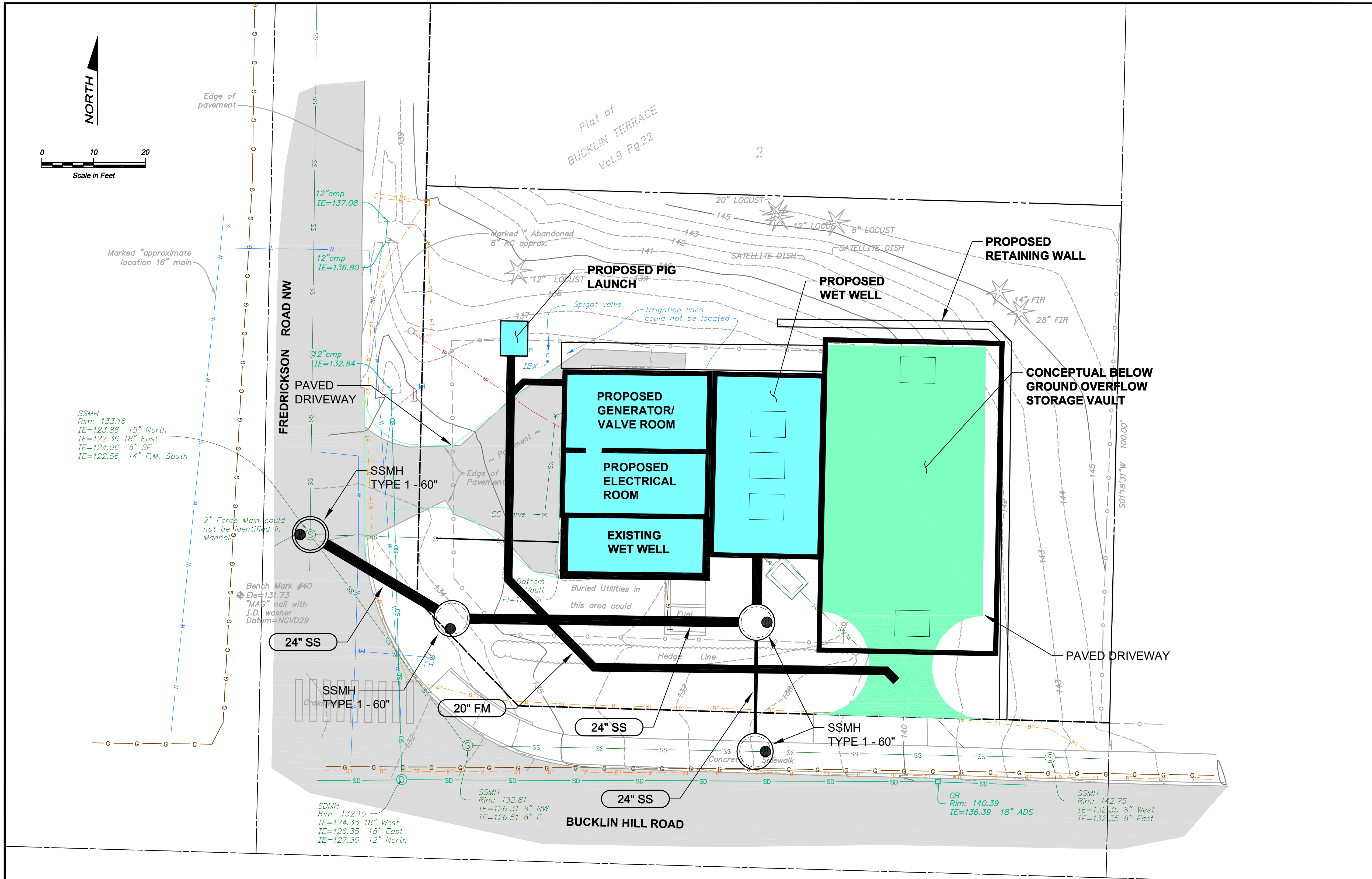
Structure	Current Flows (1,965 gpm)		Future Flows (3,420 gpm)		Full Build-Out Flows (4,530 gpm)	
	Volume	*Time*	*Volume*	*Time*	*Volume*	*Time*
New Wet Well (34L' x 20'W x 12'D[1])	61,050 gal	31 min	61,050 gal	18 min	61,050 gal	14 min
Ex. Wet Well (26'L x 10'W x 12'D[1])	23,350 gal	12 min	23,350 gal	7 min	23,350 gal	5 min
Overflow Storage (60'L x 34'W x 12'D[1])	183,100 gal	93 min	183,100 gal	53 min	183,100 gal	40 min
Total Storage/Time	267,500 gal	136 min	267,500 gal	78 min	267,500 gal	59 min

Notes:
1) Depth from lag pump off elevation to overflow elevation.

As mentioned above, full build-out flows were used to determine the required overflow storage. Peak flows under future flow conditions would require about 122,100 gallons of storage to provide a one-hour response time. This means the full buildout peak flows would require about 50% more overflow storage than the future peak flows. Further discussion during the design phase of the project may be warranted to determined how much storage is needed given the County's available response time and risk tolerance.

Providing overflow storage will require additional space on the Project site. Determining a reasonable location for this storage may be a challenge given the other improvements in the area. The preliminary design assumes the overflow vault will be located along the east side of the proposed wet well. Another issue is how to clean the storage after its been utilized. One option would be to use the submersible pumps in conjunction with piping and valves to provide an initial flush of the storage and then use clean water via a fire hydrant for a final rinse. This approach would require adequate backflow prevention on the clean water source and potentially a new fire hydrant onsite.

After reviewing the options presented in the January 10, 2019 email and because bypass operations, given the incoming flows at the station, represent a significant risk for the Project, the County indicated a preference for the Option 2 layout. Option 2 reduces the bypass risks while utilizing a portion of the existing structure. The lift station configuration for Option 2 was then refined to address County comments. Figure 4-7 and Figure 4-8 show the proposed layout of the station and the control building.



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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE 4-7
LIFT STATION 4
SITE PLAN

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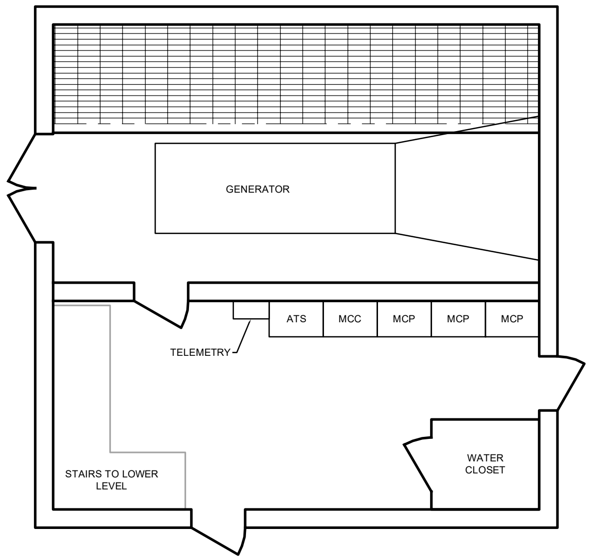
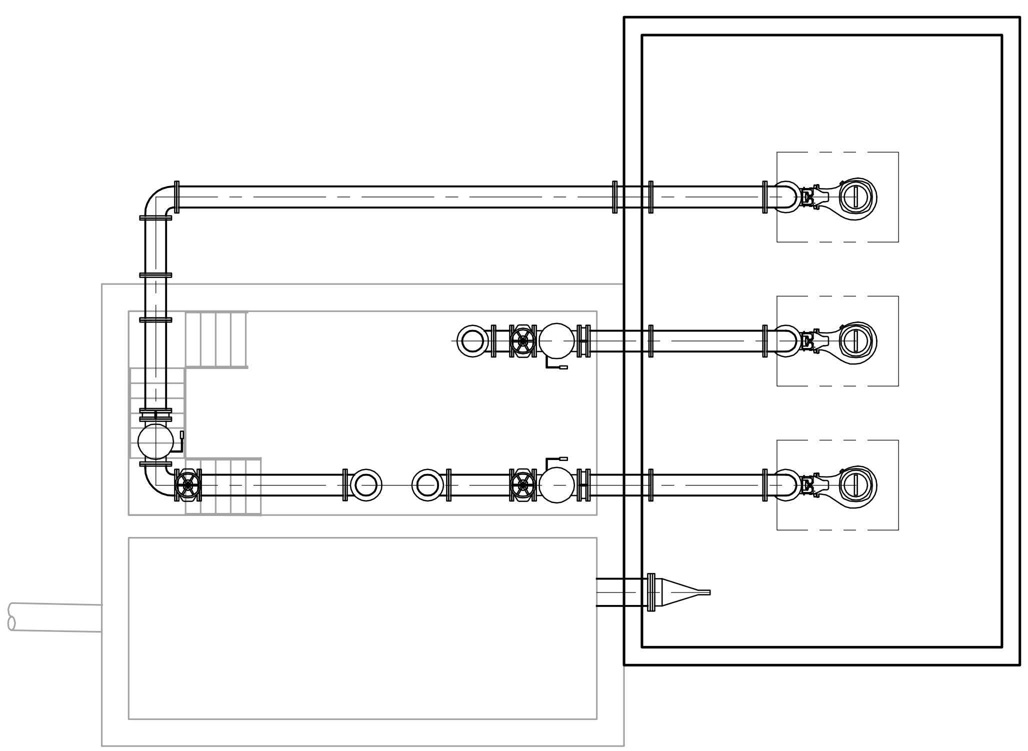
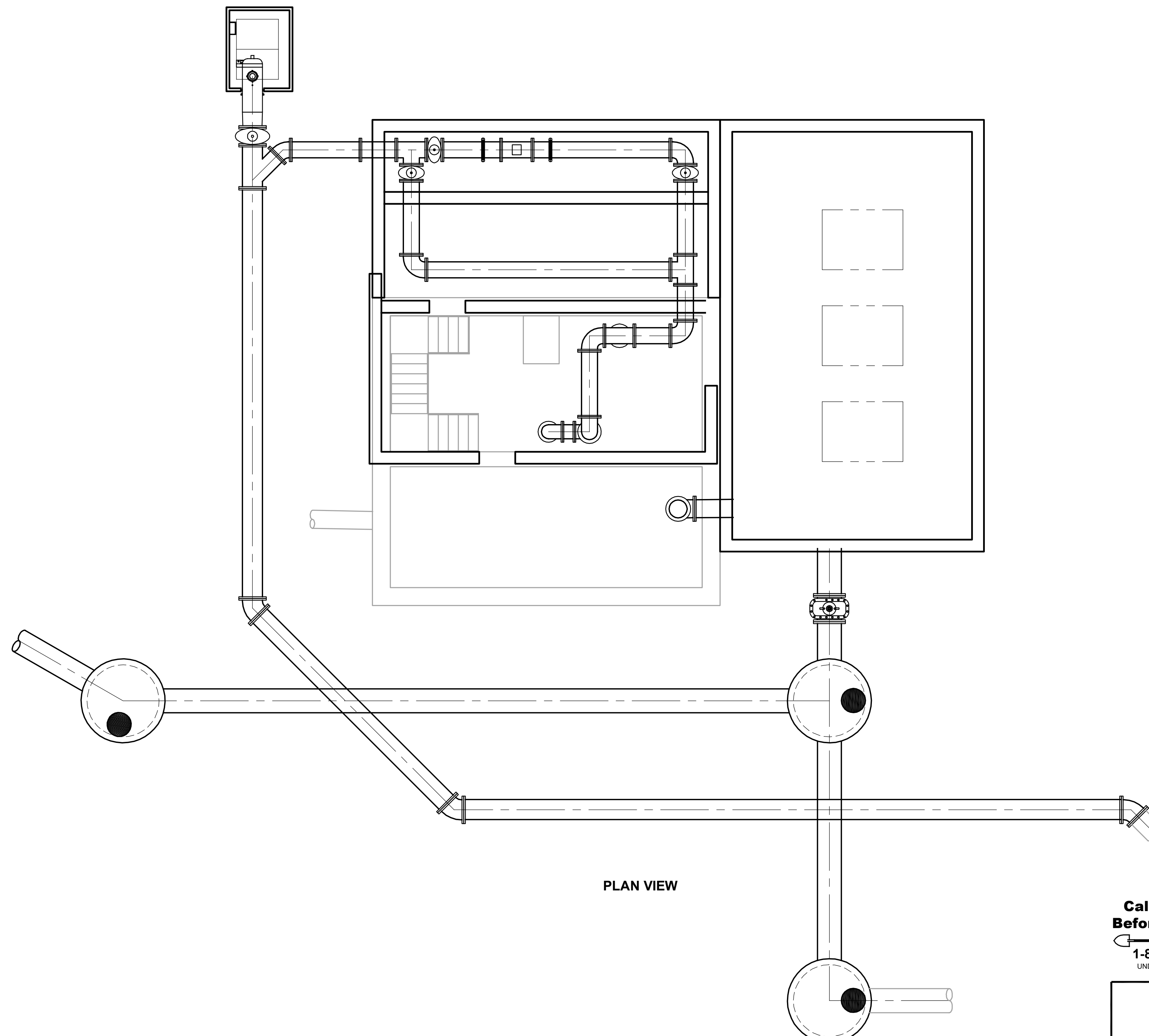


CONTROL BUILDING



MEZZANINE LOWER LEVEL



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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE 4-8
LIFT STATION 4
DETAILED PLAN VIEW

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4.2.3 Lift Station 19

The existing wet well at LS 19 is in good condition and the County indicated a preference to use it to house the new submersible pumps. Two options were then developed for the remainder of the station. These options included:

- Option 1 – Install a new valve vault and meter vault adjacent to the existing wet well and replace the existing control building with a new control building.
- Option 2 – Construct a new control building adjacent to the existing wet well. The new control building will have one room for the generator, valves, and flow meter, a separate room for the control panels, and a third room for future odor control facilities.

Option 1 would minimize the footprint of the new building but would require additional excavation to install the valve vault and meter vault. The valves and flow meter would be in confined spaces, so maintenance crews would need to follow confined space entry procedures to operate and maintain those facilities. Option 2 has the advantage of locating the valves and flow meter above ground, thus avoiding confined space issues and providing better access for operations and maintenance. However, that benefit requires a large footprint for the building. Both options will maintain the station's current ability to pump north through its own dedicated 14-inch force main or south into LS 4's 20-inch force main.

Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is also consideration at this station, given the volume of incoming flow. Additional response time may be gained by constructing additional overflow storage via a new underground vault or piping. Based on conversations with the County, a target response time of 60 minutes at full buildout flows was deemed reasonable. To achieve a one-hour response time at full buildout peak flows, about 32,300 gallons of additional overflow storage would be required. Achieving this volume of storage may be done by constructing a 30'L x 12'W x 12' deep vault or installing about 60 feet of 9' diameter pipe. The vault option may be easier to clean than the pipe, so the preliminary design utilized the vault concept. The final configuration of the overflow vault will be determined during the design phase of the project. Table 4-6 shows the response times at current, future and full buildout peak flows associated with adding 32,300 gallons of overflow storage.

Table 4-6
LS 19 Storage/Response Times

Structure	Current Flows (480 gpm)		Future Flows (650 gpm)		Full Build-Out Flows (900 gpm)	
	Volume	*Time*	*Volume*	*Time*	*Volume*	*Time*
Ex. Wet Well (20L' x 12'W x 12'D[1])	21,550 gal	45 min	21,550 gal	33 min	21,550 gal	24 min
Overflow Storage (30'L x 12'W x 12'D[1])	32,300 gal	67 min	32,300 gal	50 min	32,300 gal	36 min
Total Storage/Time	53,850 gal	112 min	53,850 gal	83 min	53,850 gal	60 min

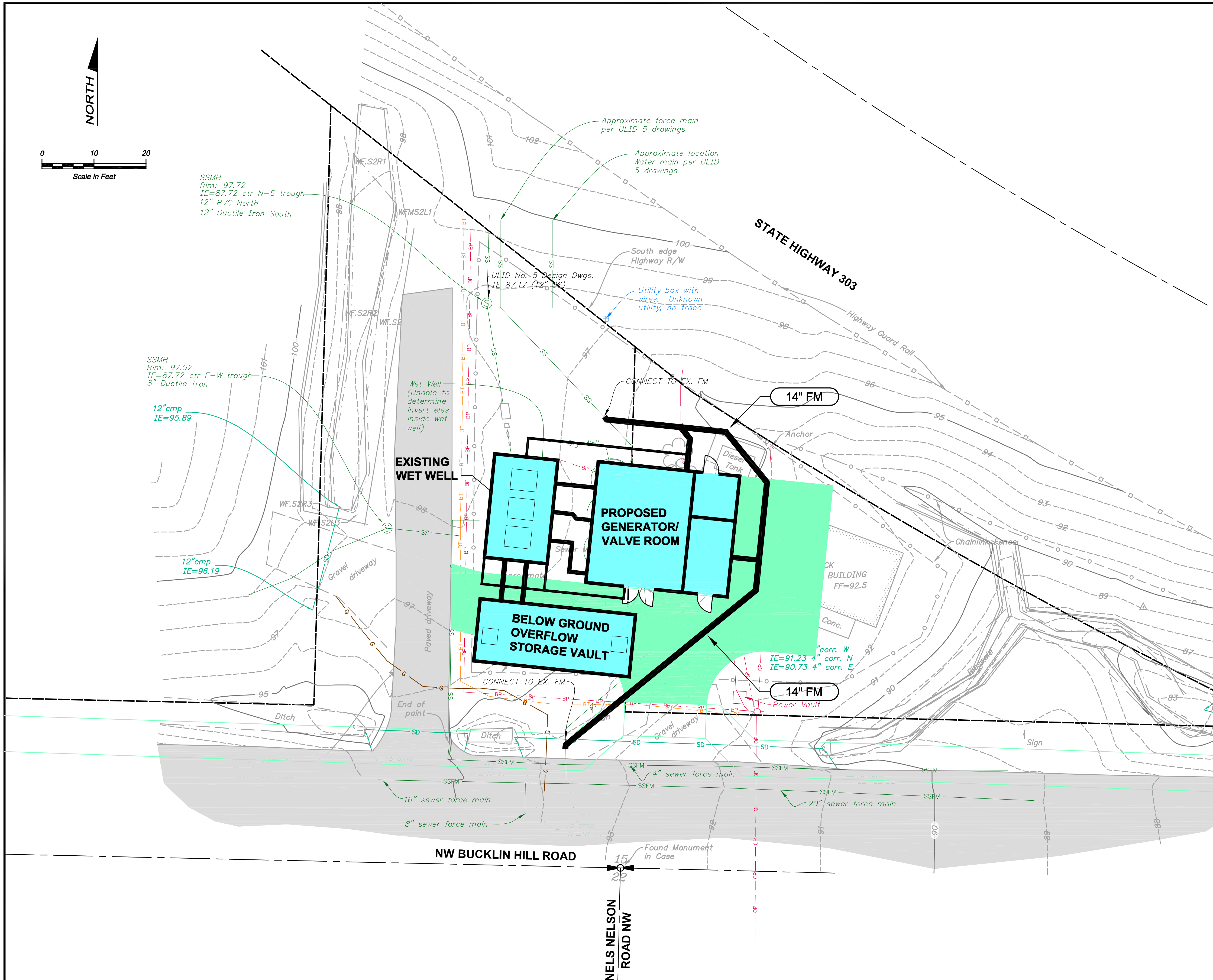
Notes:
1) Depth from lag pump off elevation to overflow elevation.

As mentioned above, full build-out flows were used to determine the required overflow storage. Peak flows under future flow conditions would require about 18,300 gallons of storage to provide a one-hour response time. This means the full buildout peak flows would require about 75% more overflow storage than the future peak flows. Given the volumes being considered, this report recommends designing around the volumes associated with full buildout peak flows. Further discussion during the design phase of the project may be warranted to determined how much storage is needed given the County's available response time and risk tolerance.

Providing overflow storage will require additional space on the Project site. Determining a reasonable location for this storage may be a challenge given the other improvements in the area. Cleaning the overflow storage will face issues similar to those at LS 3 and LS 4 and the solutions will likewise be similar. As with the other stations, the overflow storage/response time issue should be investigated further during the design phase.

Kitsap County's Roads Division is designing improvements to the intersection of Nels Nelson Road NW and NW Bucklin Hill Road which fronts LS 19. The proposed improvements include new signal lights, new sidewalks, and a revised driveway to the storm water detention pond located immediately west of the lift station. During a meeting on July 24, 2019, the Roads Division indicated the intersection upgrades may be delayed until after the LS 19 upgrades. However, because the design and construction either project will impact the other, close coordination between the Roads Division and the Wastewater Division will be required as both designs proceed to avoid future rework and/or utility conflicts.

After reviewing the options presented in the January 10, 2019 email, the County indicated a preference for layout associated with Option 2. Figure 4-9 and Figure 4-10 show the proposed layout of the station and the control building for Option 2.



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Drawn:
Checked: R. Dorn, P.E.
Approved: T. Fisher, P.E.

Scale: 1" = 10'-0"
One Inch at Full Scale
If Not One Inch Scale Accordingly

Kitsap County Public Works
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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE 4-9
LIFT STATION 19
SITE PLAN

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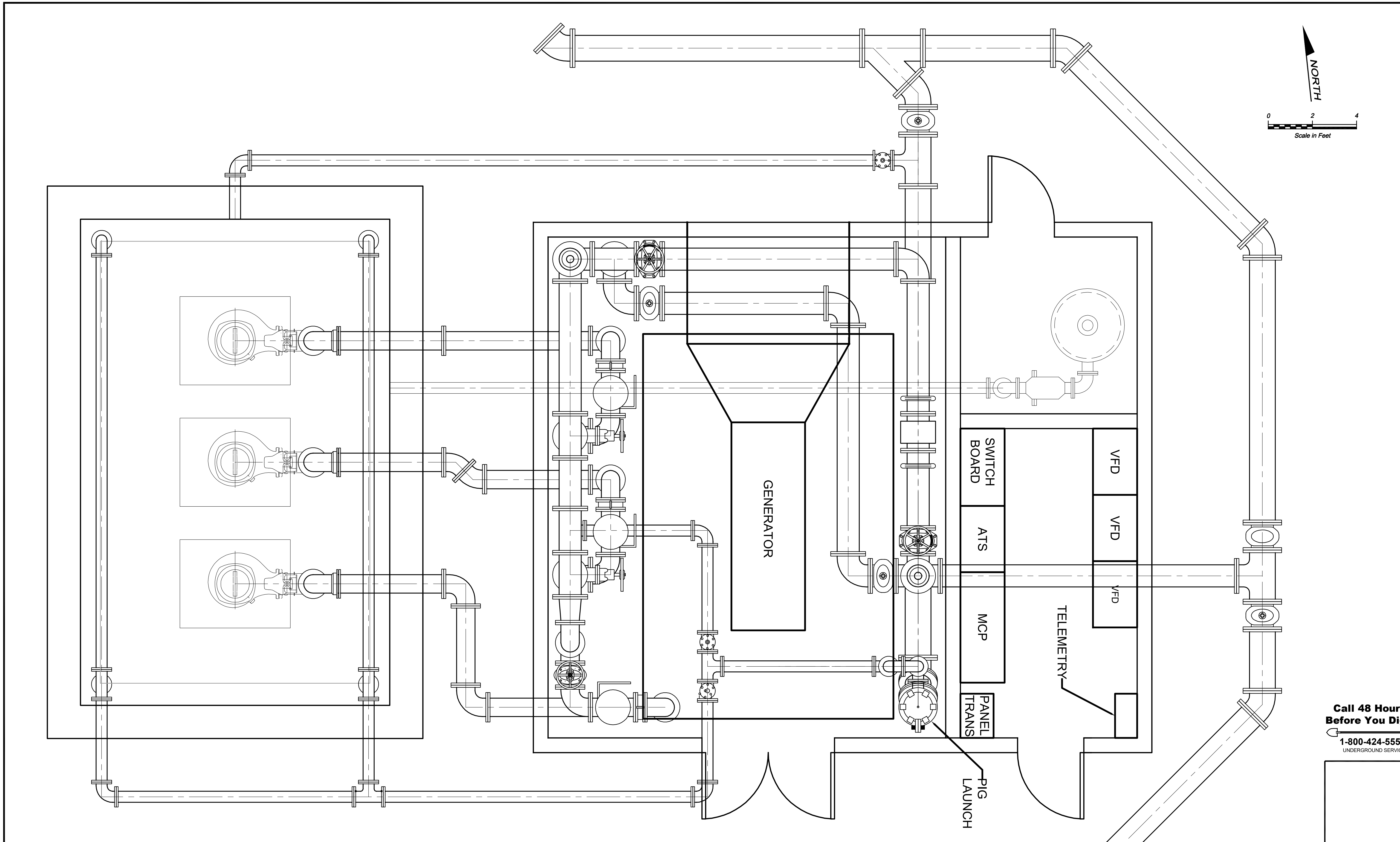

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES

FIGURE 4-10
LIFT STATION 19
DETAILED PLAN VIEW

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4.2.4 Lift Station 31

Lift Station 31 is old, and the equipment no longer operates reliably. To address the necessary upgrades to the station, two options were considered. These options included:

- Option 1 – Install a duplex grinder lift station and new valve vault adjacent to the existing wet well with a 3-inch force main from the new lift station to the 12-inch force main from LS 8 located in NE Clover Blossom Lane. The existing wet well would be converted to a conveyance manhole after the existing station is removed.
- Option 2 – Install a new duplex submersible lift station inside a new wet well and a new valve vault adjacent to the existing wet well with a 4-inch force main from the new lift station to the 12-inch force main from LS 8 located in NE Clover Blossom Lane. The existing wet well would be converted to a conveyance manhole after the existing station is removed.

Option 1 would minimize the size and pumping requirements for the station. However, since the station serves approximately 62 residences, County standards would dictate that the station be a submersible lift station. Additionally, a grinder lift station of this size would be a new entity for the County and the preference is not to add a new style station unless necessary. Therefore, Option 2 is the County's preferred option.

The design will need to upgrade the power source to 240V or 480V three-phase power as the current power is only 240V single phase. The County has also instituted a new standard of adding pressure monitoring/logging on force mains as a redundant means for monitoring lift station and force main operations, i.e. pump running/not running when called. Constructing a control building for this station would require the acquisition of additional land for the control building either via a purchase or an expansion of the existing easement. Due to the relatively small size of the station, a control building isn't necessary as the control panels can be located under a canopy-type structure to provide protection from the weather. In addition, a permanent onsite generator is unnecessary due to the limited flows seen by the station. Instead, a generator receptacle will be provided to allow a portable generator to operate the station during a power outage.

A pre-manufactured lift station, like ones provide by Romtec or One-Lift, may also be good candidates for LS 31. A pre-manufactured lift station would minimize the onsite construction time with resultant impacts to the surrounding neighborhood. Figure 4-11 and Figure 4-12 provide a preliminary site plan and a plan view layout for the submersible lift station.

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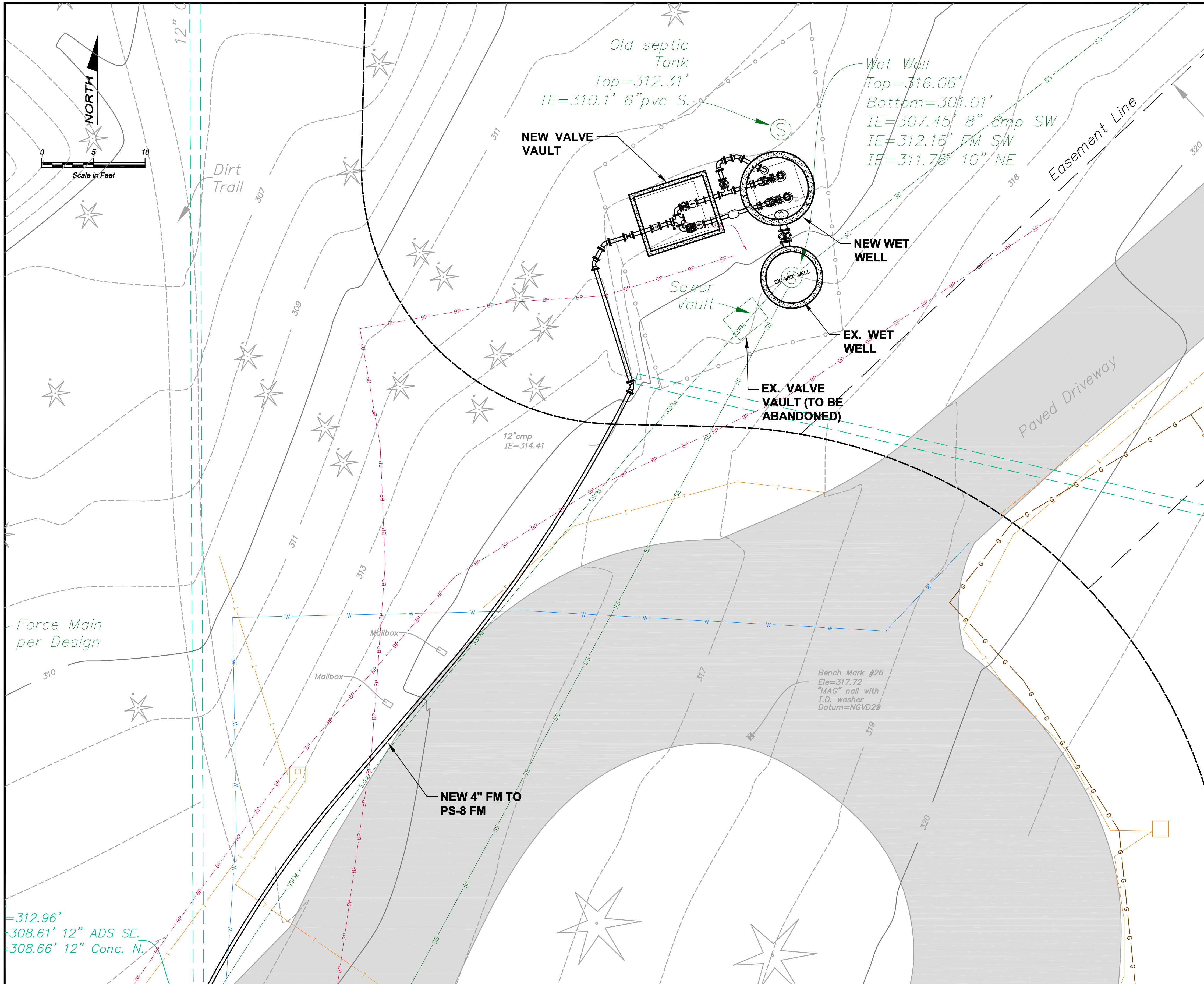

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE 4-11
LIFT STATION 31
SITE PLAN

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Date: DECEMBER 2019

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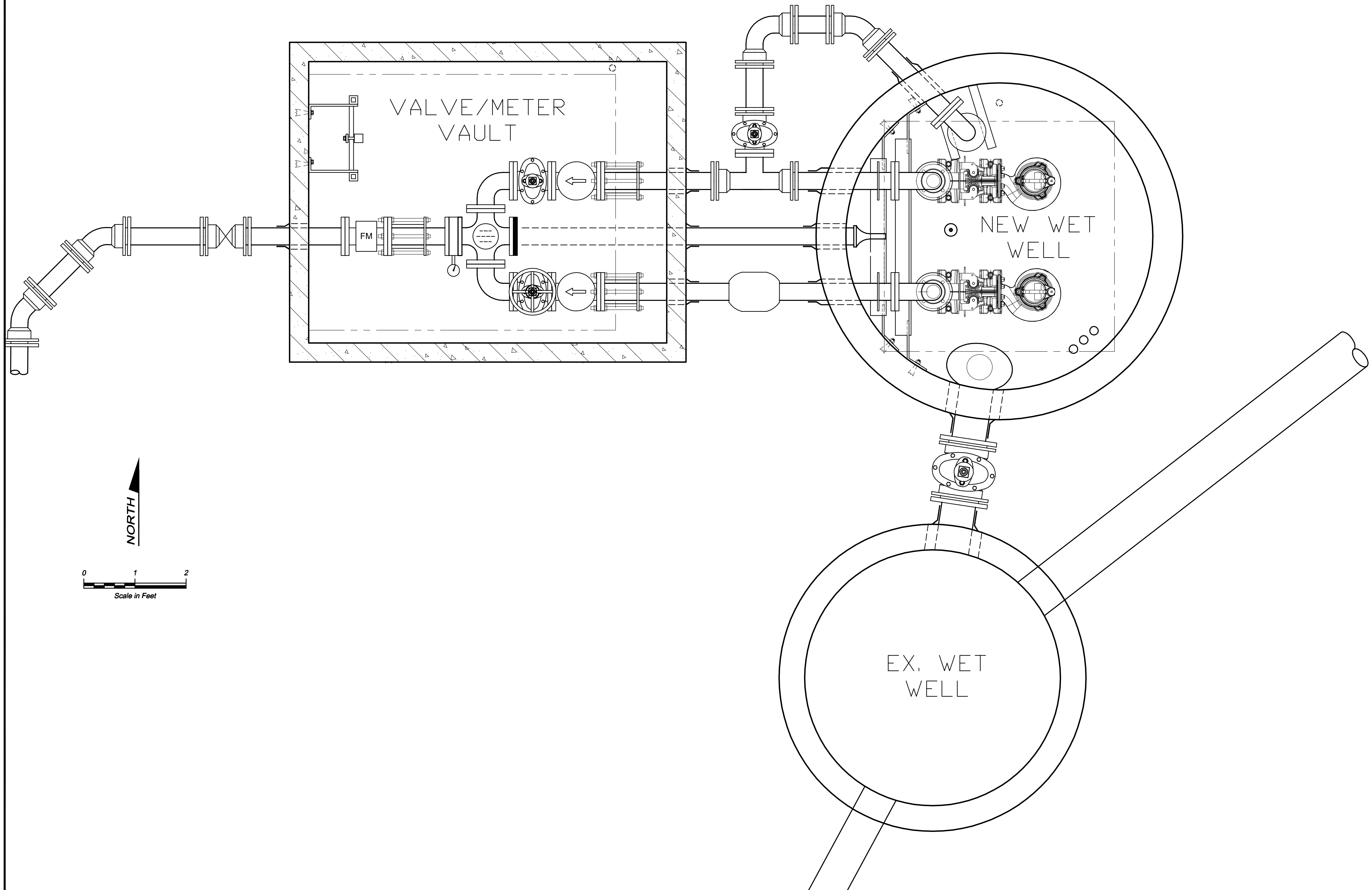

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PUMP STATIONS 3, 4, 19 AND 31 UPGRADES
FIGURE 4-12
LIFT STATION 31
DETAILED PLAN VIEW

Drawing:
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Providing adequate response time for maintenance crews to troubleshoot and address issues at the station is not a significant issue, as an 8-foot diameter wet well would provide reasonable response times at the projected peak flow rates. Table 4-7shows the response times based on storage within the proposed wet well (no additional storage onsite) during peak flows for three different wet well sizes.

Table 4-7
LS 31 Storage/Response Time Options

Structure	Current Flows (20 gpm)		Future Flows (30 gpm)		Full Build-Out Flows (80 gpm)	
	Volume	*Time*	*Volume*	*Time*	*Volume*	*Time*
New Wet Well (7' Dia. x 12'D[1])	3,450 gal.	173 min.	3,450 gal.	115 min.	3,450 gal.	43 min.
New Wet Well (8' Dia. x 12'D[1])	4,500 gal.	226 min.	4,500 gal.	150 min.	4,500 gal.	56 min.

Notes:
1) Depth from lag pump off elevation to overflow elevation.

As the table shows, response times associated with a 7-foot diameter wet well under full build-out flows would only provide about 43 minutes of response time and additional storage would likely be needed. While an 8-foot diameter wet well would still not provide a full hour response time under full build-out flows, the corresponding time 56 minutes is deemed acceptable. Therefore, proceeding with an 8-foot diameter wet well is recommended.

4.3 Hydraulic Analysis and Pump Selection

The preliminary system hydraulics for LS 3, LS 4, LS 19, and LS 31 are illustrated in Figure 4-13 through Figure 4-16. In addition, Table 4-8 describes the pertinent hydraulic parameters for the four lift stations.

Table 4-8
Lift Station Hydraulic Parameters

Parameter	LS 3	LS 4	LS 19	LS 31
Force Main High Point	122 ft	215 ft	160 ft	321.0 ft[1]
Lag Pump Off Elev.	-10 ft	117 ft	80 ft	303.0 ft
Static Head	132 ft	98 ft	80 ft	18.0 ft
Force Main Dia.	14 in.	20 in.	14 in.	4 in.
Force Main Length	7,394 ft	1,570 ft	8,324 ft	125 ft
Hazen Williams C-Factor	140	140	140	140
Flygt Pump Model #	NP 3315 HT 3~458	NP 3231/745 3~480	NP 3202 HT 3~465	NP 3069 MT 3~432

Notes:
1) High point is represented by peak grade line when LS 8 is operating with two pumps.

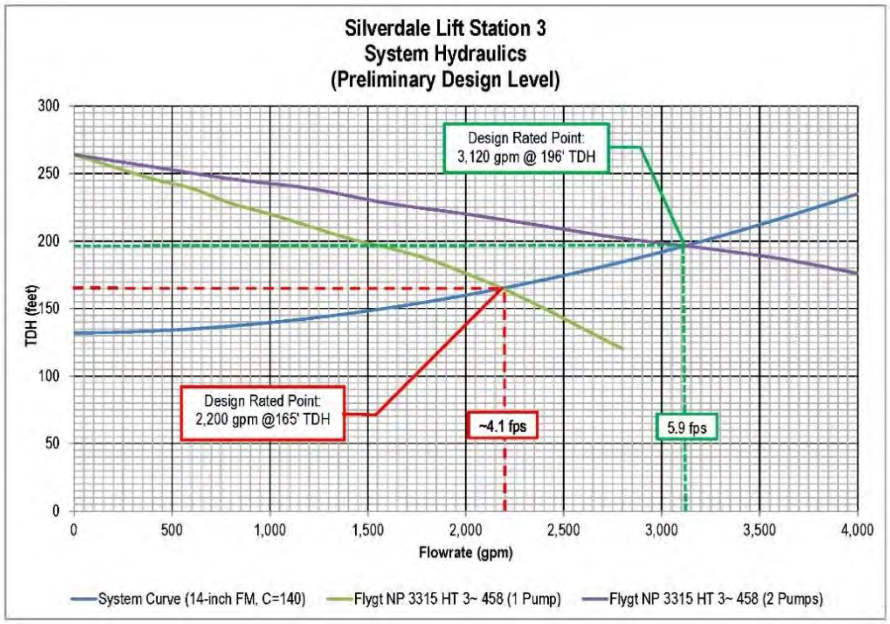

Figure 4-13 – Lift Station 3 Hydraulic Curve

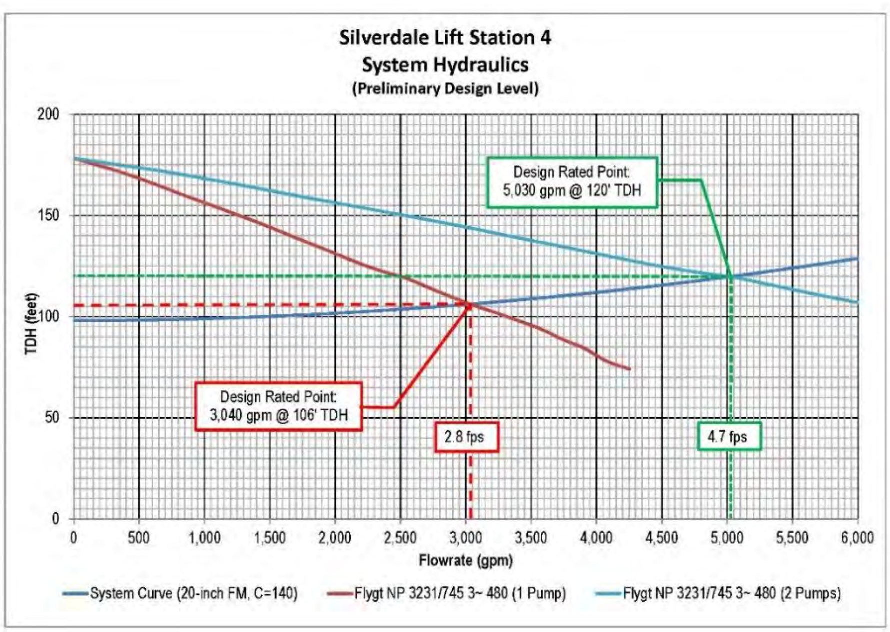

Figure 4-14 – Lift Station 4 Hydraulic Curve

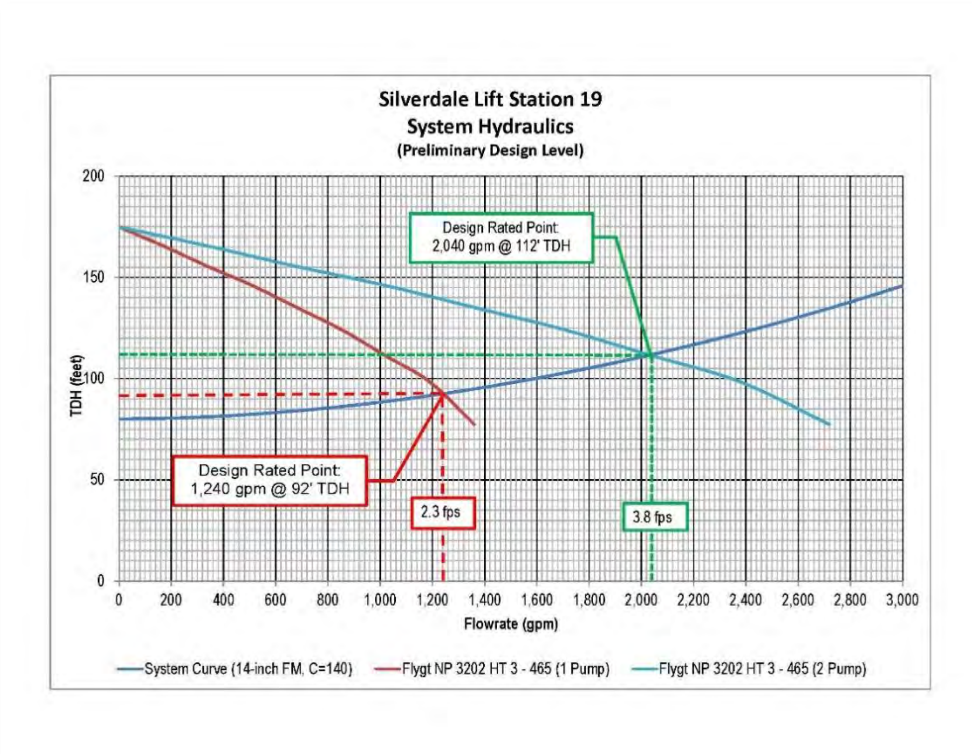

Figure 4-15 – Lift Station 19 Hydraulic Curve

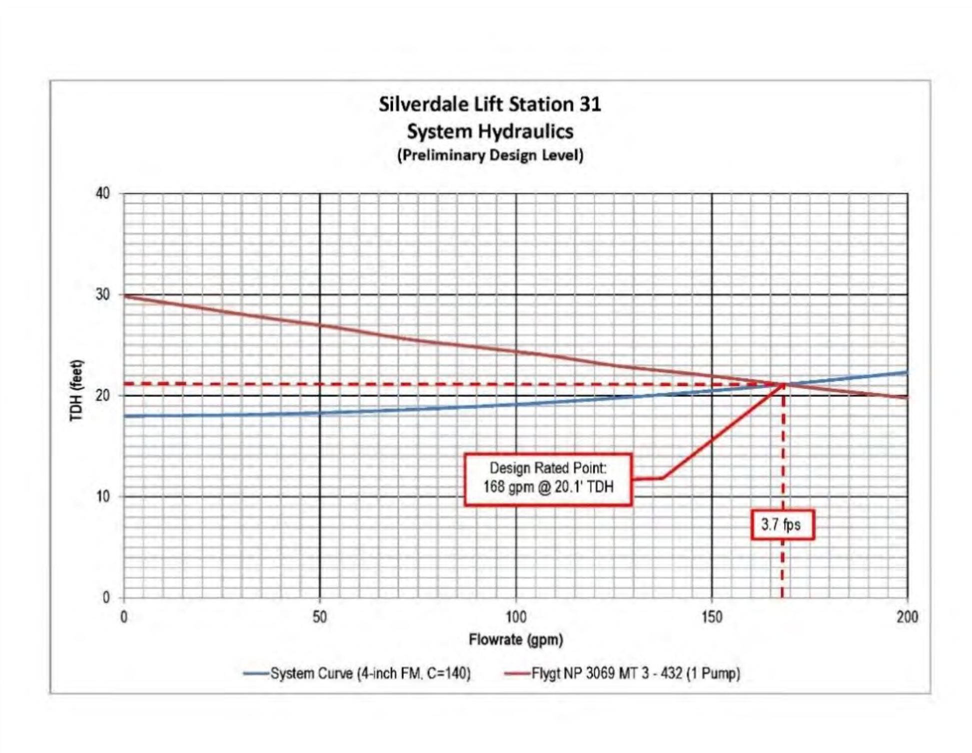

Figure 4-16 – LS 31 Hydraulic Curve

During the design phase, the total dynamic head (TDH) and pump selections should be confirmed as more information is determined regarding the onsite piping and its associated head losses. The resulting pump curve should be entered into the hydraulic models and the models ran to confirm the selected pumps are appropriate. This is especially true in situations where the proposed pumps are sharing force mains with other stations, such as at LS 19 and LS 31.

The selected pump models come with Flygt's Hard-Iron™ impeller and patented adaptive N-impeller technology. These impellers have demonstrated long term, proven performance in similar municipal wastewater applications. Flygt wastewater pumps are a County standard; therefore, no other pump manufacturers will be allowed. As it has done on other recent lift station projects, the County will pre-negotiate a cost for the Flygt pumps and startup services during final design with the equipment vendor and include that price in the contract bidding documents. Manufacturer's pump performance curves, data, and cutsheets are included as Appendix F.

4.4 Surge Analysis

A preliminary surge analysis was performed for the proposed pumps at LS 3, LS 4, LS 19, and LS 31. The purpose of this analysis was to investigate and identify potential surge conditions that could occur at each lift station. Surge pressures, also referred to as pressure transients or water hammer, occur when steady state flow conditions are changed in a pipeline. Examples of such conditions include pump startup, sudden closure of a valve or loss of power to the pumps. The impacts of these conditions are usually not significant for most potential transients and specific surge control facilities or modifications are typically unnecessary for protection. In some specific cases however, pressure surges may occur that could result in damage to pipelines and appurtenances if protection is not provided. Damaging surge events may occur when pressures in the pipe fall below the vapor pressure of the sewage. Rather than continuing to decrease in pressure, the fluid will vaporize to stabilize the negative pressure. This may cause cavitation to occur, which can lead to loss of pipe material and very high pressures when the vapor cavity subsequently collapses, and the two water columns reunite. The extreme pressures could burst the pipe if they exceed the capacity of the pipe material.

The most critical surge condition associated with lift stations typically results from a total station power failure (pump trip) when the largest flow is occurring. This condition was analyzed for all four lift stations. The lift station and piping systems were first evaluated with no surge protection. If the model results indicated a potentially damaging transients could occur, then additional evaluations of surge conditions, including surge mitigation devices to provide the necessary protection, should be analyzed during final design phase. Table 4-9 summarizes the results of this investigation and Appendix G contains a memorandum summarizing results of the surge analysis.

Table 4-9
Surge Analysis Results

Lift Station	Surge Analysis Results
LS 3	Rapid shut down conditions during a pump trip may result in a maximum pressure of about 75 psi and a minimum pressure of approximately -15 psi, which is the fluid's vapor pressure. This would indicate that surge protection may be needed at LS 3. The surges may be controlled by adding a surge tank at the station, an air-vacuum valve on the force main near the point where the LS 2 force main connects to the LS 3 force main, or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 4	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 75 psi and a minimum pressure of proximately -15 psi, which is the fluid's vapor pressure. This would indicate that surge protection may be needed at LS 4. The surges may be controlled by adding a surge tank at the station or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 19	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 44 psi and minimum pressures were at vapor pressure (cavitation) for an extended length of the force main. This would indicate that surge protection is needed at LS 19. The surges may be controlled by adding a surge tank at the station or changing the onsite piping material, which would change the speed at which pressure waves propagate through the system. Further investigation into surge issues is needed during the design phase.
LS 31	Rapid shutdown conditions during a pump trip may result in a maximum pressure of about 22 psi and minimum pressures of about a negative 5 psi. The LS 31 force main discharges into the LS 8 force main system. Therefore, the maximum pressures along the LS 31 force main occur when the LS 8 force main system is experiencing maximum head conditions of approximately 55 feet. During these maximum head conditions, however, pressures at LS 31 do not change significantly during a pump trip because the pressurized LS 8 force main buffers the pressures. The minimum pressure of negative 5 psi occurs when the LS 8 force main is not surcharge (when the LS 8 pump are off). The negative pressure is not low enough to cause cavitation, so surge mitigation measures appear to be unnecessary at LS 31. However, the analysis should be refined during the final design stages to verify the preliminary analysis results.

4.5 Lift Station Components

The major lift station components for each station are described in more detail in the following paragraphs.

4.5.1 Lift Station 3

Site Access

The existing Lift Station 3 is located on County owned property within the Silverdale Water Front Park, just west of Washington Avenue NW and south of NW Byron Street. The parcel fronts a beach associated with Dyes Inlet and storm water runoff from the station flows directly into Dyes inlet. Access to the station is achieved via a paved driveway off the southern end of Washington Avenue NW. The driveway entrance will be improved as part of the Bay Shore Pipeline project. The upgrades to the station will be designed to minimize impacts to those street improvements.

The proposed station will be located north of LS 3's current location, abutting the parking lot. The County's largest vactor truck (approximately 40 feet in length) will require a turn radius of approximately 55 feet to maintain an unobstructed turn. However, in considering the joint use of the area by park attendees, a smaller turn radius of 30-feet may be feasible, even though that would require the vactor truck to make a two or three multi-point turn to maneuver in and out of the lift station site. Another consideration that would need to be negotiated with the Port of Silverdale would be to construct a through access way whereby vactor trucks enter the site from Washington Avenue NW and exit via the parking lot to the north of the station (or vice versa). Further consideration of this topic will be given during the design phase of the project.

Finished Site Restoration

Kitsap County Code (KCC) 17.500.025 requires that at least 15 percent of the total site area be landscaped and KCC 17.500.027.A.2 requires a partial visual buffer or separation of uses from streets and other compatible uses. In addition, KCC 17.500.060 requires building façade plantings to cover at least two thirds of the horizontal distance of exterior walls with a minimum of four-foot-wide planting areas containing shrubs, ground cover, and/or trees. The station lies within the shoreline buffer area, which will also require additional landscaping and mitigation measures. Finally, the grading and landscaping at LS 3 will need to be coordinated with the Port of Silverdale given their interest in the Project and the Project's location within the Silverdale Waterfront Park. A combination of asphalt or stamped concrete and vegetative landscaping is anticipated. Figure 4-17 through Figure 4-23 depict potential concepts for the restoration at LS 3. Final quantities and locations of pervious and impervious surfaces will be determined during final design.

Wet Well, Valve Vault and Accessories

The wet well proposed for LS 3 will be a cast-in place 20'L x 16'W x 22'D rectangular structure. Access into the structure will be achieved via three aluminum access hatches that are flush with the top slab. Each hatch will be located over a submersible pump to provide direct access to that pump. The wet well's top slab will be flush with the surrounding area and slightly sloped toward the beach to the south to direct site drainage towards Dyes Inlet. A wet well depth of 22 feet will allow the inlet sewers to be located above the 3-foot operating flow depth to avoid sewage backing into the gravity sewers during normal operation, which could lead to deposition of solids and grease in the inlet pipes. A 3-foot operating depth would minimize pump cycling to four to six pump cycles each hour (one to two starts per pump based on alternating each pump).

The exterior of the wet well will be coated with a high solids epoxy (Tnemec 141 Epoxoline or accepted equal) to seal the structure and inhibit ground water from seeping through the concrete walls and impacting the interior coating system. The inside of the wet well is proposed to be coated with a 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide released from the wastewater. To counteract buoyancy uplift forces, the wet well will include a thickened and/or extended base slab.

The discharge piping check and isolation gate valves as well as the flow meter will be in an above grade room within the control building. Locating this equipment inside the control building will provide better access for maintenance without the need to deal with confined space entry issues. The inside dimensions of the valve room will be about 26'W x 16'L, which will also provide space for the backup generator. Since the piping and valves will be above ground in the room, two air-vacuum valves will be needed to allow accumulated air to escape the system.

Based on a recent discussion with County maintenance staff, consideration will be given during the design phase to isolate the generator from the isolation and check valves to prevent liquids spraying on to the generator when the valves are maintained. This may require a larger building.

Accessories in the wet well such as supports, bolts, and fasteners will be 316 stainless steel due to the corrosive and damp environments. In addition, all embedded anchors or fasteners shall be 316 stainless steel regardless of their locations. Consistent with other County lift stations, the wet well will not include a permanent ladder affixed to the structure for access. Pipe stands, supports, bolts and fasteners for the piping and valves inside the control building will be galvanized.


PARKING LOT & CENTRAL KITSAP FARMER'S MARKET
WASHINGTON AVE
BAY SHORE & WASHINGTON PROPOSED IMPROVEMENTS
SILVERDALE WATERFRONT PARK
EXISITING UTILITY EASEMENT AREA
PROPERTY BOUNDARY
OUTDOOR SHOWER OPTIONS
WET WELL SPACE
PRIMARY GATHERING SPACE
TO BOAT LAUNCH
EXISTING SEWER PUMP STATION BUILDING (TO BE DEMOLISHED)
BEACH ACCESS
SECONDARY GATHERING SPACE
TANK (TO BE REMOVED)
ORDINARY HIGH WATER LEVEL
LEGEND
MITIGATION
BAYSHORE IMPROVEMENTS
RESTORATION LANDSCAPING
SCREENING
GRASS
TRAFFIC FLOWPATH
Scale: 1" = 10'
0' 10' 20'
N
CONCEPT 1 - MAX LANDSCAPE & PLAZA
2/25/2019
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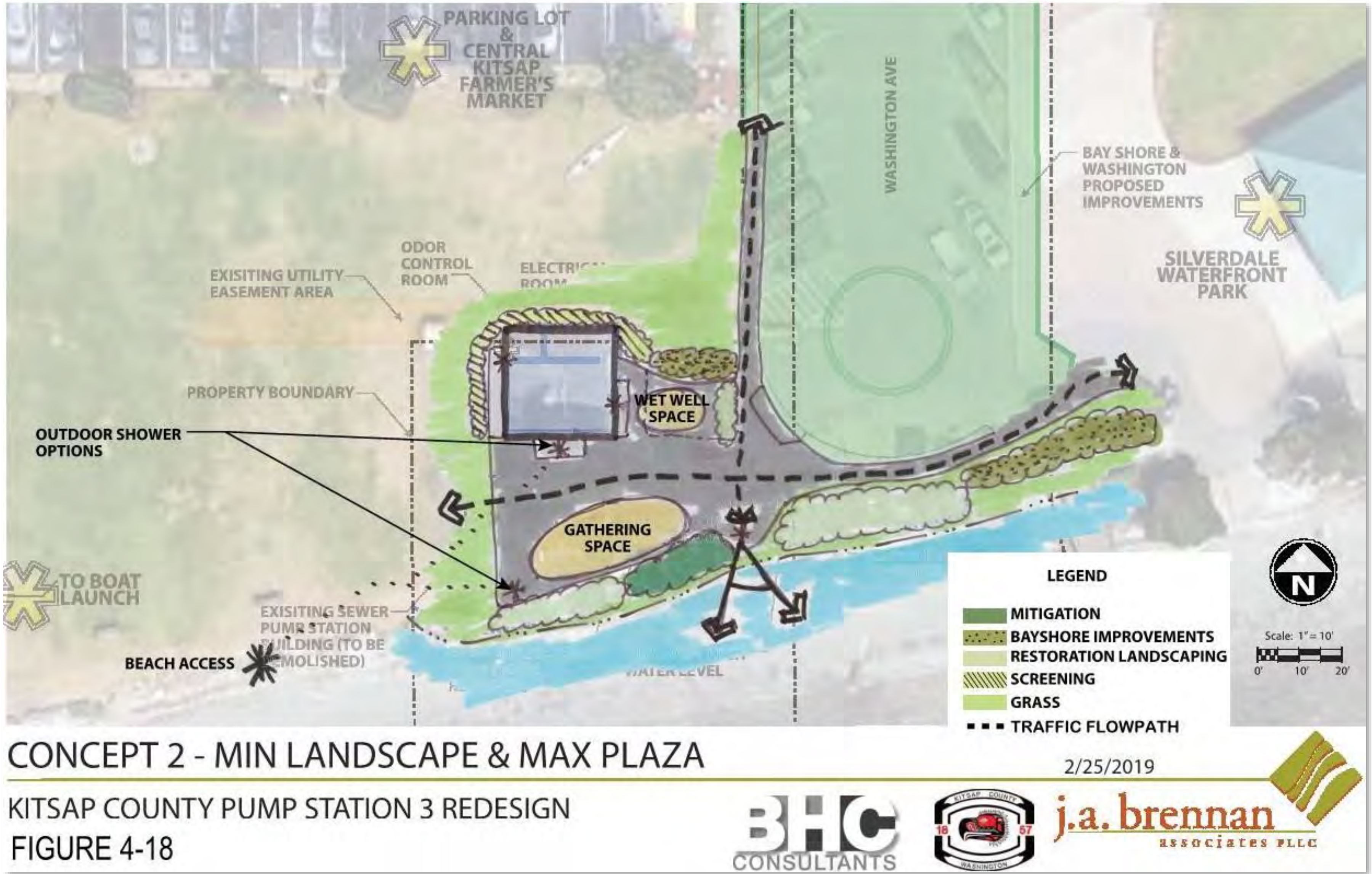
FIGURE 4-17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WASHINGTON AVE
BAY SHORE & WASHINGTON PROPOSED IMPROVEMENTS
SILVERDALE WATERFRONT PARK
ODOR CONTROL ROOM
EXISITING UTILITY EASEMENT AREA
PROPERTY BOUNDARY
WET WELL SPACE
OUTDOOR SHOWER OPTIONS
GATHERING SPACE
TO BOAT LAUNCH
EXISITING SEWER PUMP STATION BUILDING (TO BE DEMOLISHED)
BEACH ACCESS
LEGEND
MITIGATION
BAYSHORE IMPROVEMENTS
RESTORATION LANDSCAPING
SCREENING
GRASS
TRAFFIC FLOWPATH
N
Scale: 1" = 10'
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CONCEPT 2 - MIN LANDSCAPE & MAX PLAZA
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FIGURE 4-18

CONCEPT 3 - MIN LANDSCAPE & PLAZA OPTION A

2/25/2019

KITSAP COUNTY PUMP STATION 3 REDESIGN
FIGURE 4-19

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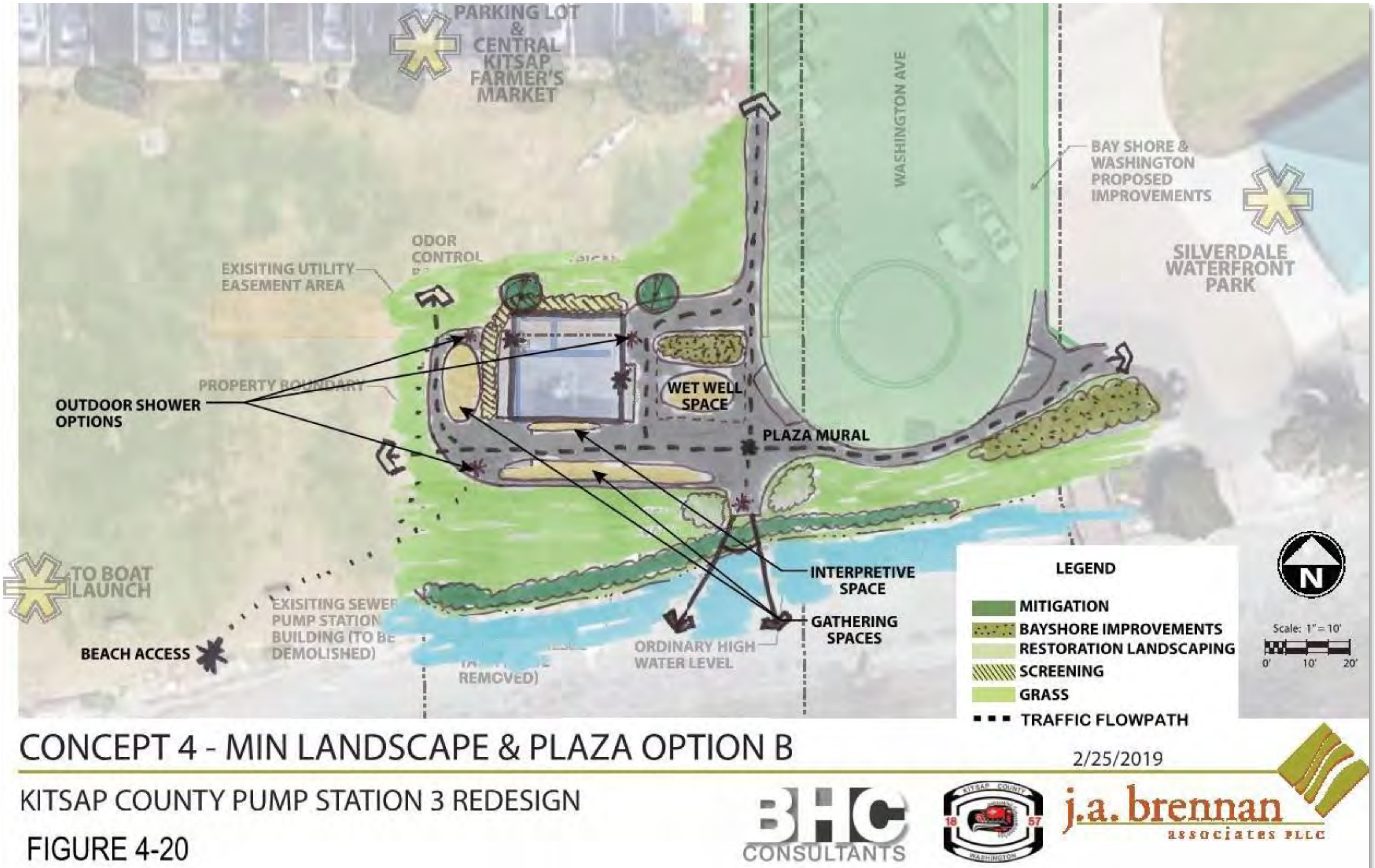
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PLAZA MURAL
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BEACH ACCESS
ORDINARY HIGH WATER LEVEL
INTERPRETIVE SPACE
GATHERING SPACES
LEGEND
MITIGATION
BAYSHORE IMPROVEMENTS
RESTORATION LANDSCAPING
SCREENING
GRASS
TRAFFIC FLOWPATH
N
Scale: 1" = 10'
0' 10' 20'
CONCEPT 4 - MIN LANDSCAPE & PLAZA OPTION B
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FIGURE 4-20


PARKING LOT & CENTRAL KITSAP FARMER'S MARKET
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SILVERDALE WATERFRONT PARK
EXISITING UTILITY EASEMENT AREA
ODOR CONTROL ROOM
ELECTRICAL ROOM
PROPERTY BOUNDARY
TYPE 1: PATH PAVING
TYPE 3: PLAZA MURAL
TYPE 2: ACTIVITY SPACE PAVING
ASPHALT
TO BOAT LAUNCH
EXISITING SEWER PUMP STATION BUILDING (TO BE DEMOLISHED)
EXISITING DIESEL TANK (TO BE REMOVED)
ORDINARY HIGH WATER LEVEL
N
Scale: 1" = 10'
0' 10' 20'
PAVING PATTERN EXPLORATION A
2/25/2019
KITSAP COUNTY PUMP STATION 3 REDESIGN
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FIGURE 4-21


PARKING LOT & CENTRAL KITSAP FARMER'S MARKET
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SILVERDALE WATERFRONT PARK
EXISITING UTILITY EASEMENT AREA
ODOR CONTROL ROOM
ELECTRICAL ROOM
PROPERTY BOUNDARY
TYPE 1: PATH PAVING
ASPHALT PAVEMENT
TYPE 2: ACTIVITY SPACE PAVING
TO BOAT LAUNCH
EXISITING SEWER PUMP STATION BUILDING (TO BE DEMOLISHED)
EXISITING DIESEL TANK (TO BE REMOVED)
ORDINARY HIGH WATER LEVEL
Scale: 1" = 10'
0' 10' 20'
PAVING PATTERN EXPLORATION B
2/25/2019
KITSAP COUNTY PUMP STATION 3 REDESIGN
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FIGURE 4-22

PAVING PATTERN EXPLORATION C

2/25/2019

KITSAP COUNTY PUMP STATION 3 REDESIGN

FIGURE 4-23

BHC CONSULTANTS

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Odor Control Facilities

Odors at LS 3 are a significant concern, given the station's location within the Silverdale Waterfront Park. The park is frequently visited by the public and odors at the existing station are a prime source of complaints by the park users. The County currently uses chemicals to control odors. However, for the proposed lift station, more active odor control measures such as a carbon scrubber are anticipated to better protect the public from noxious odors. A carbon scrubber would maintain a slightly negative air pressure within the wet well to keep untreated odors from escaping. The foul air will then be routed through an activated carbon filter before being vented through the roof of the building via piping. The carbon scrubber and associated appurtenances will be in an isolated 8' x 8' room in the control building due to the caustic nature of the chemicals. Actively addressing odors should allow the lift station to operate with minimal odor impact to the public.

Force Main and Gravity Sewer Site Piping

Lift Station 3 will be connected to the existing 14-inch force main that conveys flows to LS 4. Velocities in the force main will be about 4.1 feet per second (fps) with one pump operating and 5.9 fps with two pumps operating in parallel. The force main will exit the control building and connect to the existing force main that is located within an existing easement south of the proposed location of the new control building. The existing force main will then convey the flows along Washington Avenue NW to Bayshore Drive NW and then along Bayshore Drive NW to NW Bucklin Hill Road. At the intersection of Bayshore Drive NW and NW Bucklin Hill Road, the force main turns east and continues along NW Bucklin Hill Road until discharging into LS 4. The total length of the force main is approximately 7,400 feet. A pig launch, located inside the control building near the south wall, will allow County maintenance crews to clean the force main periodically. The pig launch will be configured to also act as a bypass pumping port if necessary.

The upgraded station will receive incoming flows via two gravity sewer systems; an 18-inch gravity sewer from the east (the existing 12" main will be upsized to 18 inches under the Bayshore and Washington Improvements Project) and an existing new 12-inch gravity sewer from the west. Gate valves will be installed on the incoming sewer mains just outside the proposed wet well to allow the wet well to be isolated from the gravity collection system if necessary.

4.5.2 Lift Station 4

Site Access

Lift Station 4 is located on a parcel owned by the County along the north side of NW Bucklin Hill Road and the east side of Fredrickson Road NW. The site slopes down from the northeast corner of the lot to the southwest corner with relatively steep slopes located along the northern and eastern sides of the lot. The station sits on a level pad in the middle of the lot.

Access to the existing station is achieved from Fredrickson Road NW. This access will be maintained under the proposed design to provide access to the control building. The proposed new wet well will require an additional access off Bucklin Hill Road for maintenance. The design may want to consider connecting the two accesses via a loop around the north side of the proposed control building. That would likely require the construction of a retaining wall along the north side of the lot. A retaining wall may also be needed along the east side of the lot, depending on the final grading.

Finished Site Restoration

The new access road to the proposed wet well will require a retaining wall to be installed along the east and north sides of the lot. The County may want to extend the retaining wall along the north side of the property and shift it further north to allow a circular driveway to be constructed around the building to facilitate entering/exiting the site. The retaining wall may impact several trees on the lot depending on its final location and height. All trees that are impacted by construction should be removed and consideration should be given to removing all trees from the site to reduce maintenance requirements from falling debris. The County may want to install screening hedges along the north and east property lines to better isolate the station from surrounding properties. Final quantities and locations of pervious and impervious surfaces will be determined during final design.

The site also has a tall hedge along the south property line that acts as a visual screen between the station and NW Bucklin Hill Road. This hedge will need to be removed to facilitate construction of the proposed improvements. The hedge may be replaced (laurel has been recommended) after all below ground facilities have been installed to restore screening of the station from traffic along NW Bucklin Hill Road. All new hedges should be provided with irrigation for the first two years to aid establishment.

Wet Well, Valve Vault and Accessories

The wet well proposed for LS 4 will be a cast-in-place 34'L x 20'W x 30'D rectangular structure. Access into the structure will be achieved via three aluminum access hatches that are flush with the top slab. Each hatch will be located over a submersible pump to provide direct access to that pump. The wet well's top slab will be raised slightly above the finished grade of the surrounding area to direct site drainage away from the openings. A wet well depth of 30 feet will allow the inlet sewers to be located above the operating flow depths to avoid sewage backing into the gravity sewers during normal operation. A 3-foot to 4-foot operating depth would minimize pump cycling to four to six pump cycles each hour (one to two starts per pump based on alternating each pump).

The discharge piping check and isolation gate valves will be in the first below ground room (mezzanine level) inside the existing dry well. The bottom floor of the existing dry well will be filled with sand or controlled density fill (CDF) after the existing pumps have been removed. Locating this equipment inside the existing dry well will provide better access for maintenance without the need to deal with confined space entry issues and will better utilize existing infrastructure. High points where air may accumulate on the proposed piping will be avoided so no air-vacuum valves are required.

Based on a recent discussion with County maintenance staff, consideration will be given during the design phase to isolate the generator from the isolation and check valves to prevent liquids spraying on to the generator when the valves are maintained. This may require a larger building.

Accessories in the wet well such as supports, bolts, and fasteners will be 316 stainless steel due to the corrosive and damp environments. In addition, all embedded anchors or fasteners shall be 316 stainless steel regardless of their locations. Consistent with other County lift stations, the wet well will not include a permanent ladder affixed to the structure for access. Pipe stands, supports, bolts and fasteners for the piping and valves inside the control building will be galvanized.

The exterior of the wet well will be coated with a high solids epoxy (Tnemec 141 Epoxoline or accepted equal) to seal the structure and inhibit ground water from seeping through the concrete walls and impacting the interior coating system. The inside of the wet well is proposed to be coated with a 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide released from the wastewater. To counteract buoyancy uplift forces, the wet well will include a thickened and/or extended base slab. In addition, the existing wet well will need to be cleaned and coated with Raven 405 or accepted equal after all necessary modifications have been completed. All interior walls of the dry well spaces to be retained need to be repainted with an appropriate coating.

Odor Control Facilities

The existing station has a biofiltration bed to treat odors at the station. Biofiltration beds require the filtration material to be replaced periodically as the material breaks down. As that breakdown occurs, the perforations in the pipe can become clogged, requiring the pipe to be replaced as well. In addition, the media must be kept moist to work effectively. Conversations with the County have indicated that this means of addressing odors has been effective, although some reservations regarding the effort required to maintain the beds were expressed by the maintenance staff.

The proposed wet well will be constructed within the footprint of the existing biofiltration bed. Therefore, the biofiltration bed would need to be relocated or replaced with a different means of treating odors. Relocating the biofiltration bed to another part of the site would require additional grading and an extension of the retaining walls proposed for the east access driveway. The construction and operating costs of relocating the filter beds should be compared to the installation and maintenance costs of a chemical additions system or carbon scrubber to determine the preferred method of odor treatment. Further investigation of this issue during the design phase is needed.

Force Main and Gravity Sewer Site Piping

Lift Station 4 will be connected to a new 20-inch force main that will convey flows east along NW Bucklin Hill Road. Velocities in the force main will be about 2.8 feet per second (fps) with one pump operating and 4.7 fps with two pumps operating in parallel. The total length of the force main is approximately 1,570 feet. A pig launch located near the northwest corner of the control building will allow the County to clean the force main periodically. The pig launch will be configured to also act as a bypass pumping port if necessary. As previously mentioned, SSMH J18 near the intersection of Spinnaker Blvd NW and NW Bucklin Hill Road should be replaced with a new air/vacuum valve station.

The existing station receives incoming flows via a 15-inch gravity sewer that is located within Fredrickson Road NW. When LS 4 is upgraded, the 15-inch sewer from Fredrickson Road NW to the existing wet well will be replaced with a 24-inch main. The 24-inch gravity sewer will be routed between the existing wet well and NW Bucklin Hill Road to a new manhole off the south side of the proposed wet well. Gravity sewer flows from the east will discharge into this manhole as well. The combined flow will then enter the proposed wet well from the south via a 24-inch diameter main. A gate valve will be installed on the 24-inch gravity sewer entering the proposed wet well to allow the station to be isolated from the gravity collection system if necessary.

Overflow piping will be added between the new wet well and the existing wet well to allow the existing wet well to operate as overflow storage. The overflow pipe will be located high in the wet wells and will include a tee within the existing wet well to facilitate cleaning. A lower pipe between the existing and proposed wet wells will include a duck bill type check valve (Red Valve Tide Flex valves or accepted equal) on the pipe end within the proposed wet well to prevent sewage from backing up into the existing wet well during normal operation. The lower pipe will allow sewage to drain from the existing wet well into the proposed wet well where the new pumps will deliver it downstream.

4.5.3 Lift Station 19

Site Access

Lift Station 19 is located on a parcel owned by the County north of the intersection of NW Bucklin Hills Road and Nels Nelson Road NW. State Route 303 borders the parcel to the north and a storm water detention pond sits along the west side of the parcel. The site slopes down from the west to the east with runoff directed to drainage ditches along the south side of the parcel.

Access to the site is achieved via a driveway off the north side of the intersection. Kitsap County Roads Division has plans to upgrade this intersection with a signal light. The access driveway may need to be relocated slightly to coincide with the light controlled intersection. The lift station access would also be used to provide maintenance access to the storm water detention pond. Adequate space in the shape of a hammerhead should be allocated to allow the County's largest vactor truck to access the wet well and to turn around onsite without backing into NW Bucklin Hills Road. This may be accomplished by constructing a paved area along the east side of the proposed building. Based on discussions with the Roads Division, construction of the Nels Nelson Intersection improvements appears to be delayed until after the PS 19 upgrades are completed. Ongoing coordination with the Roads Division will still be required as the pump station upgrades are designed to ensure the needs of all parties are addressed.

Finished Site Restoration

Extensive landscaping at LS 19 is not anticipated. Disturbed areas will be restored with hot mixed asphalt for the access roads/driveways and grass. Vegetative plantings other than grass are not envisioned, although the County may want to consider a screening hedge along the south property line adjacent to the sidewalk. The site has a wetland located along its eastern edge, so disturbances to that wetlands buffer would trigger some mitigation planting. No construction within the wetland is anticipated. Final quantities and locations of pervious and impervious surfaces will be determined during final design.

Wet Well, Valve Vault and Accessories

The existing wet well will be reused to house the proposed submersible pumps. The existing wet well is a 20'L x 12'W x 20'D (inside dimensions) rectangular concrete structure. Access to the pumps inside the existing wet well will be achieved via three aluminum access hatches that are flush with the top slab. To accommodate the new hatches, the existing top slab will be removed, and a new concrete top slab poured. Each hatch will be located over a submersible pump to provide direct access to that pump. The new top slab will be raised slightly above the finished grade of the surrounding area to direct site drainage away from the openings. The existing wet well depth of 20 feet will allow the inlet sewers to be located above the operating flow depths to avoid sewage backing into the gravity sewers during normal operation. A 3-foot operating depth would minimize pump cycling to three to six pump cycles each hour (one to two starts per pump based on alternating each pump). The inside of the wet well will be sand blasted to remove loose debris and to prepare the surface for new coat of 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide released from the wastewater.

The discharge piping check and isolation gate valves as well as the flow meter will be in an above grade room within the control building. Locating this equipment inside the control building will provide better access for maintenance without the need to deal with confined space entry issues. The inside dimensions of the valve room will be about 18'W x 22'L, which will also provide space for the backup generator and the pig launch. Since the piping and valves will be above ground in the room, two air-vacuum valves will be needed to allow accumulated air to escape the system. Separate 8'W x 14'L electrical room will be located east of the valve room and will be used to house the electrical control panels and equipment.

Based on a recent discussion with County maintenance staff, consideration will be given during the design phase to isolate the generator from the isolation and check valves to prevent liquids spraying on to the generator when the valves are maintained. This may require a larger building.

Accessories in the wet well such as supports, bolts, and fasteners will be 316 stainless steel due to the corrosive and damp environments. In addition, all embedded anchors or fasteners shall be 316 stainless steel regardless of their locations. Consistent with other County lift stations, the wet well will not include a permanent ladder affixed to the structure for access. Pipe stands, supports, bolts and fasteners for the piping and valves inside the control building will be galvanized.

Odor Control Facilities

Per discussions with the County, odors are not an issue at the current station. However, a desire was expressed to include a separate room in the proposed control building to facilitate future odor control facilities should odors become an issue. Therefore, a separate 8' x 8' room has been added to the northeast corner of the control building.

Force Main and Gravity Sewer Site Piping

Lift Station 19 will be connected to two force mains. The station's primary force main is a 14-inch main that exits the site to the north under State Route 303 (Waaga Way). This main is approximately 8,320 feet long and travels north along Nels Nelson Road NW to NW Paulson Road where it turns east. The force main continues along NW Paulson Road to Kelly Court NE where it joins with the force mains from LS 4, LS 6, and LS 7. Velocities in the 14-inch main will be 2.3 fps with one pump operating and 3.8 fps with two pumps operating. The second force main connection is to the south of the station and involves connecting to the force main from LS 4. The existing pumps may cavitate when discharging into LS 4's force main, which is why the preferred mode is to pump north through the 14-inch force main. During the design phase, the potential for cavitation at the upgraded station when pumping into the LS 4 force main will need to be reviewed. The upgraded station will include a pig launch, located inside the valve room near the southeast corner of the room. The pig launch will allow the County to clean the 14-inch force main and has fittings to allow it to act as a bypass pumping port if necessary.

The station receives incoming flows via two gravity sewer systems; a 12-inch PVC gravity sewer from the north and an 8-inch gravity sewer from the west. Isolation valves just outside the existing wet well will be added to each main to allow the wet well to be isolated from the gravity collection system if necessary.

4.5.4 Lift Station 31

Site Access

Lift Station 31 is located on an easement off a cul-de-sac at the end of NE Clover Blossom Lane. The cul-de-sac also provides access to several homes. The site slopes down from southeast to northwest with runoff eventually flowing into a deep ravine to the north of the station. Access to the site is via NE Clover Blossom Lane and the cul-de-sac. The cul-de-sac has sufficient area for the County's largest vactor truck to turn around.

Finished Site Restoration

Opportunities for adding vegetation are limited due the size of the County's easement and the County's desire to minimize landscape maintenance. Therefore, disturbed areas will be restored with hot mixed asphalt, gravel, and grass to match the existing conditions. Final quantities and locations of pervious and impervious surfaces will be determined during final design.

Wet Well, Valve Vault and Accessories

The wet well and valve vault proposed for LS 31 will be precast concrete structures. Access to each will be through H-30 load rated aluminum access hatches flush with the top slab of the precast structure. The top slab of the structures will project slightly above surrounding finished grade to direct site drainage away from the hatch openings. The wet well will have an 8-foot inside diameter to accommodate a duplex pumping configuration and will be of adequate depth to prevent excessive pump cycling. The wet well will have a depth of about 15 feet, which will allow the inlet sewer to be located above the operating flow depths to avoid sewage backing into the gravity sewers during normal operation. A 3-foot to 4-foot operating depth would minimize pump cycling to two to four pump cycles each hour (one to two starts per pump based on alternating each pump).

The valve vault is sized to house the discharge piping check and isolation gate valves and the flow meter, while providing adequate working space in the vault for maintenance. The inside dimensions of the precast vault will be 7'L x 5.5'W x 8'D. The valve vault will be equipped with a sump pump to discharge accumulated drainage back to the wet well. A gravity drain cannot be used due to the shallow wet well depth.

The exterior of the wet well and valve vault structures will be coated with a factory applied high solids epoxy (Tnemec 141 Epoxoline or accepted equal) to seal the structures and inhibit ground water from seeping through the concrete walls and impacting the interior coating system. The inside of the wet well is proposed to be coated with a 2-part epoxy (Raven 405 or accepted equal) to protect the structure from corrosive hydrogen sulfide released from the wastewater. Consistent with other County lift stations, the interior of the valve vault will also be coated with a high solids epoxy. To counteract buoyancy uplift forces, the wet well and valve vault will likely include thickened and/or extended bases.

Accessories in the wet well and valve vault such as supports, bolts, and fasteners will be 316 stainless steel due to the corrosive and damp environments. In addition, all embedded anchors or fasteners shall be 316 stainless steel regardless of their locations. Consistent with other County lift stations, the wet well will not include a permanent ladder affixed to the structure for access. The valve vault will include an aluminum ladder to facilitate access.

Odor Control Facilities

While odors are not anticipated to be an issue at this station, per discussions with the County, a goose-neck vent with a carbon canister similar to the design used at LS 74 (Yukon Harbor Lift Station) will be installed at the station.

Force Main and Gravity Sewer Site Piping

Lift Station 31 will pump southwest through a new 4-inch PVC or HDPE force main for approximately 125 feet. At that point, it will connect to LS 8's 12-inch PVC force main, which runs north along Clover Blossom Way NE to NE John Carlson Road. At NE John Carlson Road, the 12-inch force main discharges into a 15-inch gravity sewer. The velocity of the sewage in the 4-inch main will be 3.7 fps.

Two gravity sewers discharge into the existing wet well; an 8-inch pipe from the southwest and an 8-inch pipe from the northeast. Once the new station is ready to be placed into service, the existing wet well will be channeled to direct the flow from both sewers into a single 8-inch inlet into the new wet well. An isolation valve will be installed on the new 8-inch inlet to allow the wet well to be isolated from the gravity collection system if necessary.

4.5.5 Onsite Piping

All force main piping between the pumps and the pig launches at LS 3, LS 4, and LS 19 will be ductile iron lined with Protecto 401 Ceramic Epoxy or accepted equal. The force main piping between the pumps and the downstream side of the valve vault at LS 31 will also be ductile iron lined with Protecto 401 Ceramic Epoxy or accepted equal. Once the piping exits the pig launch or valve vault, the force main material will change to PVC or HDPE. Minimum cover for the force main will be 3.5 feet. New gravity sewer piping will consist of PVC gravity sewer main with a minimum cover of 5 feet.

4.5.6 Water and Natural Gas Service Site Piping

New hose bibs will be provided at LS 3, LS 4, and LS 19. The hose bibs will be located inside the control building in the valve/generator room or on the outside of the building adjacent to the wet well. Each water service will consist of a high-density polyethylene service line with a new water meter and reduced pressure backflow preventer upstream of the hose bib. Exposed piping will need to be protected from freezing temperatures. A water supply will be routed to automatic trap primers located in the control buildings to supply water to P-traps in the floor drains. The exact location of service connections and the water meter will need to be coordinated with the local water purveyor during final design.

No hose bib will be provided at LS 31, as this station does not currently have an existing water service and the station is small enough that a new service is not required. The cost of installing a new service would likely exceed the benefits the service would provide.

The generators will likely be diesel powered, hence natural gas service lines would not be required. If natural gas generators are selected for any of the lift stations, (see Section 4.6.2 for further discussions regarding standby power generators), a polyethylene service line and associated meter would need to be installed from the existing gas main to the standby generator . The exact location of the service connection and gas meter would need to be coordinated with Cascade Natural Gas during final design.

4.6 Control Building

4.6.1 Building Construction

Lift Stations 3, 4, and 19 will include new control buildings with separate rooms to house the standby generators/pumps, electrical equipment, and odor control equipment. The buildings will be designed in accordance with the 2015 or 2018 edition of the Washington State Building Code (IBC 2015). Permit applications that are made after July 2020 will need to comply with the 2018 edition. The Occupancy Group of all three rooms is U. The control building will be classified as Construction Type V-A, which allows both combustible and non-combustible materials. The exterior walls of each structure will be 1-hour rated. A 1-hour separation between each room will be provided by Concrete Masonry Unit (CMU) partitions and a gypsum board ceiling applied to the underside of the roof trusses. The roof assembly does not need to be fire rated construction.

Each building is divided into three rooms: a valve/emergency generator room, the electrical control room, and an odor control room. Access to the valve/generator room is from the exterior by means of a double door, centered on the emergency generator/pump. Access to the electrical room may be from the exterior through a single door or from the valve/generator room via a single door. Large sound attenuated intake and exhaust louvers will be provided for each generator. The louvers may need fire dampers depending on size, location, and distance to property lines. Heating and/or cooling each building will require each building to meet the Washington State Energy Code. The exterior walls will require R-21 insulation on the inside of the CMU with a fiberglass reinforced plastic (FRP) panel finish. The ceiling will be insulated with R-30 batt insulation in the attic.

The proposed construction anticipates using CMU walls with a wood truss framed roof topped by APA (The American Wood Association) rated sheathing (plywood or Oriented Strand Board (OSB)) and a standing seam metal roofing. CMU is selected for its durability and low maintenance. The CMU will be 8 inches thick, fully grouted and reinforced, supported on 8-inch thick reinforced concrete stem walls that bear on reinforced concrete strip footings. All floors will be at least 6 inches thick reinforced concrete, except where thickened at free edges around generator foundations. The CMU walls may have a split faced surface with integral color that does not need painting. Interior walls may need to be insulated to comply with energy codes. Exterior fascia, soffits, and trim may be pre-finished metal to minimize painted surfaces. The generators will be supported on isolated concrete foundations sized to minimize resonance and isolated from the surrounding floor to minimize transmission of vibration that would occur with direct contact between the foundation and the surrounding slab. The architectural appearance details for each building will be determined during final design. For LS 3, the architectural details will also need to be coordinated with the Port of Silverdale due to the station's location within the Silverdale Waterfront Park.

No building is anticipated at LS 31. However, a canopy-type structure will be designed to provide some protection from the weather for the control panels.

4.6.2 Building Heating, Ventilating, and Air Conditioning (HVAC)

The control buildings have three separate spaces, each with different HVAC requirements. The generator rooms will have electric unit heaters to be utilized in the winter months for freeze protection purposes. The heating setpoint for this space will be set to 45-50 degrees Fahrenheit (°F). Sound lined ductwork will be connected to the discharge of each generator's radiator and will be terminated at acoustical exhaust louvers. Acoustical intake louvers with motorized control dampers will also be installed in the space to provide make-up air for when each generator is in operation. Exhaust piping with critical grade silencers will be attached to the generators and routed to the roof above to discharge the engine exhaust. The electrical rooms and odor control rooms will maintain a cooling setpoint of 78°F and heating setpoint of 45-50°F through use of a split-system heat pump; protecting the equipment against overheating and potential freezing. The walls and ceiling will need to be insulated to comply with energy codes.

4.6.3 Building Plumbing

Each room in each control building will contain a floor drain with a P-trap piped to the wet well. The P-traps will be supplied by a trap primer to prevent sewer gas from the wet wells from entering the building.

4.7 Electrical, Instrumentation, and Controls

4.7.1 Motors and Connections

The new pumps at Lift Stations 3, 4, and 19 will have variable frequency drives (VFD). Oversized junction boxes with cable splice kits (aluminum with rubber gasket covers) adjacent to each wet well will provide easy disconnection and removal of the pumps. Table 4-10 identifies the rated horsepower (hp) for each pump as well as the associated fuel storage requirements.

Table 4-10
Rated Motor Horsepower

Lift Station	Rated Horsepower	Generator Size	Fuel Storage
LS 3	160 hp	400 kW	700 gal
LS 4	250 hp	600 kW	1,200 gal
LS 19	70 hp	200 kW	400 gal
LS 31	3.2 hp	N/A	N/A

4.7.2 Standby Power

Lift Stations 3, 4, and 19 will be equipped with standby generators to power the stations during utility service outages. Per County request, the generators are sized to power each lift station in a buildout condition with the largest pump out of service. Since these stations are triplex stations, the generators are sized to operate two pumps during an outage. The generators will share a room within control building with the check valves, isolation valves, and flow meters, but isolated from the electrical distribution panels. The generator and automatic transfer switch will include alarms, status monitoring, windings heaters, engine block heater, and battery charger. Due to their size, all three generators will likely be diesel driven generators. The fuel storage systems should be designed to provide 24 hours of operation at full engine generator load with fuel monitoring and leak detection systems.

Storing more than 667 gallons (2,500 liters) of fuel indoors triggers additional fire suppression requirements. Therefore, fire suppression equipment for an indoor tank or an outdoor fuel storage tank would be needed at Lift Stations 3 and 4. An underground outdoor fuel tank would be typical with public use spaces such as Lift Stations 3 and 4 and would need fuel transfer and fuel monitoring systems. The cost of the fire suppression equipment or an outdoor fuel storage tank with associated transfer and monitoring systems exceeds the benefits of 37 gallons of additional fuel storage at LS 3. Therefore, this report recommends using a subbase tank under the generator with a fuel storage capacity of 660 gallons, even though this would not provide a full 24 hours of operation at full engine generator load. A subbase tank located beneath the generator would be sufficient at LS 19.

Natural gas generators could be used at LS 3 and LS 19, but they would be more expensive at the anticipated capacities. The County will need to consider the additional costs versus the benefits of not needing to access the lift stations with diesel trucks for refueling. Natural gas generators also tend to be less noisy, which would be a benefit for community enjoyment of the public space around LS 3. A decision regarding natural gas versus diesel generators should be made early as part of the final design efforts.

Another option involves installing backup diesel driven pumps at LS 3, 4, and 19 instead of standby generators. Backup diesel pumps would have their own mechanical and controls, providing additional redundancy. Further redundancy could be including a receptacle for a portable generator in addition to the diesel pump. Table 4-11 provides a summary of the advantages and disadvantages of a diesel backup pumps, diesel generators, and natural gas generators.

Table 4-11
Standby Power Source Comparison

	Diesel Pumps	Diesel Generators	Natural Gas Generators
Advantages	▪ Redundant mechanical and control systems ▪ Generator receptacle in addition to diesel pump provides further redundancy ▪ Diesel engine not required to meet Tier 4 emission standards (Tier 3 is acceptable due to pumps emergency use designation) ▪ May be used for bypass pumping during routine maintenance of electrical driven pumps	▪ Generator may be tested without affecting station operation ▪ Successfully implemented at other County lift stations leading to maintenance crew familiarity	▪ Generator may be tested without affecting station operation ▪ Successfully implemented at other County lift stations leading to maintenance crew familiarity ▪ Does not require refilling of fuel source ▪ Often requires less noise attenuation as natural gas generators are quieter than diesel generators
Disadvantages	▪ Additional pump and control system to maintain ▪ Suction lift considerations can complicate design ▪ Requires additional piping and valves ▪ Requires time to prime the pump ▪ Requires a diesel storage tank, which could trigger additional fire suppression requirements ▪ Requires diesel truck to refill diesel tank	▪ May require larger footprint in building ▪ Does not provide contingency in event of a pump or pump control failure ▪ Requires a diesel storage tank, which could trigger additional fire suppression requirements ▪ Requires diesel truck to refill diesel tank ▪ Requires an automatic transfer switch	▪ May require larger footprint in building ▪ Does not provide contingency in event of a pump or pump control failure. ▪ Requires natural gas service, which could be subject to interruption during an earthquake.
Equipment Cost	▪ LS3 = $238,500 ▪ LS4 = $244,000 ▪ LS19 =$89,500	▪ LS3 = $99,500 ▪ LS4 = $171,500 ▪ LS19 =$67,500	▪ LS3 = $209,000 ▪ LS4 = $356,500 ▪ LS19 =$122,500

In accordance with the Kitsap County Code 10.28.080, “Sounds created by emergency equipment and work necessary in the interests of law enforcement or for health, safety or welfare of the community” are exempt from all provisions of Section 10.28.040 and 10.28.145, sections which define permissible noise levels. The Kitsap County Department of Community Development Planning and Environmental Programs Division has indicated that the standby generators are not required to meet permissible noise levels set forth in the Kitsap County Code, during emergency operation, as well as routine testing. However, as the generators at each lift station site are close to residences or within a park that is heavily used by the general public, the engine generator rooms will feature sound attenuation to reduce the sound levels of the engine at full loading to approximately 68 decibels at the closest property line. In addition, routine testing of the generators will be conducted by the County during daytime hours as much as possible. The routine testing of each engine generator may not require the engine to operate at full loading, so the actual noise generated may be less. The standby generators will be Cummins Power Generation or Caterpillar Energy Systems.

4.7.3 Electrical Service and Control Panel Equipment

Service power for all four lift stations will be 480/277Y volt, 3-phase, 60 Hertz as available from the electrical utility for electrical loads at each station. This will require an upgrade to the service power at LS 31, since the station is currently operating on 240 single phase power. The control panel equipment cabinets at LS 3, LS 4, and LS 19 will be approximately 90”L x 48”W x 2’D and installed on housekeeping pads inside the electrical rooms to elevate the free-standing electrical equipment. All wall mounted electrical equipment will be at least 12 inches above the slab to promote usability and maintenance access. For LS 31, the control panel and telemetry panels will be pedestal mounted under the proposed canopy.

The control panels will contain the County’s standard Allen-Bradley CompactLogix programmable logic controllers (PLC) to control the pumps and interface with the telemetry system. The control panels will also contain hand-off-auto (H-O-A) switches, speed potentiometers, operator interface graphical terminals, elapsed time meters, pilot lights, wet well level monitoring equipment, pump monitoring relays, power supplies, and relays. The motors are powered through variable frequency drives (VFDs). The VFDs at Lift Stations 3, 4, and 19 will be free standing, MCC style drives. The motor controllers at Lift Station 31 will be enclosed in an electrical panel but separate from the PLC control panel.

The PLC and Supervisory Control and Data Acquisition (SCADA) systems will store historical data including flow, totalized flow, and alarms. This data will be periodically transmitted through the telemetry system to the County.

4.7.4 Telemetry

Telemetry at each lift stations will be communicated via radio to match existing communications. An antenna will extend approximately 20 feet above the ground using a mast supported by the control building or attached to a light pole. At LS 31, the mast will be free standing. Spare conduits will route to the right-of-way for future fiber optic telemetry system upgrades. Each telemetry panel will be the County’s standard arrangement comprised of an Allen Bradley 1400 PLC with Viper CAL-Amp SC-100, 173.3125 MHZ Ethernet radio unit.

4.7.5 Flow Measurement

Each lift station will be equipped with a magnetic flow meter. For LS 3 and LS 19, the flow meters will be above ground in the generator/valve/meter room. At LS 4, the flow meter will be in a below ground utilidor in the generator room. Lift Station 31's flow meter will be in the valve vault. The flow meters for LS 3, LS 4, and LS 19 will have piping and valves that can be manipulated to bypass flows around the flow meter in the event the meter needs to be removed for servicing. At LS 31, a fabricated flanged spool piece (the same length as the flow meter) will be provided, which can be installed in place of the meter should the flow meter require servicing. All four flow meters will be County standard Siemens 5000 series or Krohne Enviromag 2000 series.

4.7.6 Level Measurement

Wet well levels will be measured with submersible pressure transducers. The transducers will be mounted in removable fiberglass stilling wells to allow wet well cleaning. Backup level measurement and pump control will be implemented using float switches. The float switches will also be mounted on removable cables to permit cleaning. Transducers will be the County's standard Evoqua (formerly Siemens) A1000.

4.7.7 Building Monitoring

Door open switches and occupancy sensors will monitor for unauthorized access to the station. The wet well and in-ground utility structures will not have hatch monitoring switches. Additionally, the PLC will monitor the control room temperature and small particulate matter, such as smoke.

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Chapter 5. Easement and Permit Requirements

5.1 Easements

Temporary or permanent easements may need to be acquired to facilitate the upgrades. The following sections provide more information on the specific needs for easements at each lift station.

5.1.1 Lift Station 3

The proposed conveyance piping improvements are located within County ROW and the new lift station is located on County property. However, as discussions proceed with the Port of Silverdale, the station is anticipated to shift about 50 feet north to provide more clearance between the station and the beach along Dyes Inlet for use by the park. Shifting the station north will locate the station on property owned by the Port of Silverdale, so a permanent easement would be necessary for the station. As previously mentioned in Section 4.2.1, this property was purchased with Federal Land and Water Conservation Funds. While recent conversations between the County, RCO, and the National Park Services indicate that shifting the lift station towards the parking lot on property owned by the Port of Silverdale would likely not require further mitigation by the County or the Port of Silverdale, the RCO and National Parks will need the final location and footprint of the upgraded station before that determination can be finalized.

Temporary easements should also be acquired from the Port of Silverdale as needed to facilitate construction of the proposed improvements. The location and size of the temporary easements will need to be determined early in the final design phase to allow the County to include those requirements in the ongoing negotiations with the Port. The Contractor will be responsible for acquiring any additional staging areas beyond the temporary or permanent easement limits.

5.1.2 Lift Station 4 and Lift Station 19

The proposed conveyance piping improvements associated with these two lift stations are located within County ROW and the new lift stations are located on County property. Therefore, new permanent utility easements are not anticipated to be required for the sewer main piping or the lift stations. However, temporary construction easements may need to be acquired from the properties to the north and east of LS 4 to facilitate construction of the retaining walls. The size and extents of those temporary easements will need to be determined once the grading plan and the associated retaining walls for the proposed upgrades are determined during the final design phase. The Contractor will be responsible for acquiring any additional staging areas beyond the temporary or permanent easement limits.

5.1.3 Lift Station 31

The existing station is located on a permanent easement on Tax Lot 4926-000-053. The proposed station is anticipated to remain within the existing permanent easement and the force main will be located within the public right-of-way, so additional permanent easements should not be needed. Temporary construction easements may be needed to facilitate installation of the proposed upgrades. The need for temporary easements and their associated size/extents should be addressed early in the final design phase to allow the County sufficient time to acquire the easements. The Contractor will be responsible for acquiring any additional staging areas beyond the temporary or permanent easement limits.

5.2 Permitting

The following permitting requirements have been compiled based on preliminary project descriptions for each station, review of Kitsap County permit requirements, and experience with similar projects. As the design is finalized, the permitting and regulatory requirements should be confirmed with County and Agency staff.

5.2.1 Site Development Activity Permit

Kitsap County's Site Development Activity Permit (SDAP) provides a mechanism to ensure storm water quality and quantity concerns are addressed prior to site development. An SDAP permit will be required for each lift station. The application is processed by Kitsap County's Department of Community Development. The SDAP will require temporary erosion and sedimentation control plans for construction activities. In addition, the County's permitting agency will review drainage construction plans and other storm water documents for improvements. If additional storm water facilities are required, County personnel will need to inspect them for compliance with the County codes after the facilities have been constructed. This permit would be obtained for each site using the final (100 percent design) contract documents.

5.2.2 Building Permit

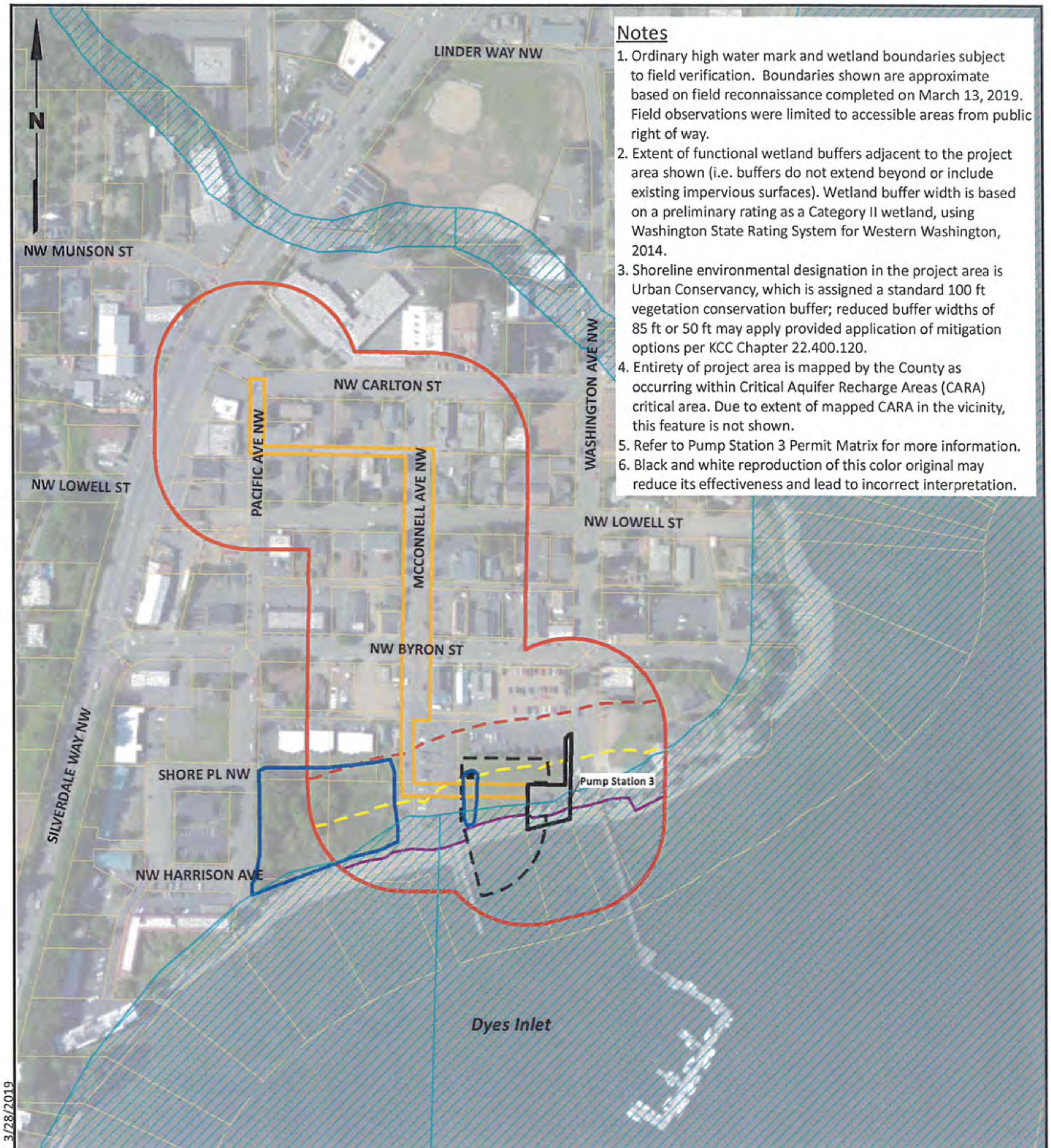
All four lift stations will need building permits to address the proposed control building at LS 3, LS 4, and LS 19 as well as the canopy at LS 31. In addition, the retaining walls at LS 4 will require a separate building permit. Separate permit applications for each site will be made to the Kitsap County Department of Community Development and will need to include final construction design drawings and supporting documents. The County's permitting agency will then review the documents for compliance with the County's codes. These permits will not be issued by the County until the SDAP for each site has been approved and issued.

5.2.3 PSE Application

All four lift stations will need separate applications to Puget Sound Energy (PSE) for revised electrical services. The applications will be made using the 60% design drawings. Once the applications are received, PSE typically takes about two to three months to process them.

5.2.4 Environmental Permits

Landau Associates conducted a preliminary investigation into the environmental permits that will be needed for each station. Their findings are shown on Figure 5-1 through Figure 5-4 and the regulatory issues are summarized in Table 5-1 through Table 5-4 on the following pages. The need for some of these permits will depend on whether the Project financing includes any funds from federal or state sources.



Legend

- Drain
- OHWM
- Conveyance Lines Project Area
- Pump Station Project Area
- Study Area
- Estimated Wetland Boundary
- 100 Year Floodplain
- Tax Parcels
- Shoreline Buffer
- Shoreline Jurisdiction
- Wetland Buffer

0 300 600

Scale in Feet

Data Sources: USFW; Kitsap County GIS; Esri World Imagery.

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LANDAU ASSOCIATES

Kitsap County Pump Station 3 Upgrades Silverdale, Washington	**Lift Station 3** **Environmental Site Features**	Figure 5-1

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Table 5-1
Lift Station 3 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Lift station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Shoreline Management Act	Kitsap County Department of Community Development	"Development" within shoreline jurisdiction (below ordinary high water and extending 200 ft landward).	Project activities within 200 ft of the ordinary high-water line of Dyes Inlet.	▪ Joint Aquatic Resources Permit Application ▪ SEPA Checklist ▪ Shoreline Master Program Consistency Evaluation Narrative ▪ Project plans	Up to 120 days	Depending on the proposed configuration, the project may be considered for "exemption" as normal maintenance or repair of existing structures/developments or would otherwise be considered a "substantial development." Utilities are permitted in the Urban Conservancy shoreline environment; landscaping may be required to satisfy wetland/vegetation conservation buffer requirements. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland buffer and shoreline master program jurisdiction location.
Section 404 Clean Water Act (Waters of the U.S.)	U.S. Army Corps of Engineers	Dredge and/or fill in wetlands, below ordinary high-water line (streams), or mean higher high-water line (tidal waters).	Fill or dredge activity in wetlands. Installation of utility lines using directional drill techniques under wetlands does not require permit.	▪ Joint Aquatic Resources Permit Application ▪ Wetland/Waterways Critical Areas Report	3 to 6 months	Installation of utility lines using directional drill techniques does not require permit. However, if unavoidable wetland impacts occur as a result of utility line installation, authorization under the Nationwide Permit program is likely. The USACE will also require documentation of consultations under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act as part of the State Environmental Review Process (SERP). If SERP does not apply, the application to the USACE would require a no effect determination or a biological assessment and cultural resources investigation report. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland locations.
Critical Areas Ordinance – Wetlands	Kitsap County Department of Community Development	Development in wetlands or associated buffers.	Development in wetland and/or associated buffers.	▪ Wetland/Waterways Critical Areas Report	Concurrent with SEPA review	Installation of utilities using directional drill techniques does not require compensatory mitigation, which would be presented in the critical areas report. Landscaping may be necessary to satisfy wetland/shoreline vegetation conservation buffer mitigation requirements. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for wetland locations.
Critical Areas Ordinance – Frequently Flooded Areas	Kitsap County Department of Community Development	Development in 100-year floodplains.	Lift station improvements.	▪ Evaluation of cut/fill in the floodplain ▪ No effect determination or biological assessment	Concurrent with SEPA review	Any fill above base flood elevation would require mitigation to compensate for volume of flood storage removed. Refer to Figure 5-1 Lift Station No. 3 Environmental Features for mapped floodplain locations.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA.	Hydrogeology report (if needed)	Concurrent with SEPA review	Category II CARA mapped in the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Cross cutter report	Varies, and is contingent on consultations with other agencies.	SERP compliance requires supporting documentation as detailed below, and compliance with Section 404 Clean Water Act and Floodplain Management (i.e., Critical Areas – Frequently Flooded Areas) as identified above.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historic buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance areas occur in the project area.	Completed with SERP	No air quality non-attainment or maintenance areas occur in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act (Essential Fish Habitat)	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and US Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment.	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance.		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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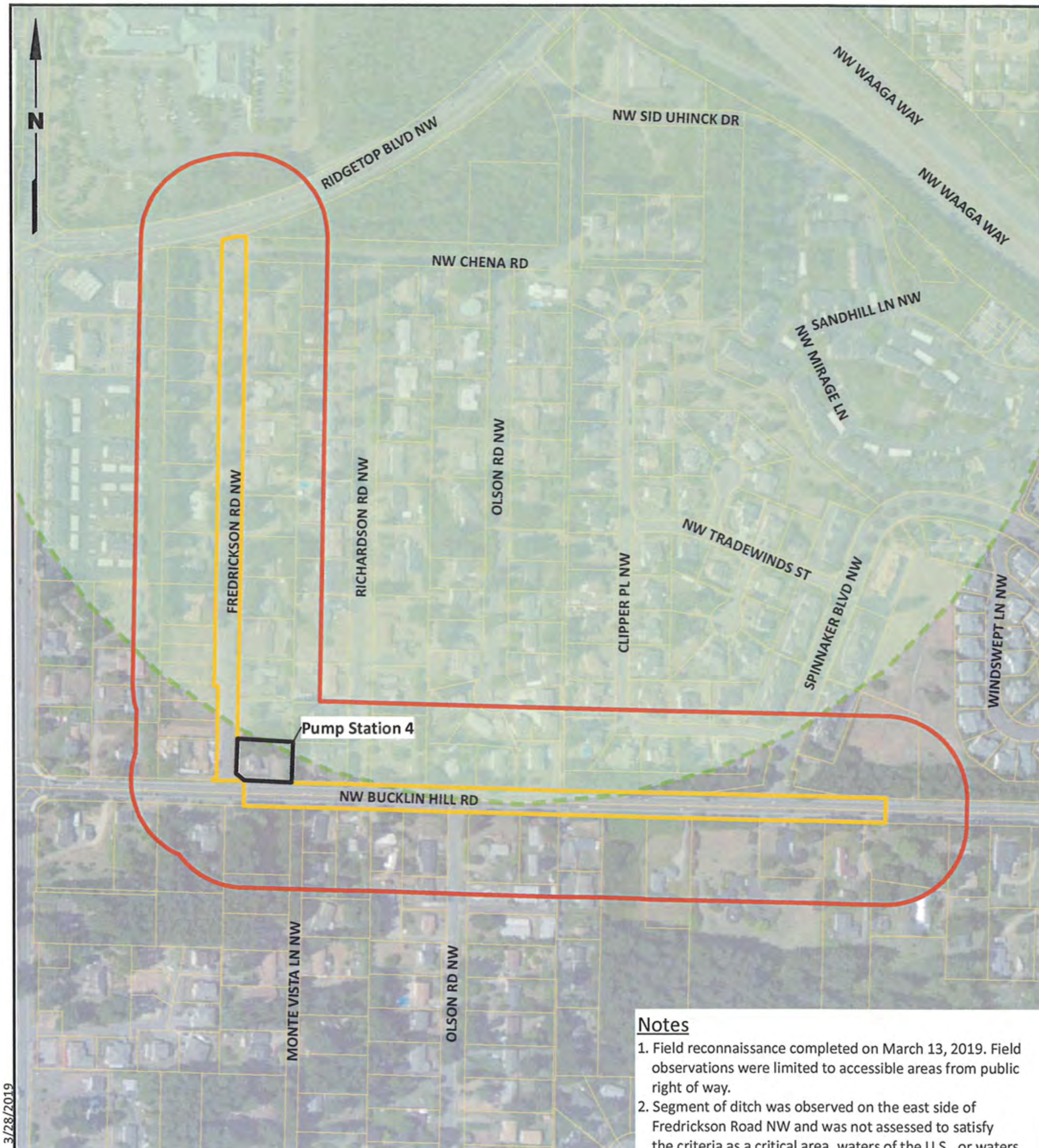

Notes

1. Field reconnaissance completed on March 13, 2019. Field observations were limited to accessible areas from public right of way.
2. Segment of ditch was observed on the east side of Fredrickson Road NW and was not assessed to satisfy the criteria as a critical area, waters of the U.S., or waters of the state (i.e. not regulated as a stream or wetland).
3. Refer to Pump Station 4 Permit Matrix for more information.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Study Area
- Pump Station Project Area
- Conveyance Lines Project Area
- Tax Parcels
- Critical Aquifer Recharge Areas

0 350 700

Scale in Feet

Data Sources: USFW; Kitsap County GIS; Esri World Imagery.

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LANDAU ASSOCIATES

Kitsap County
Pump Station 4 Upgrades
Silverdale, Washington

Lift Station 4
Environmental Site Features

Figure 5-2

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Table 5-2
Lift Station 4 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Lift station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA.	Hydrogeology report (if needed)	Concurrent with SEPA review	Category I CARA mapped in segment of the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Cross cutter report	Varies, and is contingent on consultations with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s)	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historic buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Section 404 Clean Water Act/ Executive Order 11990 (Wetlands Protection)	Ecology Water Quality Program (and U.S. Army Corps of Engineers [USACE] if unavoidable wetland/waterway impacts)	Projects with federal assistance. (USACE – Dredge and/or fill in wetlands, below ordinary high-water line of streams, or mean higher high-water line of tidal waters).		Not applicable, no wetlands/waterways occur in the project area.	Completed with SERP	No wetlands/waterways occur in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and US Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment.	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program			Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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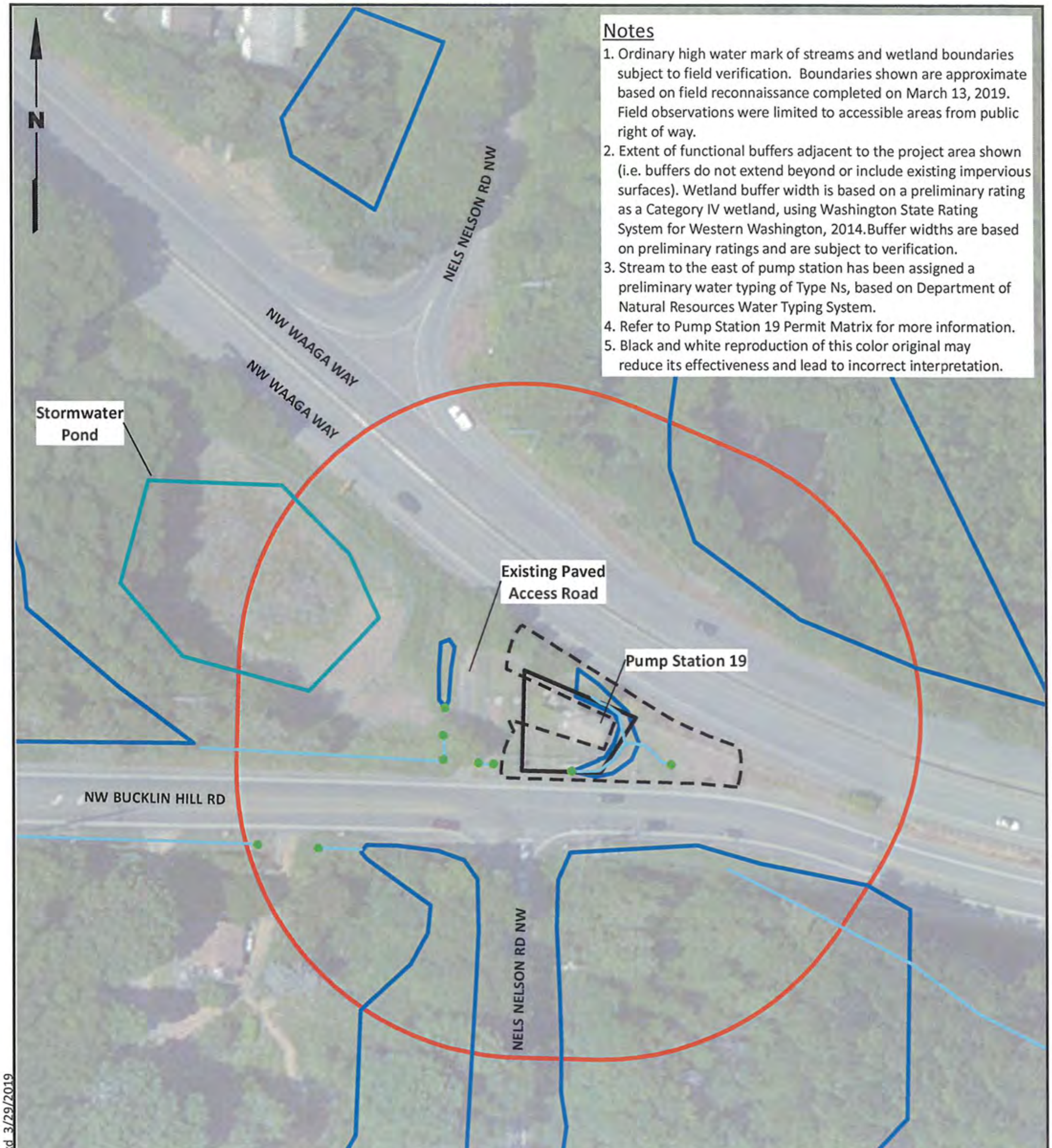

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Legend

- Culvert
- Potentially Jurisdictional Watercourse
- Pump Station Project Area
- Study Area
- Tax Parcels
- Stormwater Pond
- Estimated Wetland Boundary
- Wetland/Waterway Buffer

0 100 200

Scale in Feet

Data Sources: USFW; Kitsap County GIS; Esri World Imagery.

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Kitsap County
Pump Station 19 Upgrades
Silverdale, Washington

Lift Station 19
Environmental Site Features

Figure
5-3

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Table 5-3
Lift Station 19 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Lift station construction ▪ Utility lines more than 12 inches in diameter	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Section 404 Clean Water Act (Waters of the U.S.)	U.S. Army Corps of Engineers	Dredge and/or fill in wetlands, below ordinary high-water line (streams), or mean higher high-water line (tidal waters).	Fill or dredge activity in wetlands. Installation of utility lines using directional drill techniques under wetlands does not require permit.	▪ Joint Aquatic Resources Permit Application ▪ Wetland/Waterways Critical Areas Report	3 to 6 months	Site design may avoid wetland and/or stream impacts and permitting may not be necessary. However, if unavoidable wetland/stream impacts occur, authorization under the Nationwide Permit program is likely. The USACE will also require documentation of consultations under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act as part of the SERP process. If SERP does not apply, application to the USACE would require a no effect determination or biological assessment and cultural resources investigation report. Refer to Figure 5-3 Lift Station No. 19 Environmental Features for wetland/stream locations.
Critical Areas Ordinance – Wetlands	Kitsap County Department of Community Development	Development in wetlands or associated buffers.	Development in wetland and/or associated buffers.	▪ Wetland/Waterways Critical Areas Report	Concurrent with SEPA review	Site design may avoid wetland and/or stream impacts, and permitting may not be necessary, or may be limited to unavoidable impacts to buffers. Landscaping may be required to satisfy wetland/stream buffer mitigation requirements. Refer to Figure 5-3 Lift Station No. 19 Environmental Features for wetland location.
Critical Areas Ordinance – Fish and Wildlife Habitat Conservation Areas	Kitsap County Department of Community Development	Development in protected habitats (including streams and associated buffers).	Development in streams and/or associated buffers.			
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).	Cross cutter report	Varies, and is contingent on consultation with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below, and compliance with Section 404 of the Clean Water Act as identified above.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historical buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act (Essential Fish Habitat)	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries and U.S. Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance.		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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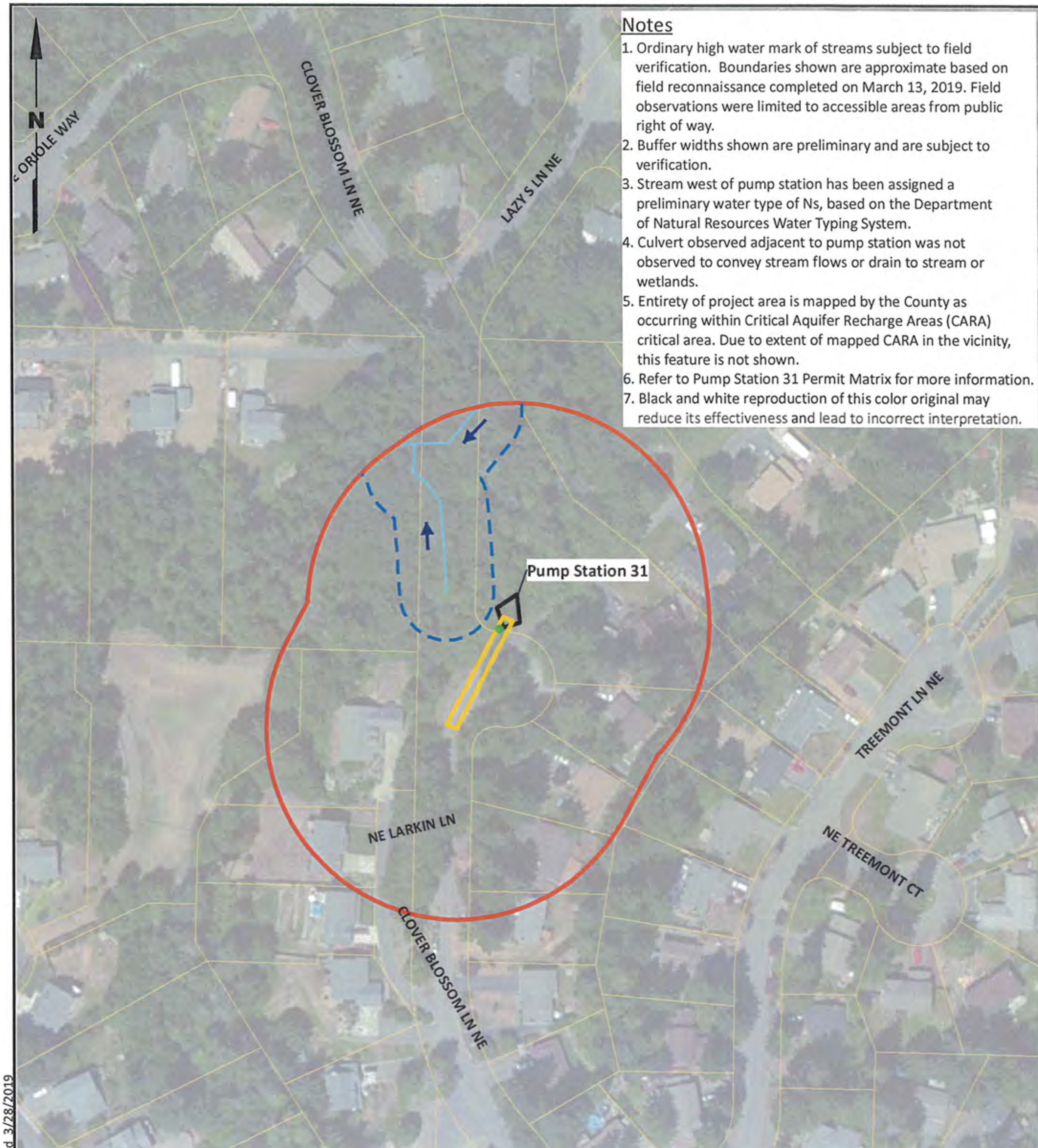

Notes

1. Ordinary high water mark of streams subject to field verification. Boundaries shown are approximate based on field reconnaissance completed on March 13, 2019. Field observations were limited to accessible areas from public right of way.
2. Buffer widths shown are preliminary and are subject to verification.
3. Stream west of pump station has been assigned a preliminary water type of Ns, based on the Department of Natural Resources Water Typing System.
4. Culvert observed adjacent to pump station was not observed to convey stream flows or drain to stream or wetlands.
5. Entirety of project area is mapped by the County as occurring within Critical Aquifer Recharge Areas (CARA) critical area. Due to extent of mapped CARA in the vicinity, this feature is not shown.
6. Refer to Pump Station 31 Permit Matrix for more information.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Culvert
- Conveyance Lines Project Area
- Estimated Stream Location
- Stream Buffer
- Pump Station Project Area
- Study Area
- Tax Parcels
- Surface Water Flow Direction

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 150 300

Scale in Feet

Data Sources: USFW; Kitsap County GIS; Esri World Imagery.

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Kitsap County Pump Station 31 Upgrades Silverdale, Washington	**Pump Station 31** **Environmental Site Features**	Figure 5-4

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Table 5-4
Lift Station 31 Environmental Permitting Summary Matrix

Permit or Act Compliance	Agency Reviewing Permit	Permit Trigger	Project Activity Initiating Permit Need	Permit Submittal Requirement(s)[B]	Agency Timeframe for Approval	Notes
State Environmental Policy Act (SEPA)	Kitsap County Department of Community Development	Any proposal that involves a non-exempt government "action." Project actions involve an agency decision on a specific project, including non-project actions that involve decisions on policies, plans, or programs.	▪ Lift station construction ▪ Utility lines with diameters greater than 12 inches	SEPA checklist	Approximately 30 days (County review is 15 days, and 14-day public notice is required unless using the optional DNS process, which allows one concurrent 15-day notice).	SEPA checklist may be prepared based on conceptual design. SEPA review will include consideration of studies listed below, as necessary. Agency timeframe for approval assumes SEPA DNS or mitigated DNS and is based on County determination of a complete application.
Critical Areas Ordinance – Critical Aquifer Recharge Areas (CARA)	Kitsap County Department of Community Development	Development in Category I or II CARA.	Activities with potential to adversely affect groundwater in a CARA	Hydrogeology report (if needed)	Concurrent with SEPA review.	Category I and II CARA mapped in the project area. Due to existing developments and similar utility infrastructure, the proposed improvements are not likely to result in adverse effects to groundwater.
State Environmental Review Process (SERP)	Ecology Water Quality Program	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF).[A]	Project funding provided by the Washington State Water Pollution Control Revolving Fund (SRF)	Cross cutter report	Varies, and is contingent on consultation with other agencies, as detailed below.	SERP compliance requires supporting documentation as detailed below.
Coastal Zone Management Act	Ecology Shorelines and Environmental Assistance (SEA) Program	Projects with a federal nexus (i.e., federal funding or federal permit) that occur in one of Washington's 15 coastal counties (includes Kitsap County).		Federal Consistency Certification Form	Up to 180 days	Form can be emailed to Ecology SEA Program.
Section 106 of National Historic Preservation Act	Ecology Water Quality Program in consultation with Washington State Department of Archeology and Historic Preservation (DAHP and affected tribe(s))	Projects with a federal nexus (i.e., federal funding or federal permit).		Cultural Resources Report	Minimum of 30 to 45 days	Evaluation for archaeological resources and/or historical buildings may be required. Minimum 30- to 45-day approval period allowed for consultation with DAHP and affected tribe(s).
Section 404 Clean Water Act/ Executive Order 11990. (Wetlands Protection)	Ecology Water Quality Program (and U.S. Army Corps of Engineers [USACE] if unavoidable wetland/waterway impacts)	Projects with federal assistance. (USACE – Dredge and/or fill in wetlands, below ordinary high-water line of streams, or mean higher high water line of tidal waters).		Not applicable, no wetlands/waterways occur in the project area.	Completed with SERP	No wetlands/waterways occur in the project area.
Clean Air Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) occurring in air quality nonattainment or maintenance areas.		Not applicable, no air quality non-attainment or maintenance area occurs in the project area.	Completed with SERP	No air quality non-attainment or maintenance area occurs in the project area.
Title IV of the Civil Rights Act of 1964, Executive Order 13166, Executive Order 12898 (Environmental Justice)	Ecology Water Quality Program	Projects with federal assistance.		Documentation of environmental impacts, presence of protected populations, and summary of public outreach.	Completed with SERP	Evaluation of any necessary detours during construction. Project is not anticipated to result in disproportionate adverse impacts to protected populations.
Section 7 Endangered Species Act/Sustainable Fisheries Act	Ecology Water Quality Program in consultation with EPA, NOAA Fisheries, and U.S. Fish and Wildlife Service (if necessary)	Projects with a federal nexus (i.e., federal funding or federal permit).		No effect determination or biological assessment	Completed with SERP	Project is likely to result in a no effect determination, which would not require preparation of a biological assessment or consultation with USFWS and/or NOAA Fisheries.
Farmland Protection Policy Act	Ecology Water Quality Program	Projects with a federal nexus (i.e., federal funding or federal permit) that result in conversion of farmland.		Not applicable, no agricultural lands occur in the project area.	Completed with SERP	No agricultural lands occur in the project area.
Floodplain Management	Ecology Water Quality Program	Project activities in floodplains.		Not applicable, no designated floodplains in the project area.	Completed with SERP	No designated floodplains occur in the project area.
Wild and Scenic Rivers Act	Ecology Water Quality Program	Projects with federal assistance		Not applicable, no designated wild and scenic rivers in the project area.	Completed with SERP	No designated wild and scenic rivers in the project area.
Safe Drinking Water Act	Ecology Water Quality Program	Project activities affecting sole source aquifers.		Not applicable, no sole source aquifers occur in the project area.	Completed with SERP	No sole source aquifers occur in the project area

Notes:
A. SRF funding is, in part, by the Federal Clean Water Act of 1987 (as amended).
B. Pre-application inquiry/meeting with agencies is recommended to clarify project-specific application needs.

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5.2.4.1 Joint Aquatic Resource Permit Application (JARPA)

To streamline the environmental permitting process, multiple regulatory agencies joined together to create one application that can be used to apply for more than one permit at a time (the Joint Aquatic Resources Permit Application (JARPA) permit). The JARPA is a master form used by federal, state, and local agencies for environmental review and issuance of permits on projects that have water-related impacts (e.g. wetlands, streams, and shorelines). Information for the JARPA will be derived from design information, wetland delineation reports, wildlife and fish habitat survey, and other available information obtained from the County and other agencies. The JARPA application will include a copy of the Wetland and Waterway Delineation Report and the necessary restoration plans compiled to address Critical Areas Mitigation requirements. Additional supporting documentation includes the Biological Assessment and Cultural Resources Assessment. The Wetland Delineation, Critical Areas Mitigation, Biological Assessment and Cultural Resources Assessment are described below.

5.2.4.2 Wetland Delineation/Critical Areas Mitigation

A wetland reconnaissance was completed by Landau as part of the preliminary design process to identify wetlands, waterways and associated buffers in the Project areas. Based on the findings of the wetland reconnaissance, wetlands will need to be delineated near LS 3, LS 19, and LS 31 during the design phase. No wetlands were identified within the Project limits associated with LS 4. Landau will complete the delineation and AES will locate the wetland flags to produce a survey record of the wetland boundaries. This information will then be used to establish the wetland buffer limits, which will dictate some of the restoration requirements and permitting needs.

5.2.4.3 Biological Assessment (BA)

Biological Assessments (BA) for compliance with the Endangered Species Act (ESA) are required for projects that are on federal property, require approval by a federal agency, or receive federal funding. Review of BAs by NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) is known as "consultation with the services." Concurrence must be received by both services for other federal agencies to issue permits or approvals. A BA is filed under JARPA when submitted to a federal agency and/or the State Environmental Review Process (SERP) process.

BAs are evaluations of impacts caused by project construction and the completed project on listed species/critical habitat within the Project action area. BA results are used to determine whether conditions in the Project action area support listed species and critical habitats and severity of impacts (both beneficial and adverse), if present. None of the Project areas are on federal property. However, if federal funding is obtained, then a BA would need to be prepared to identify the effects of the Project on any endangered species and critical habitat and to recommend mitigation measures to offset impacts. The BA would also include an assessment of impacts to 100-year floodplains, if necessary.

5.2.4.4 Cultural Resources Assessment

Cultural resources investigation, including archaeological resources, for compliance with Section 106 of the National Historic Preservation Act (NHPA) is required for projects seeking approval by a federal agency or funding from federal or state sources. Section 106 NHPA requires defining the Project Area of Potential Effect (APE), which represents the limit of the cultural resource investigation. Consultation on the cultural resources assessment is completed with the Department of Archaeology and Historic Preservation (DAHP) and affected Tribes and is coordinated through the lead federal agency. Governor Executive Order 05-05 requires cultural/archaeological resources review for capital projects not undergoing Section 106 NHPA review.

Phase I cultural resources investigations have been performed by Cascadia Archaeology (Cascadia) along the Project limits. The Phase I Assessment is included as Appendix H. The Suquamish Tribe has requested a Phase 2 Cultural Resources assessment be conducted at all four proposed lift station sites during the design phase of the project when more information pertaining to ground disturbance limits is known.

5.2.4.5 National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Storm Water Discharges Associated with Construction Activities

BHC will prepare a Storm Water Pollution Prevention Plan (SWPPP) that will be included as part of the construction documents. The SWPPP will be reviewed and approved by the County's construction manager prior to submittal to the Department of Ecology (Ecology). Once the County has approved the SWPPP, the document will be submitted to Ecology along with a Notice of Intent (NOI) to obtain coverage under Ecology's Construction Storm Water General Permit. The County will be listed as the responsible agency on the NOI. However, once the contractor has been selected, an application will be made to transfer responsibility for compliance to the contractor.

5.2.5 Other Permits Considered

The County will be responsible for applying for and obtaining the permits described above. The contractor will be responsible for obtaining all required permits for construction that are not obtained by the County. These are anticipated to include, but not be limited to the following:

- Encroachment/ROW/Roadway Permit
- Demolition Permit
- Electrical Permit

Chapter 6. Project Costs and Schedules

6.1 Preliminary Opinions of Probable Project Cost

The opinions of probable project cost (OPPC) are considered Class 3 estimates, as defined by the Association for the Advancement of Cost Engineering International (AACE). The associated level of project definition is 10 to 40 percent (a 30% contingency was included in the OPPC). The accuracy of Class 3 estimates ranges from -20 to +30 percent due to the preliminary nature of project data and engineering. The opinions of probable project costs were developed based on 2019 dollars and detailed breakdowns for the conveyance piping and lift station are presented in Appendix I.

6.1.1 Lift Station 3 and Associated Conveyance Piping Improvements

As previously discussed, upgrades to Lift Station 3 and the Silverdale Way gravity sewers will be addressed as part of this project. The preliminary OPPC for these two projects are as follows:

Silverdale Way Gravity Sewer Upgrades	$825,500
Lift Station 3 Upgrades	$5,280,000
Total	$6,005,500

6.1.2 Conveyance Piping Improvements and Lift Station 4

As previously discussed, upgrades to Lift Station 4, the Fredrickson Road gravity sewers, and the Lift Station 4's force main will be addressed as part of this project. The preliminary OPPC for these three projects are as follows:

Fredrickson Road Sewer Upgrades	$1,870,000
Lift Station 4 Force Main Upgrades	$1,643,500
Lift Station 4 Upgrades	$6,710,000
Total	$10,223,500

6.1.3 Conveyance Piping Improvements and Lift Station 19

As previously discussed, upgrades to Lift Station 19 will be addressed as part of this project. No conveyance upgrades are required. The preliminary OPPC for the proposed upgrades to LS 19 is as follows:

Conveyance Pipe Upgrades	N/A
Lift Station 19 Upgrades	$4,465,500
Total	$4,465,500

6.1.4 Conveyance Piping Improvements and Lift Station 31

As previously discussed, upgrades to Lift Station 31 will be addressed as part of this project. No conveyance upgrades are required. The preliminary OPPC for the proposed upgrades to LS 31 is as follows:

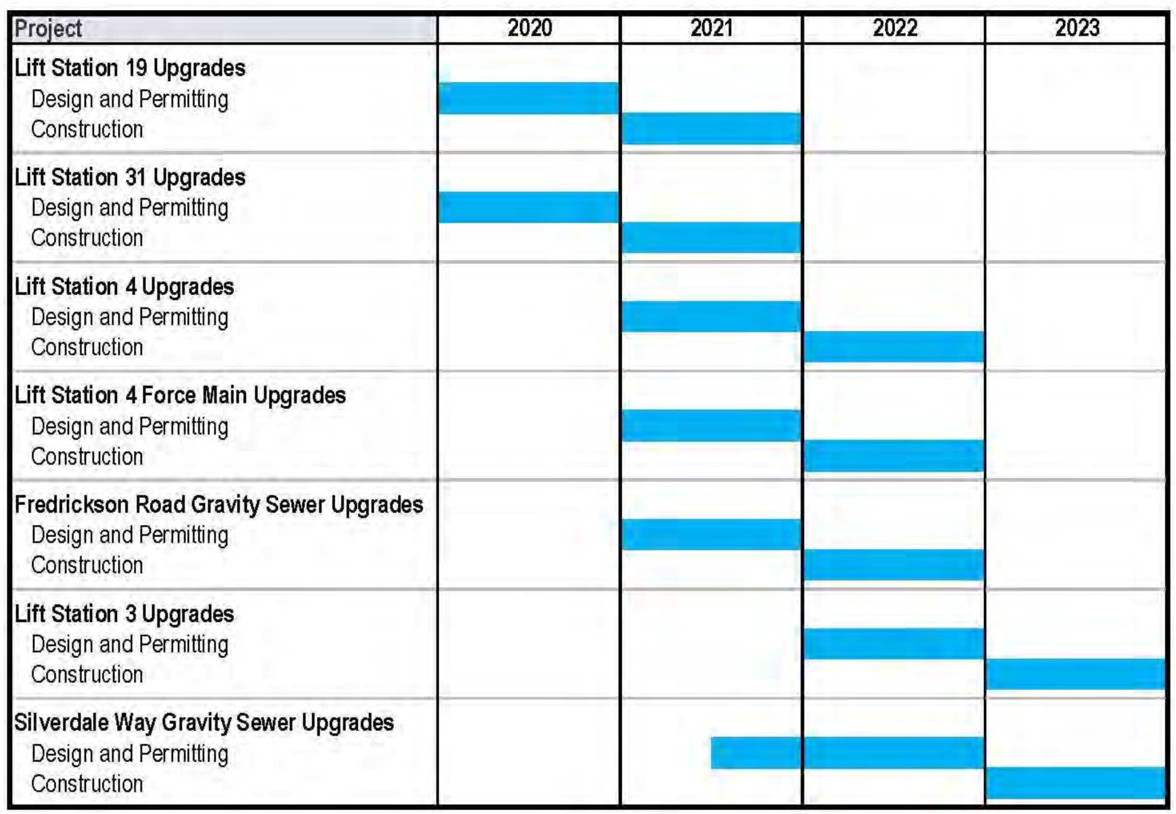
Conveyance Pipe Upgrades	N/A
Lift Station 19 Upgrades	$1,576,500
Total	$1,576,500

6.2 Estimated Final Design and Construction Schedules

Final design and construction of the four projects will be staggered over the next several years. Based on discussions with the County, the upgrades to Lift Station 19 and Lift Station 31 and their associated conveyance systems will occur first, followed by the upgrades to Lift Station 4 and its associate conveyance systems. The upgrades to Lift Station 3 and the Silverdale Way Gravity Sewer Upgrades will be the last improvements made under this project.

t, primarily because Lift Station 4 must be upgraded prior to Lift Station 3 in order to handle the upgraded flows from Lift Station 3. The ongoing negotiations with the Port of Silverdale, which will continue through the final design stage of the project, are anticipated to increase the project time required to complete the upgrades. Table 6-1 summarizes the anticipated schedules for the upgrades to each lift station and associated conveyance systems.

Table 6-1 Project Schedule



The estimated final design period for each lift station and its associated conveyance upgrades is 300 working days, including 10 days of County review time for each of the 60 and 90 percent and Final Bid Document deliverables. The final design period includes developing bid documents, permitting, bid period, and notification of award to the low bid contractor. The design period for each project may run concurrently, depending on how the County wants to package the contracts. Currently, the County has authorized BHC to proceed with the final design of the upgrades for LS 19 and LS 31. The bid opening for these lift station upgrades is anticipated to occur in January 2021. The Project milestones are identified in Table 6-2 and a copy of the current baseline design schedule is included as Appendix J. The estimated construction duration for the Project is 240 working days. The actual construction schedule is the responsibility of the awarded contractor.

Table 6-2
Project Milestones – LS 19 & LS 31

Milestone Activity	Milestone Date
Notice to Proceed	December 2019
60% Design Submittal	December 2019 – May 2020
90% Design Submittal	June 2020 – October 2020
Final Design	October 2020 – December 2020
Bid Period	January 2020 – January 2020
Construction	February 2020 – January 2022

Detailed schedules and project milestones for LS 3 and LS 4 will be determined once the County has authorized the design of the upgrades for those two stations to begin.

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APPENDIX A

2019 HYDRAULIC MODEL UPDATE – POPULATION PROJECTIONS AND CALIBRATION METHODS

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APPENDIX B

2019 HYDRAULIC MODEL UPDATE – MODEL RESULTS

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APPENDIX C

GEOTECHNICAL ENGINEERING ASSESSMENTS

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APPENDIX D

STRATEGY FOR CONSTRUCTION TRAFFIC CONTROL MEMORANDUM

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APPENDIX E

LIFT STATION 3 ALTERNATIVE LOCATIONS MEMORANDUM

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APPENDIX F

FLYGT PUMP DATA

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APPENDIX G

SURGE ANALYSIS

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APPENDIX H

PHASE 1 CULTURAL RESOURCES ASSESSMENT

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APPENDIX I

OPINIONS OF PROBABLE PROJECT COSTS

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APPENDIX J

BASELINE PROJECT DESIGN SCHEDULE – LS 19 & LS 31

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APPENDIX K

LIFT STATION 17 FORCE MAIN HYDRAULICS MEMORANDUM

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Kitsap County
Silverdale Lift Stations 3, 4, 19, and 31 Upgrades
Preliminary Engineering Report

APPENDICES

January 10, 2020

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APPENDICES

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APPENDIX A

2019 HYDRAULIC MODEL UPDATE – POPULATION PROJECTIONS AND CALIBRATION METHODS

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MEMORANDUM

Date: August 7, 2019

To: Barbara Zaroff

From: Sara Palmerton

CC: Tony Fisher

Subject: 2019 Hydraulic Model Update – Population Projections & Calibration Methods

1.0 Introduction

This memo describes the methods used to update the wastewater flow projections in Kitsap County's (County) Central Kitsap service area current (2017) and 20-year (2038) hydraulic computer models. Updating both models with reliable wastewater flow projections enables the County to satisfy the requirements of the Growth Management Act (GMA) by identifying capital improvements that support the County's land use plan and growth targets for the period 2018-2038.

The Central Kitsap service area is the largest system in Kitsap County. This service area includes the naval facilities at Bangor and Keyport; the City of Poulsbo; and the Silverdale and Central Kitsap Urban Growth Areas (UGAs). The collection system consists of approximately 44 lift stations and over 145 miles of gravity mains and force mains. All wastewater flows are conveyed to the Central Kitsap Wastewater Treatment Plant (CKWWTP) where the treated effluent is discharged into the northern portion of Port Orchard Bay in the Puget Sound.

This model update follows the methodology used for the Kitsap County GMA Remand Study (BHC 2012). Several assumptions that affect future wastewater flows were reviewed with Kitsap County staff including population forecasts for the UGA's, connection of currently unsewered homes to the County sewer system, and sewered parcel areas outside of the UGA. In addition, assumptions were made for per capita wastewater flows, commercial connections to the sewer systems and flow peaking factors. Each of these assumptions is described in more detail in the following sections, which provide a discussion of the following topics: the data sources and methodology utilized to update the 2017 and 2038 hydraulic models; the 2017 and 2038 model calibration process; and the key differences in the methodology utilized to develop population projections for the 2038 and full buildout models.

2.0 Data Sources and Methodology

The Central Kitsap Service Area contains two UGAs: Silverdale and Central Kitsap. These two UGAs are further divided into Traffic Analysis Zones (TAZ). Each TAZ contains population data for residential and commercial populations located within the defined geographical boundary of the TAZ. GIS shapefiles containing the TAZ boundaries were provided by the County in 2010 as part of the Remand Study and were checked for consistency as part of this model update.

2.1 Population Data

Employment (Commercial Population) Data

A custom data request was sent to the Puget Sound Regional Council (PSRC) to obtain an estimate of present-day and future (2035 and 2040) employment within the Central Kitsap and Silverdale UGAs. The data request was accompanied by a GIS shapefile of the TAZ boundaries for the Central Kitsap Service Area.

PSRC maintains an agreement with the Washington State Department of Labor to access Covered Employment statistics on a parcel basis. Covered Employment refers to positions covered by the Washington Unemployment Insurance Act and accounts for approximately 85-90% of all employment. Each year, PSRC uses Covered Employment to model Total Employment. Total Employment data for 2016 was used for the model update. For employment estimates for the years 2035 and 2040, PSRC provided estimates for the Central Kitsap and Silverdale UGAs based on PSRC's Land Use Vision (LUV) long-range model.

Rebeccah Maskin, Principal Planner at the PSRC, provided employment data via email in March and April 2018. Commercial population data was provided for the years 2016, 2035, and 2040. This data was provided on a per UGA basis and not broken down by TAZ. To breakdown the commercial population data per TAZ, the total area within each TAZ that was zoned commercially was calculated. The commercial population data was then prorated based on the TAZ percentage of total commercial area. This method of calculating the commercial population per TAZ follows the method used in the 2012 Remand Model update. Employment data is summarized in the Table 2.1.

Table 2.1 Employment (Commercial Population) Data *

Growth Area	2016	2035	2040
Central Kitsap UGA	3,992	5,389	6,183
Silverdale UGA	12,050	18,422	22,919
* PSRC employment data (both 2016 and future) is subject to suppression to protect confidentiality. Small geographies and places that do not have a lot of jobs are often suppressed.			

Residential Population

Residential population data and projections for Central Kitsap and Silverdale UGAs were also provided by Rebeccah Maskin via email in March and April 2018. This data addressed current information (2017) and future projections (2035, and 2040). The PSRC generated population projections for the years 2035 and 2040 was based on PSRC's LUV long-range model and was provided on a per TAZ basis. Residential population data is summarized in the Table 2.2.

Table 2.2 Residential Household Population Data

Growth Area	2017	2035	2040
Central Kitsap UGA	23,358	32,440	33,379
Silverdale UGA	18,220	25,555	33,430
* PSRC employment data (both 2016 and future) is subject to suppression to protect confidentiality. Small geographies and places that do not have a lot of jobs are often suppressed.			

Model Population Inputs

The 2016 commercial population data and the 2017 residential population data were used to calculate wastewater flows for the 2017 model. The projected 2035 and 2040 commercial and residential population data was interpolated to calculate the projected 2038 population data, assuming a constant growth rate between 2035 and 2040. The 2038 commercial and residential population data were then used to calculate wastewater flows for the 2038 model.

2.2 Model Load Points

Wastewater flow is represented within the MIKE Urban modeling platform through elements called load points. Load points are geographical point features that input wastewater flows generated from residential and commercial demand into the model. Each load point is assigned a wastewater load rate in gallons per day. These load points were initially created during development of the original model for the 2009 Facilities Plan. Each load point represented an individual parcel within the service area. The load points were subsequently updated for the 2012 Remand analysis, forming the basis for the current model.

Developing the 2017 and 2038 models involved revising wastewater load rates for all load points located within the UGA on a per TAZ basis. The method outlined below describes how wastewater load rates were calculated for the 2017 and 2038 models.

1. The 2017 and 2038 models assumed 100% of un-sewered properties were converted from septic systems to sewer systems.

2. The number of load points in each TAZ were manually counted. GIS shapefiles identifying commercially zoned areas and residential parcels were used to visually identify load points represented commercial and residential demands.

   a. For the 2017 model, load points within a TAZ that were not located in commercial areas or residential parcels were considered 'future' load points and were not counted or assigned a wastewater load.

   b. For the 2038 model, load points located within a TAZ, but outside of the commercial areas or residential parcels were counted. When these load points were developed for the 2012 Remand Model, they were added to represent 'future' development. These load points were all assumed to be residential and assigned a residential wastewater load.

   c. Since the shapefiles representing commercial areas were based on zoning data and the shapefiles representing residential were based on parcel data, the commercial areas and residential parcels sometimes overlapped in the TAZ. When this occurred, the load point was considered commercial and assigned the commercial wastewater load specific to that TAZ.

3. The commercial unit loading per TAZ was then calculated by dividing the number of commercial load points by the TAZ's commercial population. The same method was used to calculate the residential unit loading per TAZ.

4. For each TAZ, the unit loading for commercial and residential load points was then multiplied by a sewer service demand of 70 gallons per capita per day (gpcd). A review of current wastewater flow data and the Kitsap County Capital Facility Plan determined the 70 gpcd was more representative of current per capita wastewater flows than the 76 gpcd used for the 2012 Remand modeling. The resulting values represent the wastewater load size in gallons per day for all load points located in commercial areas and residential parcels in each TAZ.

5. Two load point selection sets were created for each TAZ. Separating the selection sets for residential and commercial load points simplified the wastewater load size modification process.

6. To update the load size for the commercial load points, the corresponding selection set was opened in the model and all the commercial load points in the TAZ were highlighted. The MIKE Urban Field Editor function was then used to change the load rate to the value calculated in step three for the highlighted load points. The same method was repeated to update the residential load points in the TAZ.

7. Only load points located inside the UGA were modified. Some areas outside the UGA have already been developed and connected to the County's sewer system. The load points associated with those areas were not revised.

2.3 Additional Flows

The Central Kitsap collection system also services the naval facilities at Bangor and Keyport and the City of Poulsbo. The wastewater demand for these areas is represented in both models through network loads instead of load points. Network loads distribute wastewater flow, in units of gallons per day, into the model at a specified node. The model contains separate network loads for the Bangor and Keyport Naval Bases and for the City of Poulsbo. These network loads were updated when developing the 2017 and 2038 models. Table 2.3 provides a summary of the associated network loads for the 2017 and 2038 models. Data sources for all network loads are also included in the table below.

Table 2.3 Network Loads for Bangor, Keyport, and City of Poulsbo

Service Area	Network Loads	
	2017 Model	2038 Model
Bangor[1]	627,110 gpd	890,807 gpd
Keyport[1]	206,720 gpd	332,530 gpd
Poulsbo[2]	650,000 gpd	1,000,000 gpd

1. Network load values taken from Page 23 of the 8/1/2008 tech memo from BHC Consultants to the County detailing wastewater flow projections for the Central Kitsap service area.
2. Network load values taken from Page 2-28 of the September 2016 City of Poulsbo Comprehensive Sewer Plan Update developed by BHC Consultants.

2.4 Methodology Comparison

A full buildout model in which all zoning capacity is fully utilized with 100% septic to sewer conversion was developed after the 2017 and 2038 models. The model response generated by the full buildout model supplemented the system deficiency analysis in the 2038 model and was used to assist with the sizing of improvements needed to address system deficiencies identified in the 2038 model.

The memorandum. "Method Used for and Employment Population Estimates" created by BHC on August 7, 2019 describes the methods used to generate full buildout population projections for commercial and residential populations within the Silverdale and Central Kitsap UGAs. The methodology used to generate the population projections followed the County's "Land Capacity Analysis – GIS Methodology" that was shared with BHC planners in October 2018.

Inherent differences between the two methods of developing population projections for the 2038 and full buildout models became apparent when creating the full buildout model. Specifically, the population projections for the 2038 model were based on population forecast data generated by the PSRC's LUV long-range model while the population projections for the full buildout model were generated by analyzing zoning requirements and underdeveloped land use within the UGAs. Due to these distinct differences, the commercial population for a TAZ in the 2038 model was sometimes greater than the commercial population for a TAZ in the full buildout model. This trend is non-intuitive as the commercial population would be expected to increase as the zoning capacity is fully utilized in the build-out model, thus resulting in a greater population per TAZ.

Therefore, the population projection discrepancies were analyzed further, and the differences were reconciled. Although the commercial population for some TAZ's decreased from the 2038 model to the full buildout model, the overall commercial population increased. An increase in total commercial population in the Silverdale and Central Kitsap UGA's translates to an increase in total wastewater demand derived from commercial populations within these UGAs. Since the overall wastewater demand increased from the 2038 model to the full buildout model, the differences in commercial population projections were deemed acceptable.

3.0 Model Calibration

After the new wastewater loads for the load points in the 2017 model were updated, wet weather flow calibration was performed. During the development of the 2012 Remand Model, calibration was based on the maximum peak daily flow into the treatment plant between 2002 and 2006. A similar approach was used during calibration for the 2017 model. The methodology utilized for 2017 model calibration, and subsequently 2038 model calibration, is discussed below.

1. CKWWTP inflow data was obtained from the County for a 6-year period from 2012 to 2018.

2. Data corresponding to the plant's maximum daily inflow was extracted from the inflow data. The plant's maximum daily inflow occurred on January 21, 2016.

    a. Kitsap County rainfall data shows 3.3-inches of rainfall accumulation during the 24-hr event in January 2016. Western Washington Isopluvial maps in the Department of Ecology's Stormwater Management Manual for Western Washington were referenced to determine the 24-hr design storm that coincides with 3.3-inches of rainfall in Kitsap County. The isopluvial maps show the January 2016 rainfall event corresponds to a 25-year, 24-hour design storm.

b. After discussing the event with the County, this design storm was selected as the basis of the wet weather flow calibration. This storm was also used to determine the peaking factor for peak daily flow to peak hourly flow.

3. The County provided CKWWTP inflow data in 15-minute increments for the January 2016 storm. The inflow data was then graphed with a trendline to eliminate outliers. Based on the information in the graph, the average plant inflow was determined and the maximum (peak) inflow was found based on the trendline.

4. Next, the peak plant inflow was divided by the average plant inflow to yield a peak daily flow to peak hourly flow multiplier of 1.5.

5. The 1.5 peak hourly multiplier was then used as the basis for model calibration in the 2017 model. Model iterations were performed by adjusting the individual multipliers within the peak day diurnal pattern to yield a peak daily flow to peak hourly flow multiplier of 1.5 at the treatment plant. The resulting peak day diurnal pattern was copied into the 2038 model to complete model calibration.

References

1. BHC Consultants
   2012. Kitsap County Public Works Technical Memorandum, Kitsap County GMA Remand, Analysis of Sewer System Needs for Preferred Central Kitsap, Silverdale, and Kingston UGAs.

2. BHC Consultants
   2018 Proposed Method for Residential and Employment Estimates Memorandum dated February 13, 2018.

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BHC CONSULTANTS

MEMORANDUM

Date: August 7, 2019

To: Barbara Zaroff

From: Talia Tittelfitz

CC: Tony Fisher

Subject: Method Used for Residential and Employment Population Estimates

This memo summarizes the method used to generate residential and employment estimates for the Central Kitsap and Silverdale Urban Growth Areas (UGAs). These estimates were then used in MIKE Urban hydraulic model to identify capacity restrictions and evaluate future infrastructure needs. This memo identifies the data sources that were used for UGA estimates and for the pump station basins (basins) that subdivide the UGAs. This method is based on the following assumptions:

- Each basin was entirely contained within the UGAs and each UGA was divided into sub-basins with a unique identifier.
- A consensus on the basin delineations was reached with the County before work began.
- A GIS shapefile was generated for each basin delineation.
- A baseline year of 2017 was established as the year the most recent data was available.
- Targets for future estimates included 2038 and a hypothetical "buildout" scenario (in which all zoning capacity was fully utilized and 100% of properties were converted from septic systems to sewer).

2017 Residential Estimate

BHC submitted a custom data request to the Office of Financial Estimates Small Area Estimate Program (OFM SAEP) for an estimate of 2017 residential population within each of the UGAs as well as within each of the basins which subdivide the UGAs. The data request was accompanied by a GIS shapefile of the basin delineations. OFM SAEP returned the data as a spreadsheet with 2017 residential estimates listed for each basin. Basin data that was suppressed by OFM SAEP for confidentiality reasons was estimated by BHC using the total population data for that UGA plus information that could be reasonably collected regarding the likely residential population of the suppressed basin. That data included parcel size and distribution, aerial searches, county assessor parcel data, and local knowledge.

Data Sources: OFM SAEP 2017 Residential Custom Estimate

2017 Employment Estimate

BHC submitted a custom data request to the Puget Sound Regional Council (PSRC) for an estimate of 2017 employment within each of the UGAs as well as within the basins which subdivide the UGAs. PSRC maintains an agreement with the Washington State Department of Labor to access Covered Employment statistics on a parcel basis. Covered Employment refers to positions covered by the Washington Unemployment Insurance Act, and the data accounts for approximately 85-90% of all employment. Each year, PSRC uses Covered Employment to model Total Employment.

PSRC provided Total Employment estimates or Covered Employment estimates. When Covered Employment estimates were provided, BHC estimated the Total Employment by using the most recent American Community Survey (ACS) 5-year self-employment data for Kitsap County, which is exempt from the WA Unemployment Insurance Act and therefore not included in Covered Employment estimates.

The data request to PSRC was accompanied by a GIS shapefile of the basin delineations. PSRC returned the data as a spreadsheet with 2017 employment data listed for each basin. Basin data suppressed by PSRC for confidentiality reasons was estimated by BHC using the total employment data for that UGA plus ground information that could be reasonably collected regarding the likely employment within the suppressed basin. That data included parcel size and distribution, aerial searches, county assessor parcel data, and local knowledge.

Data Sources:

- **PSRC 2017 Total Employment Custom Estimate**
- **PSRC 2017 Covered Employment Custom Estimate**
- **American Community Survey 5-Year Self Employment for Kitsap County**

<u>2038 and "Buildout" Residential and Employment Estimates</u>

BHC submitted a custom data request to the Puget Sound Regional Council (PSRC) for a Residential and Total Employment estimate for each of the UGAs as well as within the basins which subdivide the UGAs based on PSRC's Land Use Vision (LUV) long-range model. The custom request was for the years 2035, 2040, and "capacity."

BHC assumed the LUV models a constant growth rate between 2035 and 2040, and a straight-line interpolation was used between 2035 and 2040 to generate the residential and total employment estimates for 2038. Residential and employment forecasts that seemed spurious (e.g. employment that fluctuates up and down greatly) may reflect idiosyncrasies in the LUV model rather than an accurate forecast. In those cases, basins were adjusted to reflect known conditions on the ground based on truthing exercises with Kitsap County where a basis and the tabular data for each basin was presented for discussion.

Data Sources:

- **PSRC LUV Custom Estimate, Residential and Total Employment, for 2035, 2040, and "Capacity."**

APPENDIX B

2019 HYDRAULIC MODEL UPDATE – MODEL RESULTS

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NORTHERN OLD MILITARY ROAD SEWER UPGRADES

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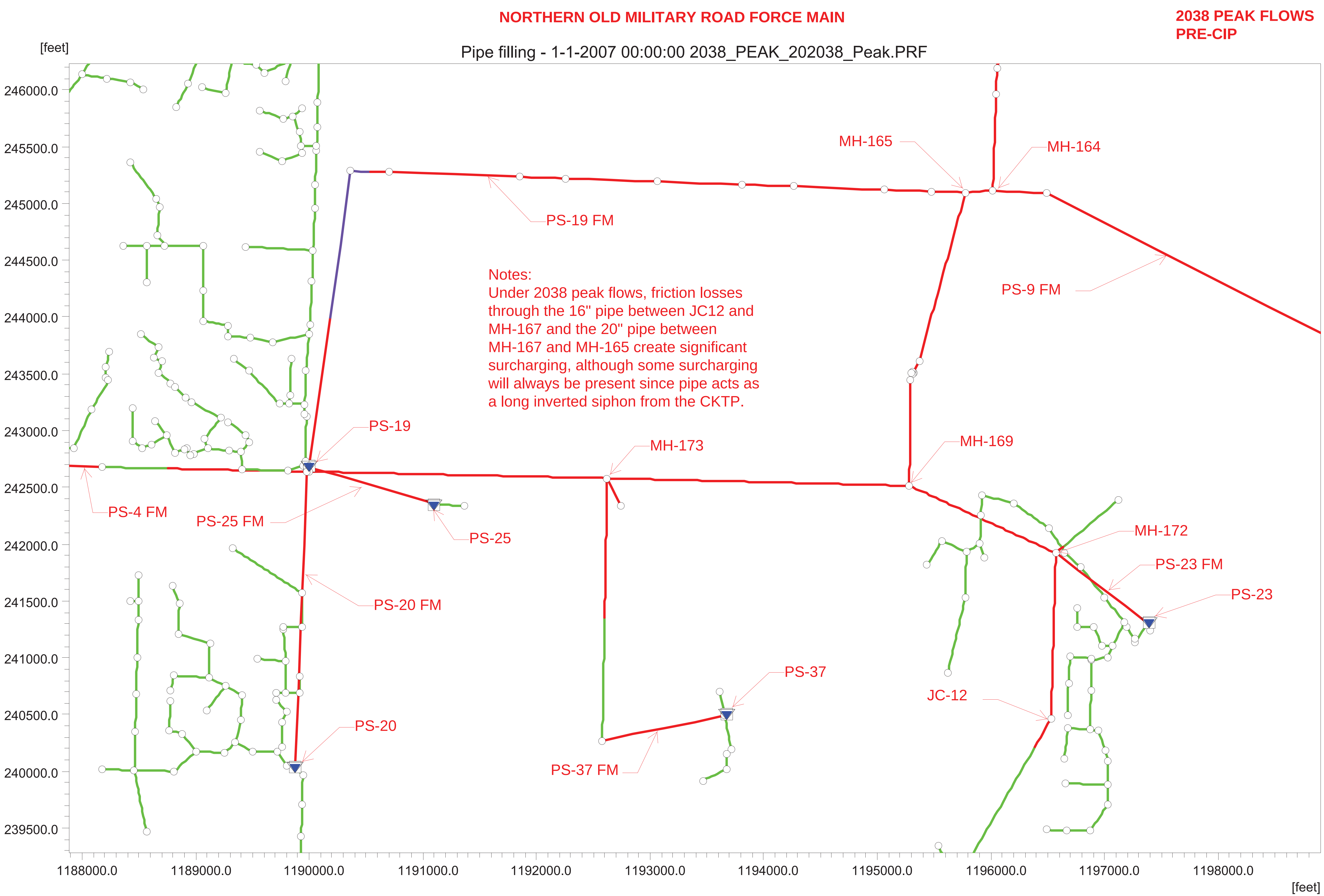


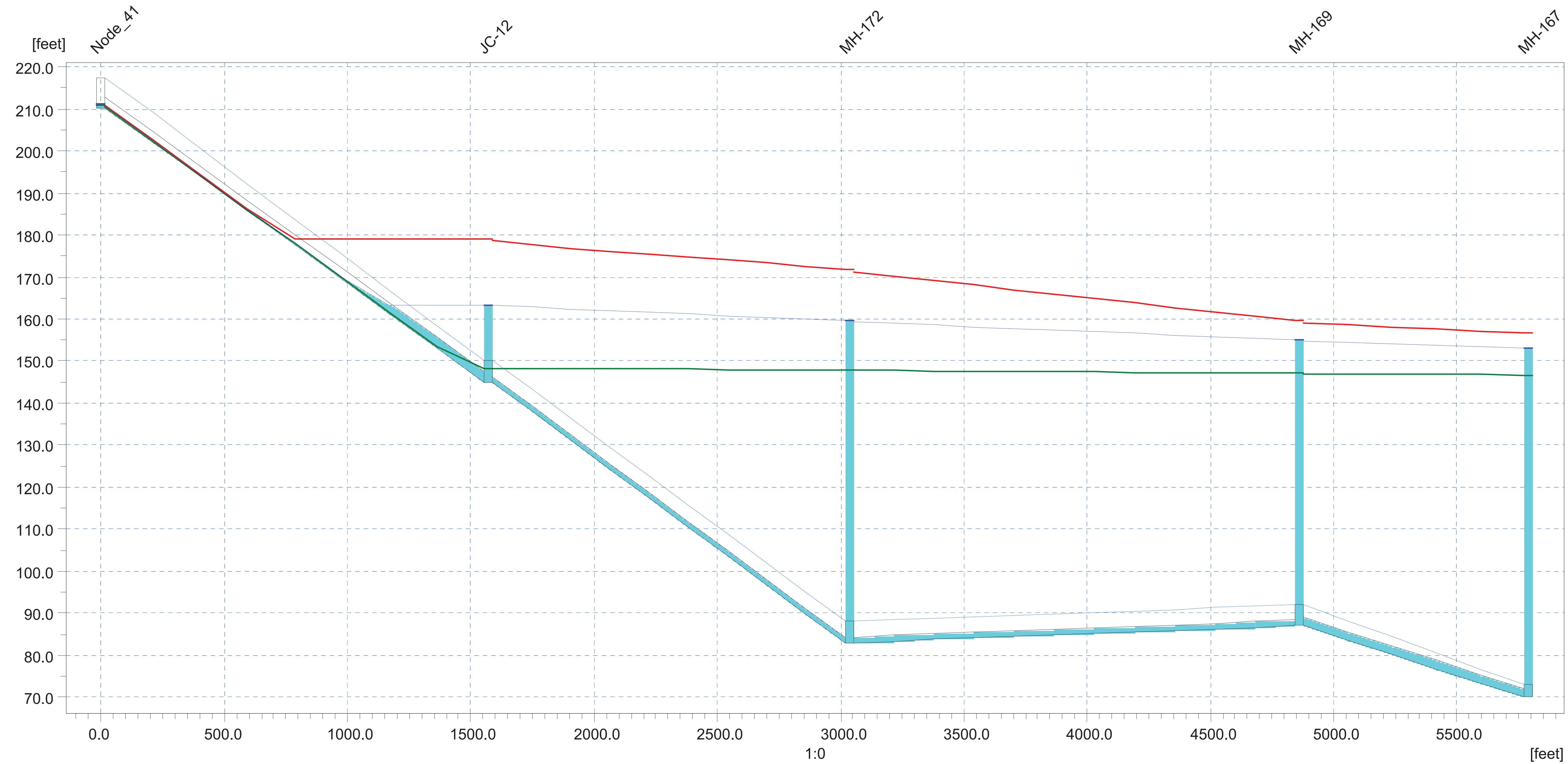
NORTHERN OLD MILITARY ROAD FORCE MAIN
2038 PEAK FLOWS
PRE-CIP
Pipe filling - 1-1-2007 00:00:00 2038_PEAK_202038_Peak.PRF
[feet]
Notes:
Under 2038 peak flows, friction losses through the 16" pipe between JC12 and MH-167 and the 20" pipe between MH-167 and MH-165 create significant surcharging, although some surcharging will always be present since pipe acts as a long inverted siphon from the CKTP.
MH-165
MH-164
PS-19 FM
PS-9 FM
PS-19
MH-173
MH-169
PS-4 FM
PS-25 FM
PS-25
MH-172
PS-23 FM
PS-23
PS-20 FM
PS-37
JC-12
PS-20
PS-37 FM
246000.0
245500.0
245000.0
244500.0
244000.0
243500.0
243000.0
242500.0
242000.0
241500.0
241000.0
240500.0
240000.0
239500.0
1188000.0
1189000.0
1190000.0
1191000.0
1192000.0
1193000.0
1194000.0
1195000.0
1196000.0
1197000.0
1198000.0
[feet]

NORTHERN OLD MILITARY ROAD FORCE MAIN

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	5.879	4.118	4.053	10.399	cfs

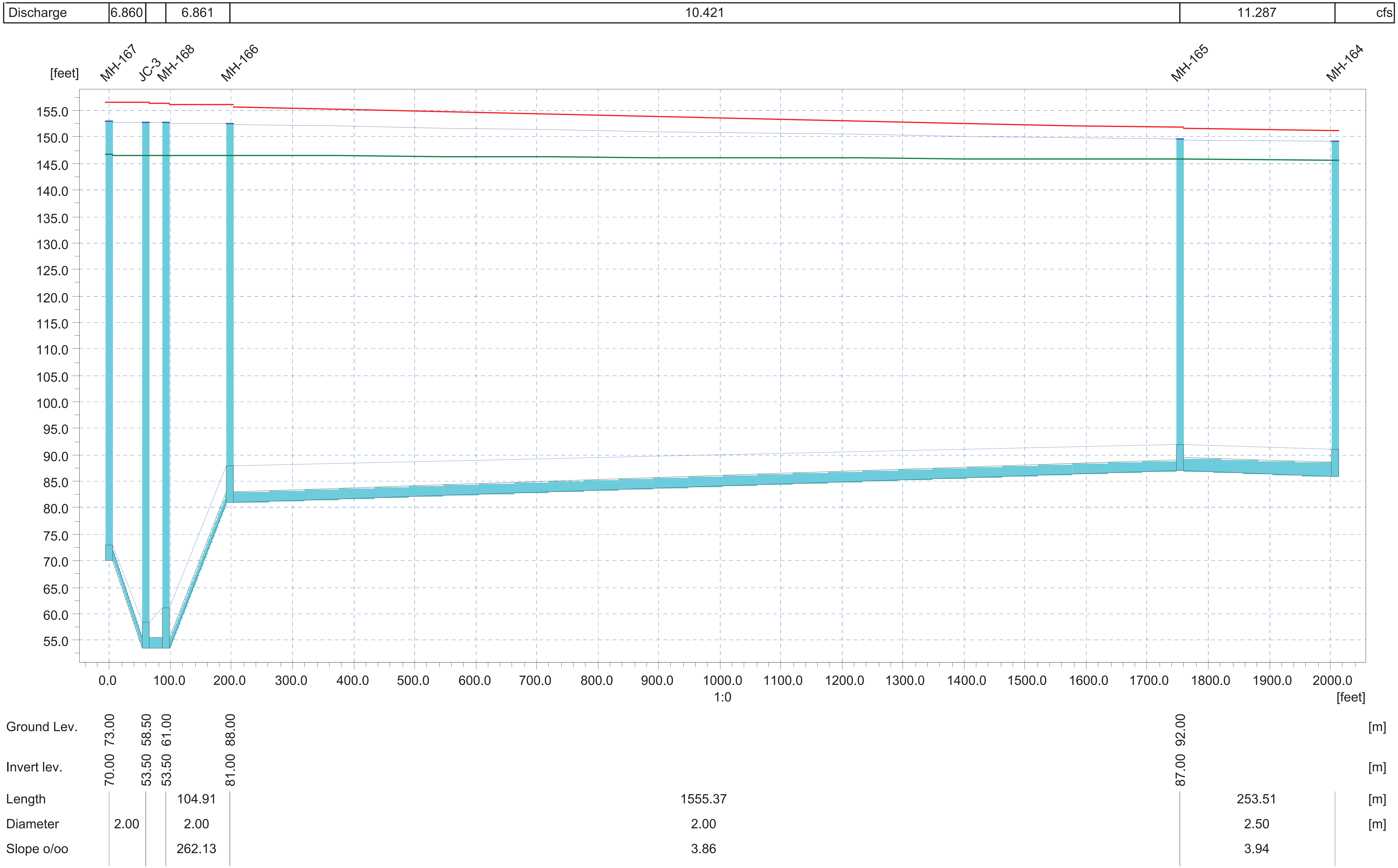


	Node_41		JC-12		MH-172		MH-169		MH-167	
Ground Lev.	217.50		150.00		88.00		92.00			[m]
Invert lev.	210.30		145.00		83.00		87.00			[m]
Length		1571.18		1463.97		1824.82		927.30		[m]
Diameter		2.50		1.33		1.33		2.00		[m]
Slope o/oo		41.56		42.35		2.19		18.33		

NORTHERN OLD MILITARY ROAD FORCE MAIN

2038 PEAK FLOW CONDITIONS
PRE-CIP

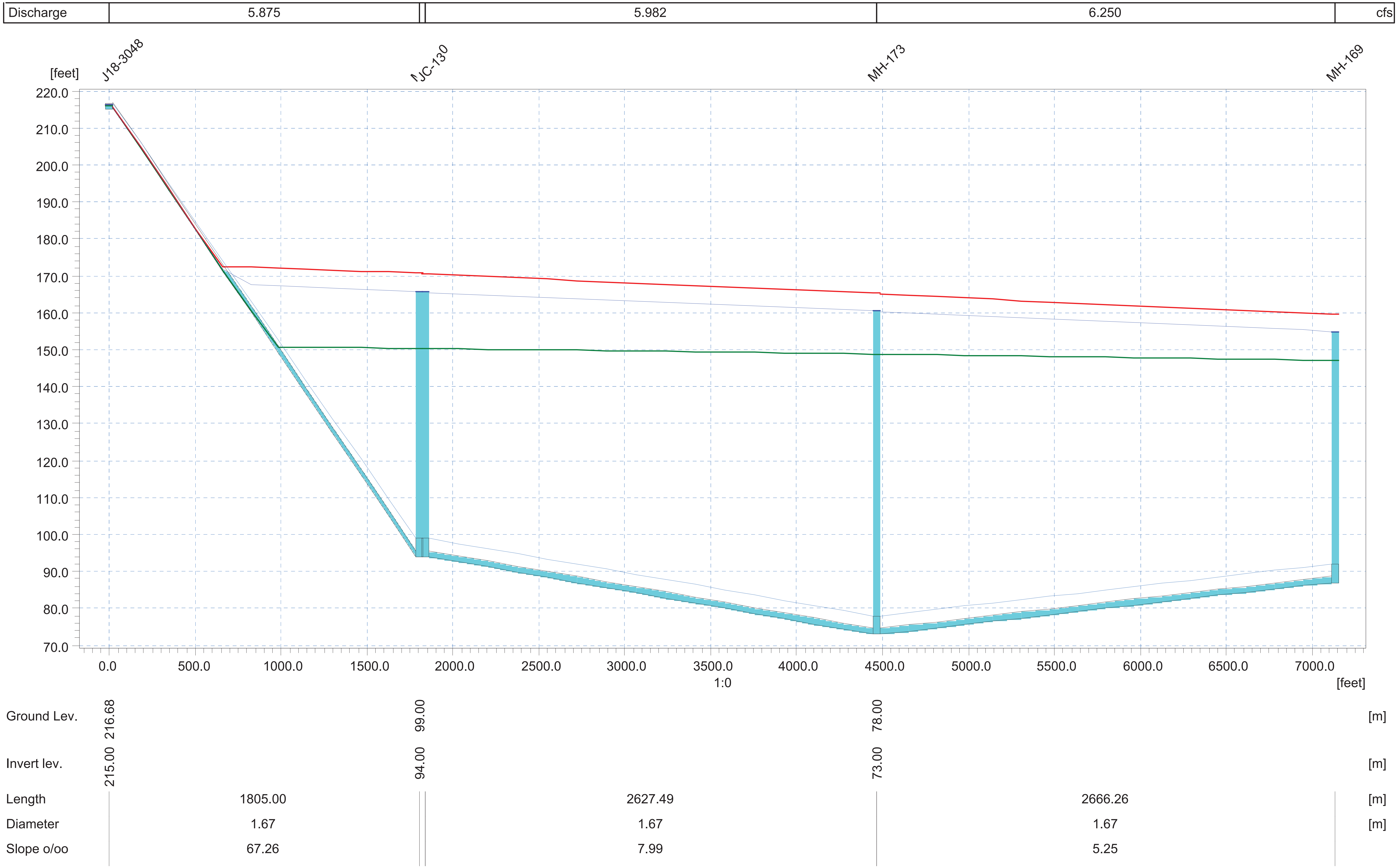
Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF



NORTHERN OLD MILITARY ROAD FORCE MAIN

2038 PEAK FLOW CONDITIONS
PRE-CIP

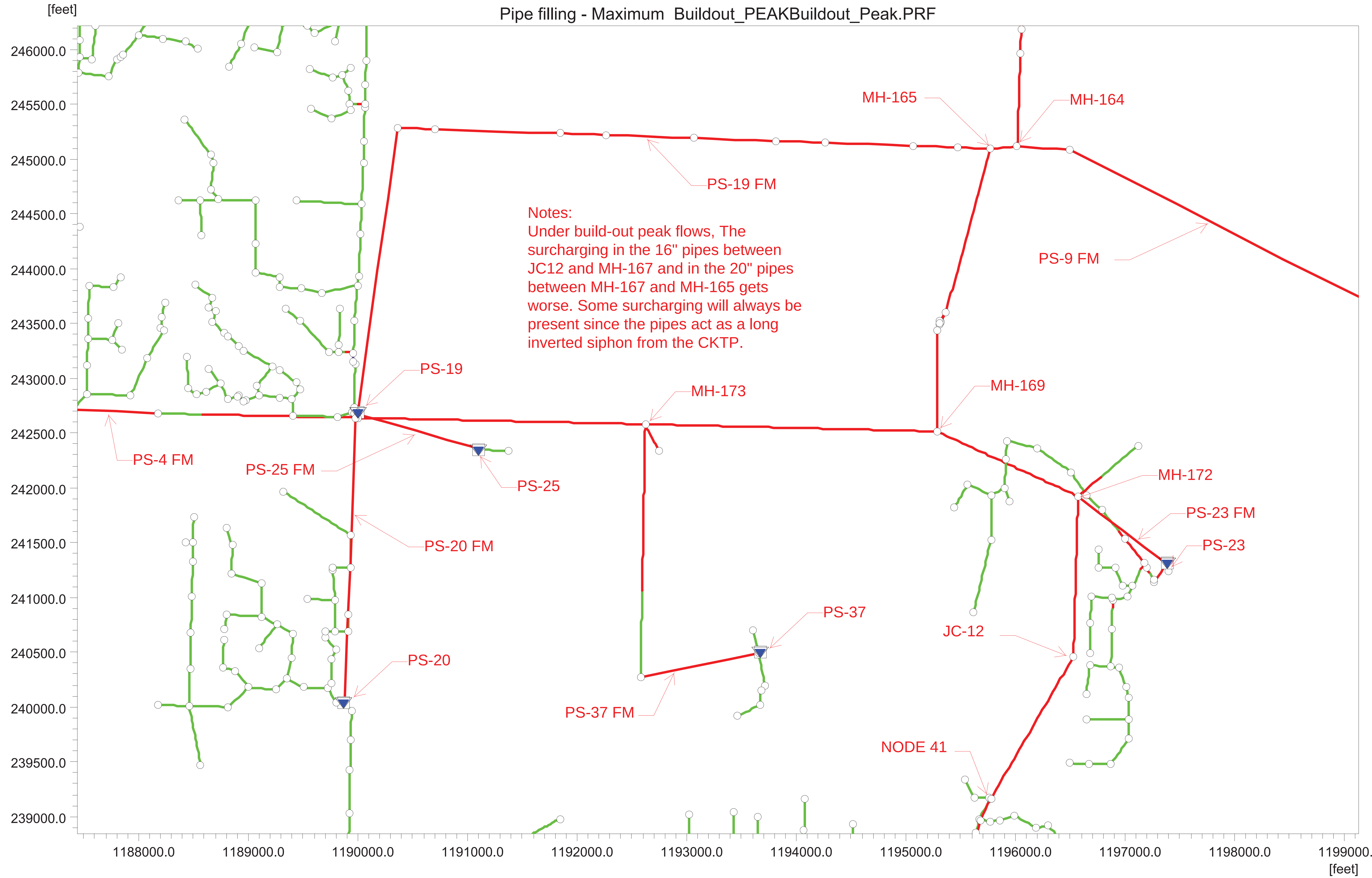
Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF



NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOWS
PRE-CIP

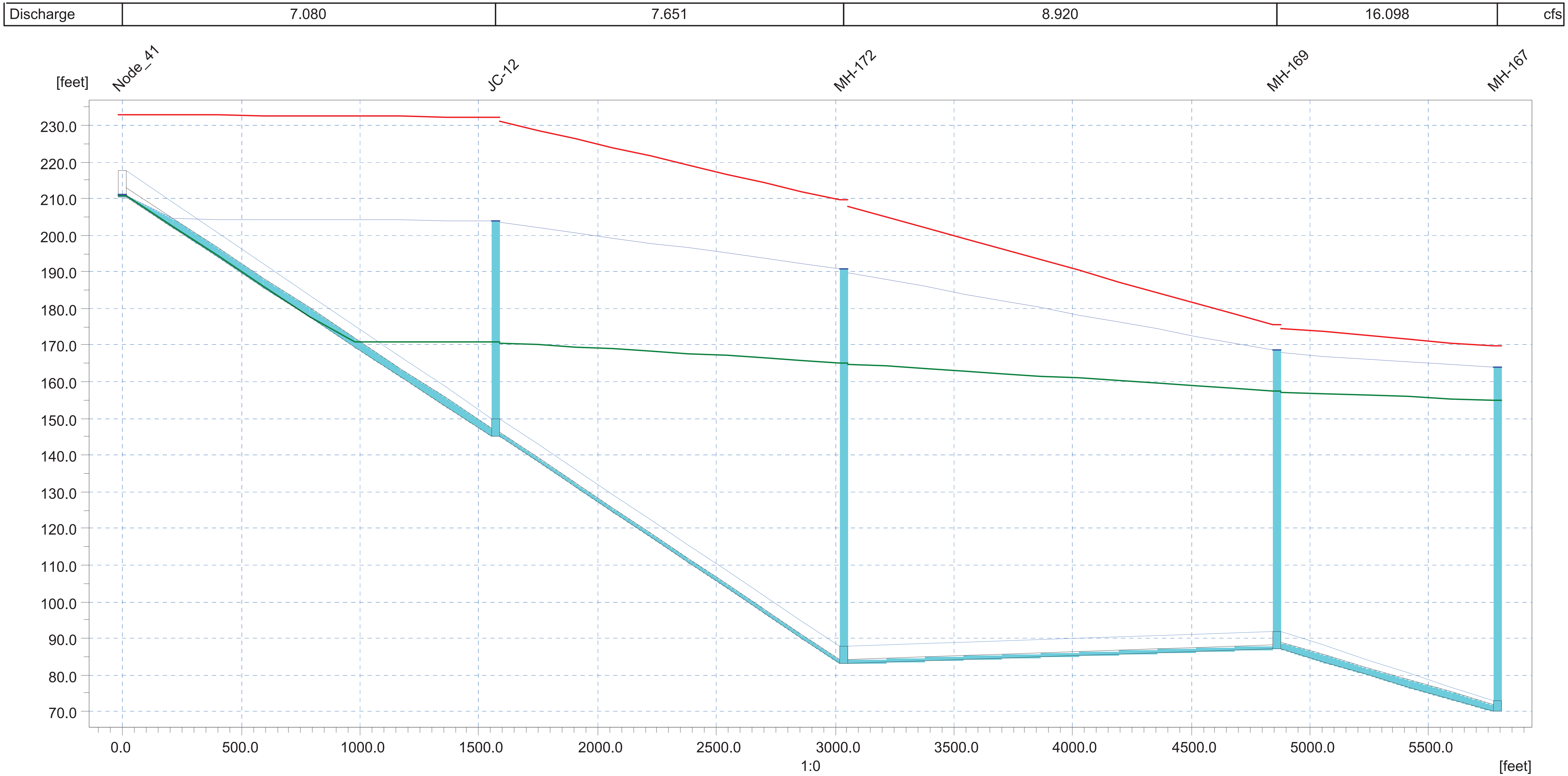
Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF



NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF



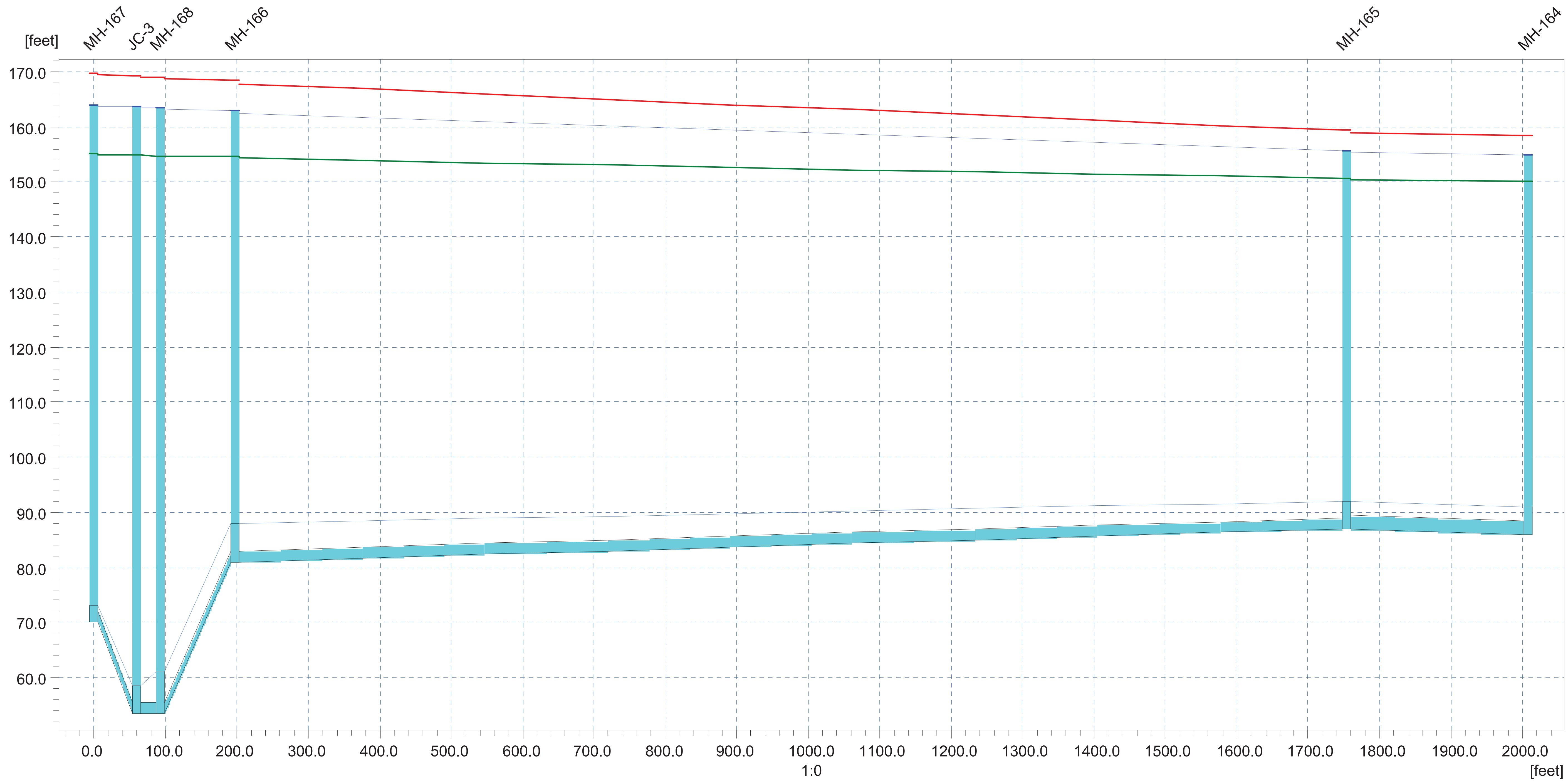
	Node_41		JC-12		MH-172		MH-169		MH-167	
Ground Lev.	217.50		150.00		88.00		92.00			[m]
Invert lev.	210.30		145.00		83.00		87.00			[m]
Length		1571.18		1463.97		1824.82		927.30		[m]
Diameter		2.50		1.33		1.33		2.00		[m]
Slope o/oo		41.56		42.35		2.19		18.33		

NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge			10.657	16.187	17.181	cfs



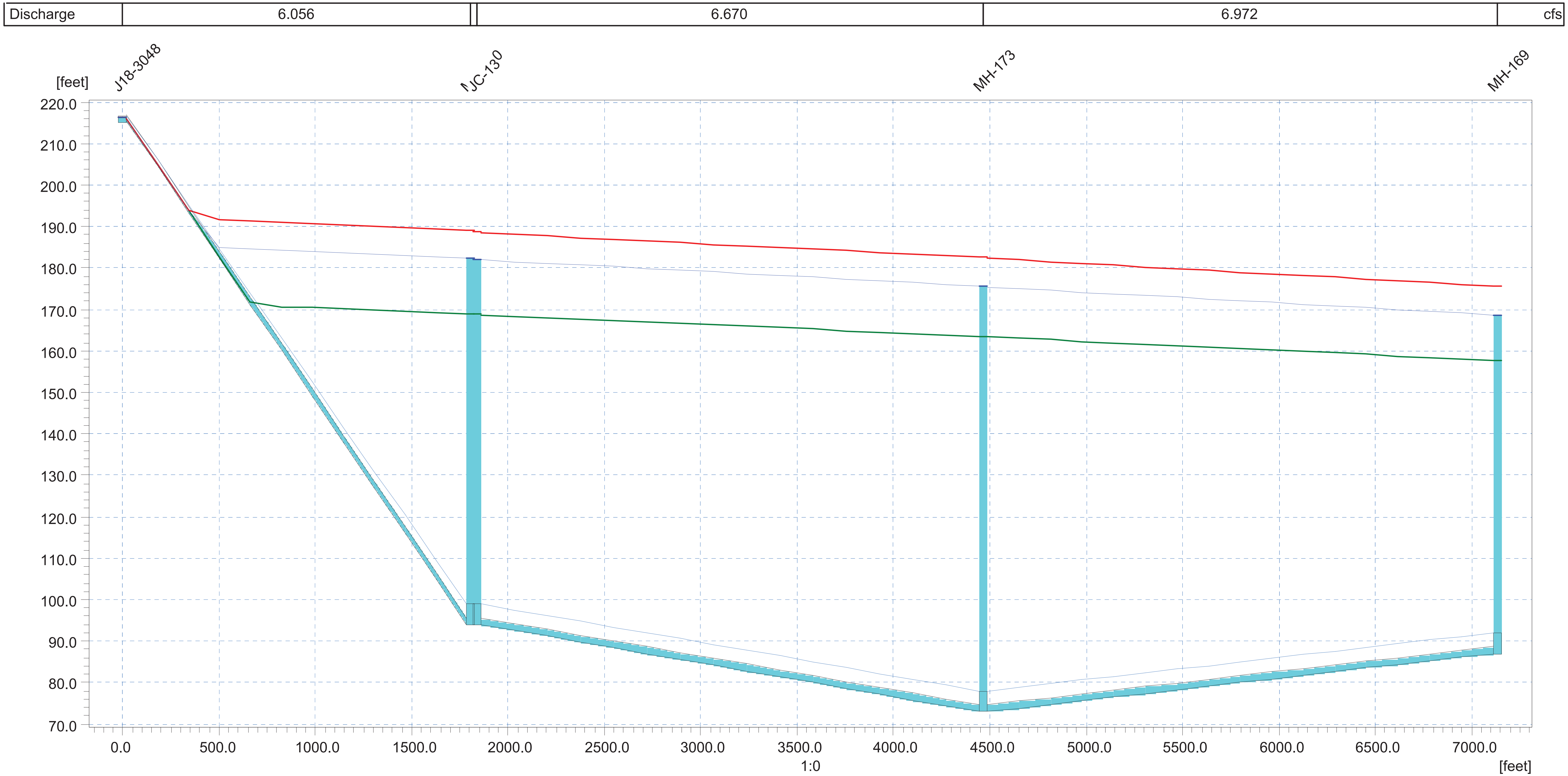
	MH-167	JC-3	MH-168	MH-166	MH-165	
Ground Lev.	73.00	58.50	61.00	88.00	92.00	[m]
Invert lev.	70.00	53.50	53.50	81.00	87.00	[m]

Length			104.91	1555.37	253.51	[m]
Diameter	2.00		2.00	2.00	2.50	[m]
Slope o/oo			262.13	3.86	3.94	

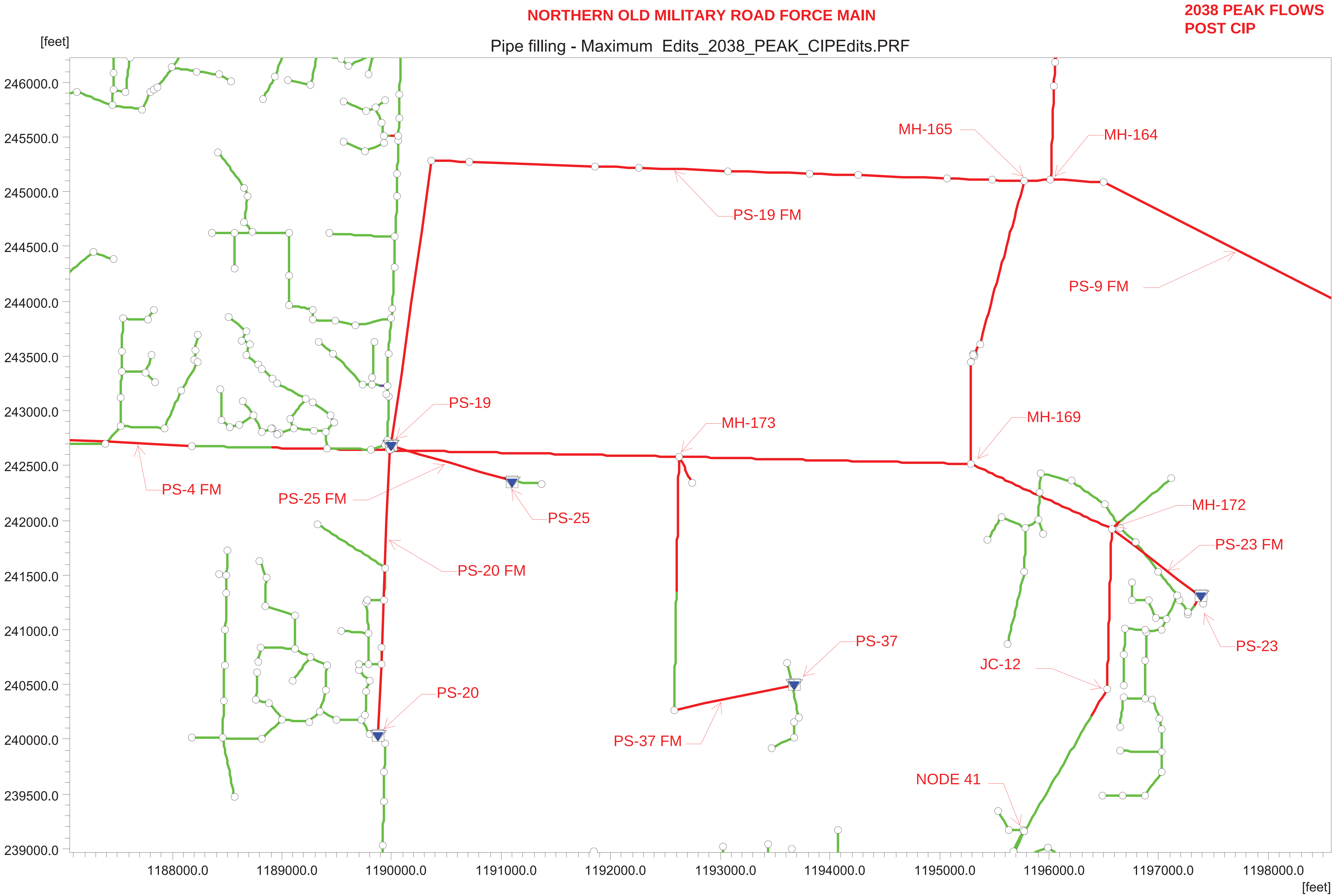
NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF



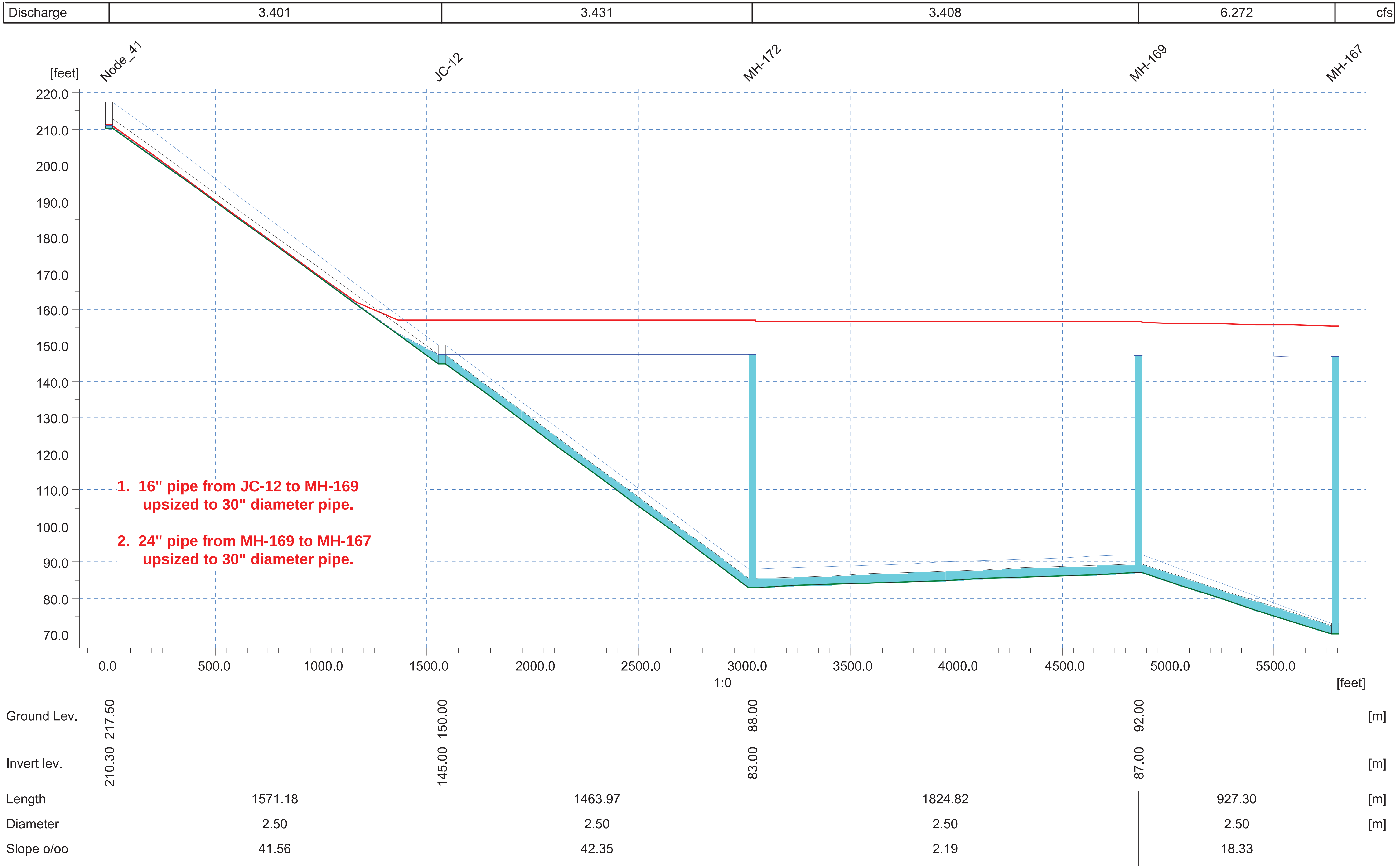
Ground Lev.	216.68		99.00		78.00		[m]
Invert lev.	215.00		94.00		73.00		[m]
Length		1805.00		2627.49		2666.26	[m]
Diameter		1.67		1.67		1.67	[m]
Slope o/oo		67.26		7.99		5.25	


NORTHERN OLD MILITARY ROAD FORCE MAIN
2038 PEAK FLOWS
POST CIP
Pipe filling - Maximum Edits_2038_PEAK_CIPEdits.PRF
[feet]
246000.0
245500.0
245000.0
244500.0
244000.0
243500.0
243000.0
242500.0
242000.0
241500.0
241000.0
240500.0
240000.0
239500.0
239000.0
1188000.0
1189000.0
1190000.0
1191000.0
1192000.0
1193000.0
1194000.0
1195000.0
1196000.0
1197000.0
1198000.0
[feet]
MH-165
MH-164
PS-19 FM
PS-9 FM
PS-19
MH-173
MH-169
PS-4 FM
PS-25 FM
PS-25
MH-172
PS-23 FM
PS-20 FM
PS-37
PS-23
JC-12
PS-20
PS-37 FM
NODE 41

NORTHERN OLD MILITARY ROAD FORCE MAIN

2038 PEAK FLOW CONDITIONS
POST CIP

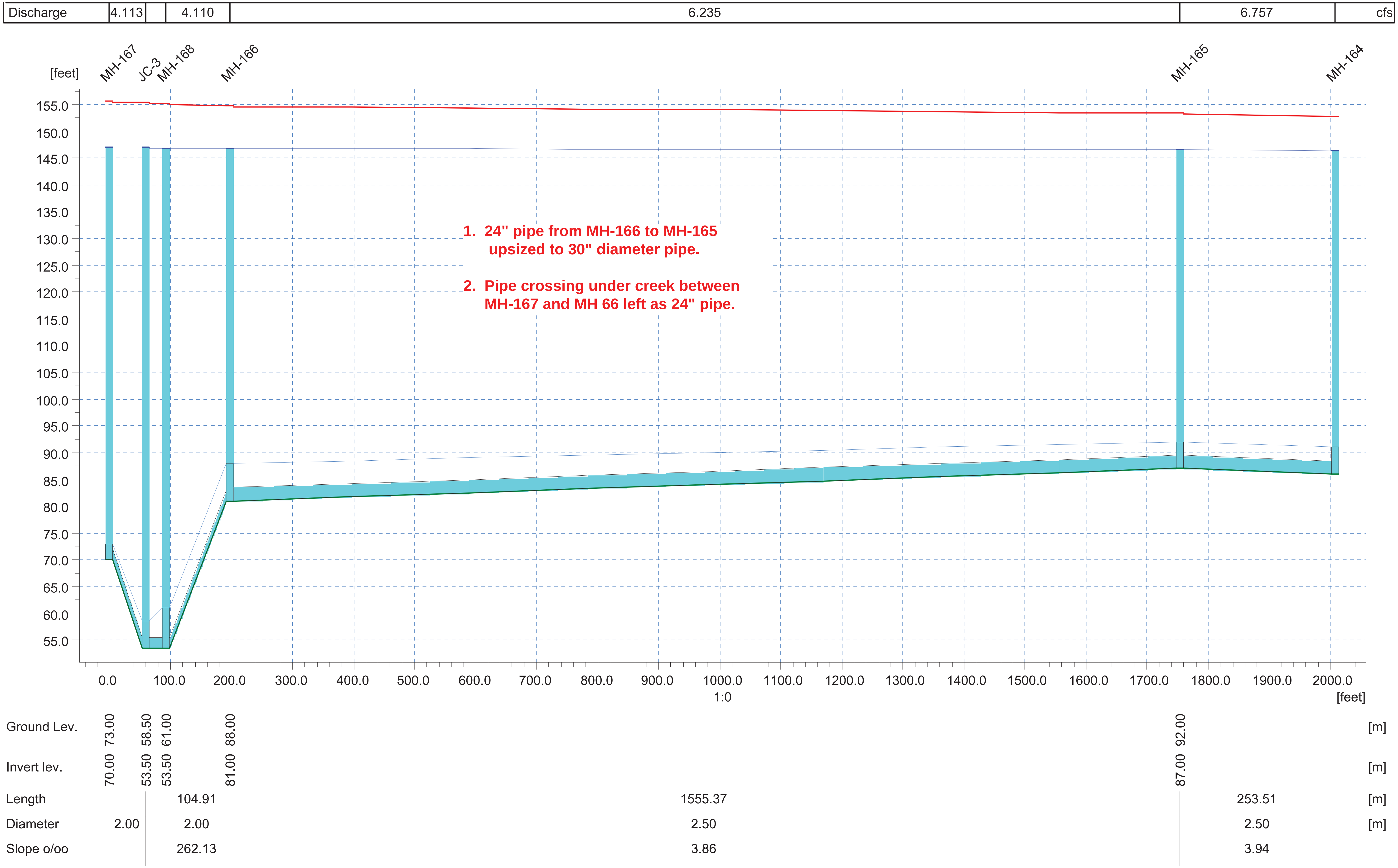
Link Water Level - 1-1-2007 05:30:00 Edits_2038_PEAK_CIPEdits.PRF



NORTHERN OLD MILITARY ROAD FORCE MAIN

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 05:30:00 Edits_2038_PEAK_CIPEdits.PRF

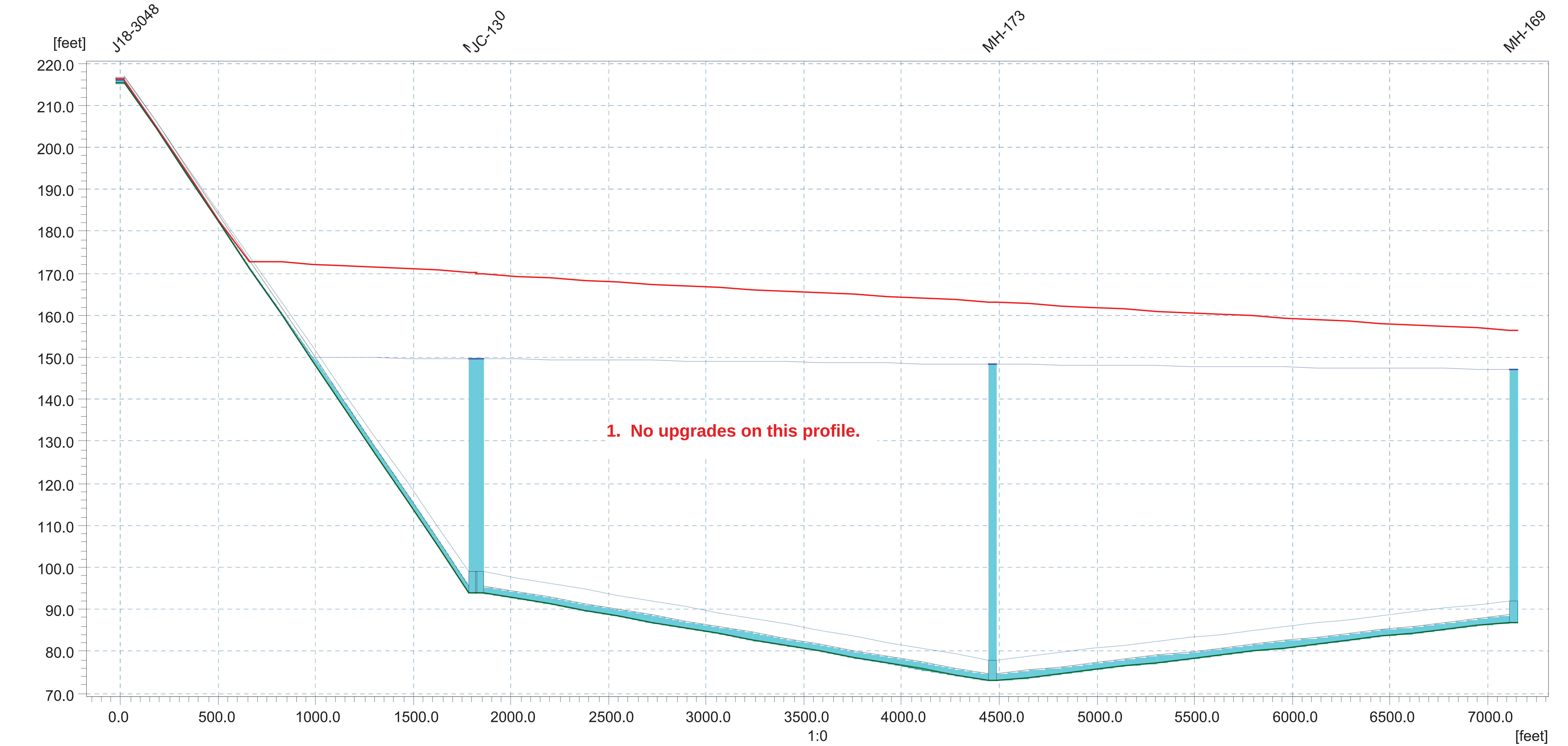


NORTHERN OLD MILITARY ROAD FORCE MAIN

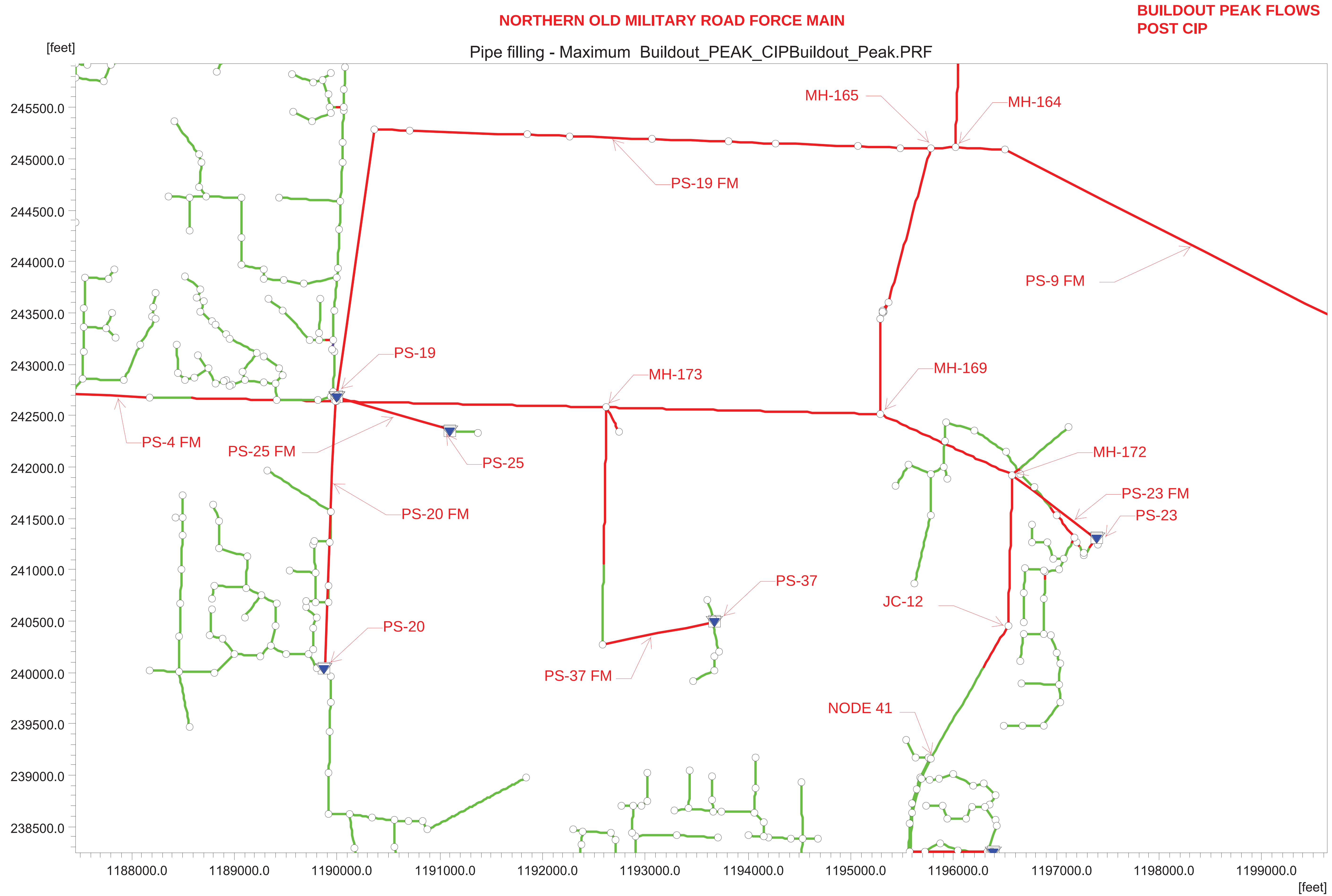
2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 05:28:59 Edits_2038_PEAK_CIPEdits.PRF

Discharge	3.067	2.959	2.972	cfs



Ground Lev.	216.68	99.00	78.00		[m]
Invert lev.	215.00	94.00	73.00		[m]
Length	1805.00	2627.49	2666.26		[m]
Diameter	1.67	1.67	1.67		[m]
Slope o/oo	67.26	7.99	5.25		

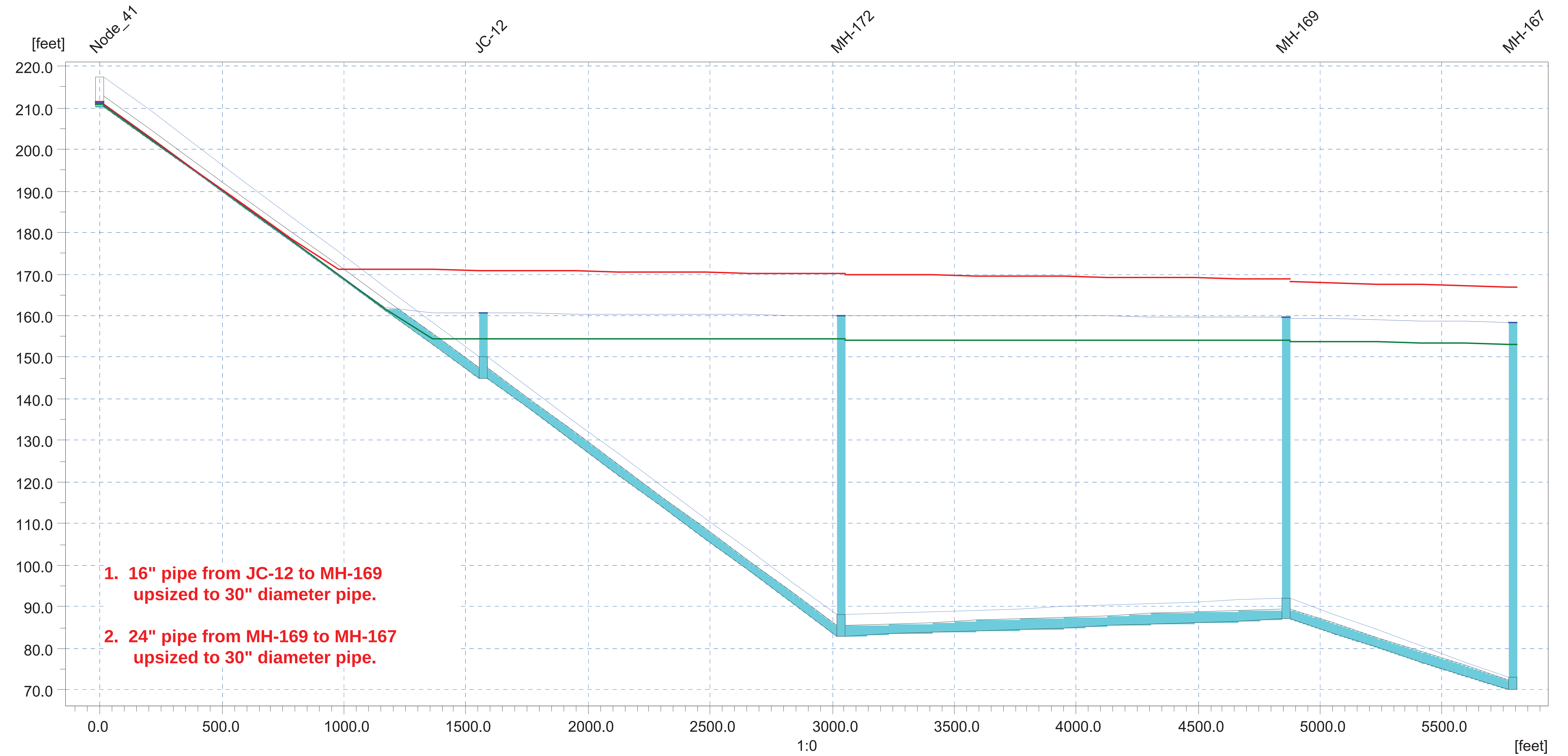

NORTHERN OLD MILITARY ROAD FORCE MAIN
BUILDOUT PEAK FLOWS
POST CIP
Pipe filling - Maximum Buildout_PEAK_CIPBuildout_Peak.PRF
[feet]
245500.0
245000.0
244500.0
244000.0
243500.0
243000.0
242500.0
242000.0
241500.0
241000.0
240500.0
240000.0
239500.0
239000.0
238500.0
1188000.0
1189000.0
1190000.0
1191000.0
1192000.0
1193000.0
1194000.0
1195000.0
1196000.0
1197000.0
1198000.0
1199000.0
[feet]
MH-165
MH-164
PS-19 FM
PS-9 FM
PS-19
MH-173
MH-169
PS-4 FM
PS-25 FM
PS-25
MH-172
PS-20 FM
PS-23 FM
PS-23
PS-37
JC-12
PS-20
PS-37 FM
NODE 41

NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	7.055	6.538	7.716	15.987	cfs



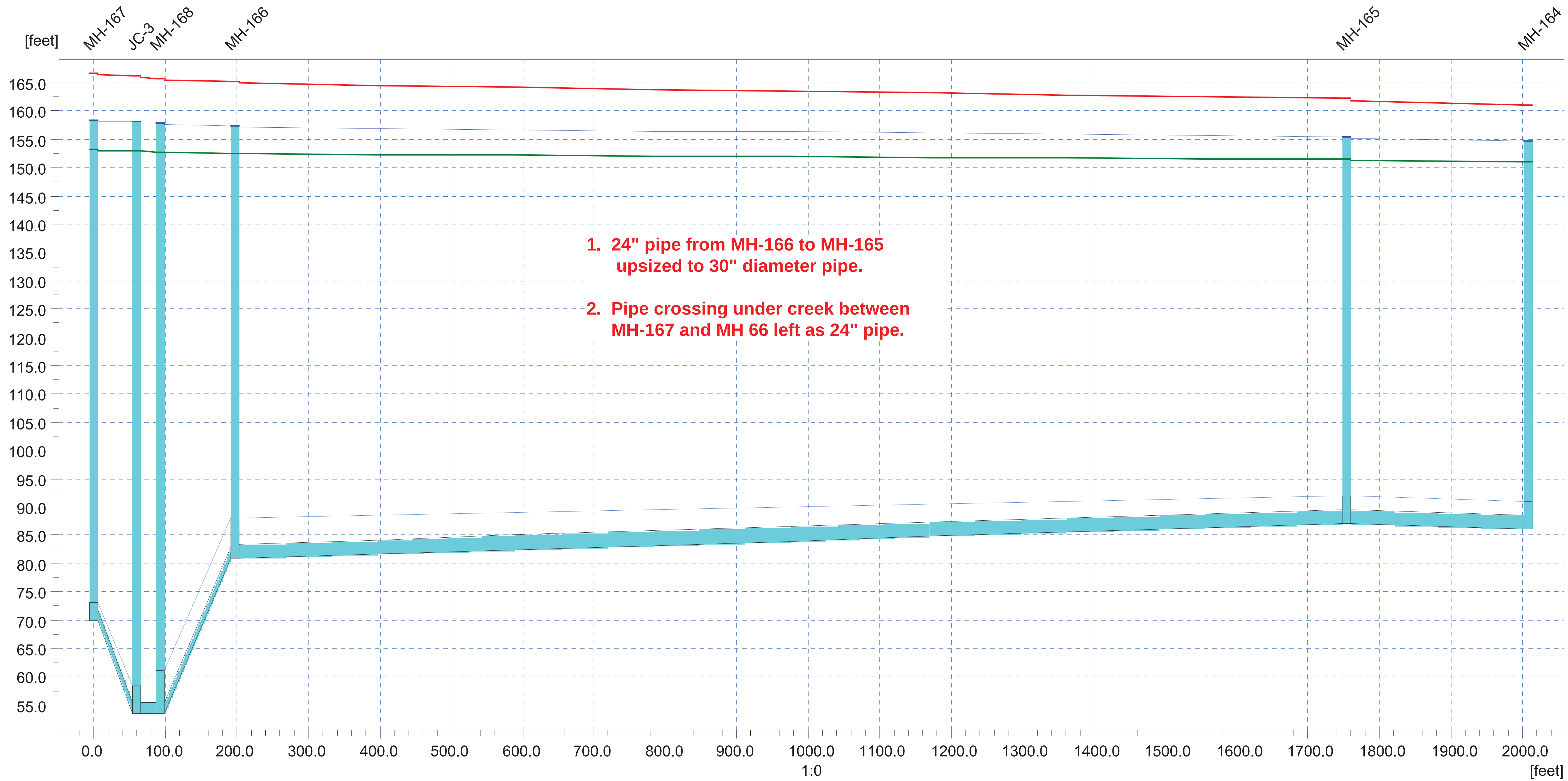
	Node_41		JC-12		MH-172		MH-169		MH-167	
Ground Lev.	217.50		150.00		88.00		92.00			[m]
Invert lev.	210.30		145.00		83.00		87.00			[m]
Length		1571.18		1463.97		1824.82		927.30		[m]
Diameter		2.50		2.50		2.50		2.50		[m]
Slope o/oo		41.56		42.35		2.19		18.33		

NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge			10.589	16.086	17.116	cfs



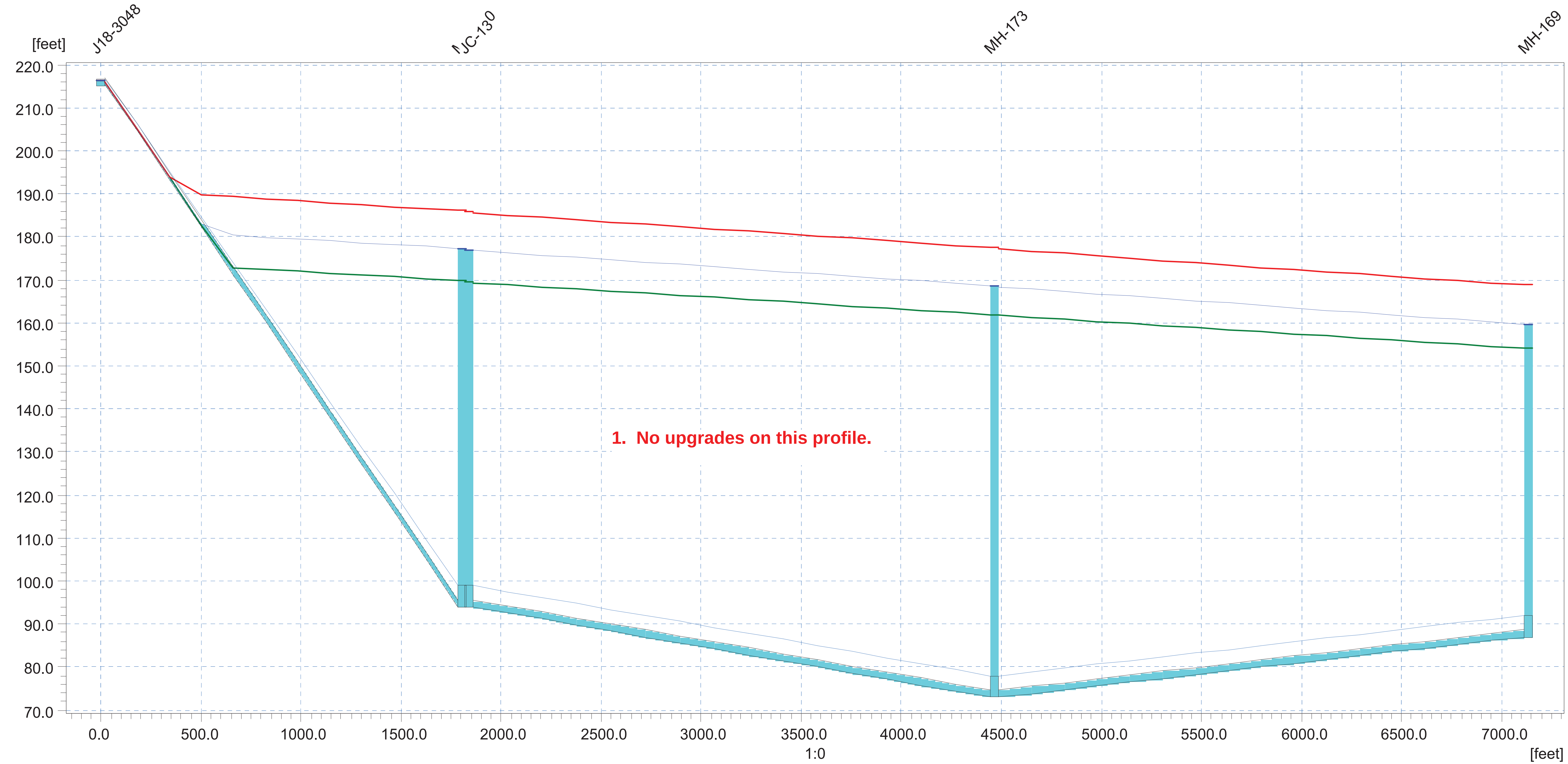
	MH-167		JC-3		MH-168		MH-166		MH-165		MH-164	
Ground Lev.	73.00		58.50		61.00		88.00		92.00			[m]
Invert lev.	70.00		53.50		53.50		81.00		87.00			[m]
Length						104.91		1555.37		253.51		[m]
Diameter		2.00				2.00		2.50		2.50		[m]
Slope o/oo						262.13		3.86		3.94		

NORTHERN OLD MILITARY ROAD FORCE MAIN

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	7.061	7.670	7.902	cfs



	J18-3048	JC-130	MH-173	
Ground Lev.	216.68	99.00	78.00	[m]
Invert lev.	215.00	94.00	73.00	[m]

Length	1805.00	2627.49	2666.26	[m]
Diameter	1.67	1.67	1.67	[m]
Slope o/oo	67.26	7.99	5.25	

BAYSHORE AND WASHINGTON IMPROVEMENTS

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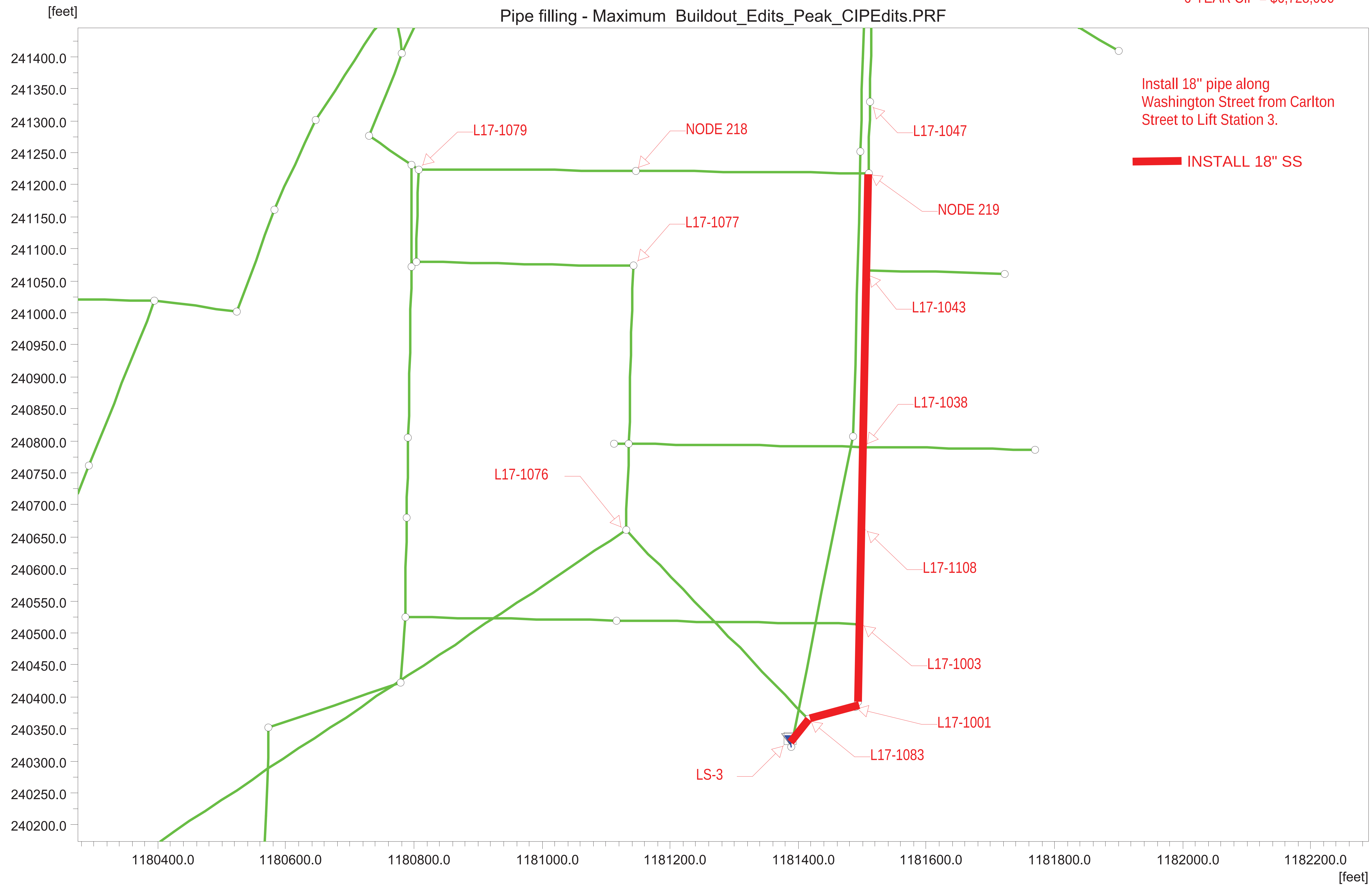
BAYSHORE AND WASHINGTON IMPROVEMENTS

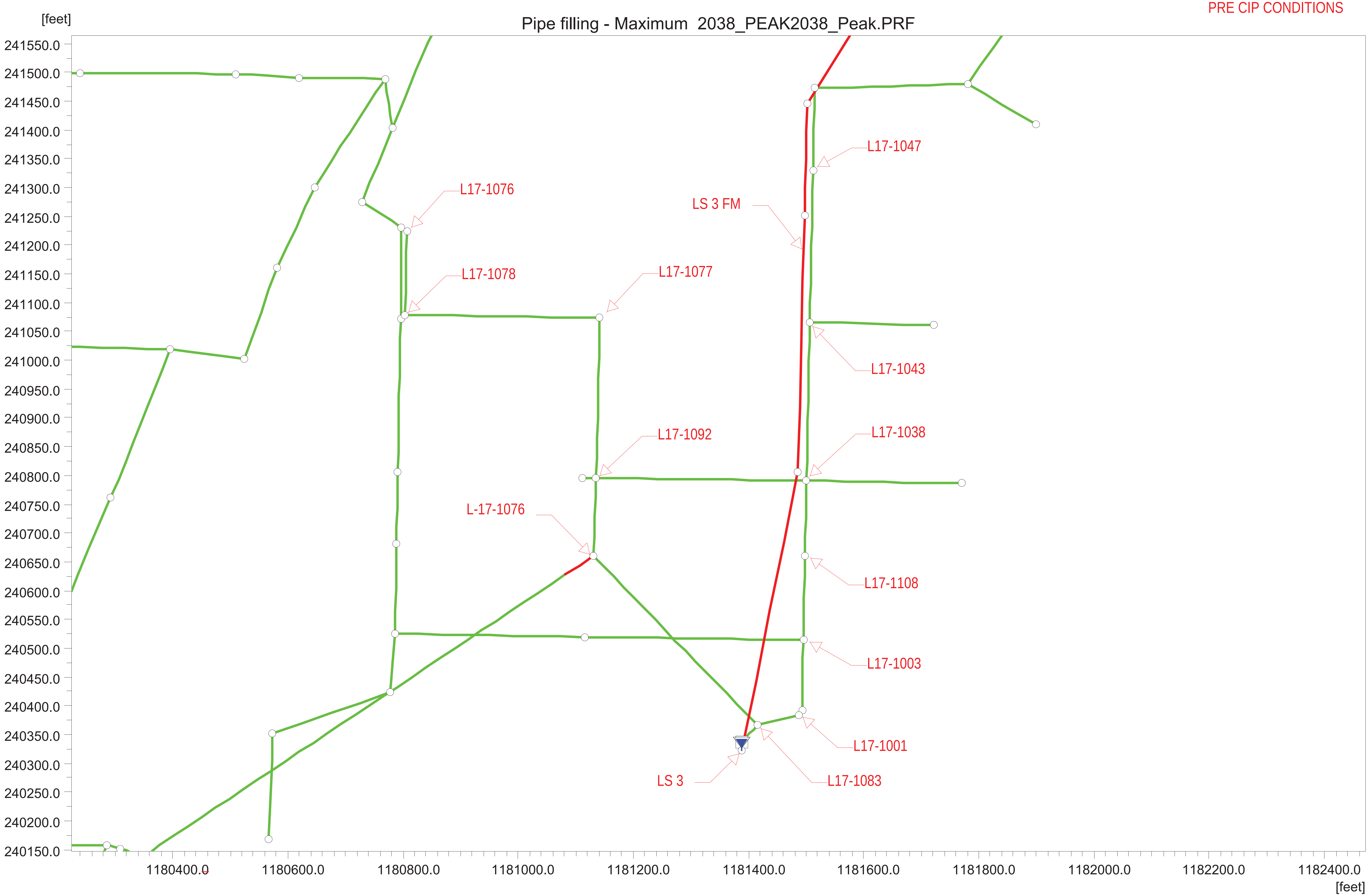
PROPOSED UPGRADES
6-YEAR CIP = $6,728,000



BAYSHORE AND WASHINGTON IMPROVEMENTS

2038 PEAK FLOWS
PRE CIP CONDITIONS

Pipe filling - Maximum 2038_PEAK2038_Peak.PRF

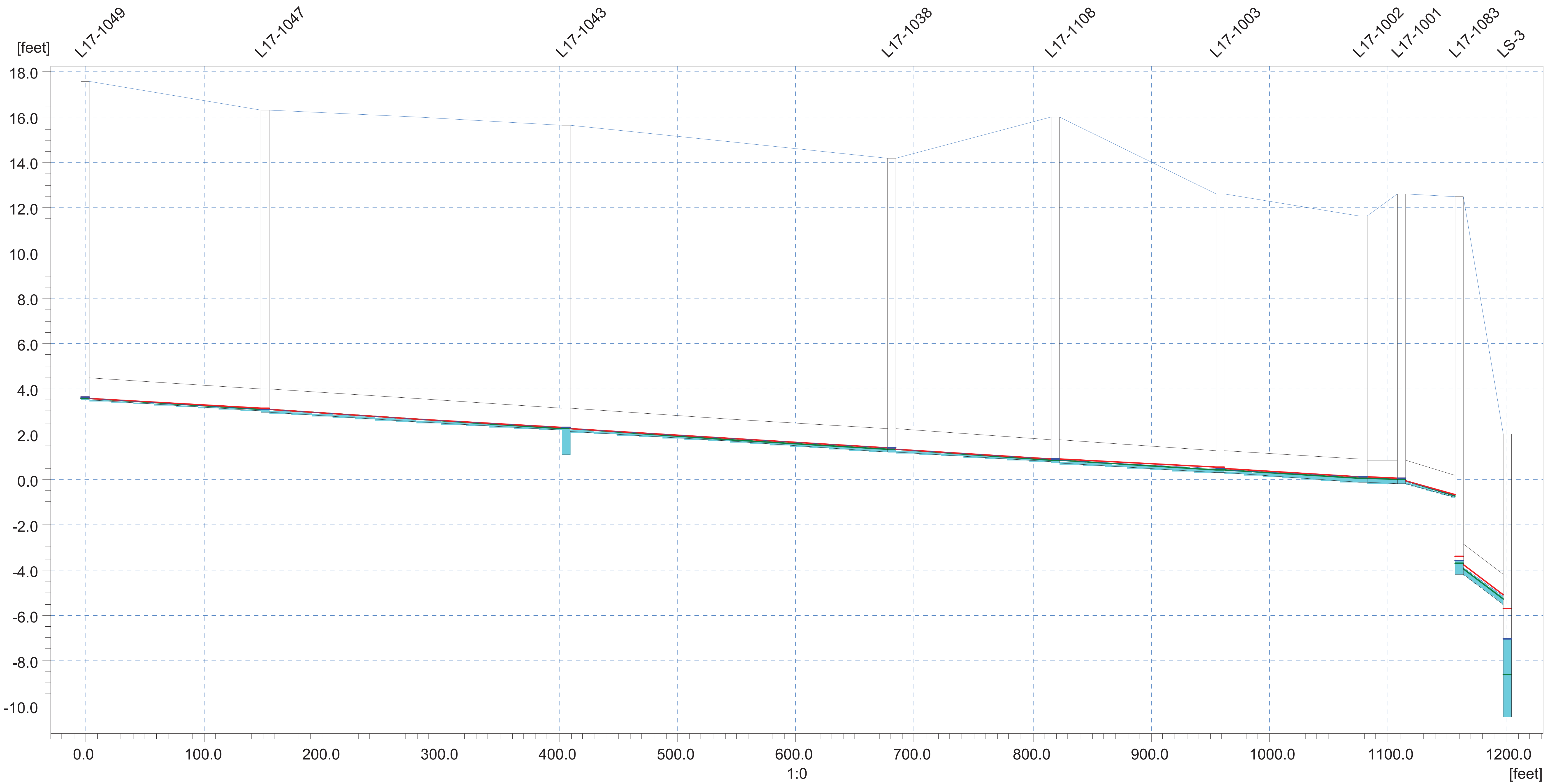


BAYSHORE AND WASHINGTON IMPROVEMENTS

2038 PEAK FLOWS
PRE CIP CONDITIONS

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.034	0.042	0.051	0.064	0.064	0.112		0.112	1.591	cfs



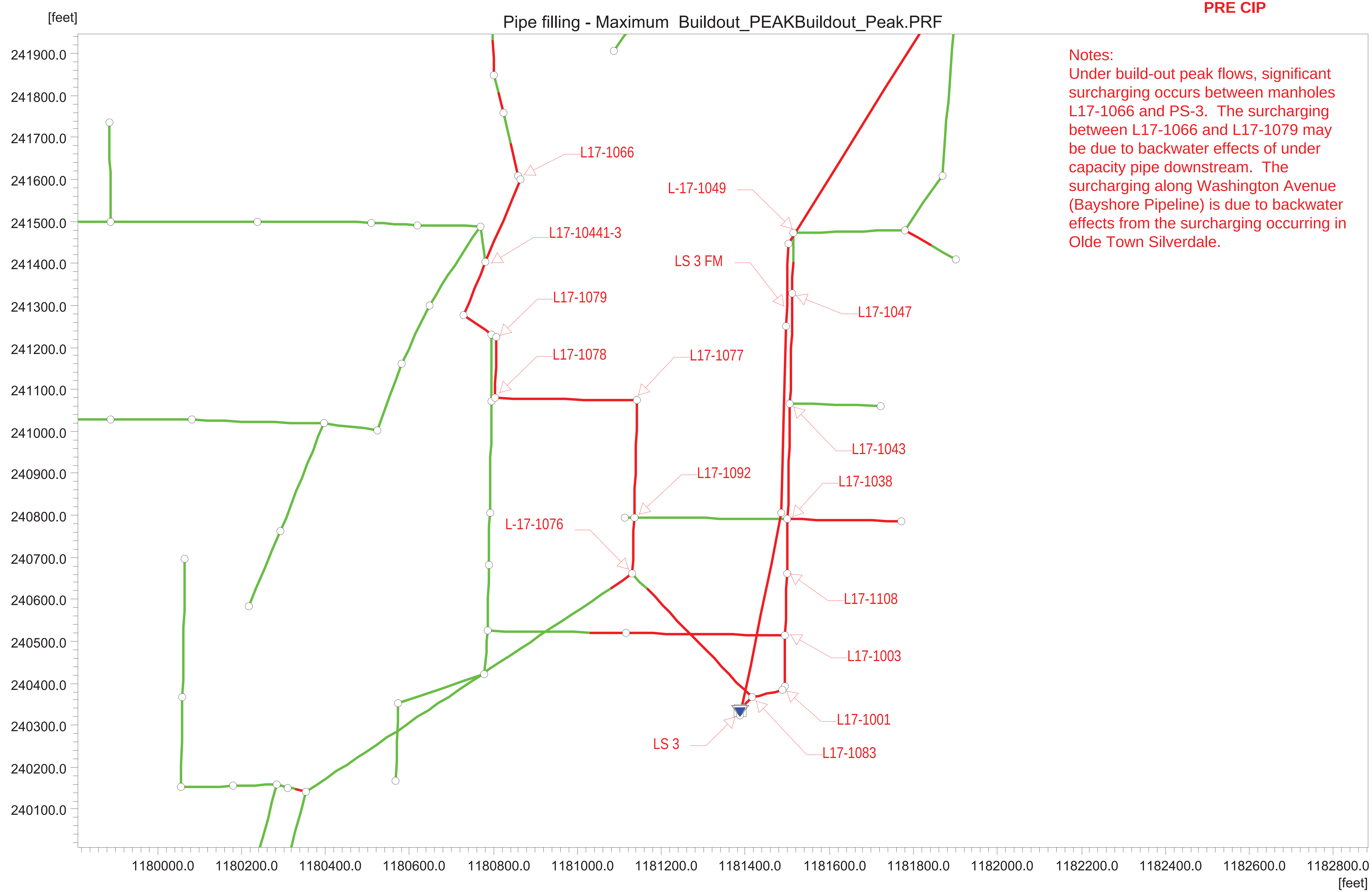
Node	L17-1049	L17-1047	L17-1043	L17-1038	L17-1108	L17-1003	L17-1002	L17-1001	L17-1083	LS-3	
Ground Lev.	17.59	16.34	15.65	14.20	16.02	12.63	11.64	12.62	12.49		[m]
Invert lev.	3.50	2.99	1.10	1.22	0.75	0.29	-0.13	-0.17	-4.20		[m]

	L17-1049 – L17-1047	L17-1047 – L17-1043	L17-1043 – L17-1038	L17-1038 – L17-1108	L17-1108 – L17-1003	L17-1003 – L17-1002	L17-1002 – L17-1001	L17-1001 – L17-1083	L17-1083 – LS-3	
Length	152.00	254.00	275.00	138.00	139.00	121.00		48.00	40.66	[m]
Diameter	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.33	[m]
Slope o/oo	3.29	3.31	3.31	3.33	3.31	3.31	1.22	13.54	31.98	

BAYSHORE AND WASHINGTON IMPROVEMENTS

BUILDOUT FLOWS
PRE CIP

Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF



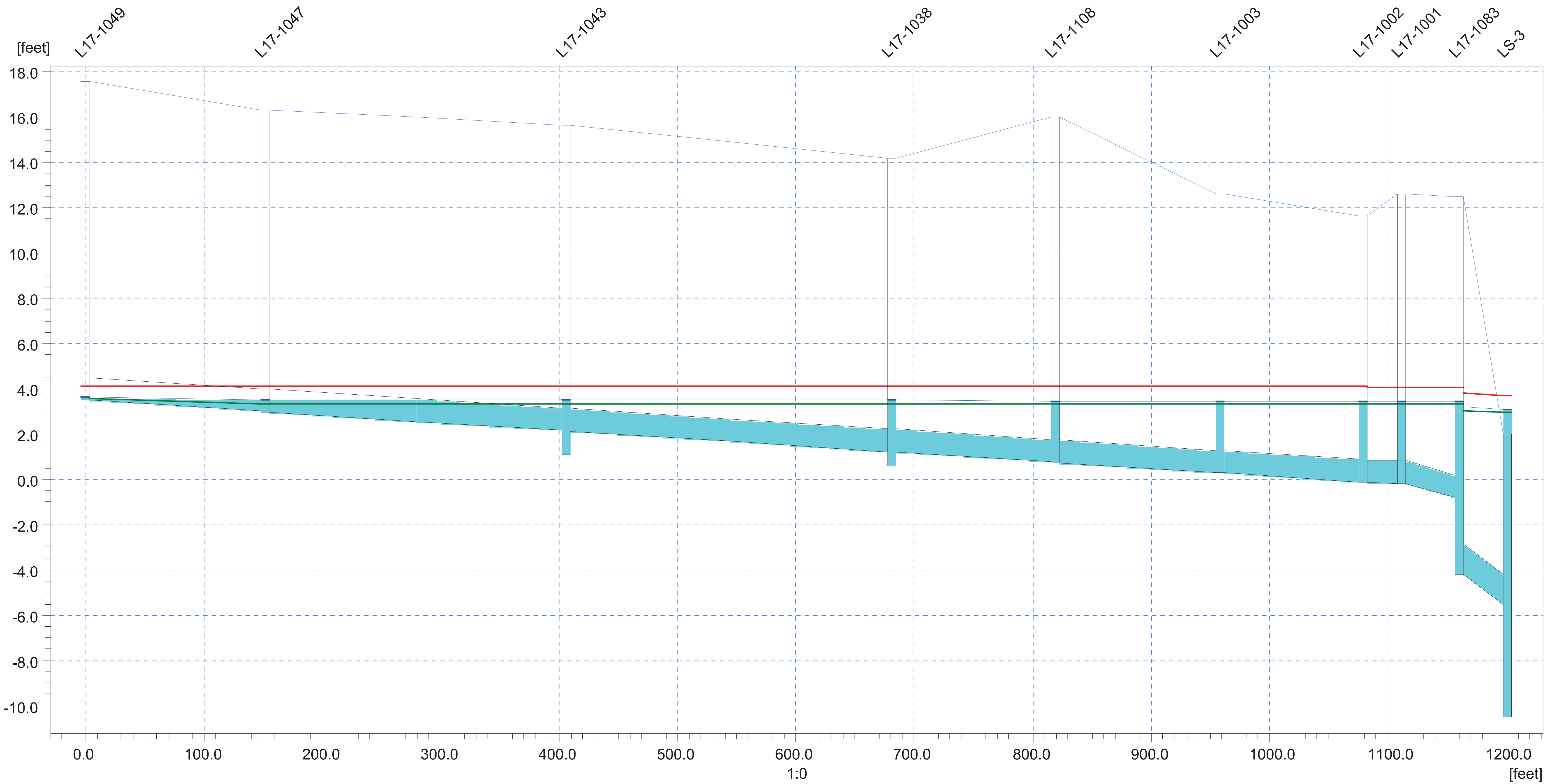
Notes:
Under build-out peak flows, significant surcharging occurs between manholes L17-1066 and PS-3. The surcharging between L17-1066 and L17-1079 may be due to backwater effects of under capacity pipe downstream. The surcharging along Washington Avenue (Bayshore Pipeline) is due to backwater effects from the surcharging occurring in Olde Town Silverdale.

BAYSHORE AND WASHINGTON IMPROVEMENTS

BUILDOUT FLOWS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	0.056	0.064	0.069	0.075	0.075	0.391		0.391	3.889	cfs



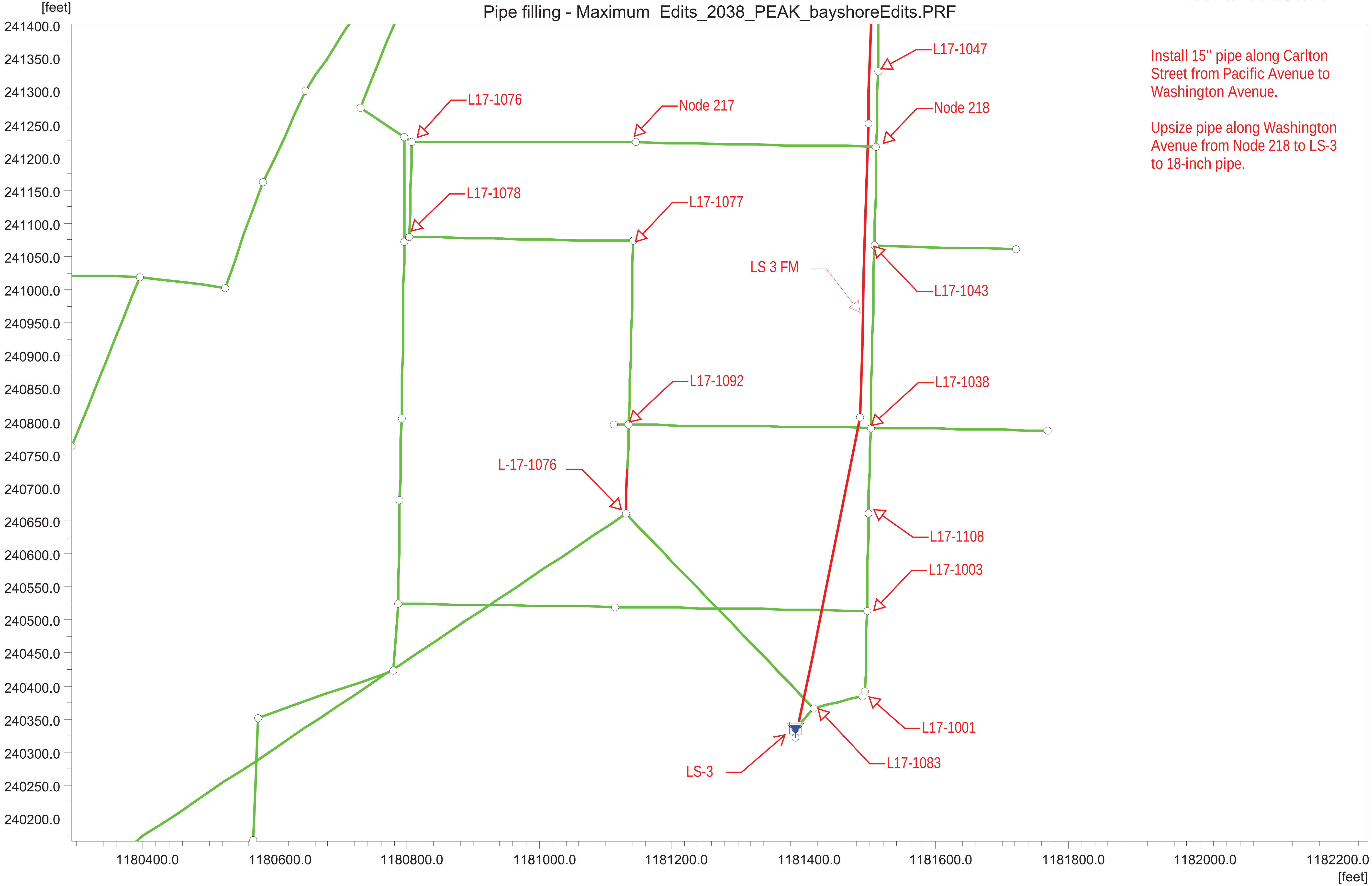
Ground Lev.	17.59	16.34	15.65	14.20	16.02	12.63	11.64	12.62	12.49	[m]
Invert lev.	3.50	2.99	1.10	0.60	0.75	0.29	-0.13	-0.17	-4.20	[m]

Length	152.00	254.00	275.00	138.00	139.00	121.00		48.00	40.66	[m]
Diameter	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.33	[m]
Slope o/oo	3.29	3.31	3.31	3.33	3.31	3.31	1.22	13.54	31.98	

2038 PEAK FLOWS
POST CIP CONDITIONS

BAYSHORE AND WASHINGTON IMPROVEMENTS

Pipe filling - Maximum Edits_2038_PEAK_bayshoreEdits.PRF



Install 15" pipe along Carlton Street from Pacific Avenue to Washington Avenue.

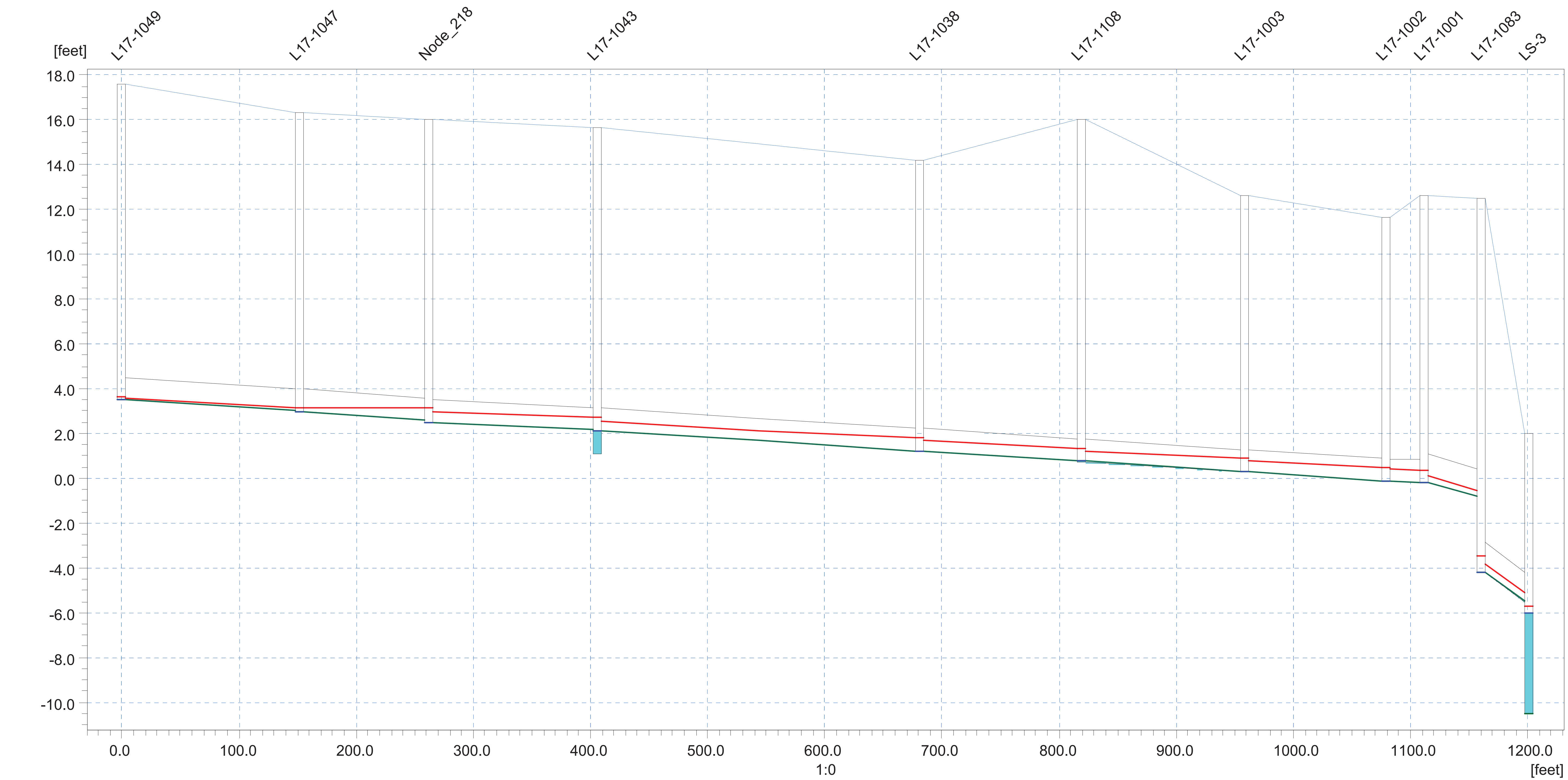
Upsize pipe along Washington Avenue from Node 218 to LS-3 to 18-inch pipe.

BAYSHORE AND WASHINGTON IMPROVEMENTS

2038 PEAK FLOWS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_bayshoreEdits.PRF

Discharge											
	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.001	cfs



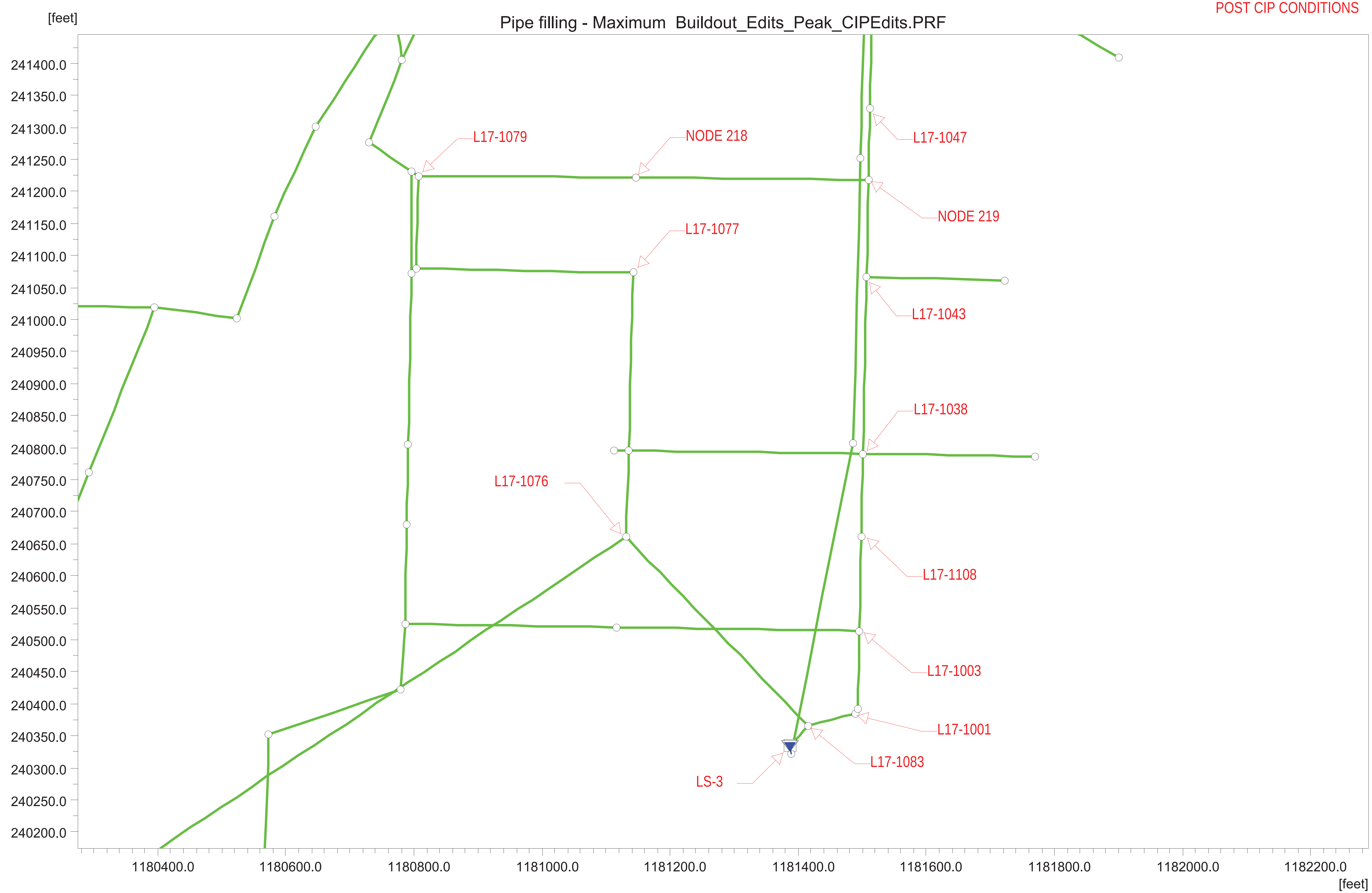
	L17-1049	L17-1047	Node_218	L17-1043	L17-1038	L17-1108	L17-1003	L17-1002	L17-1001	L17-1083	LS-3	
Ground Lev.	17.59	16.34	16.04	15.65	14.20	16.02	12.63	11.64	12.62	12.49		[m]
Invert lev.	3.50	2.99	2.50	1.10	1.22	0.75	0.29	-0.13	-0.17	-4.20		[m]

Length	152.00	109.43	144.57	275.00	138.00	139.00	121.00		48.00	40.66	[m]
Diameter	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.33	[m]
Slope o/oo	3.29	3.56	2.42	3.31	3.33	3.31	3.31	1.22	13.54	31.98	

BAYSHORE AND WASHINGTON IMPROVEMENTS

BUILDOUT PEAK FLOW
POST CIP CONDITIONS

Pipe filling - Maximum Buildout_Edits_Peak_CIPEdits.PRF

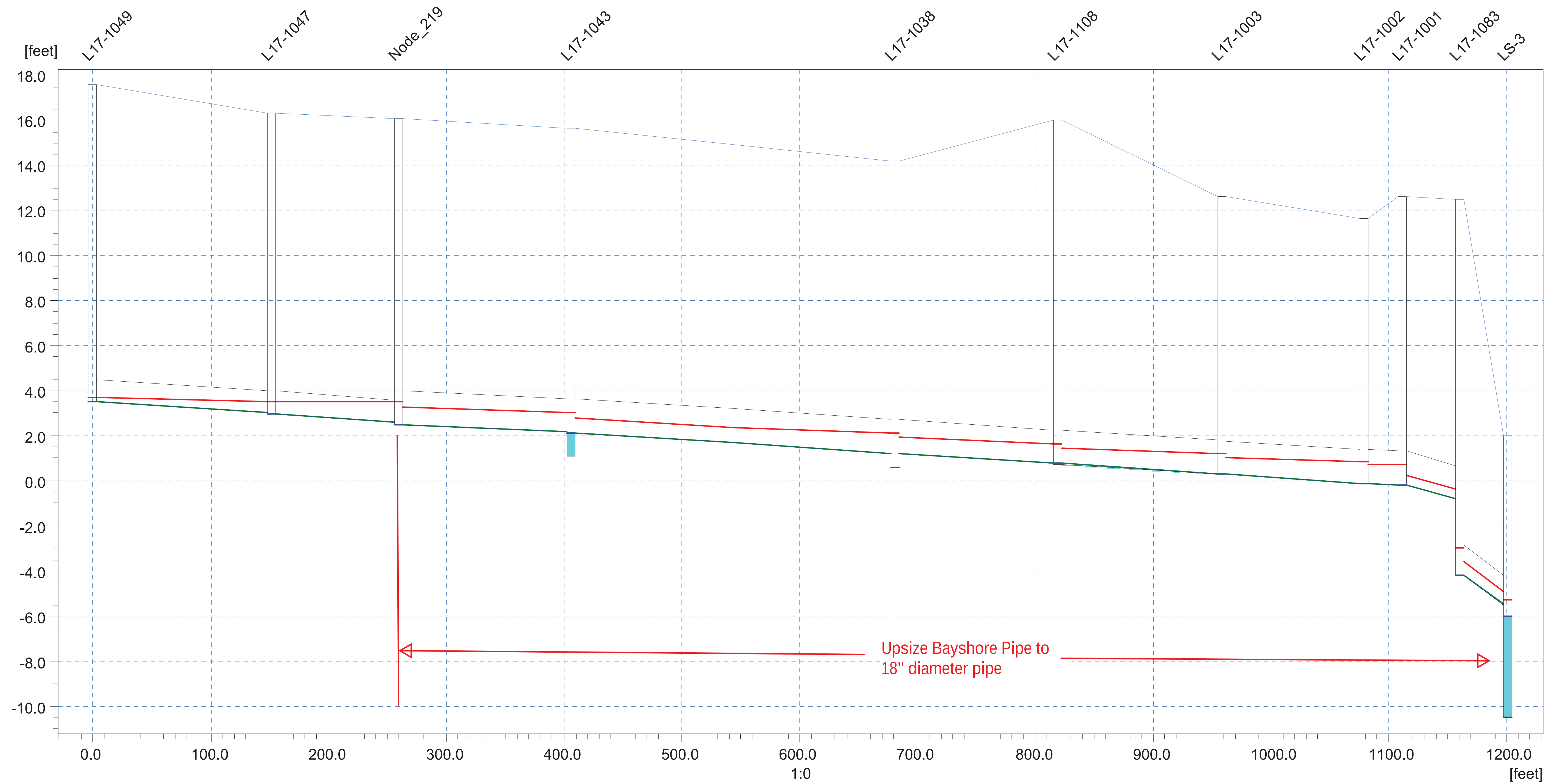


BAYSHORE AND WASHINGTON IMPROVEMENTS

BUILOUT PEAK FLOWS
POST-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_Edits_Peak_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.001	0.001	cfs



	L17-1049	L17-1047	Node_219	L17-1043	L17-1038	L17-1108	L17-1003	L17-1002	L17-1001	L17-1083	LS-3	
Ground Lev.	17.59	16.34	16.05	15.65	14.20	16.02	12.63	11.64	12.62	12.49		[m]
Invert lev.	3.50	2.99	2.50	1.10	0.60	0.75	0.29	-0.13	-0.17	-4.20		[m]

Length	152.00	107.66	146.34	275.00	138.00	139.00	121.00		48.00	40.66	[m]
Diameter	1.00	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.33	[m]
Slope o/oo	3.29	3.62	2.39	3.31	3.33	3.31	3.31	1.22	13.54	31.98	

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OLD TOWN SILVERDALE SEWER UPGRADES

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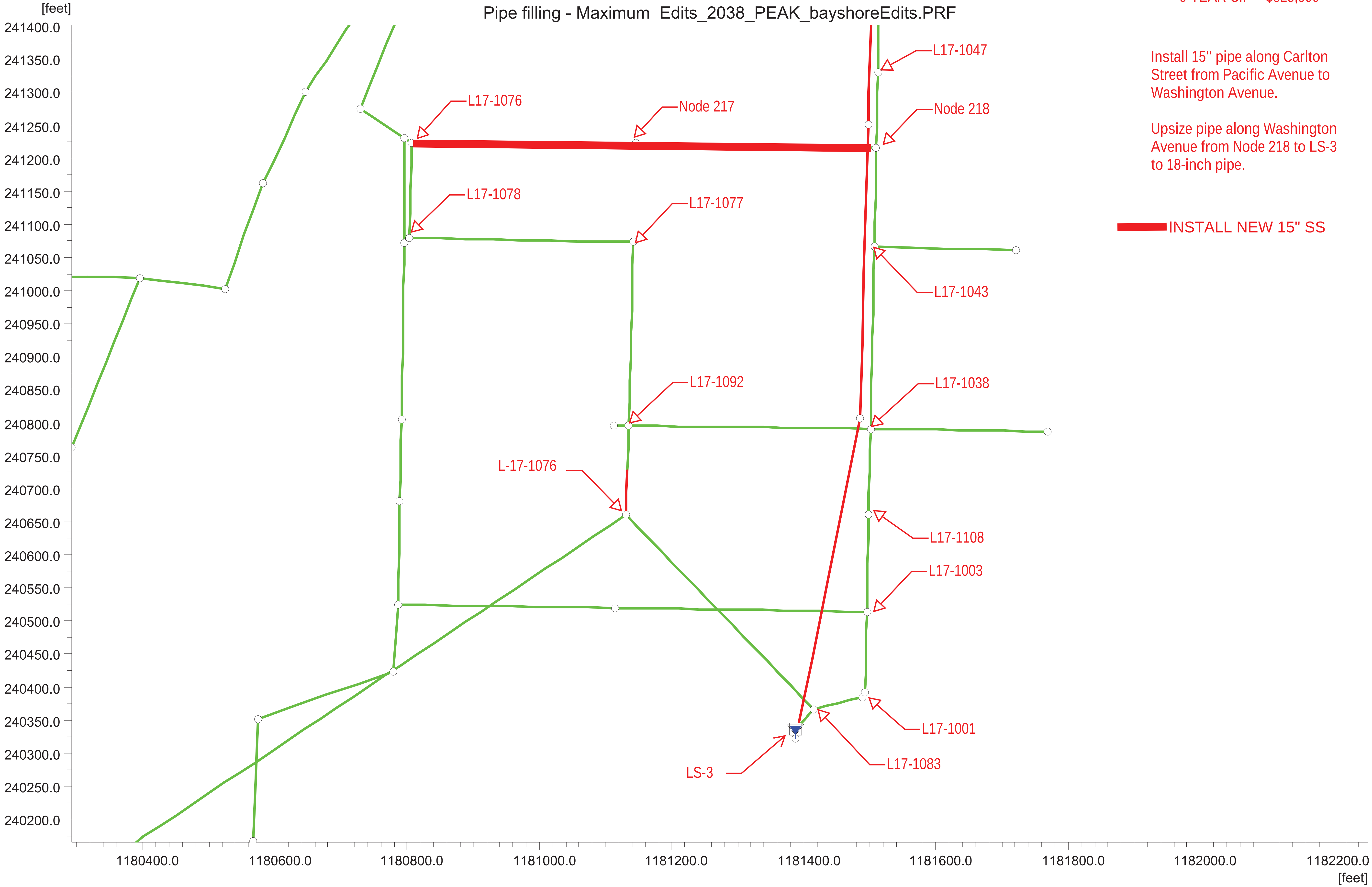
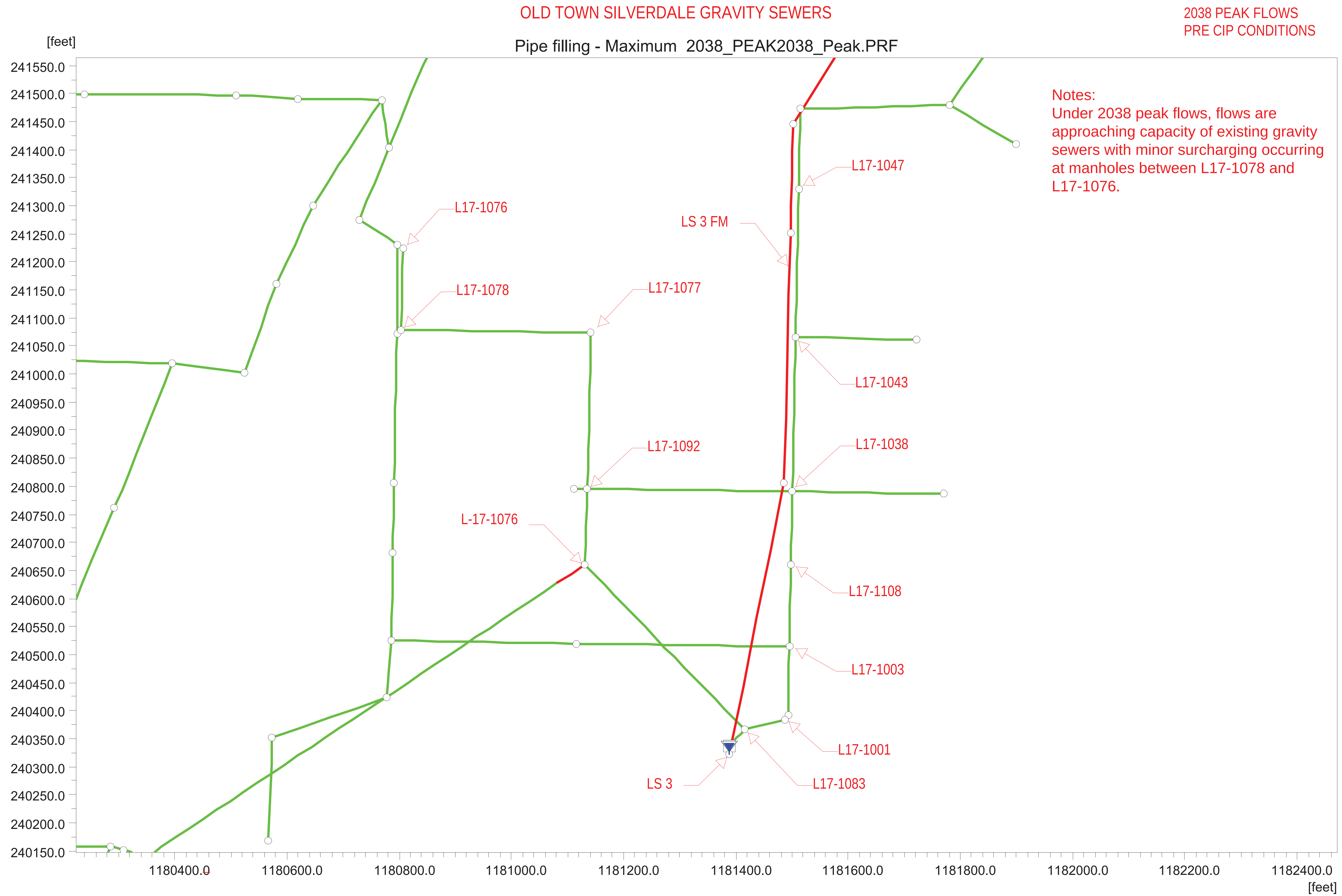
PROPOSED UPGRADES
6-YEAR CIP = $825,500

OLD TOWN SILVERDALE GRAVITY SEWERS

Pipe filling - Maximum Edits_2038_PEAK_bayshoreEdits.PRF





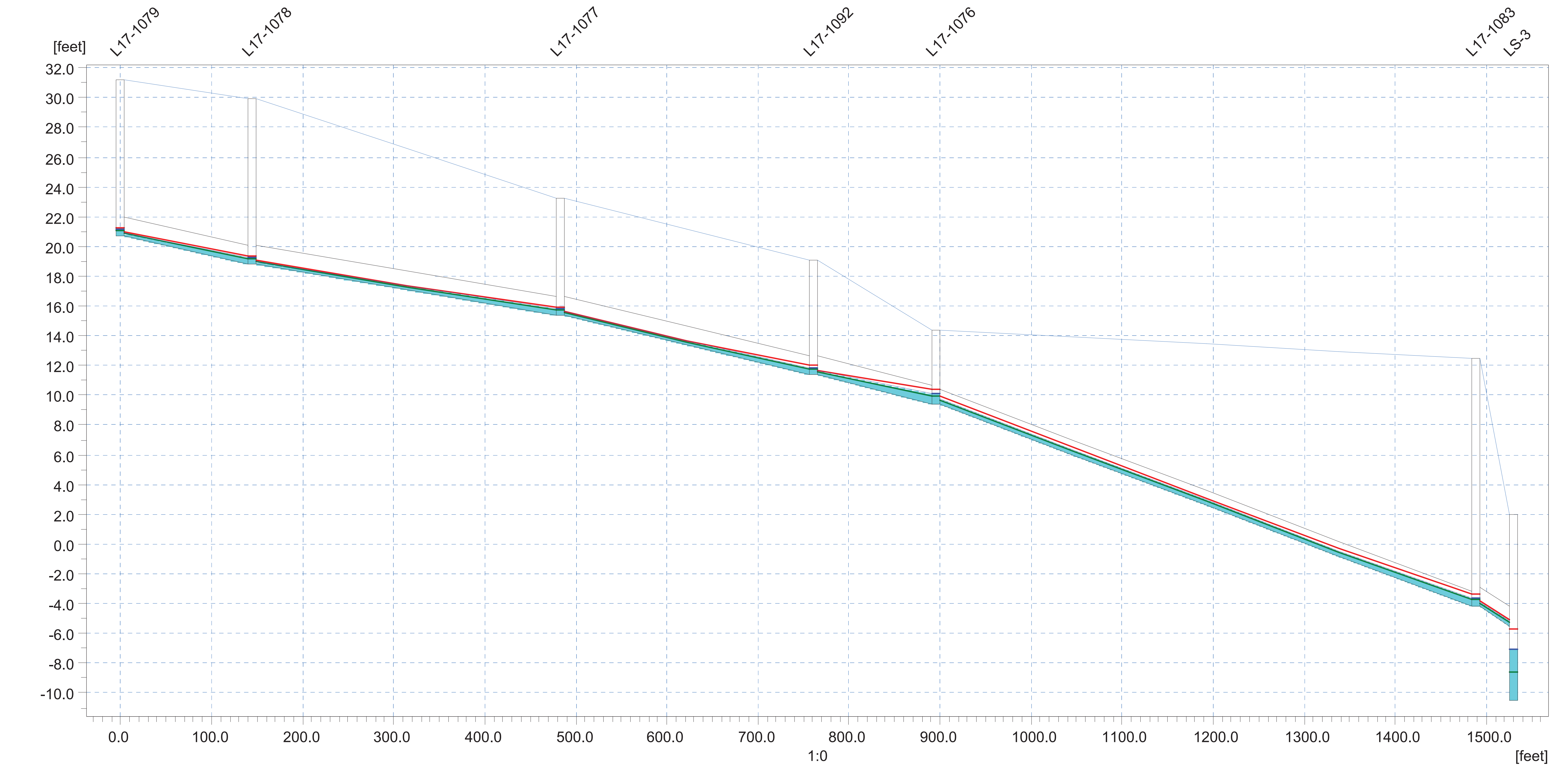
OLD TOWN SILVERDALE GRAVITY SEWERS
2038 PEAK FLOWS
PRE CIP CONDITIONS
Pipe filling - Maximum 2038_PEAK2038_Peak.PRF
Notes:
Under 2038 peak flows, flows are approaching capacity of existing gravity sewers with minor surcharging occurring at manholes between L17-1078 and L17-1076.
L17-1047
L17-1076
LS 3 FM
L17-1078
L17-1077
L17-1043
L17-1092
L17-1038
L-17-1076
L17-1108
L17-1003
L17-1001
LS 3
L17-1083
[feet]
241550.0
241500.0
241450.0
241400.0
241350.0
241300.0
241250.0
241200.0
241150.0
241100.0
241050.0
241000.0
240950.0
240900.0
240850.0
240800.0
240750.0
240700.0
240650.0
240600.0
240550.0
240500.0
240450.0
240400.0
240350.0
240300.0
240250.0
240200.0
240150.0
1180400.0
1180600.0
1180800.0
1181000.0
1181200.0
1181400.0
1181600.0
1181800.0
1182000.0
1182200.0
1182400.0
[feet]

OLD TOWN SILVERDALE GRAVITY SEWERS

2038 FLOWS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.511	0.516	0.526	0.529	1.527		cfs



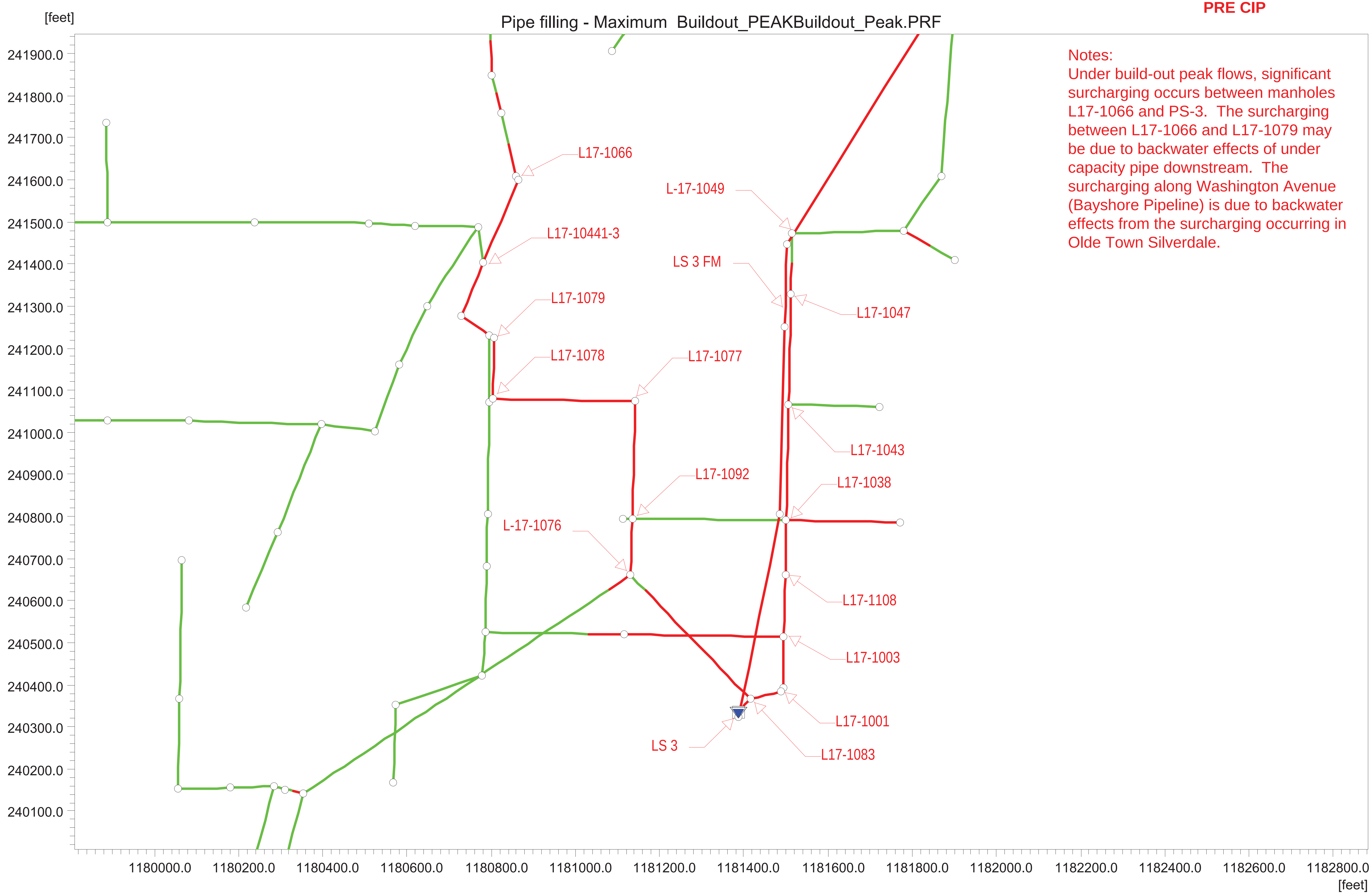
	L17-1079	L17-1078	L17-1077	L17-1092	L17-1076	L17-1083	
Ground Lev.	31.20	29.90	23.20	19.10	14.40	12.49	[m]
Invert lev.	20.70	18.80	15.40	11.40	9.40	-4.20	[m]

Length	144.66	338.56	278.33	134.59	592.53		[m]
Diameter	1.25	1.25	1.25	1.25	1.00	1.33	[m]
Slope o/oo	13.13	10.04	14.37	14.86	22.95		

OLD TOWN SILVERDALE GRAVITY SEWERS

BUILDOUT FLOWS
PRE CIP

Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF

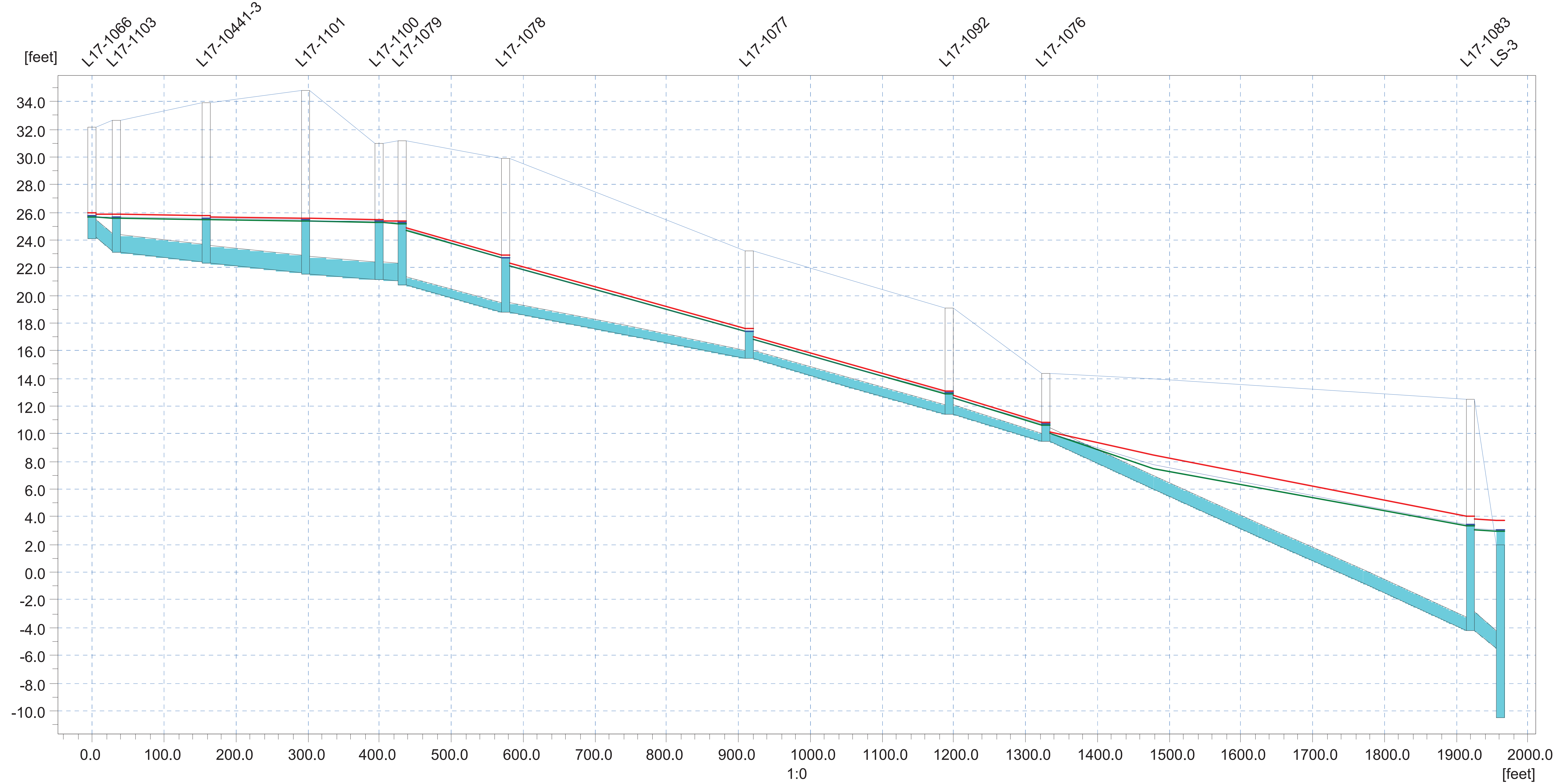


BUILDOUT FLOWS
PRE CIP

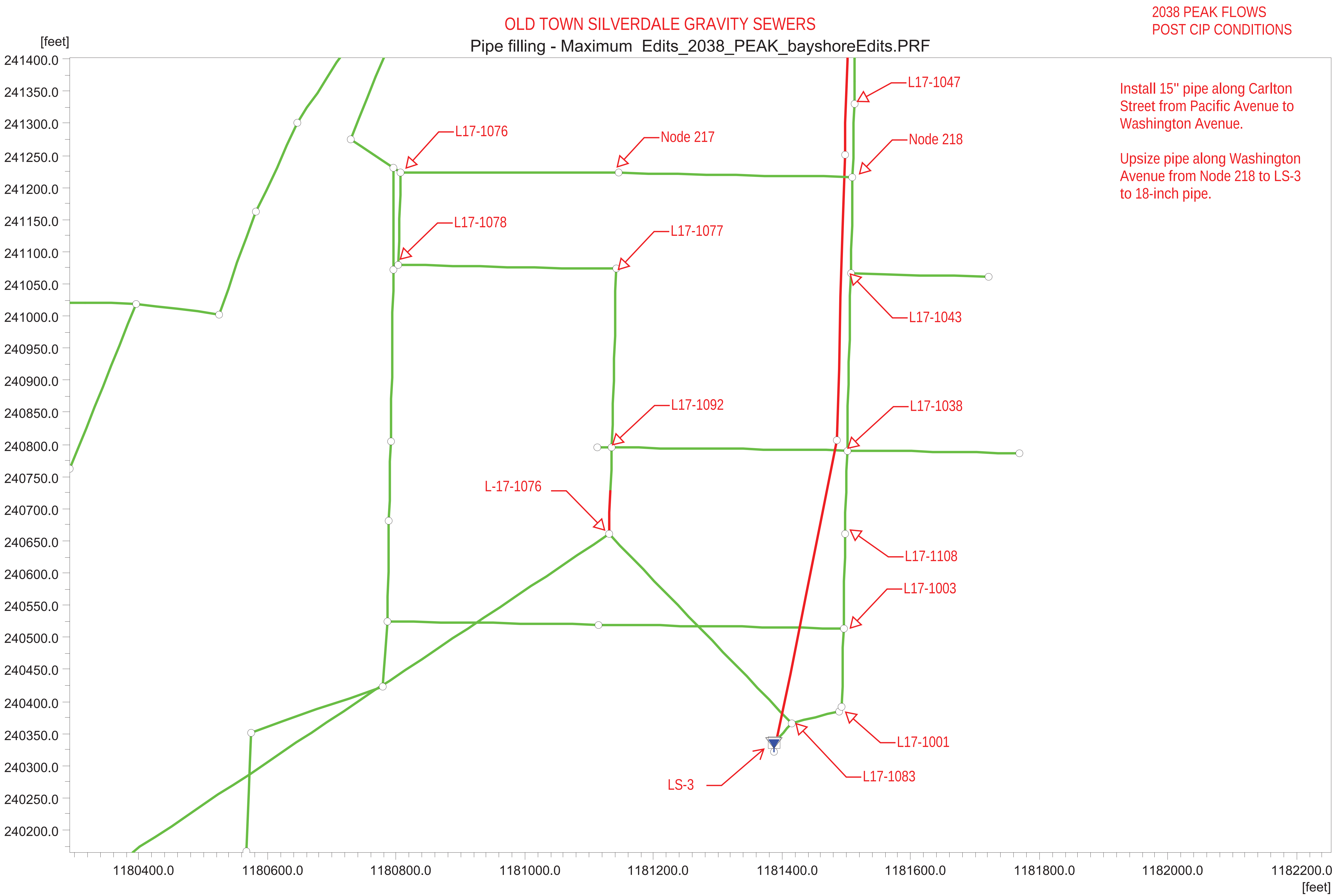
OLD TOWN SILVERDALE GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Link	Discharge (cfs)	Length [m]	Diameter [m]	Slope o/oo
L17-1066 – L17-1103				
L17-1103 – L17-10441-3	1.508	126.00	1.25	5.00
L17-10441-3 – L17-1101	1.689	138.00	1.25	5.00
L17-1101 – L17-1100	1.689	102.00	1.25	4.31
L17-1100 – L17-1079				
L17-1079 – L17-1078	1.426	144.66	0.67	13.13
L17-1078 – L17-1077	1.428	338.56	0.67	10.04
L17-1077 – L17-1092	1.432	278.33	0.67	14.37
L17-1092 – L17-1076	1.432	134.59	0.67	14.86
L17-1076 – L17-1083	3.498	592.53	1.00	22.95
L17-1083 – LS-3				



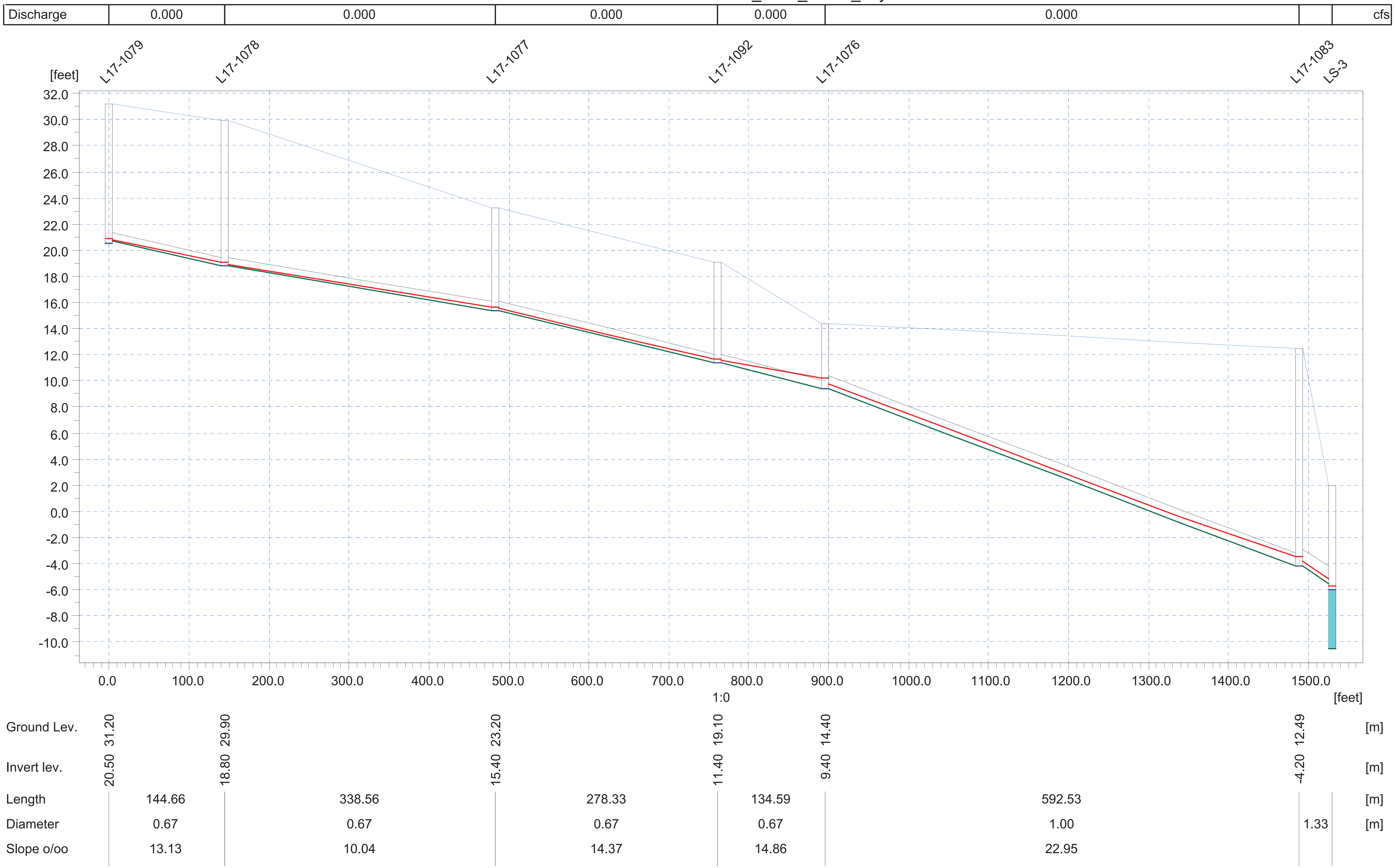
Node	Ground Lev. [m]	Invert lev. [m]
L17-1066	32.10	24.10
L17-1103	32.60	23.09
L17-10441-3	33.91	22.36
L17-1101	34.80	21.57
L17-1100	31.00	21.13
L17-1079	31.20	20.70
L17-1078	29.90	18.80
L17-1077	23.20	15.40
L17-1092	19.10	11.40
L17-1076	14.40	9.40
L17-1083	12.49	-4.20
LS-3		


OLD TOWN SILVERDALE GRAVITY SEWERS
Pipe filling - Maximum Edits_2038_PEAK_bayshoreEdits.PRF
2038 PEAK FLOWS
POST CIP CONDITIONS
Install 15" pipe along Carlton Street from Pacific Avenue to Washington Avenue.
Upsize pipe along Washington Avenue from Node 218 to LS-3 to 18-inch pipe.
[feet]
241400.0
241350.0
241300.0
241250.0
241200.0
241150.0
241100.0
241050.0
241000.0
240950.0
240900.0
240850.0
240800.0
240750.0
240700.0
240650.0
240600.0
240550.0
240500.0
240450.0
240400.0
240350.0
240300.0
240250.0
240200.0
1180400.0
1180600.0
1180800.0
1181000.0
1181200.0
1181400.0
1181600.0
1181800.0
1182000.0
1182200.0
[feet]
L17-1076
Node 217
L17-1047
Node 218
L17-1078
L17-1077
L17-1043
L17-1092
L17-1038
L-17-1076
L17-1108
L17-1003
L17-1001
L17-1083
LS-3

OLD TOWN SILVERDALE GRAVITY SEWERS

2038 PEAK FLOW
POST CIP CONDITIONS

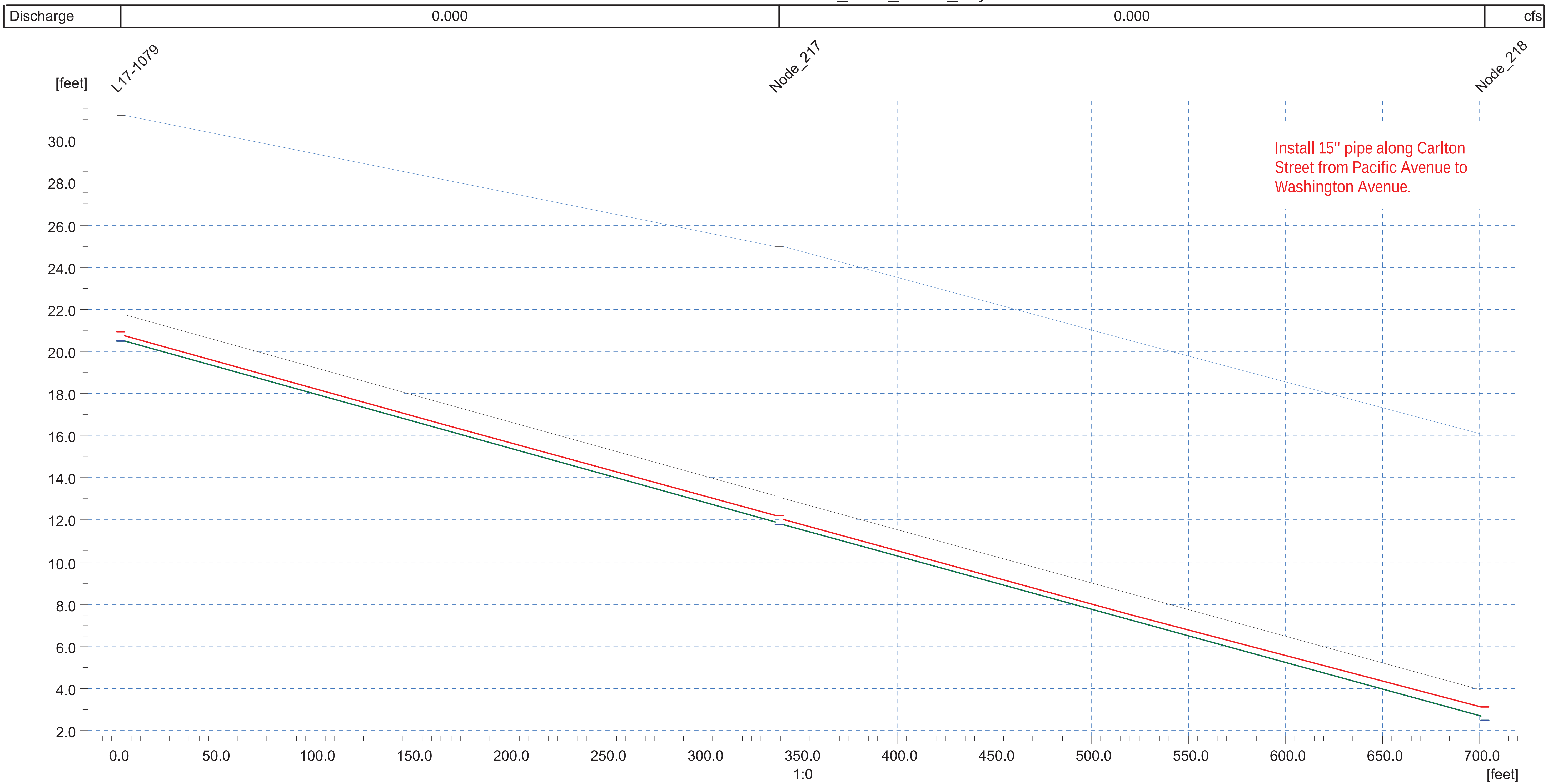
Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_bayshoreEdits.PRF



OLD TOWN SILVERDALE GRAVITY SEWERS
(CARLTON STREET)

2038 PEAK FLOWS
POST CIP CONDITIONS

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_bayshoreEdits.PRF

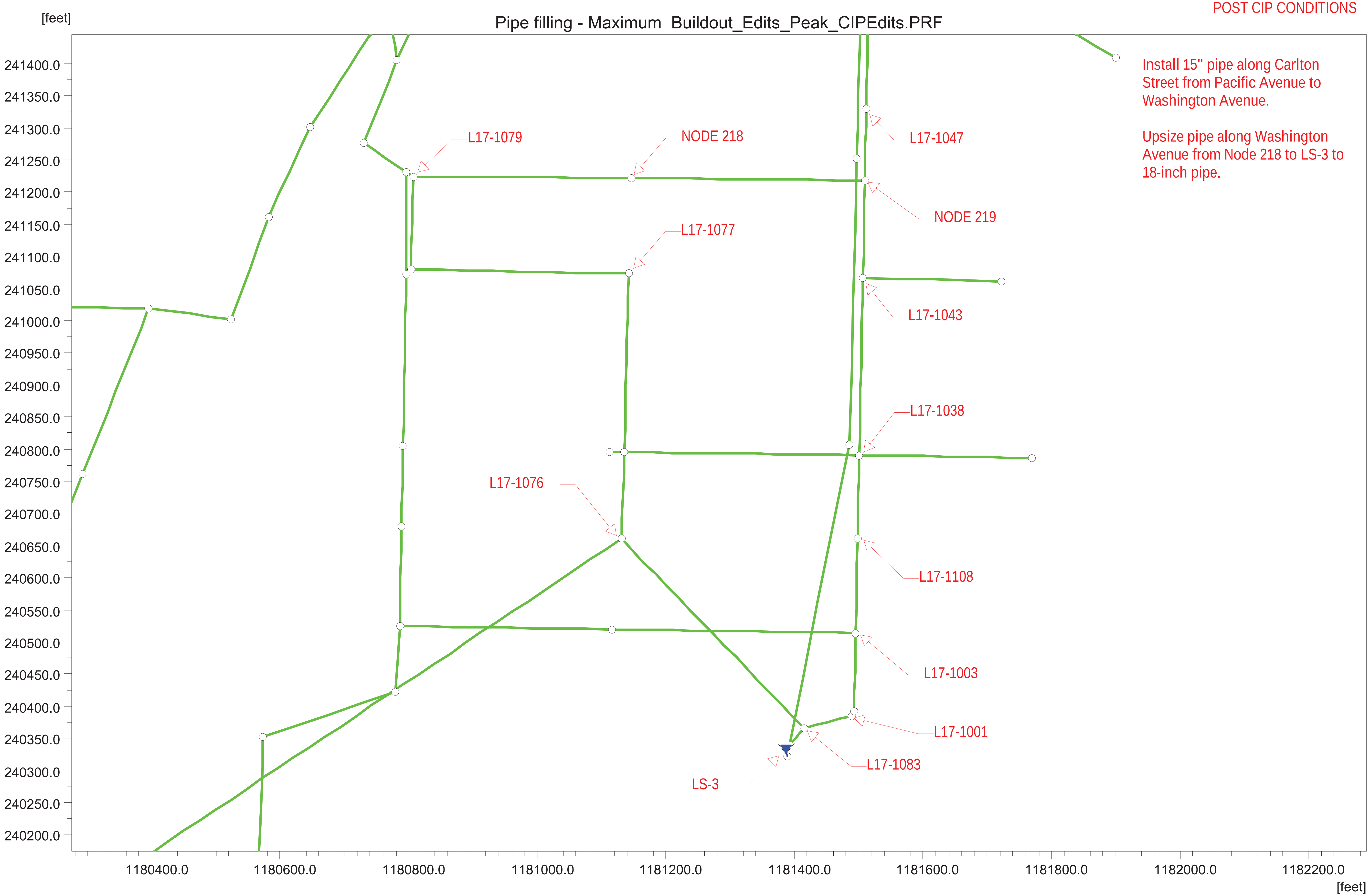


	L17-1079		Node_217		
Ground Lev.	31.20		25.00		[m]
Invert lev.	20.50		11.80		[m]
Length		339.27		363.42	[m]
Diameter		1.25		1.25	[m]
Slope o/oo		25.35		25.04	

BAYSHORE AND WASHINGTON IMPROVEMENTS

BUILDOUT PEAK FLOW
POST CIP CONDITIONS

Pipe filling - Maximum Buildout_Edits_Peak_CIPEdits.PRF



Install 15" pipe along Carlton Street from Pacific Avenue to Washington Avenue.

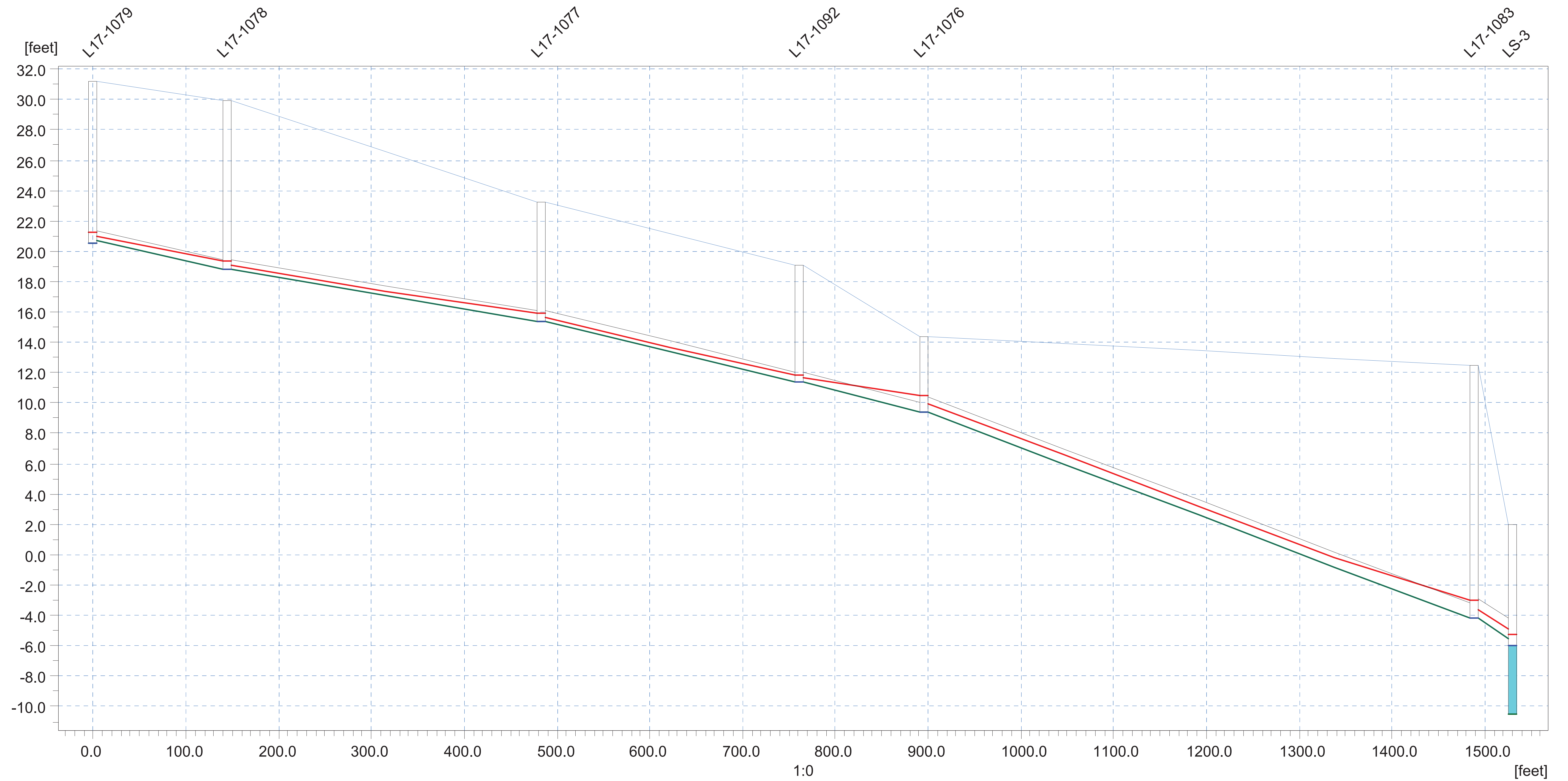
Upsize pipe along Washington Avenue from Node 218 to LS-3 to 18-inch pipe.

OLD TOWN SILVERDALE GRAVITY SEWERS

BUILDOUT PEAK FLOW
POST CIP CONDITIONS

Link Water Level - 1-1-2007 00:00:00 Buildout_Edits_Peak_CIPEdits.PRF

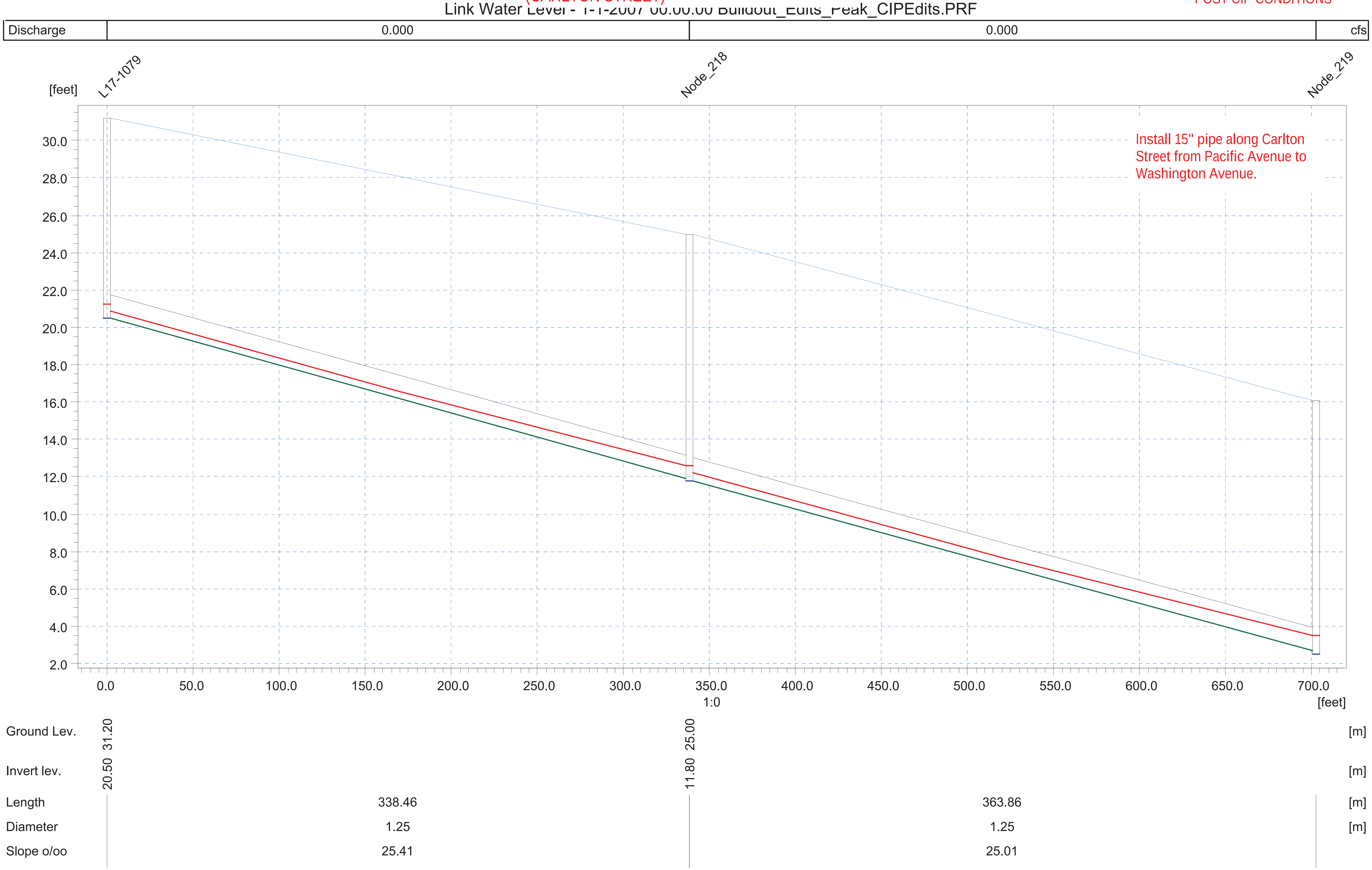
Discharge	0.000	0.000	0.000	0.000	0.000		cfs



Ground Lev.	31.20	29.90	23.20	19.10	14.40	12.49		[m]
Invert lev.	20.50	18.80	15.40	11.40	9.40	-4.20		[m]
Length	144.66	338.56	278.33	134.59	592.53			[m]
Diameter	0.67	0.67	0.67	0.67	1.00	1.33		[m]
Slope o/oo	13.13	10.04	14.37	14.86	22.95			

OLD TOWN SILVERDALE GRAVITY SEWERS
(CARLTON STREET)

2038 PEAK FLOWS
POST CIP CONDITIONS



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ANDERSON HILL SEWER UPGRADES

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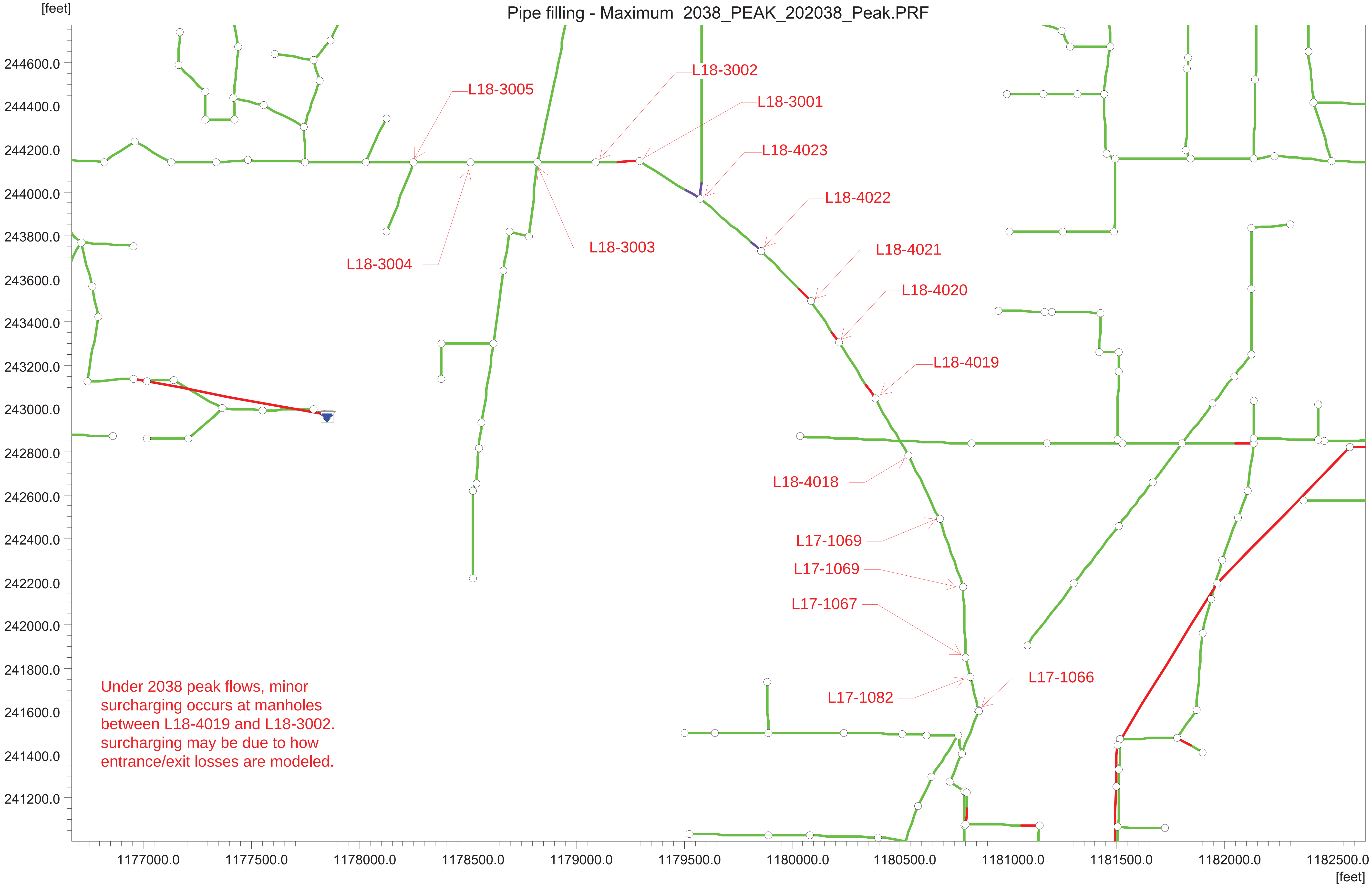
2038 PEAK FLOWS
PRE-CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Pipe filling - Maximum 2038_PEAK_202038_Peak.PRF

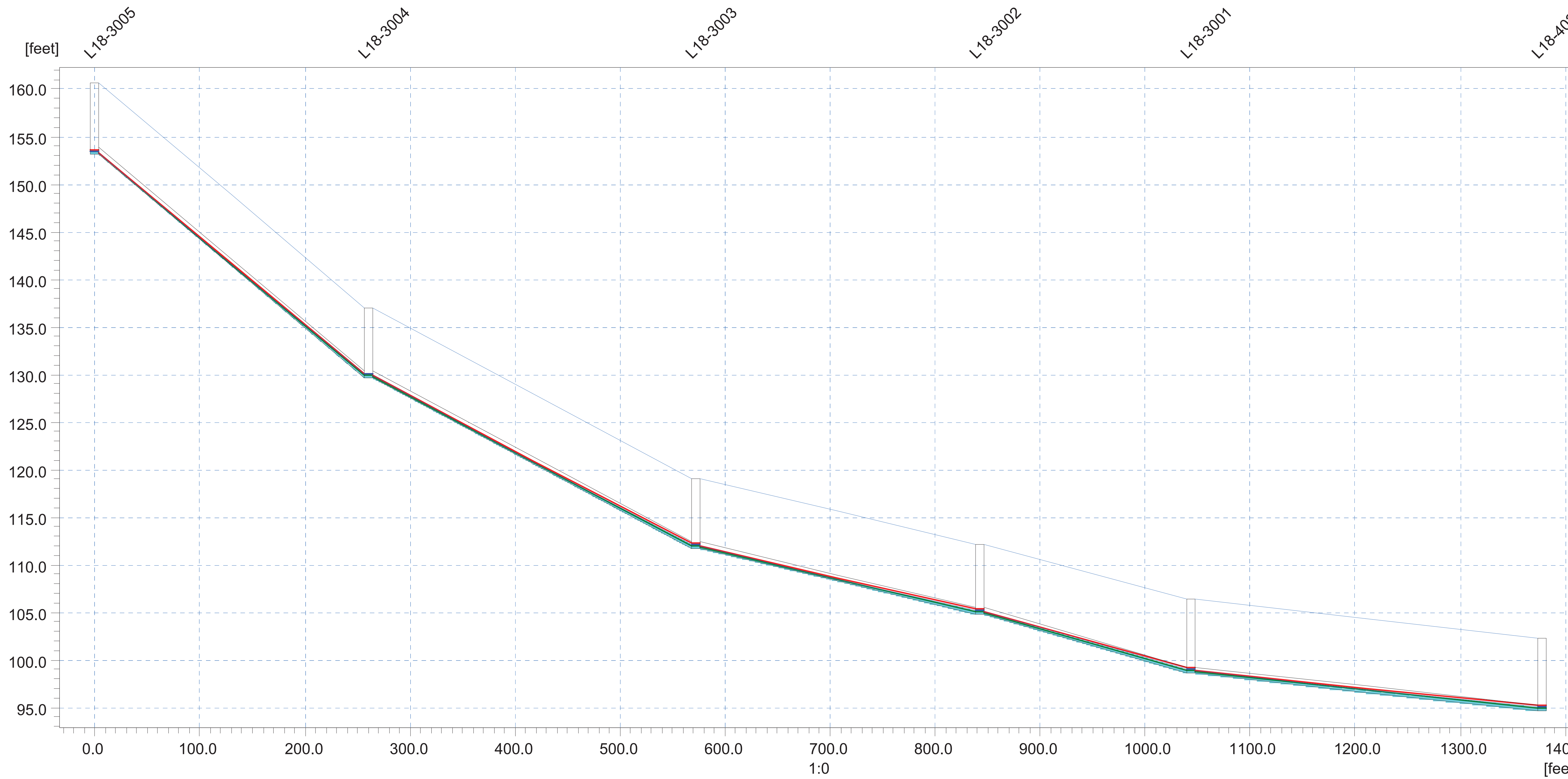


ANDERSON HILL ROAD GRAVITY SEWERS

2038 PEAK FLOWS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.401	0.402	0.479	0.457	0.441	cfs



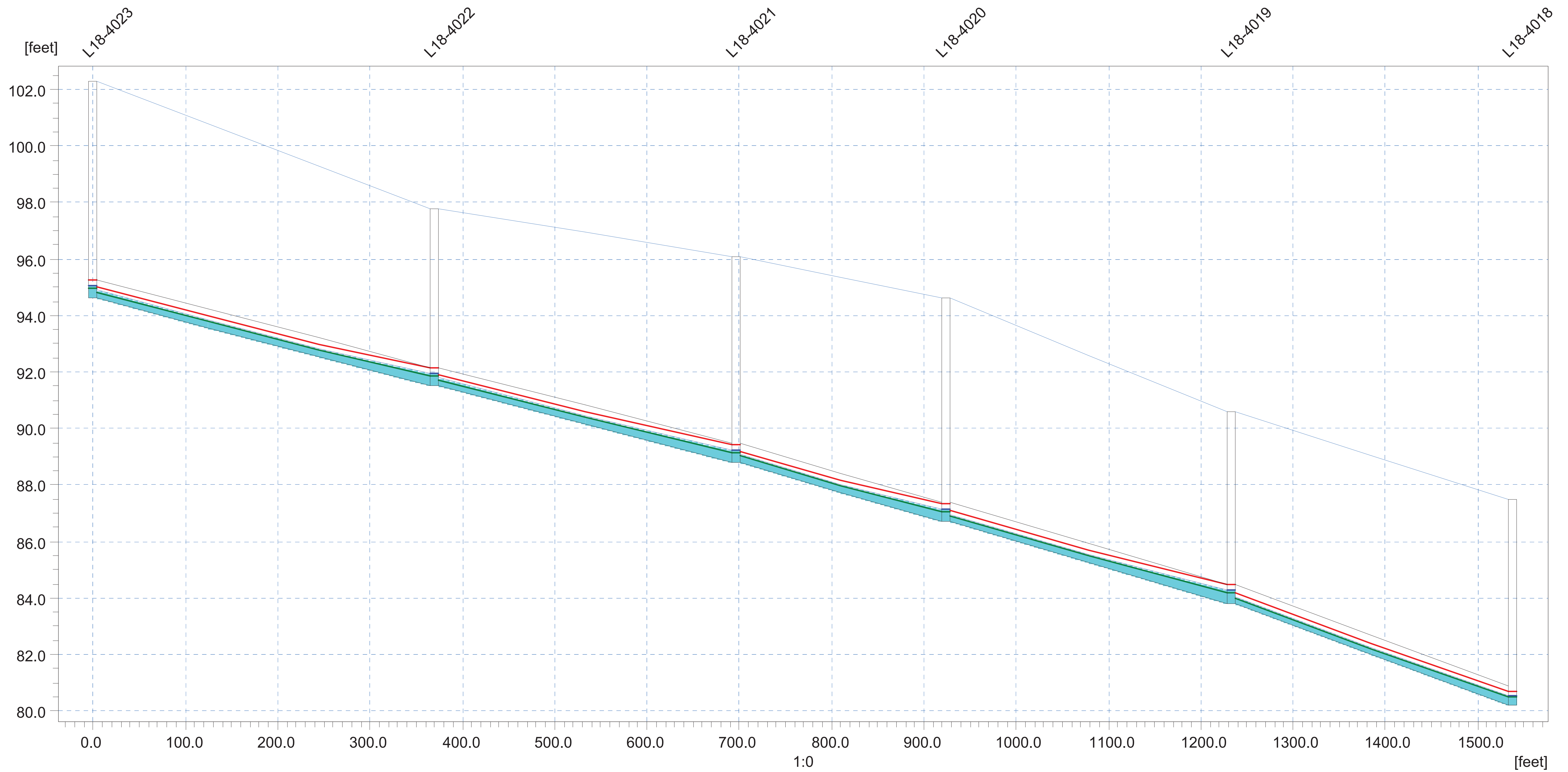
	L18-3005		L18-3004		L18-3003		L18-3002		L18-3001		L18-4023	
Ground Lev.	160.70		137.00		119.10		112.10		106.40			[m]
Invert lev.	153.20		129.70		111.70		104.80		98.60			[m]
Length		260.71		311.95		269.16		201.34		334.18		[m]
Diameter		0.67		0.67		0.67		0.67		0.67		[m]
Slope o/oo		90.14		57.70		25.64		30.79		11.97		

2038 PEAK FLOWS
PRE-CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.444	0.431	0.425	0.423	0.425	cfs



	L18-4023	L18-4022	L18-4021	L18-4020	L18-4019	L18-4018	
Ground Lev.	102.30	97.80	96.10	94.60	90.60		[m]
Invert lev.	94.60	91.50	88.80	86.70	83.80		[m]

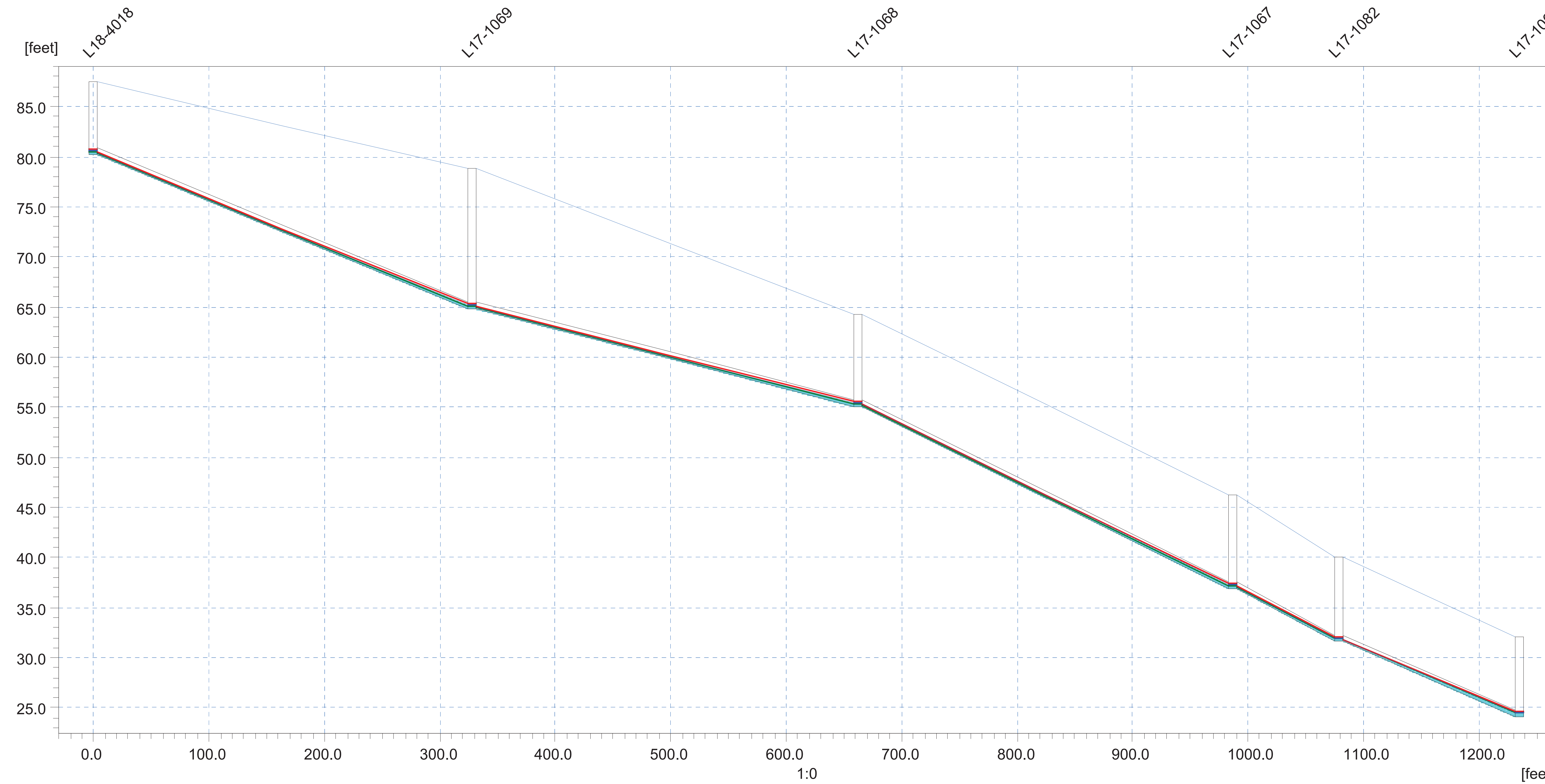
Length	369.23	326.71	227.74	309.52	303.83	[m]
Diameter	0.67	0.67	0.67	0.67	0.67	[m]
Slope o/oo	8.40	8.26	9.22	9.37	11.85	

ANDERSON HILL ROAD GRAVITY SEWERS

2038 PEAK FLOWS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.433	0.446	0.453	0.457	0.460	cfs

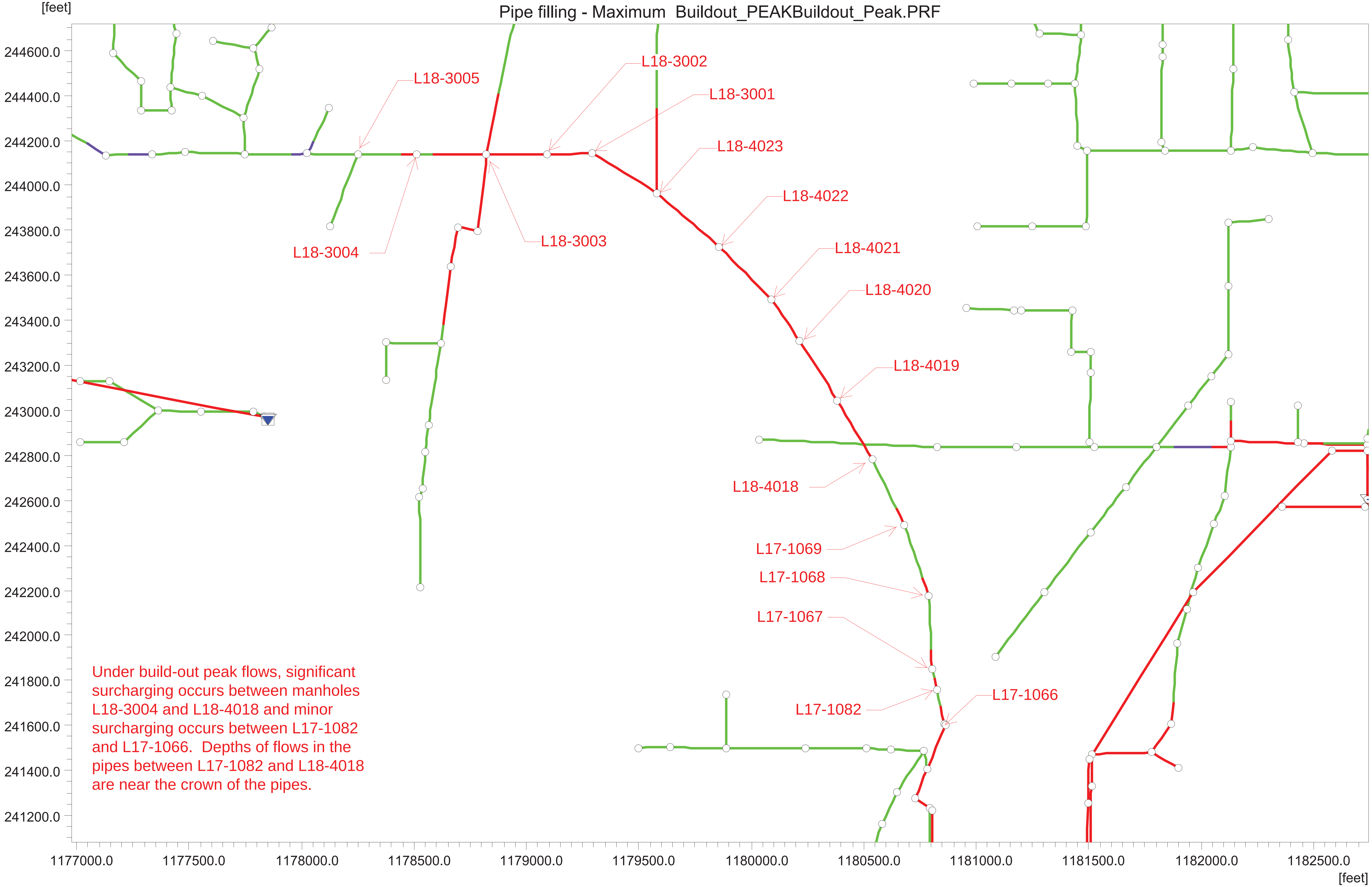


	L18-4018		L17-1069		L17-1068		L17-1067		L17-1082		L17-1066	
Ground Lev.	87.50		78.80		64.20		46.30		40.00			[m]
Invert lev.	80.20		64.80		55.10		36.90		31.60			[m]
Length		327.31		334.51		324.76		92.34		155.71		[m]
Diameter		0.67		0.67		0.67		0.67		0.67		[m]
Slope o/oo		47.05		29.00		56.04		57.40		48.17		

ANDERSON HILL ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOWS
PRE-CIP

Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF

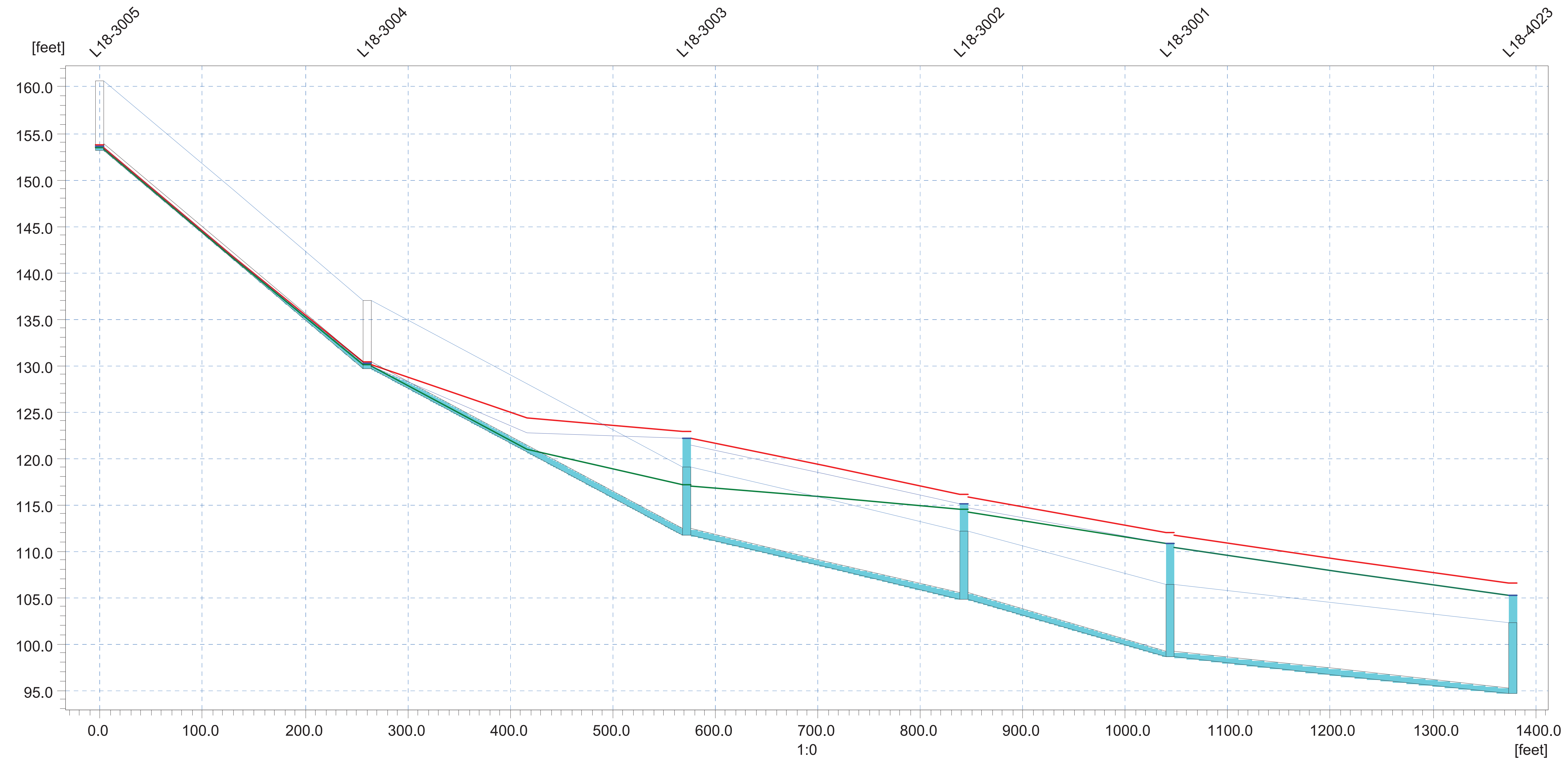


ANDERSON HILL ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	0.721	0.752	1.847	1.685	1.499	cfs



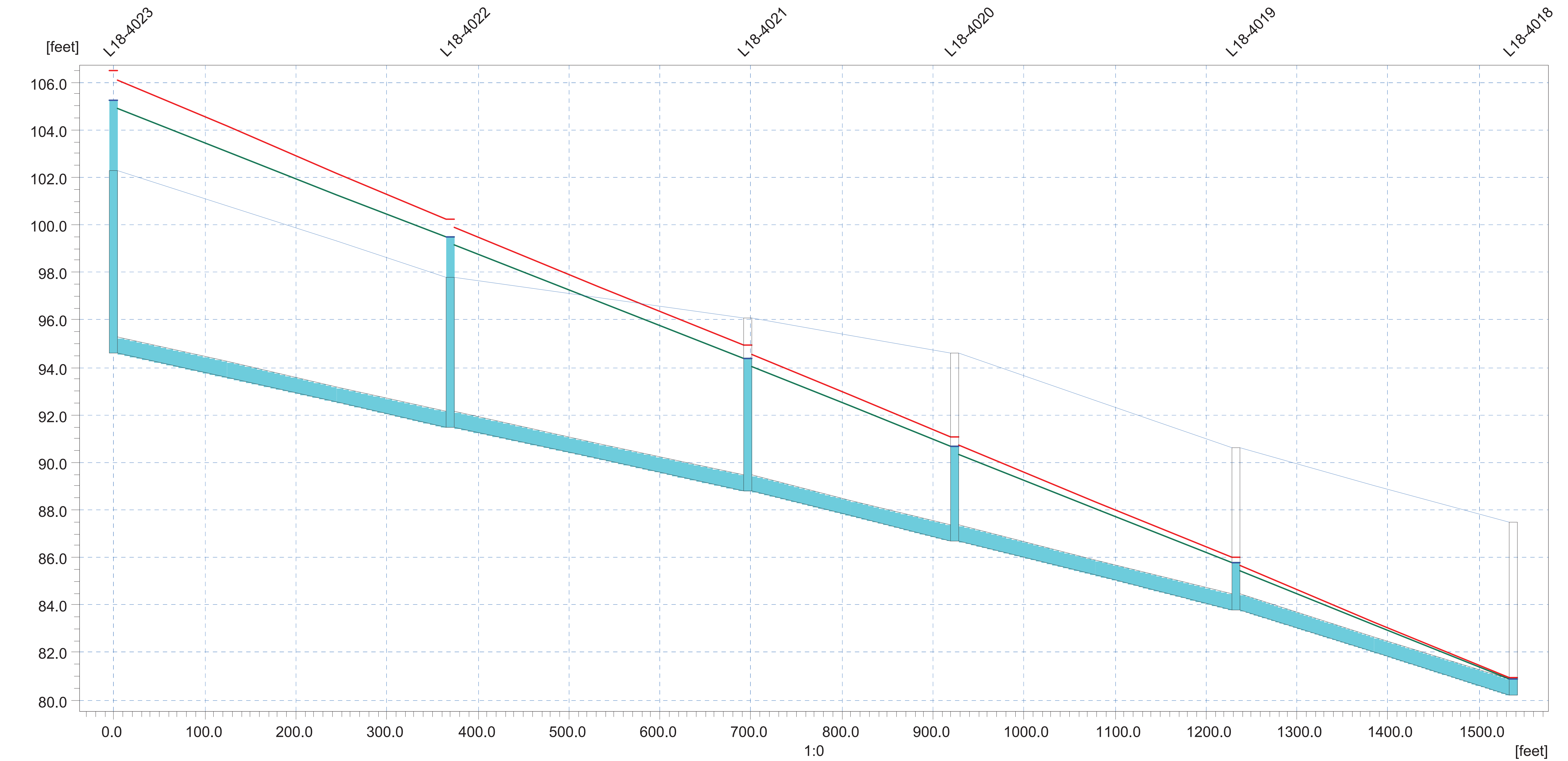
	L18-3005		L18-3004		L18-3003		L18-3002		L18-3001		L18-4023	
Ground Lev.	160.70		137.00		119.10		112.10		106.40			[m]
Invert lev.	153.20		129.70		111.70		104.80		98.60			[m]
Length		260.71		311.95		269.16		201.34		334.18		[m]
Diameter		0.67		0.67		0.67		0.67		0.67		[m]
Slope o/oo		90.14		57.70		25.64		30.79		11.97		

BUILDOUT PEAK
FLOW CONDITIONS
PRE-CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	1.462	1.459	1.462	1.466	1.476	cfs



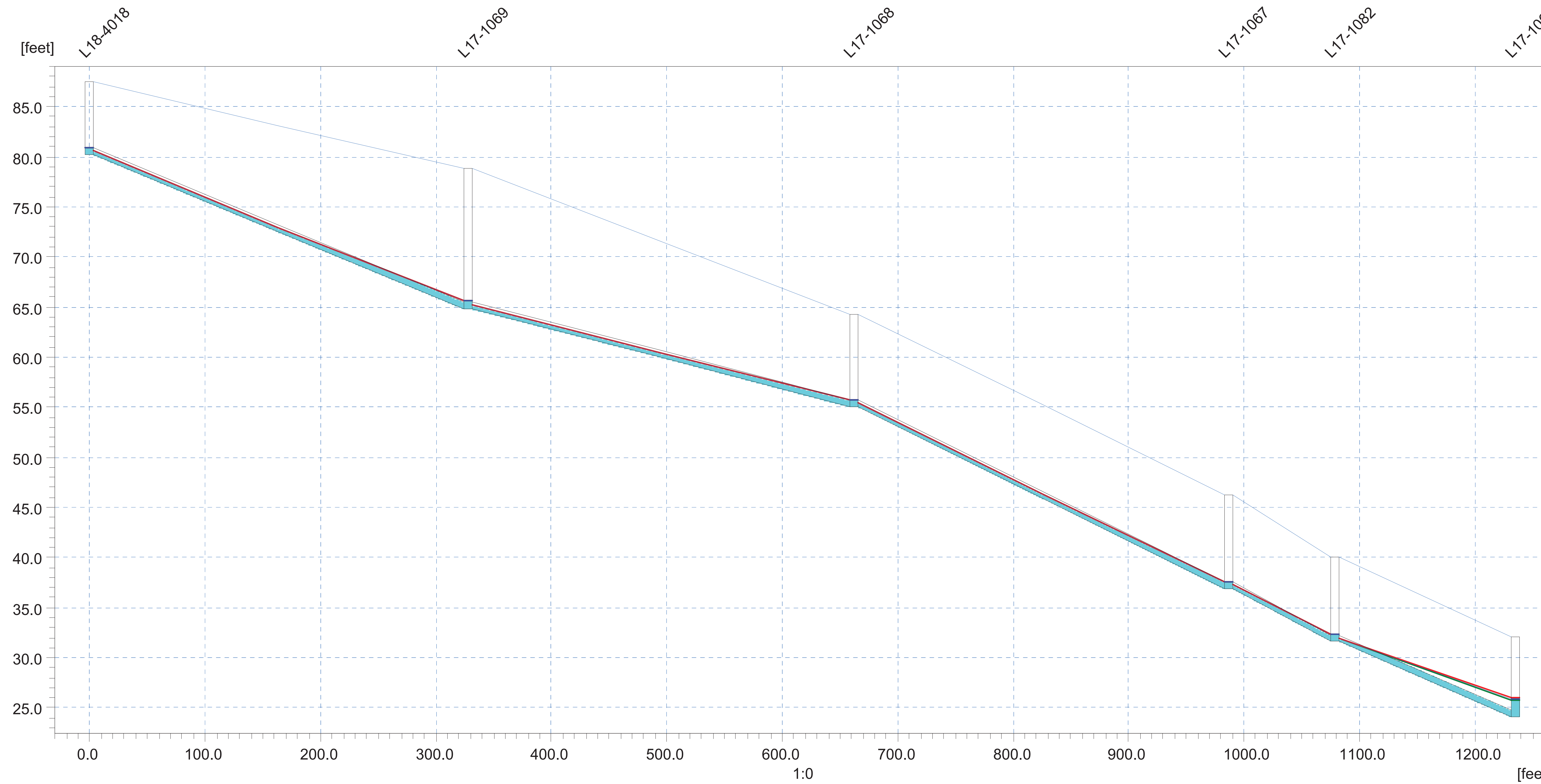
Ground Lev.	102.30	97.80	96.10	94.60	90.60		[m]
Invert lev.	94.60	91.50	88.80	86.70	83.80		[m]
Length	369.23	326.71	227.74	309.52	303.83		[m]
Diameter	0.67	0.67	0.67	0.67	0.67		[m]
Slope o/oo	8.40	8.26	9.22	9.37	11.85		

BUILDOUT PEAK
FLOW CONDITIONS
PRE-CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

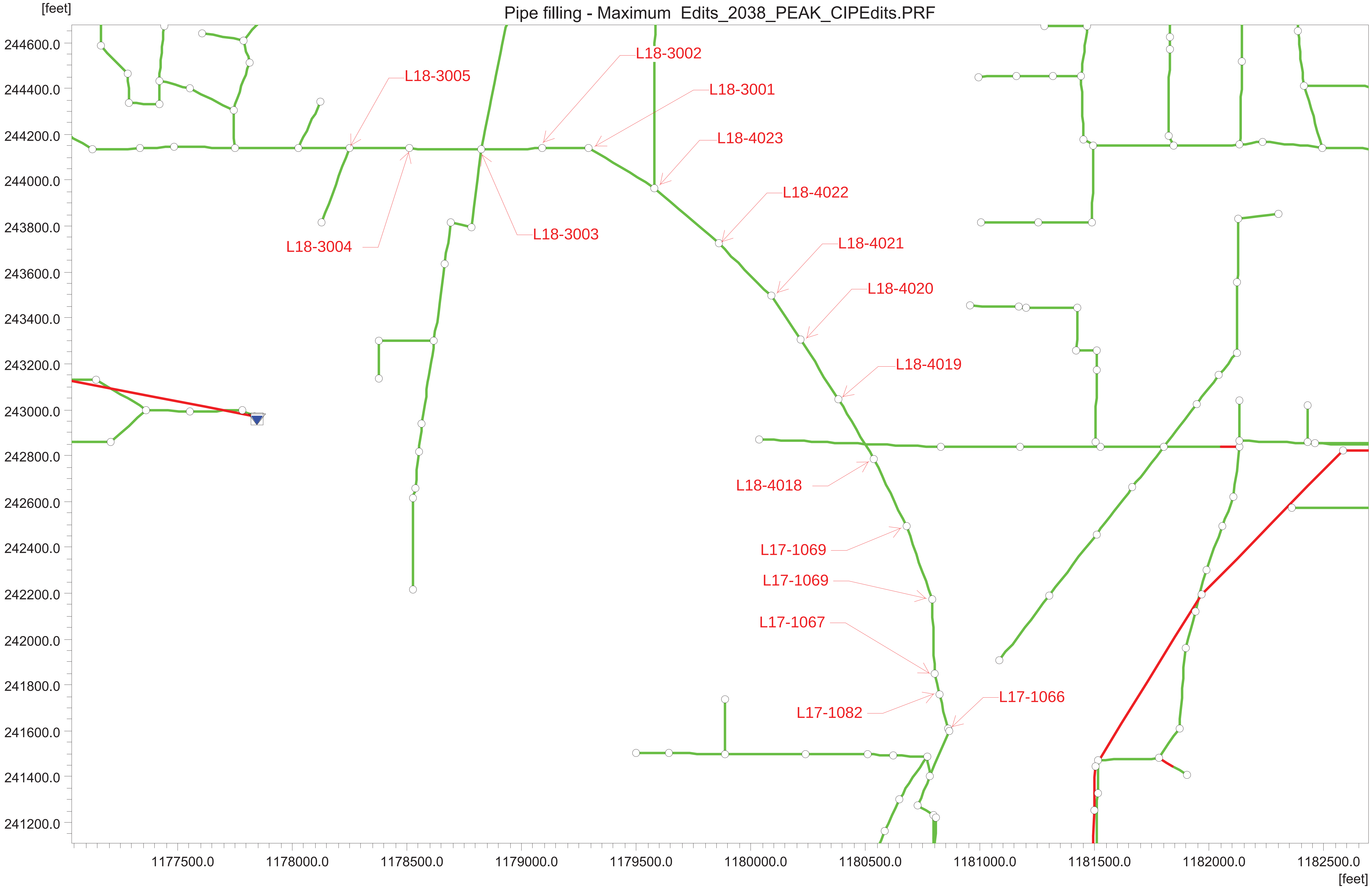
Discharge	1.482	1.494	1.500	1.503	1.505	cfs



	L18-4018		L17-1069		L17-1068		L17-1067		L17-1082		
Ground Lev.	87.50		78.80		64.20		46.30		40.00		[m]
Invert lev.	80.20		64.80		55.10		36.90		31.60		[m]
Length		327.31		334.51		324.76		92.34		155.71	[m]
Diameter		0.67		0.67		0.67		0.67		0.67	[m]
Slope o/oo		47.05		29.00		56.04		57.40		48.17	

ANDERSON HILL ROAD GRAVITY SEWERS

2038 PEAK FLOWS
POST-CIP

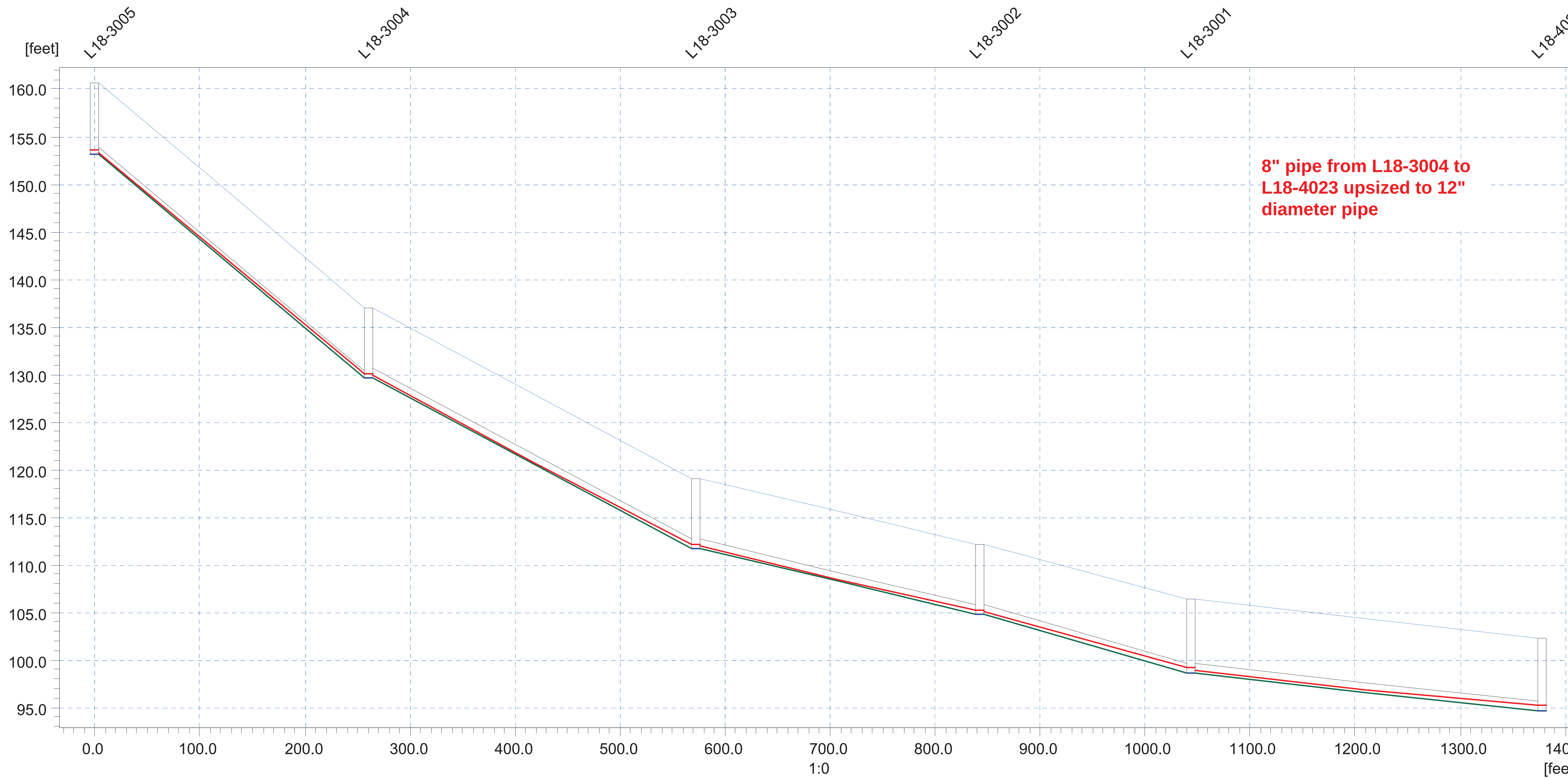


2038 PEAK FLOW CONDITIONS - POST CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	cfs



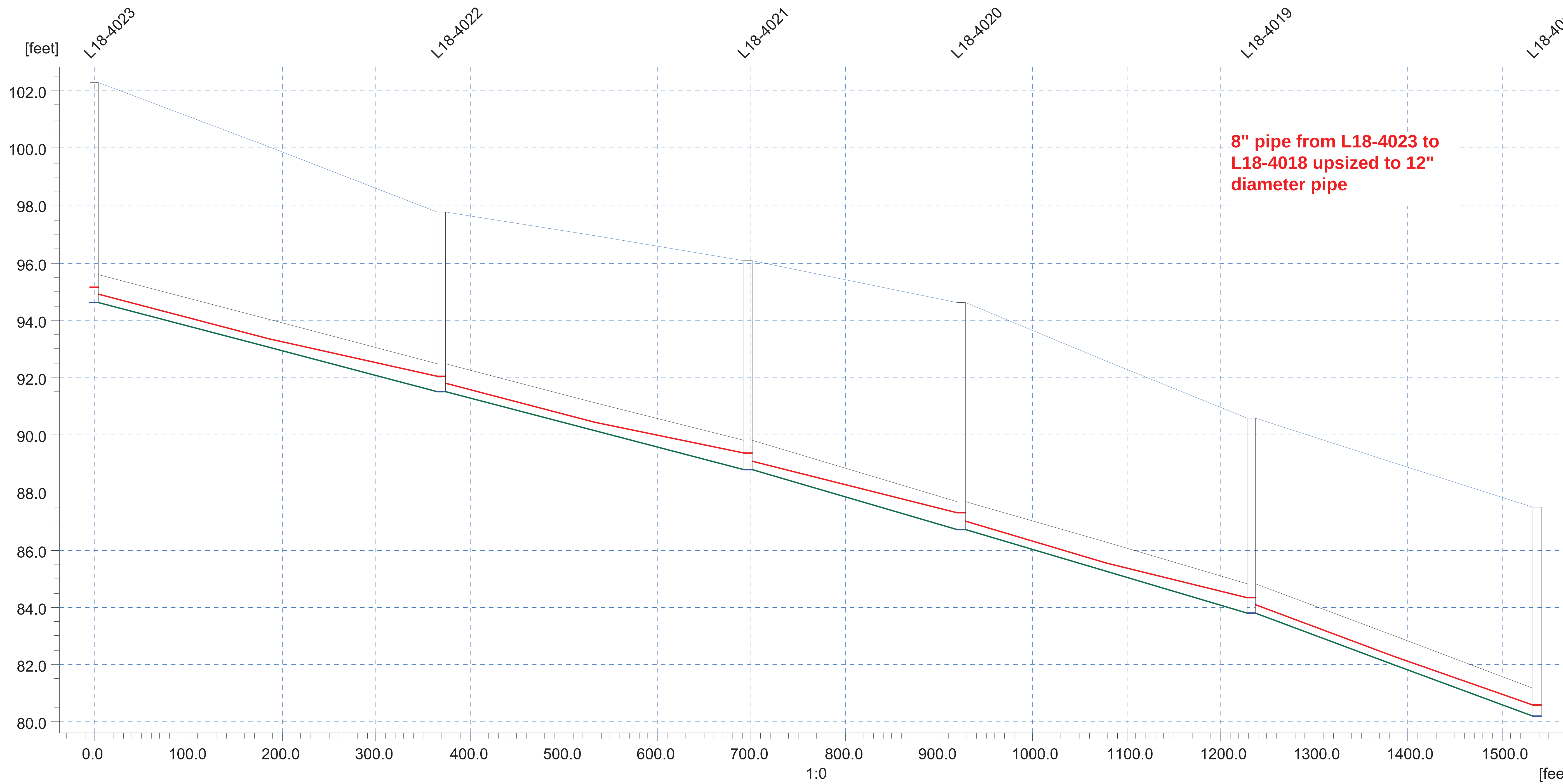
	L18-3005		L18-3004		L18-3003		L18-3002		L18-3001		L18-4023	
Ground Lev.	160.70		137.00		119.10		112.10		106.40			[m]
Invert lev.	153.20		129.70		111.70		104.80		98.60			[m]
Length		260.71		311.95		269.16		201.34		334.18		[m]
Diameter		0.67		1.00		1.00		1.00		1.00		[m]
Slope o/oo		90.14		57.70		25.64		30.79		11.97		

2038 PEAK FLOW CONDITIONS - POST CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	cfs



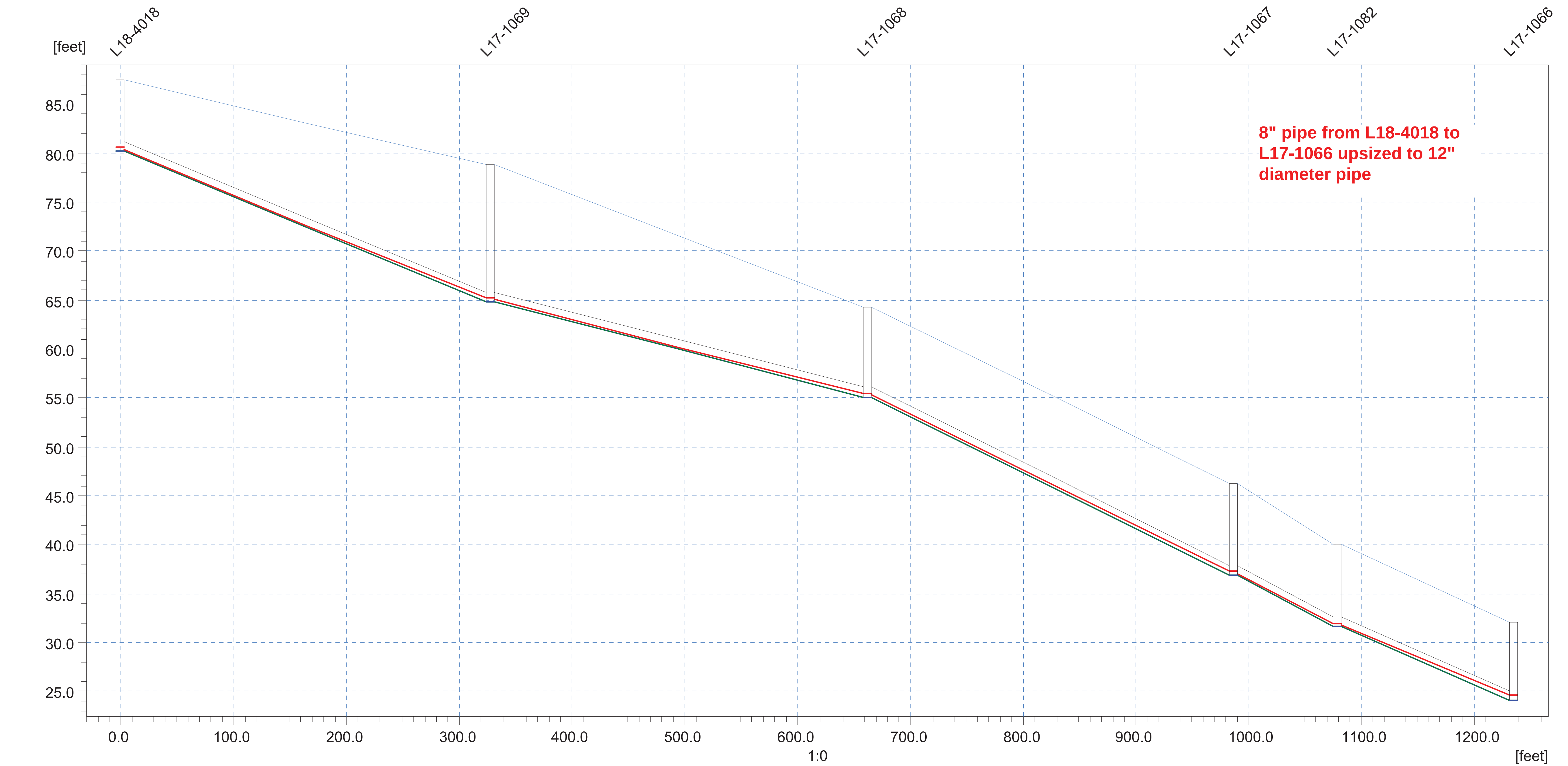
	L18-4023		L18-4022		L18-4021		L18-4020		L18-4019		L18-4018	
Ground Lev.	102.30		97.80		96.10		94.60		90.60			[m]
Invert lev.	94.60		91.50		88.80		86.70		83.80			[m]
Length		369.23		326.71		227.74		309.52		303.83		[m]
Diameter		1.00		1.00		1.00		1.00		1.00		[m]
Slope o/oo		8.40		8.26		9.22		9.37		11.85		

2038 PEAK FLOW CONDITIONS - POST CIP

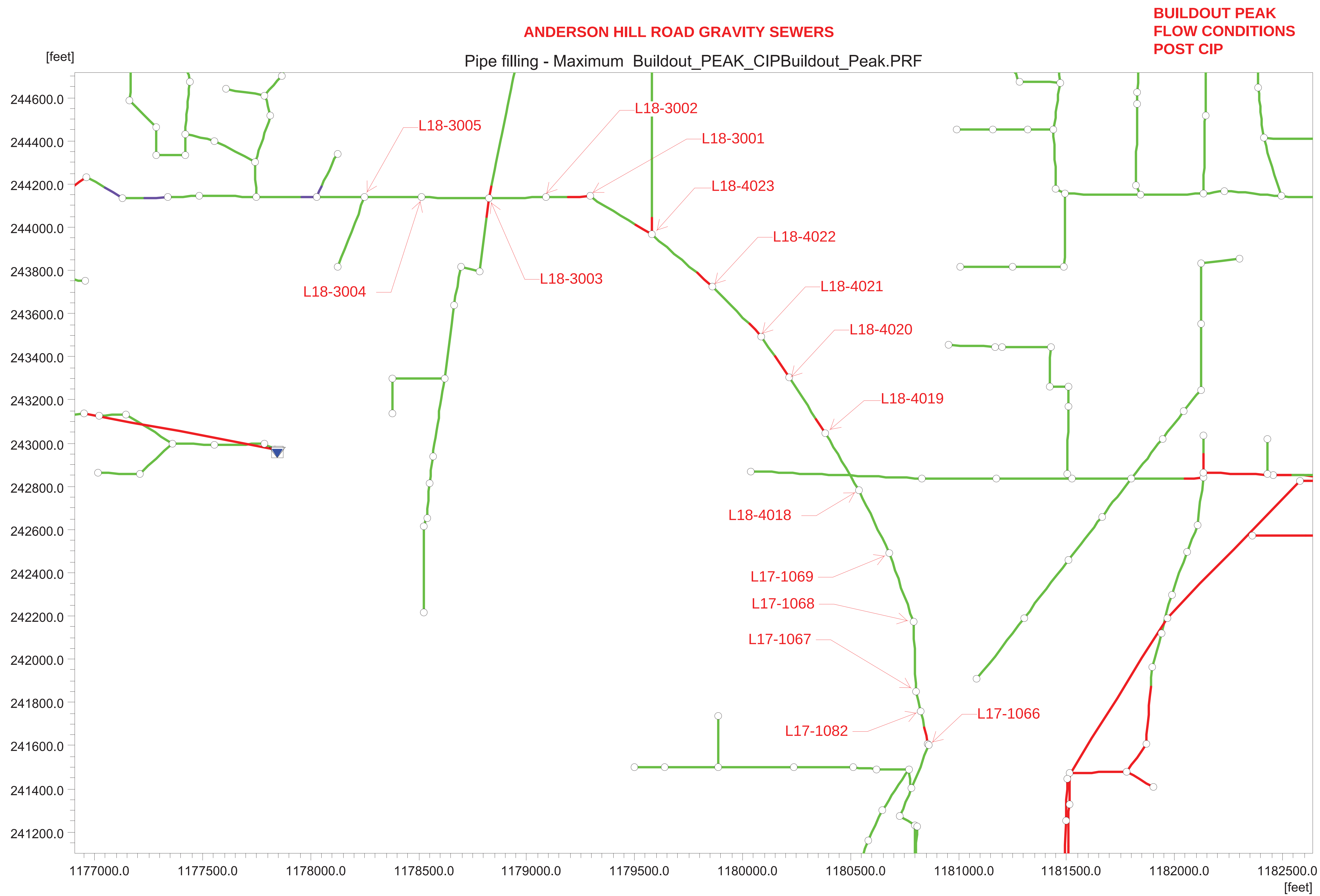
ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	cfs



	L18-4018		L17-1069		L17-1068		L17-1067		L17-1082		L17-1066	
Ground Lev.	87.50		78.80		64.20		46.30		40.00			[m]
Invert lev.	80.20		64.80		55.10		36.90		31.60			[m]
Length		327.31		334.51		324.76		92.34		155.71		[m]
Diameter		1.00		1.00		1.00		1.00		1.00		[m]
Slope o/oo		47.05		29.00		56.04		57.40		48.17		



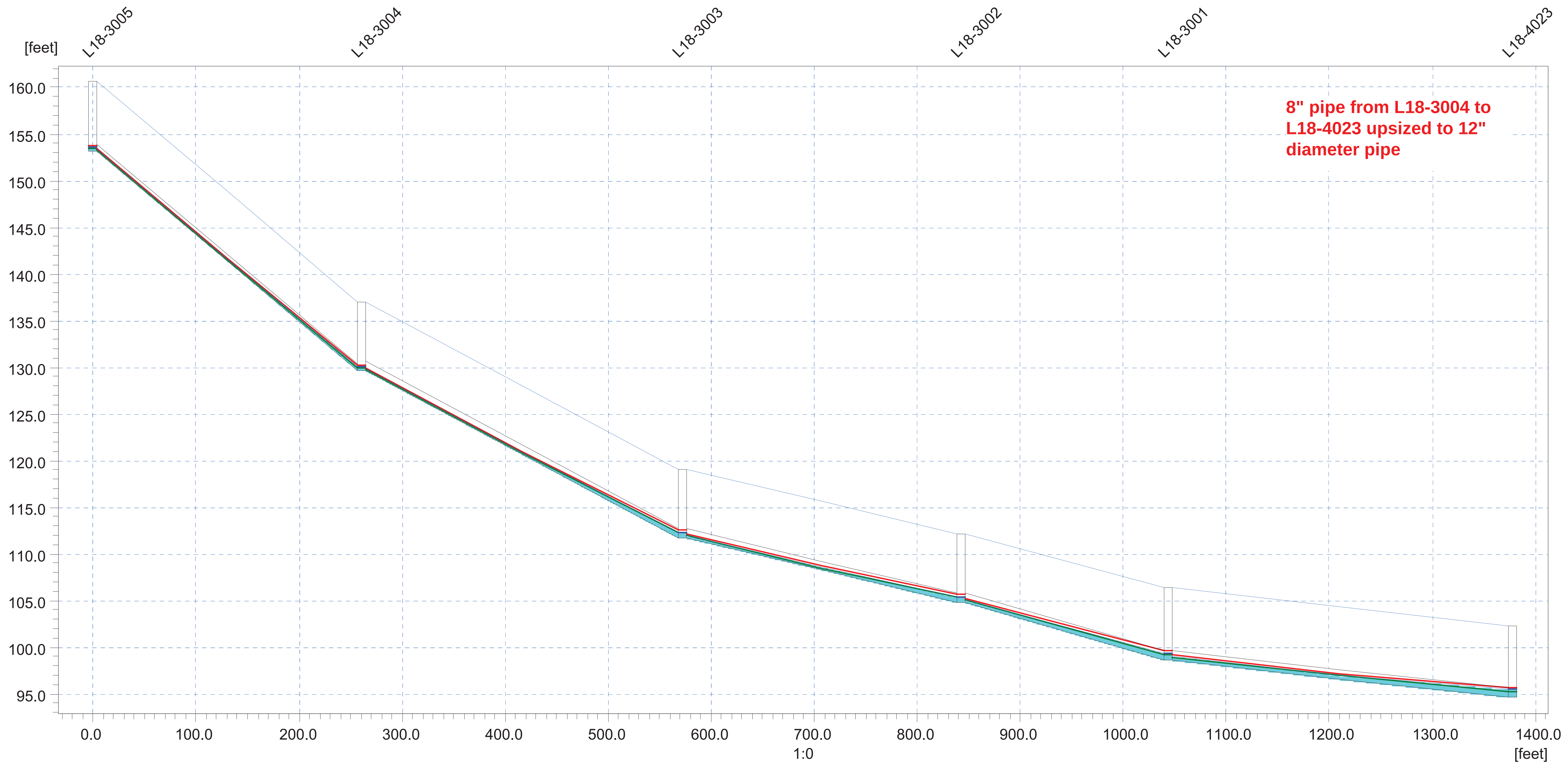
ANDERSON HILL ROAD GRAVITY SEWERS
BUILDOUT PEAK
FLOW CONDITIONS
POST CIP
Pipe filling - Maximum Buildout_PEAK_CIPBuildout_Peak.PRF
[feet]
244600.0
244400.0
244200.0
244000.0
243800.0
243600.0
243400.0
243200.0
243000.0
242800.0
242600.0
242400.0
242200.0
242000.0
241800.0
241600.0
241400.0
241200.0
1177000.0
1177500.0
1178000.0
1178500.0
1179000.0
1179500.0
1180000.0
1180500.0
1181000.0
1181500.0
1182000.0
1182500.0
[feet]
L18-3005
L18-3002
L18-3001
L18-4023
L18-4022
L18-3003
L18-3004
L18-4021
L18-4020
L18-4019
L18-4018
L17-1069
L17-1068
L17-1067
L17-1066
L17-1082

BUILDOUT PEAK FLOW CONDITIONS POST CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	0.721	0.752	1.527	1.529	1.541	cfs



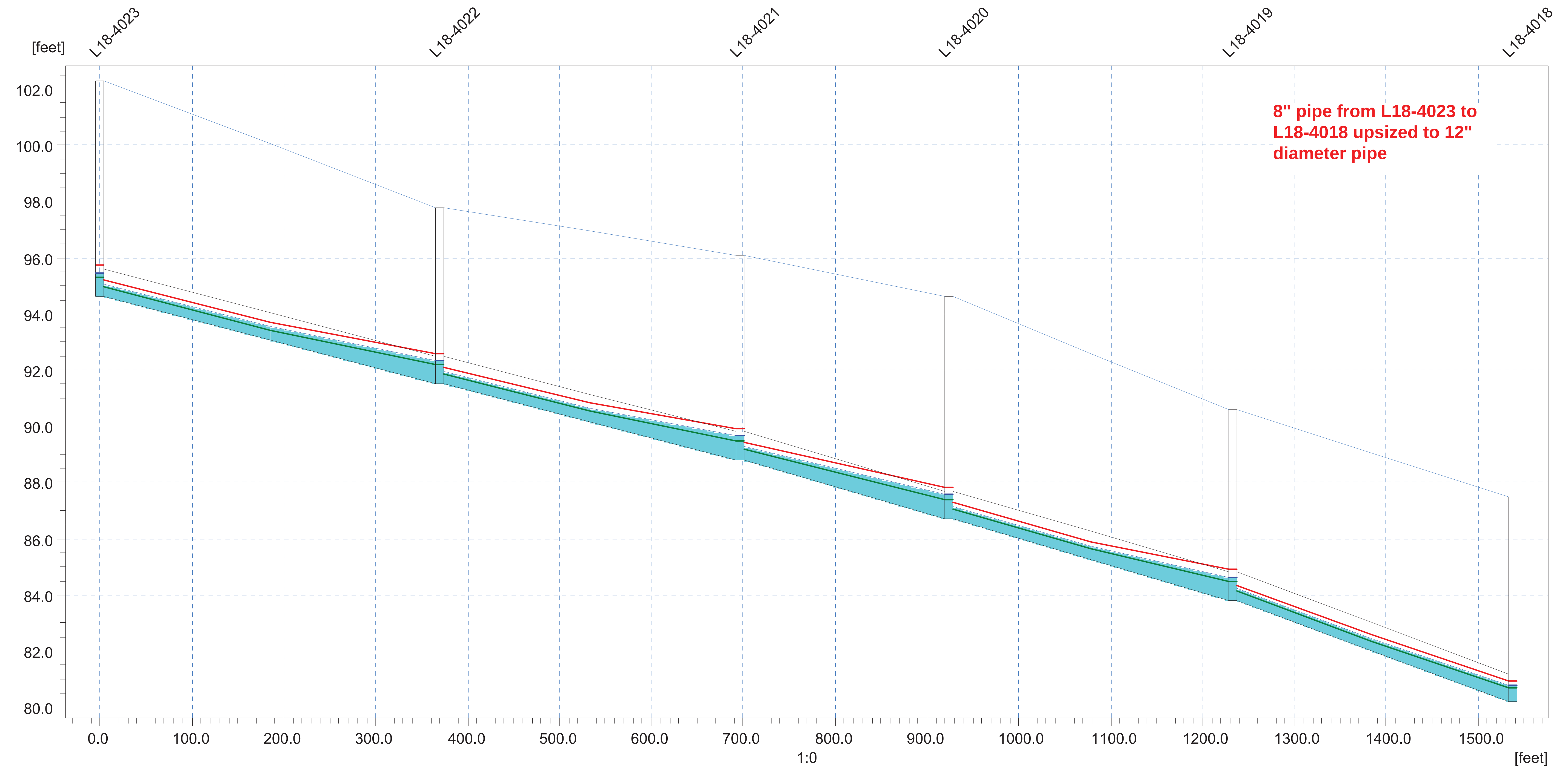
	L18-3005		L18-3004		L18-3003		L18-3002		L18-3001		L18-4023	
Ground Lev.	160.70		137.00		119.10		112.10		106.40			[m]
Invert lev.	153.20		129.70		111.70		104.80		98.60			[m]
Length		260.71		311.95		269.16		201.34		334.18		[m]
Diameter		0.67		1.00		1.00		1.00		1.00		[m]
Slope o/oo		90.14		57.70		25.64		30.79		11.97		

BUILDOUT PEAK FLOW CONDITIONS POST CIP

ANDERSON HILL ROAD GRAVITY SEWERS

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	1.634	1.649	1.656	1.663	1.675	cfs



	L18-4023	L18-4022	L18-4021	L18-4020	L18-4019	L18-4018	
Ground Lev.	102.30	97.80	96.10	94.60	90.60		[m]
Invert lev.	94.60	91.50	88.80	86.70	83.80		[m]

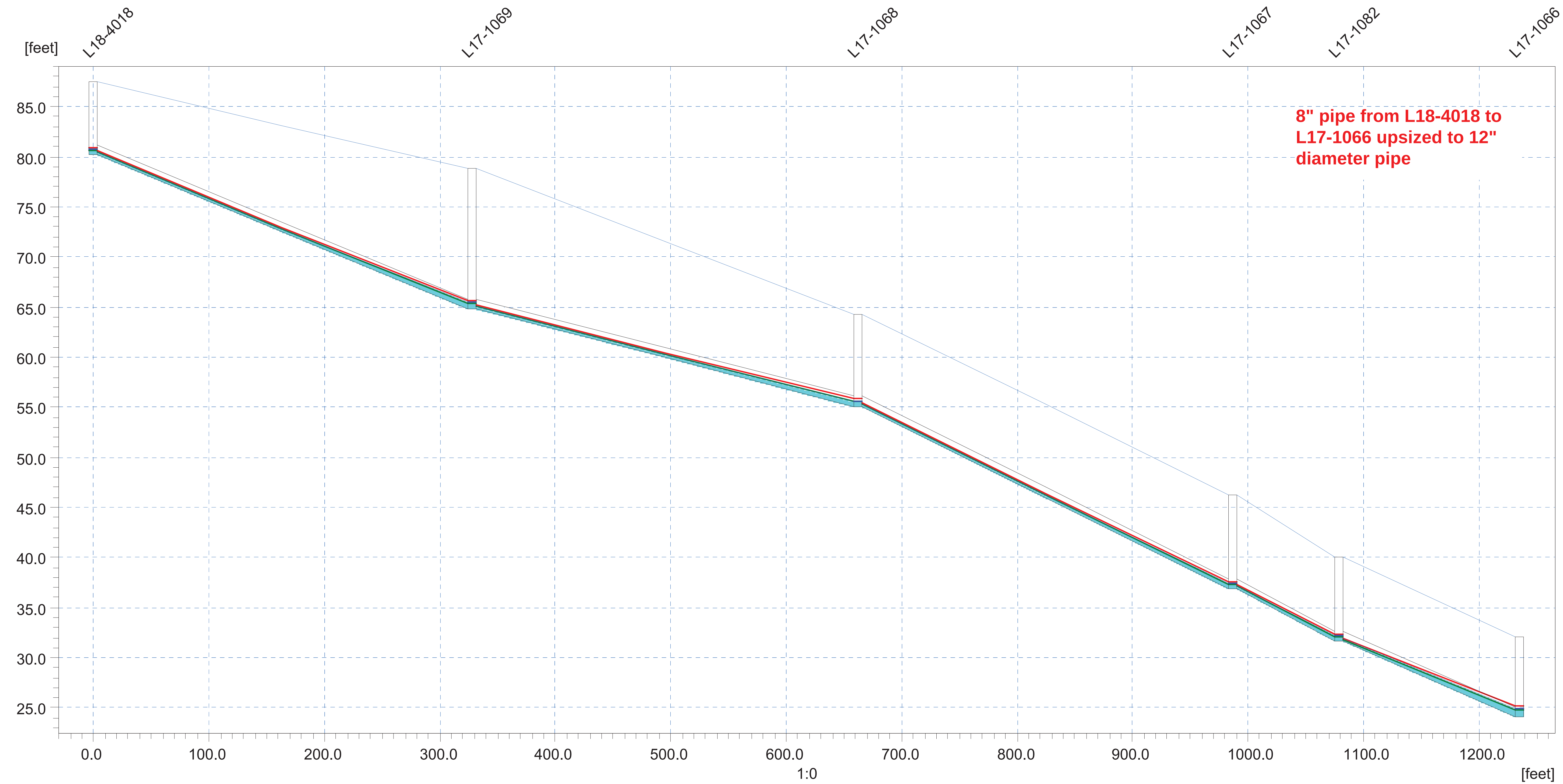
Length	369.23	326.71	227.74	309.52	303.83	[m]
Diameter	1.00	1.00	1.00	1.00	1.00	[m]
Slope o/oo	8.40	8.26	9.22	9.37	11.85	

ANDERSON HILL ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	1.684	1.698	1.706	1.711	1.715	cfs



	L18-4018	L17-1069	L17-1068	L17-1067	L17-1082	L17-1066	
Ground Lev.	87.50	78.80	64.20	46.30	40.00		[m]
Invert lev.	80.20	64.80	55.10	36.90	31.60		[m]

Length	327.31	334.51	324.76	92.34	155.71	[m]
Diameter	1.00	1.00	1.00	1.00	1.00	[m]
Slope o/oo	47.05	29.00	56.04	57.40	48.17	

DICKEY ROAD SEWER UPGRADES

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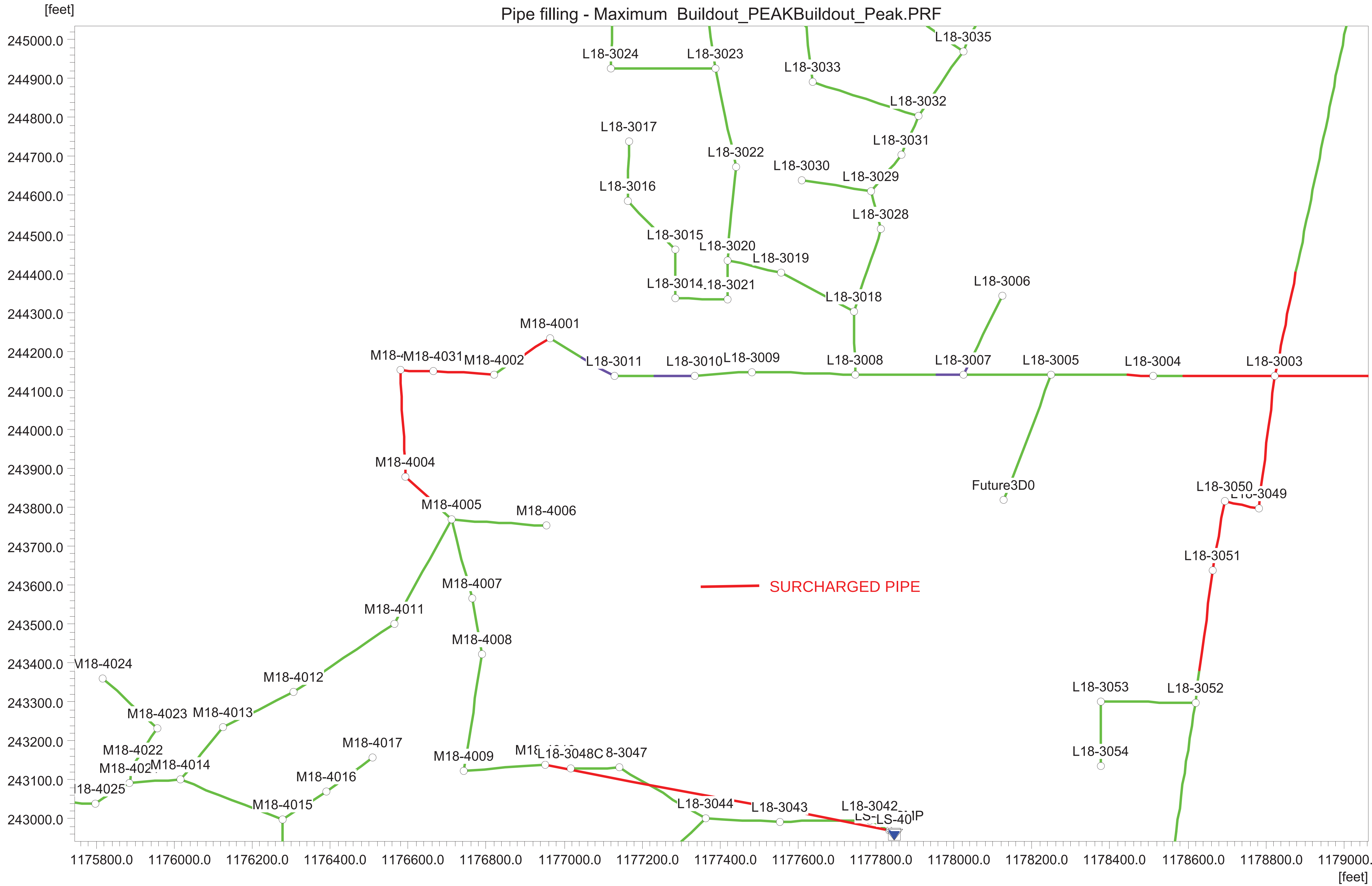
BUILD-OUT PEAK MODEL FLOWS
(CURRENT ZONING)

PRE-CIP

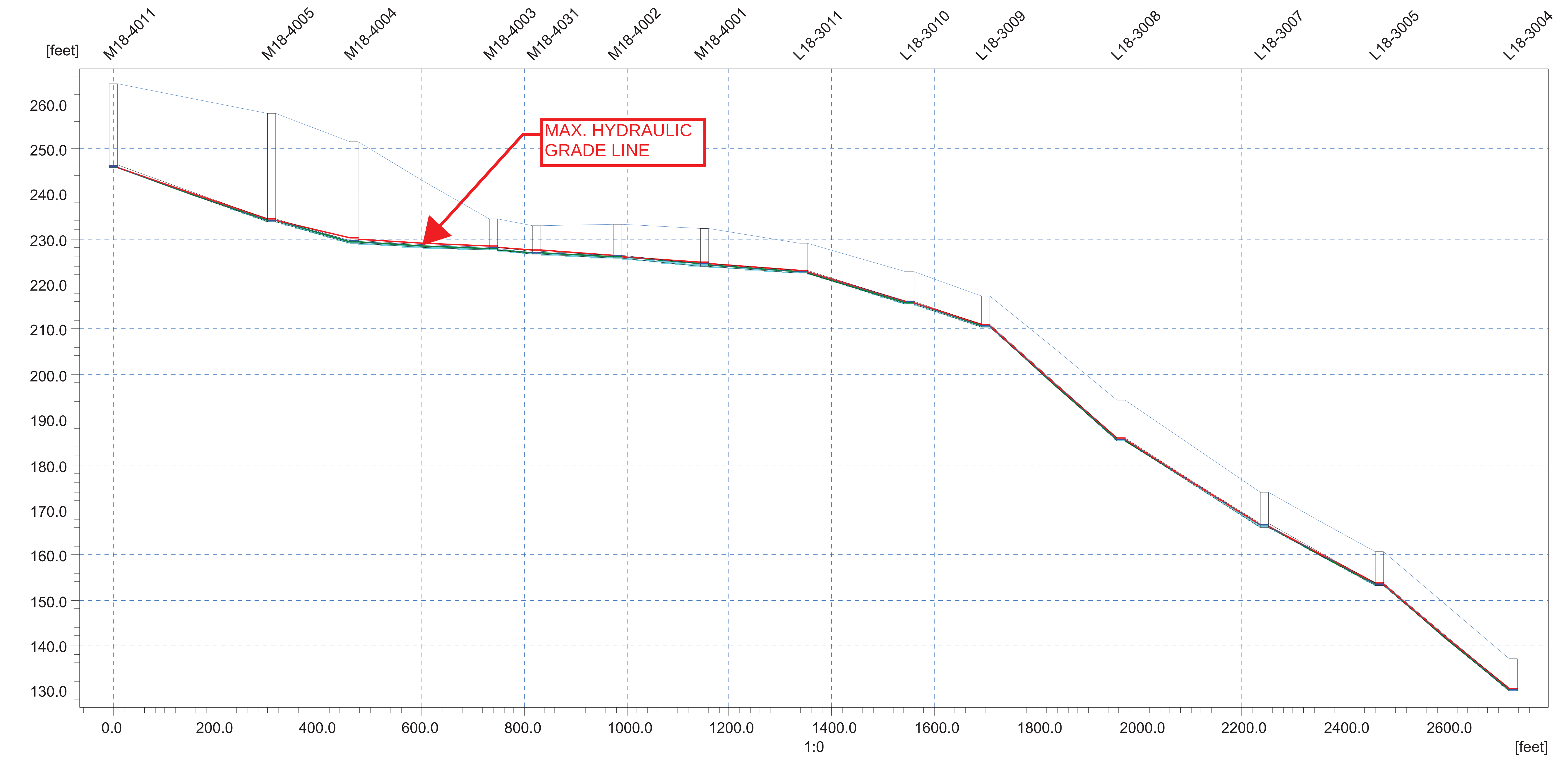


BUILD-OUT PEAK MODEL FLOWS
(CURRENT ZONING)

PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	0.194	0.218	0.496	0.497	0.498	0.507	0.510	0.512	0.514	0.515	0.673	0.697	0.721	cfs

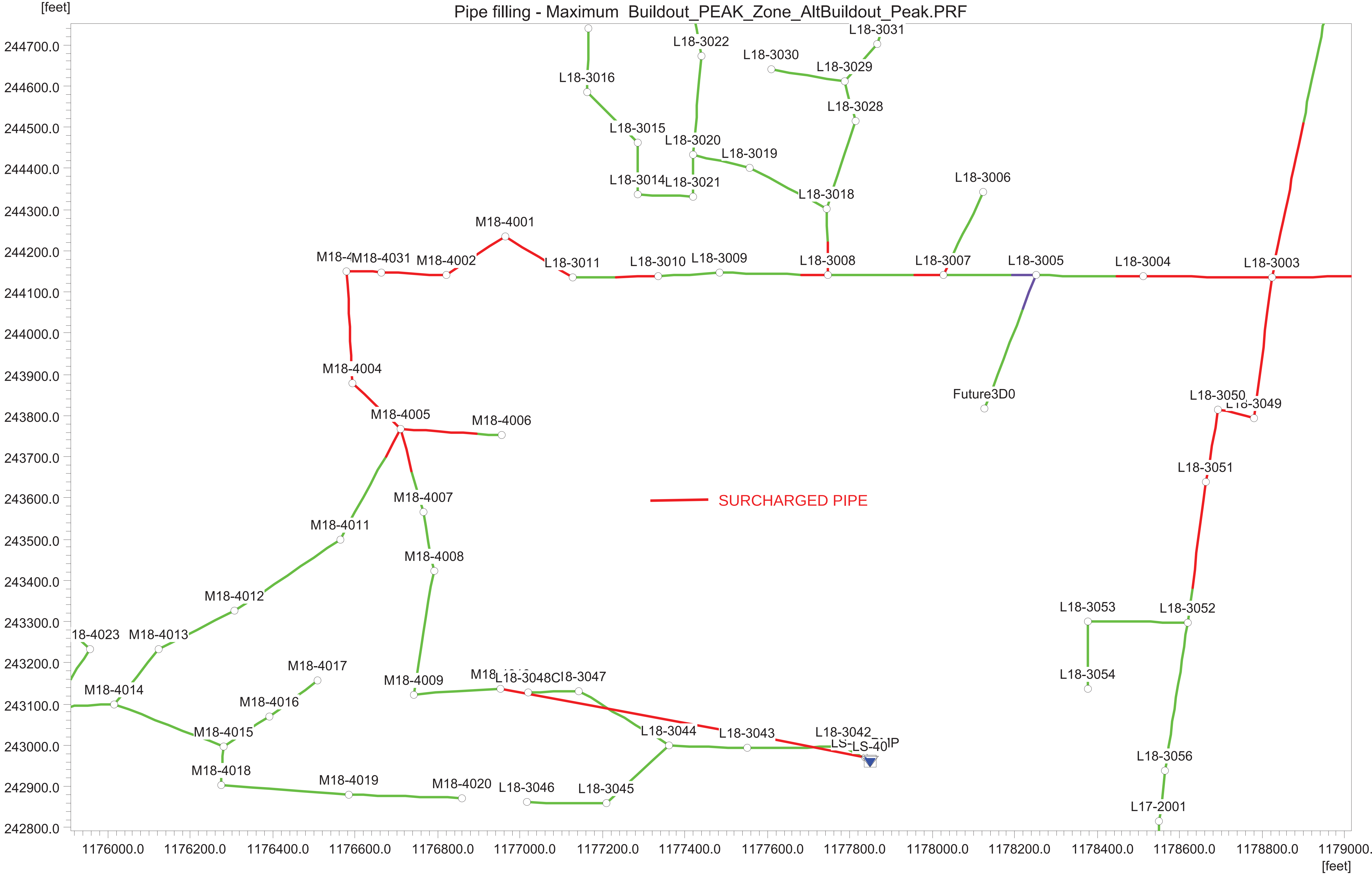


	M18-4011	M18-4005	M18-4004	M18-4003	M18-4031	M18-4002	M18-4001	L18-3011	L18-3010	L18-3009	L18-3008	L18-3007	L18-3005	L18-3004	
Ground Lev.	264.50	257.90	251.40	234.40	233.00	233.30	232.20	229.10	222.60	217.30	194.30	174.00	160.70		[m]
Invert lev.	245.80	233.90	229.00	227.40	226.60	225.70	224.00	222.40	215.60	210.50	185.20	166.20	153.20		[m]

Length	306.50	161.19	272.98	83.72	157.22	170.00	192.63	208.10	147.22	264.72	278.47	224.43	260.71	[m]
Diameter	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	[m]
Slope o/oo	38.83	30.40	5.86	9.56	5.72	10.00	8.31	32.68	34.64	95.57	68.23	57.92	90.14	

BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 1 REVISED ZONING)

PRE-CIP

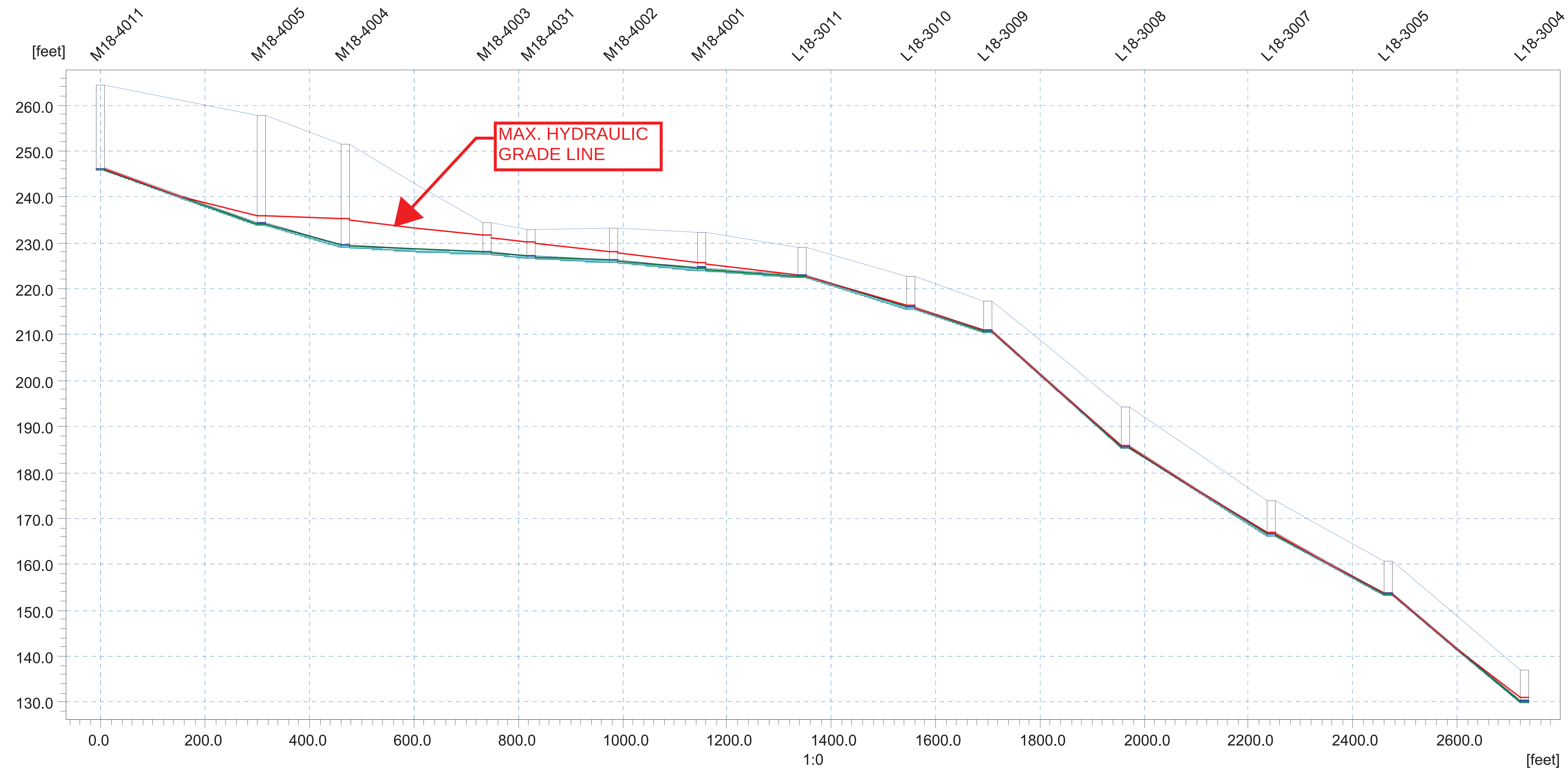


BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 1 REVISED ZONING)

PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_Zone_AltBuildout_Peak.PRF

Discharge	0.355	0.380	0.777	0.781	0.782	0.791	0.794	0.796	0.798	0.799	0.958	0.982	1.006	cfs

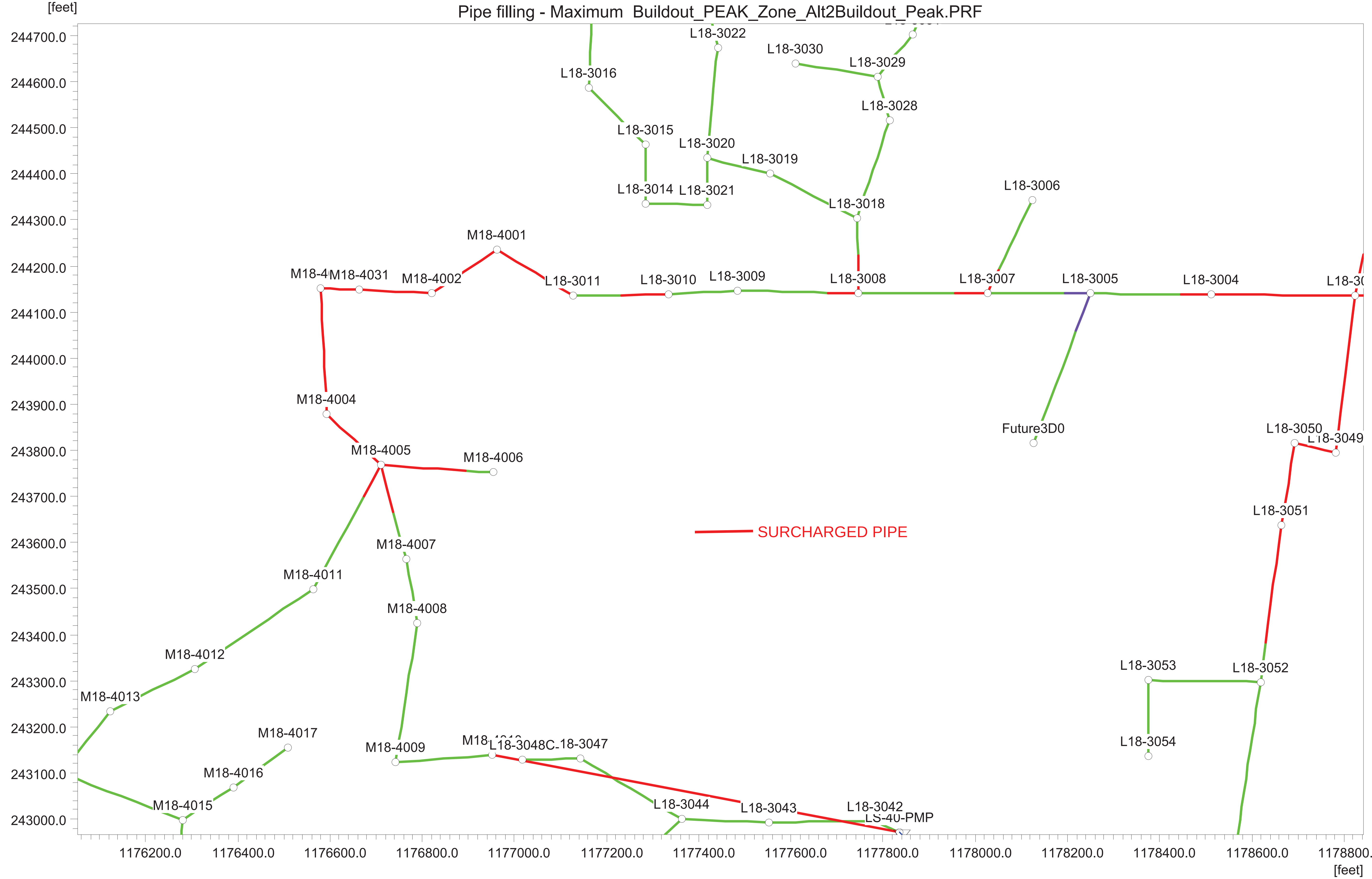


	M18-4011	M18-4005	M18-4004	M18-4003	M18-4031	M18-4002	M18-4001	L18-3011	L18-3010	L18-3009	L18-3008	L18-3007	L18-3005	L18-3004	
Ground Lev.	264.50	257.90	251.40	234.40	233.00	233.30	232.20	229.10	222.60	217.30	194.30	174.00	160.70		[m]
Invert lev.	245.80	233.90	229.00	227.40	226.60	225.70	224.00	222.40	215.60	210.50	185.20	166.20	153.20		[m]

Length	306.50	161.19	272.98	83.72	157.22	170.00	192.63	208.10	147.22	264.72	278.47	224.43	260.71	[m]
Diameter	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	[m]
Slope o/oo	38.83	30.40	5.86	9.56	5.72	10.00	8.31	32.68	34.64	95.57	68.23	57.92	90.14	

BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 2 REVISED ZONING)

PRE-CIP

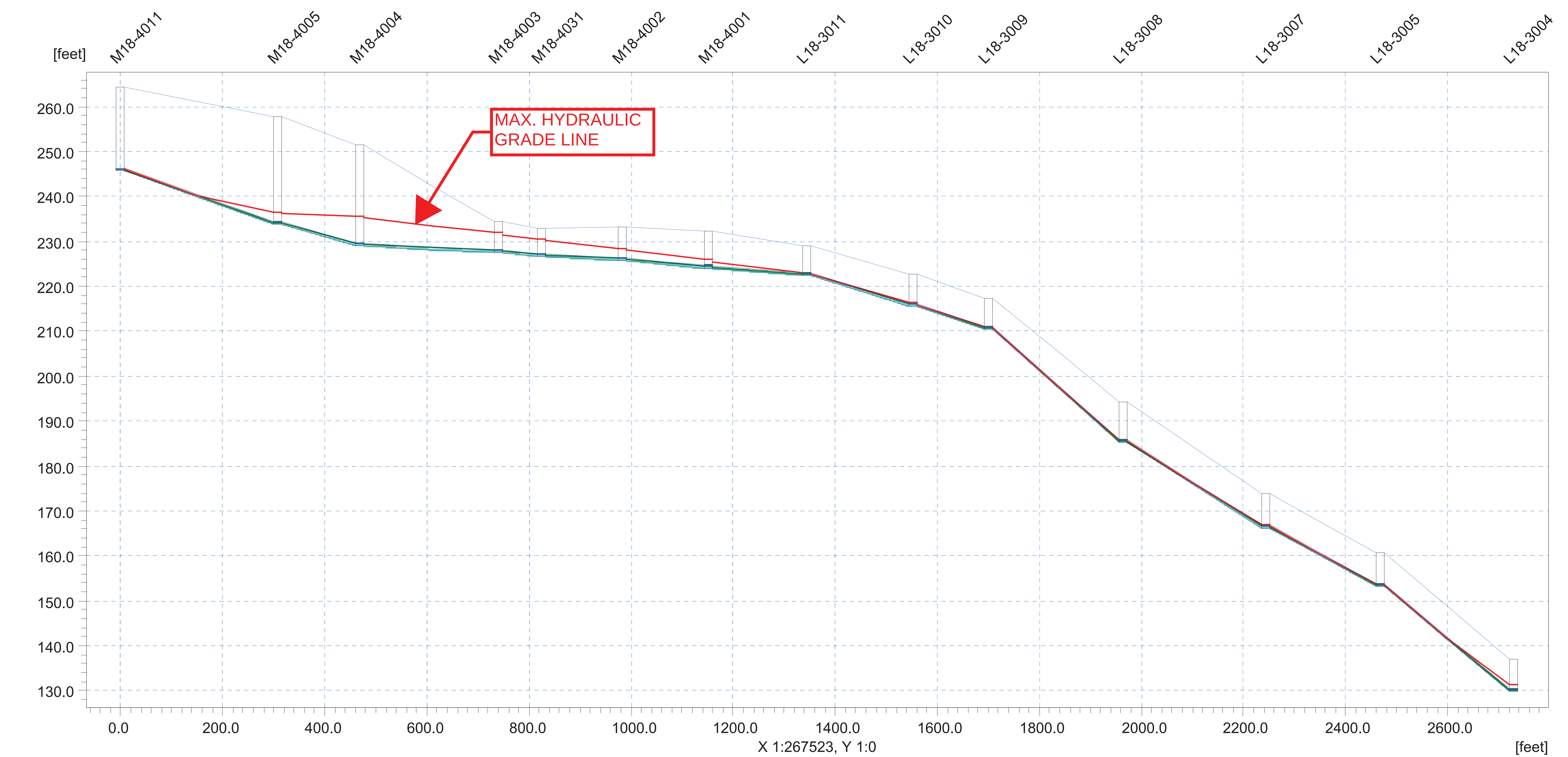


BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 2 REVISED ZONING)

PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_Zone_Alt2Buildout_Peak.PRF

Discharge	0.362	0.386	0.788	0.791	0.792	0.801	0.804	0.806	0.808	0.810	0.968	0.992	1.017	cfs

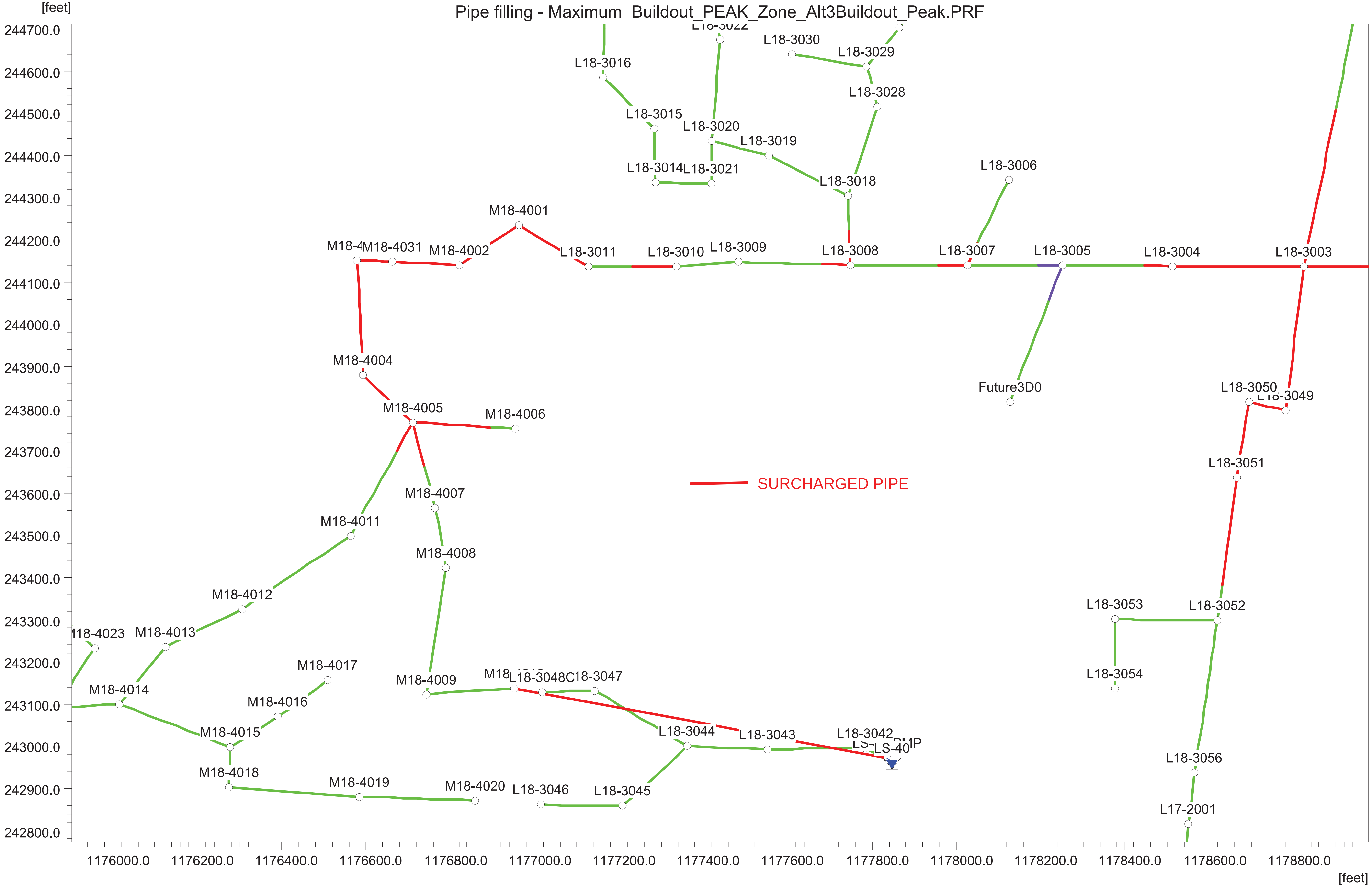


Node	Ground Lev. [m]	Invert lev. [m]
M18-4011	264.50	245.80
M18-4005	257.90	233.90
M18-4004	251.40	229.00
M18-4003	234.40	227.40
M18-4031	233.00	226.60
M18-4002	233.30	225.70
M18-4001	232.20	224.00
L18-3011	229.10	222.40
L18-3010	222.60	215.60
L18-3009	217.30	210.50
L18-3008	194.30	185.20
L18-3007	174.00	166.20
L18-3005	160.70	153.20

Length	306.50	161.19	272.98	83.72	157.22	170.00	192.63	208.10	147.22	264.72	278.47	224.43	260.71	[m]
Diameter	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	[m]
Slope o/oo	38.83	30.40	5.86	9.56	5.72	10.00	8.31	32.68	34.64	95.57	68.23	57.92	90.14	

BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 3 REVISED ZONING)

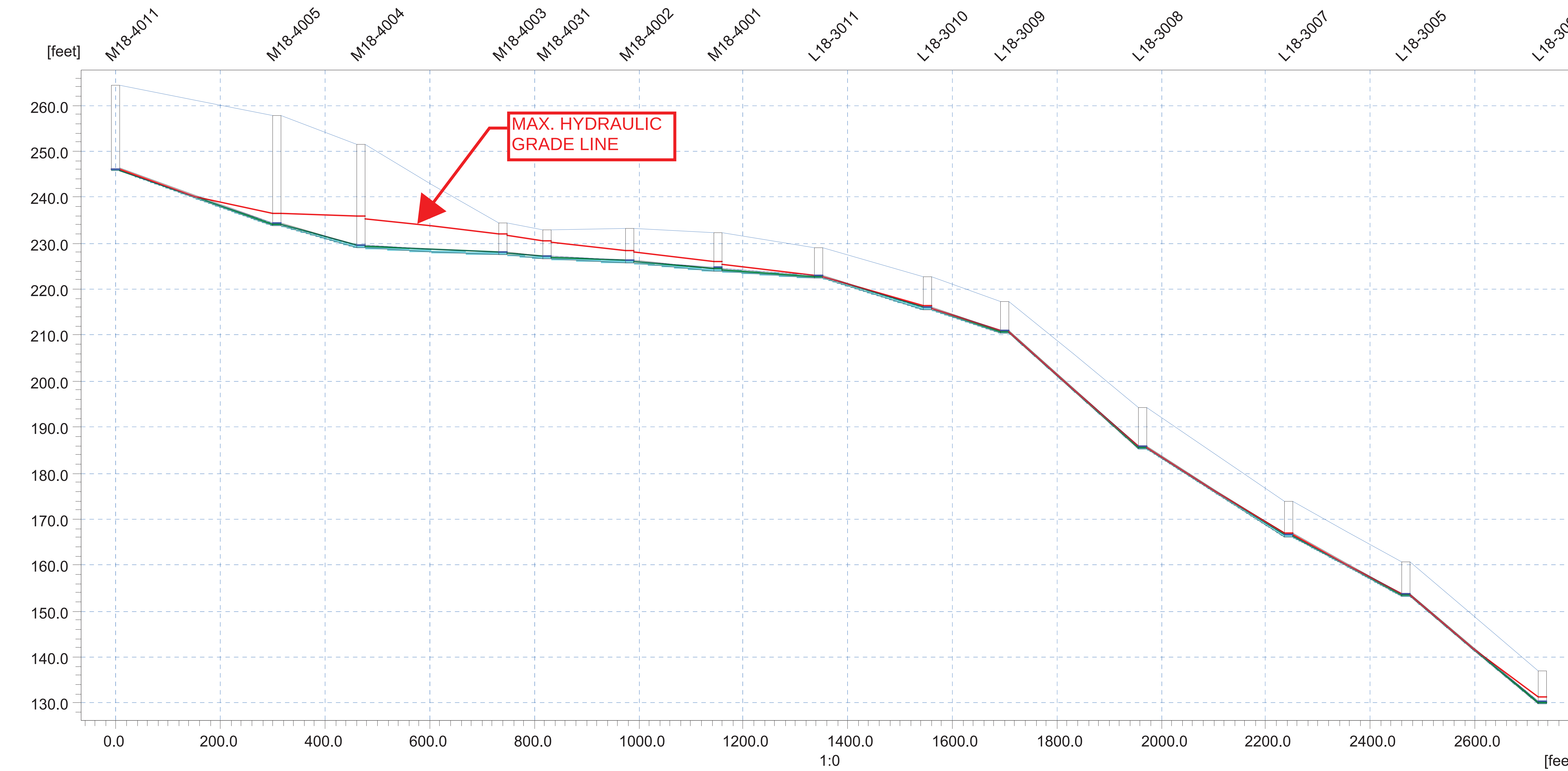
PRE-CIP



BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE 3 REVISED ZONING)

PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_Zone_Alt3Buildout_Peak.PRF

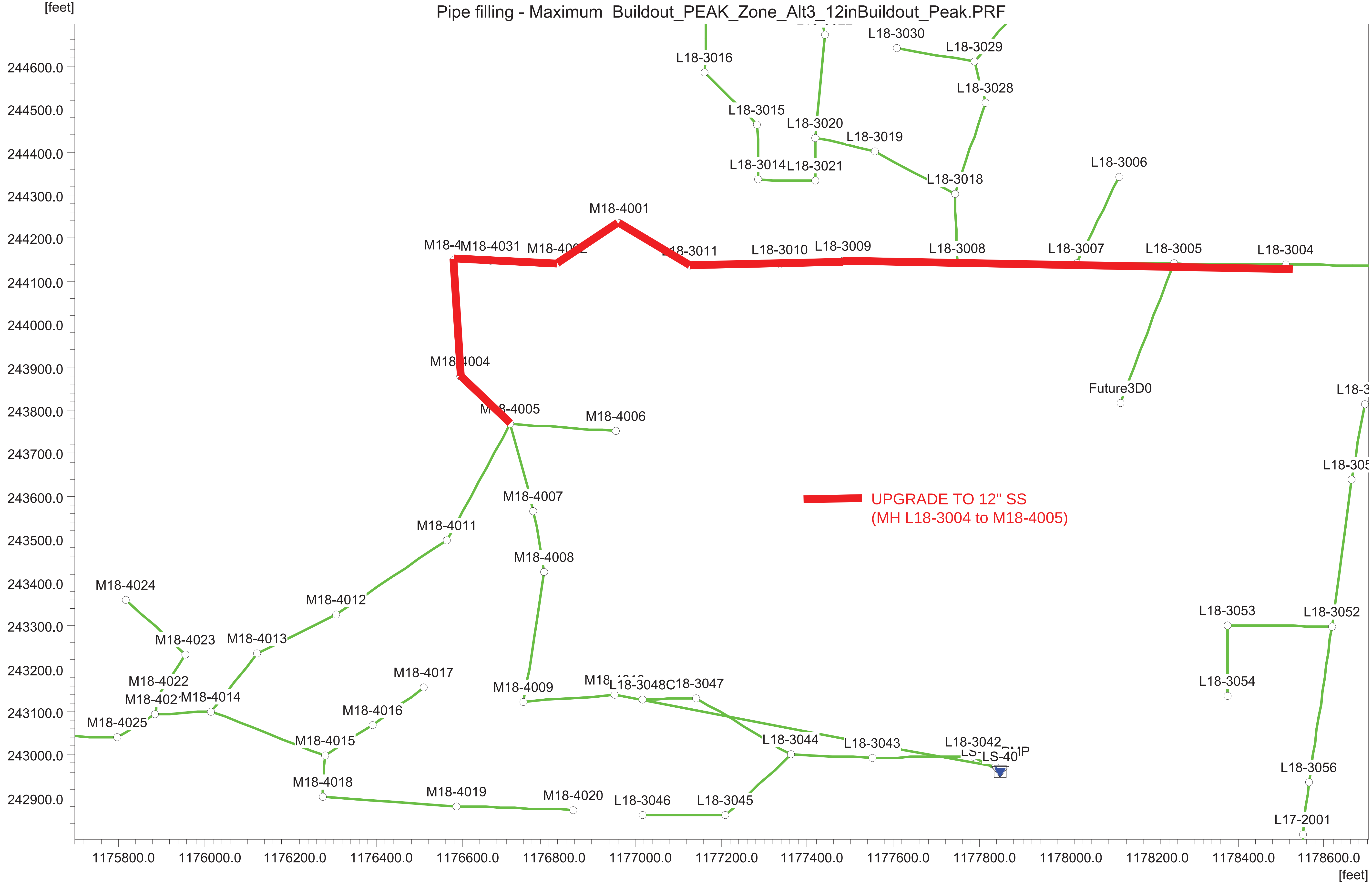


Node	Ground Lev. [m]	Invert lev. [m]
M18-4011	264.50	245.80
M18-4005	257.90	233.90
M18-4004	251.40	229.00
M18-4003	234.40	227.40
M18-4031	233.00	226.60
M18-4002	233.30	225.70
M18-4001	232.20	224.00
L18-3011	229.10	222.40
L18-3010	222.60	215.60
L18-3009	217.30	210.50
L18-3008	194.30	185.20
L18-3007	174.00	166.20
L18-3005	160.70	153.20
L18-3004		

Link (from – to)	Discharge [cfs]	Length [m]	Diameter [m]	Slope o/oo
M18-4011 – M18-4005	0.366	306.50	0.67	38.83
M18-4005 – M18-4004	0.390	161.19	0.67	30.40
M18-4004 – M18-4003	0.795	272.98	0.67	5.86
M18-4003 – M18-4031	0.798	83.72	0.67	9.56
M18-4031 – M18-4002	0.799	157.22	0.67	5.72
M18-4002 – M18-4001	0.808	170.00	0.67	10.00
M18-4001 – L18-3011	0.811	192.63	0.67	8.31
L18-3011 – L18-3010	0.813	208.10	0.67	32.68
L18-3010 – L18-3009	0.815	147.22	0.67	34.64
L18-3009 – L18-3008	0.817	264.72	0.67	95.57
L18-3008 – L18-3007	0.975	278.47	0.67	68.23
L18-3007 – L18-3005	0.999	224.43	0.67	57.92
L18-3005 – L18-3004	1.024	260.71	0.67	90.14

BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE ZONING)

POST-CIP

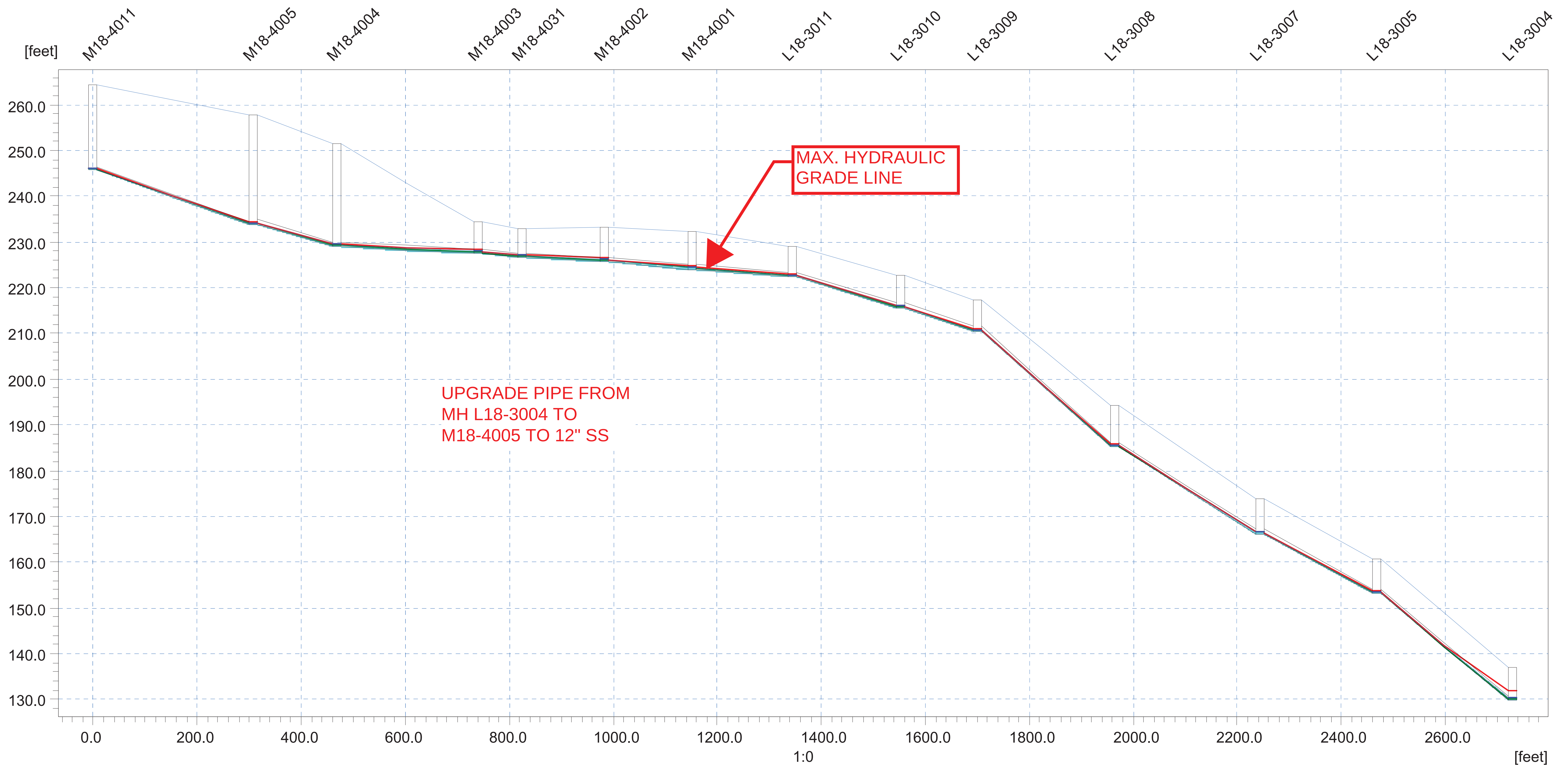


BUILD-OUT PEAK MODEL FLOWS
(ALTERNATIVE ZONING)

POST-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_Zone_Alt3_12inBuildout_Peak.PRF

Discharge	0.366	0.390	0.795	0.797	0.798	0.808	0.812	0.814	0.816	0.818	0.976	1.001	1.025	cfs



	M18-4011	M18-4005	M18-4004	M18-4003	M18-4031	M18-4002	M18-4001	L18-3011	L18-3010	L18-3009	L18-3008	L18-3007	L18-3005	L18-3004	
Ground Lev.	264.50	257.90	251.40	234.40	233.00	233.30	232.20	229.10	222.60	217.30	194.30	174.00	160.70		[m]
Invert lev.	245.80	233.90	229.00	227.40	226.60	225.70	224.00	222.40	215.60	210.50	185.20	166.20	153.20		[m]

Length	306.50	161.19	272.98	83.72	157.22	170.00	192.63	208.10	147.22	264.72	278.47	224.43	260.71	[m]
Diameter	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	[m]
Slope o/oo	38.83	30.40	5.86	9.56	5.72	10.00	8.31	32.68	34.64	95.57	68.23	57.92	90.14	

MYHRE ROAD SEWER UPGRADES

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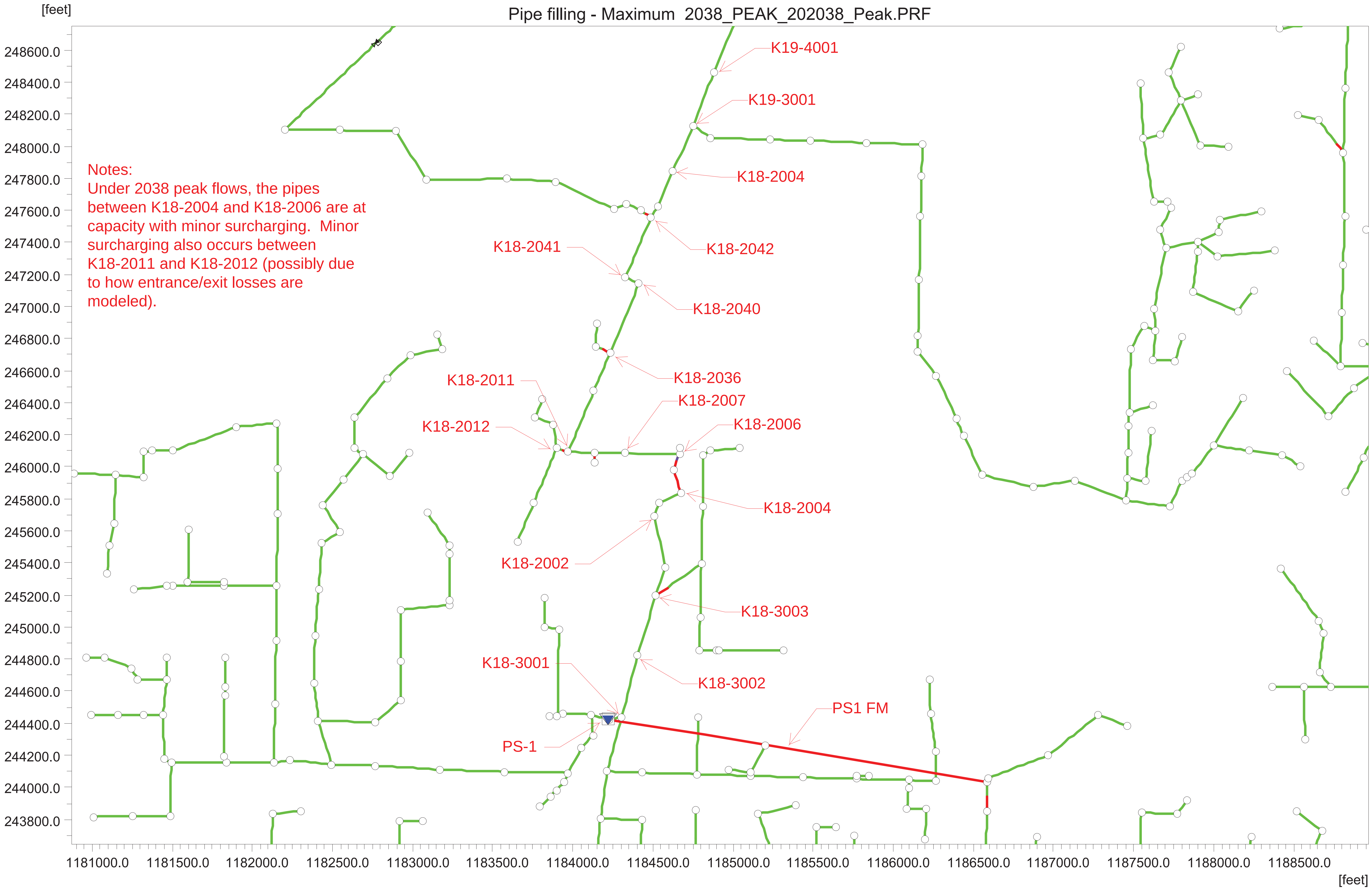
MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOWS
PRE-CIP

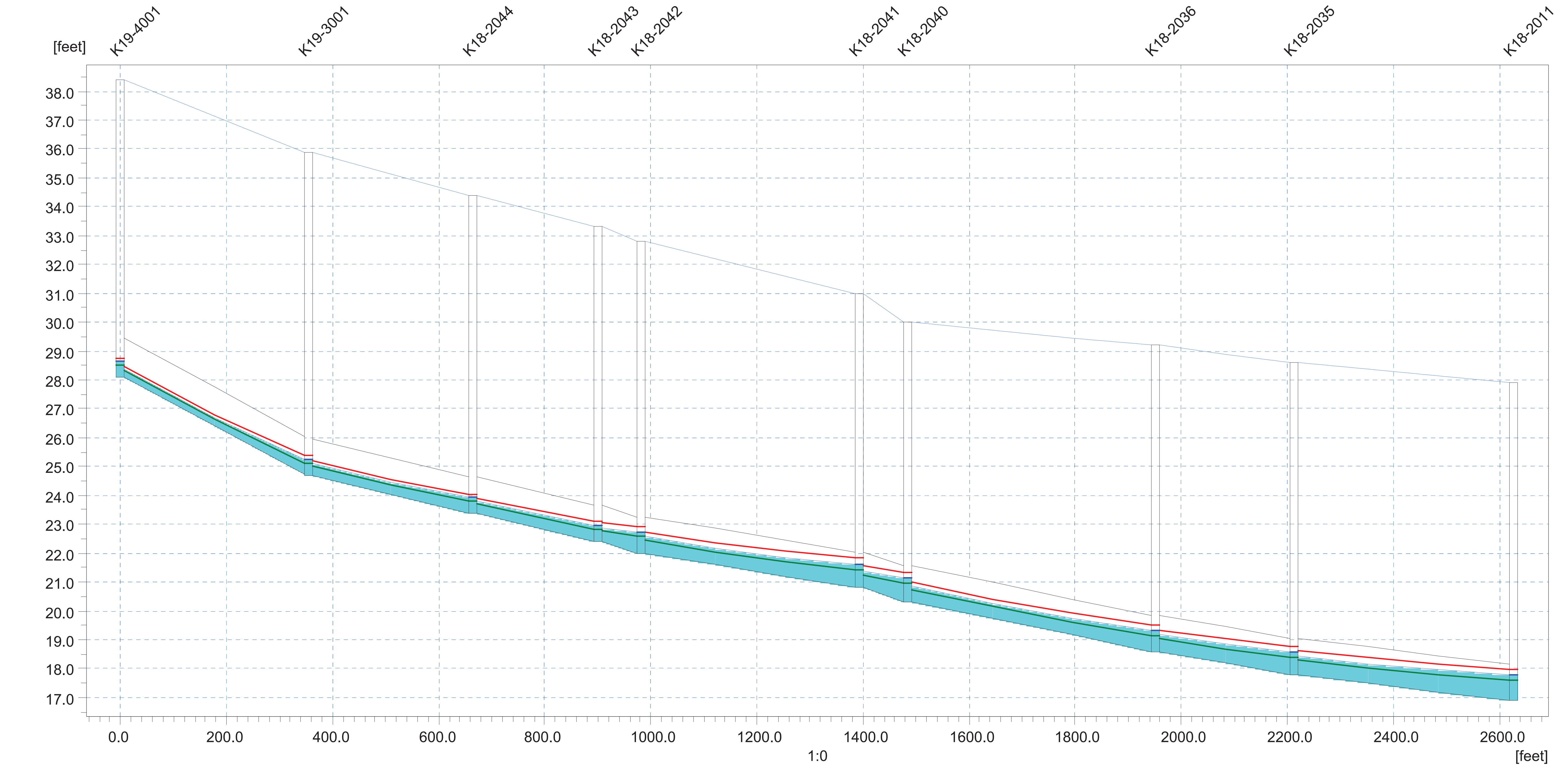


MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	0.798	0.892	0.884	0.885	1.476	1.497	1.521	1.576	1.596	cfs

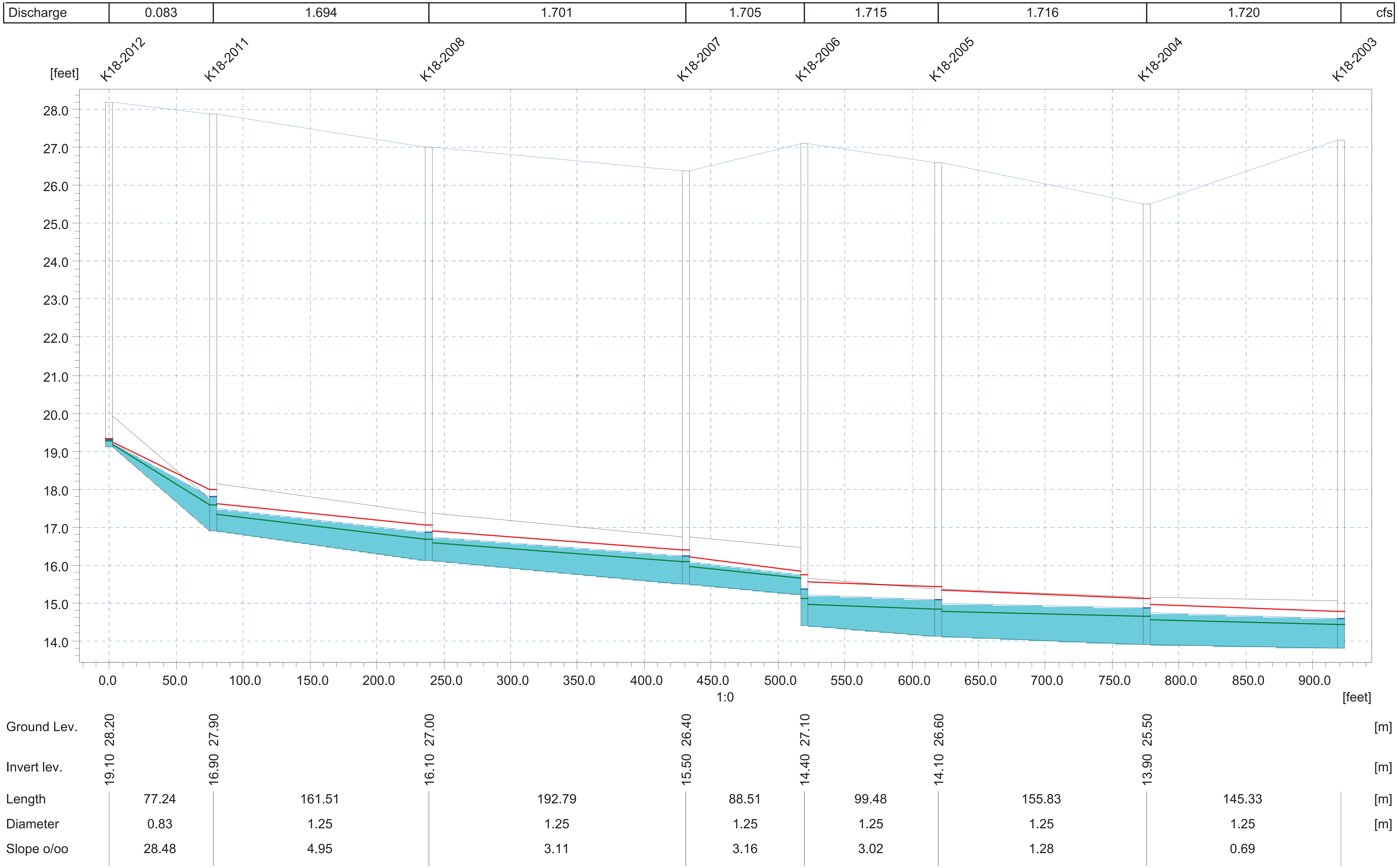


	K19-4001		K19-3001		K18-2044		K18-2043		K18-2042		K18-2041		K18-2040		K18-2036		K18-2035		
Ground Lev.	38.40		35.90		34.40		33.30		32.80		31.00		30.00		29.20		28.60			[m]
Invert lev.	28.10		24.70		23.40		22.40		22.00		20.80		20.30		18.60		17.80			[m]
Length		354.90		308.82		237.47		79.77		410.98		93.30		466.87		260.95		412.68		[m]
Diameter		1.33		1.25		1.25		1.25		1.25		1.25		1.25		1.25		1.25		[m]
Slope o/oo		9.50		4.21		4.21		5.01		2.92		5.36		3.64		3.07		2.18		

MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

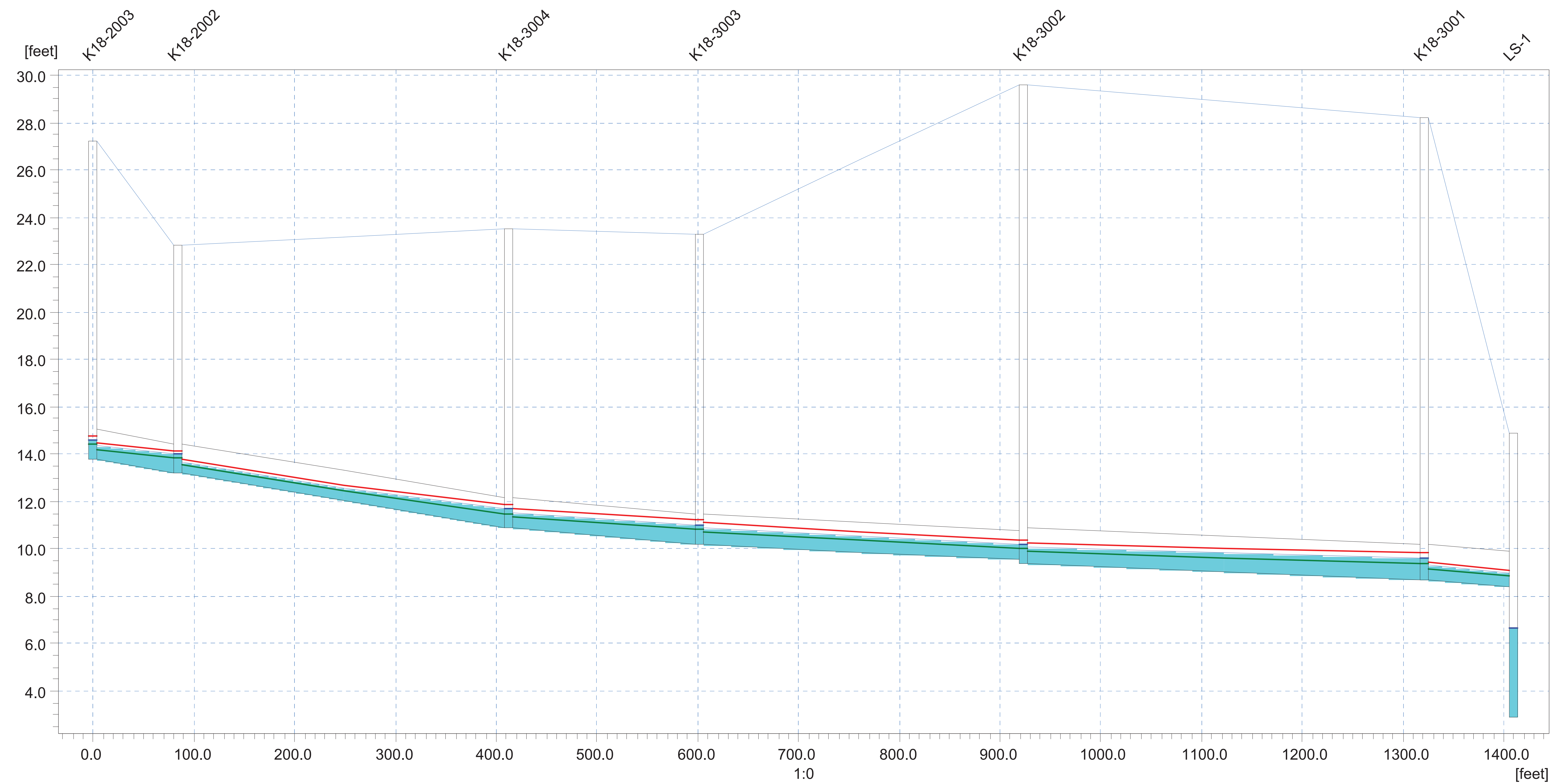


MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	1.720	1.726	1.731	1.829	1.838	2.216	cfs

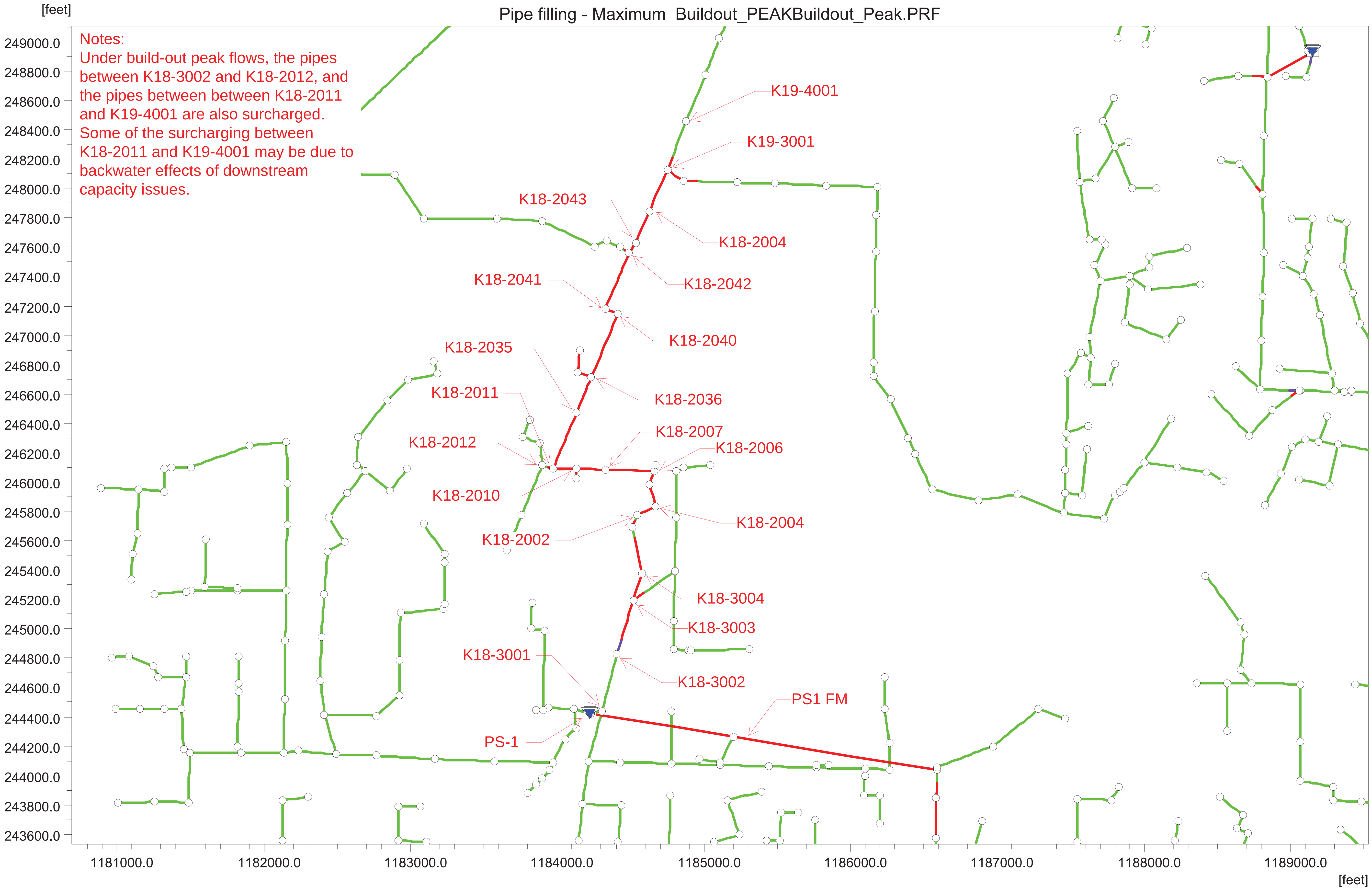


Ground Lev.	27.20	22.80	23.50	23.30	29.60	28.20	[m]
Invert lev.	13.80	13.20	10.90	10.20	9.40	8.70	[m]

Length	84.43	328.17	189.13	320.91	398.08	88.17	[m]
Diameter	1.25	1.25	1.25	1.25	1.50	1.50	[m]
Slope o/oo	7.11	7.01	3.70	2.06	1.76	3.40	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOWS
PRE CIP

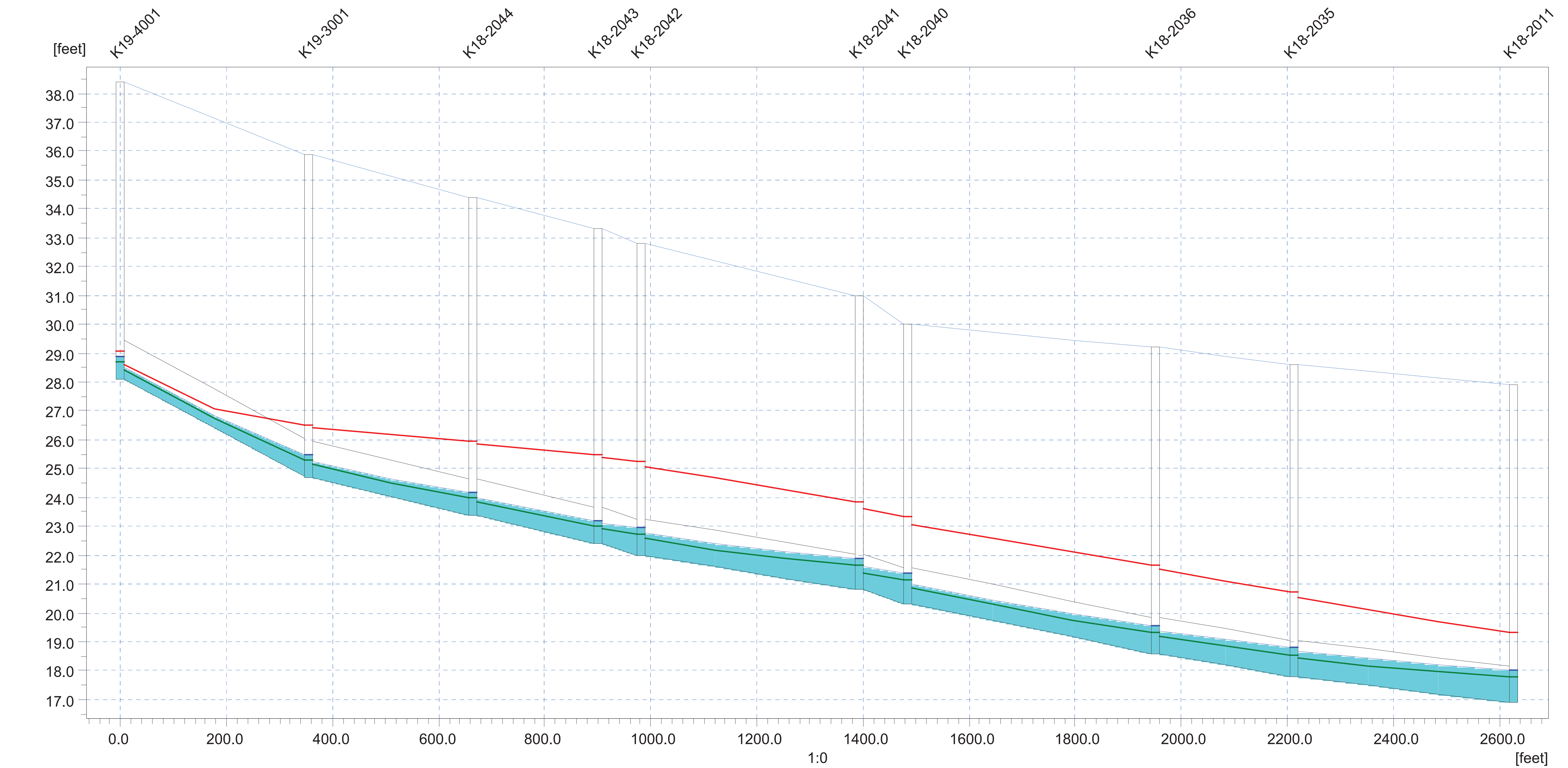


MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	1.615	1.773	1.772	1.776	2.389	2.408	2.435	2.465	2.483	cfs



	K19-4001	K19-3001	K18-2044	K18-2043	K18-2042	K18-2041	K18-2040	K18-2036	K18-2035	K18-2011	
Ground Lev.	38.40	35.90	34.40	33.30	32.80	31.00	30.00	29.20	28.60		[m]
Invert lev.	28.10	24.70	23.40	22.40	22.00	20.80	20.30	18.60	17.80		[m]

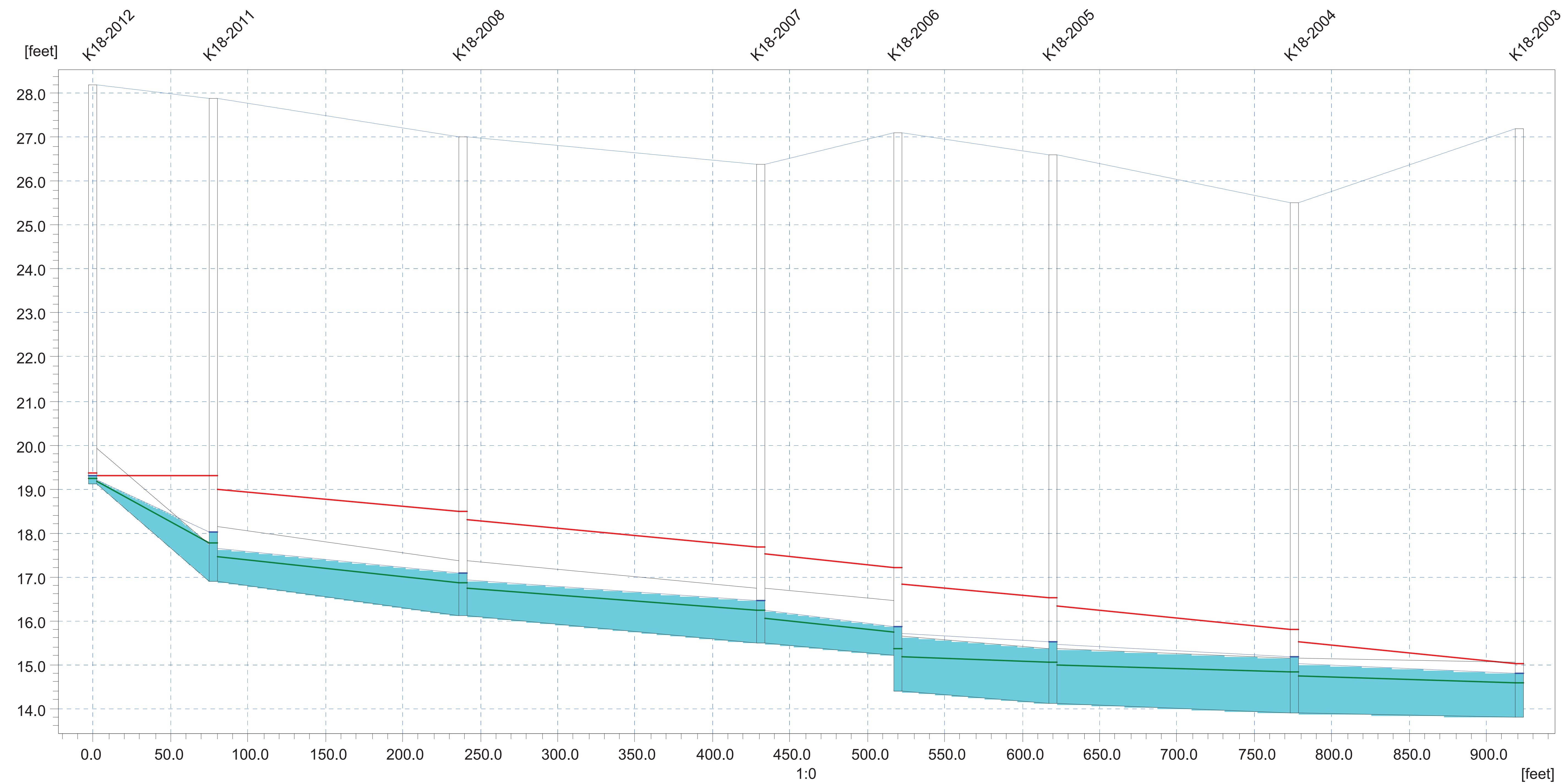
Length	354.90	308.82	237.47	79.77	410.98	93.30	466.87	260.95	412.68	[m]
Diameter	1.33	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo	9.50	4.21	4.21	5.01	2.92	5.36	3.64	3.07	2.18	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	0.085	2.583	2.593	2.603	2.622	2.623	2.630	cfs



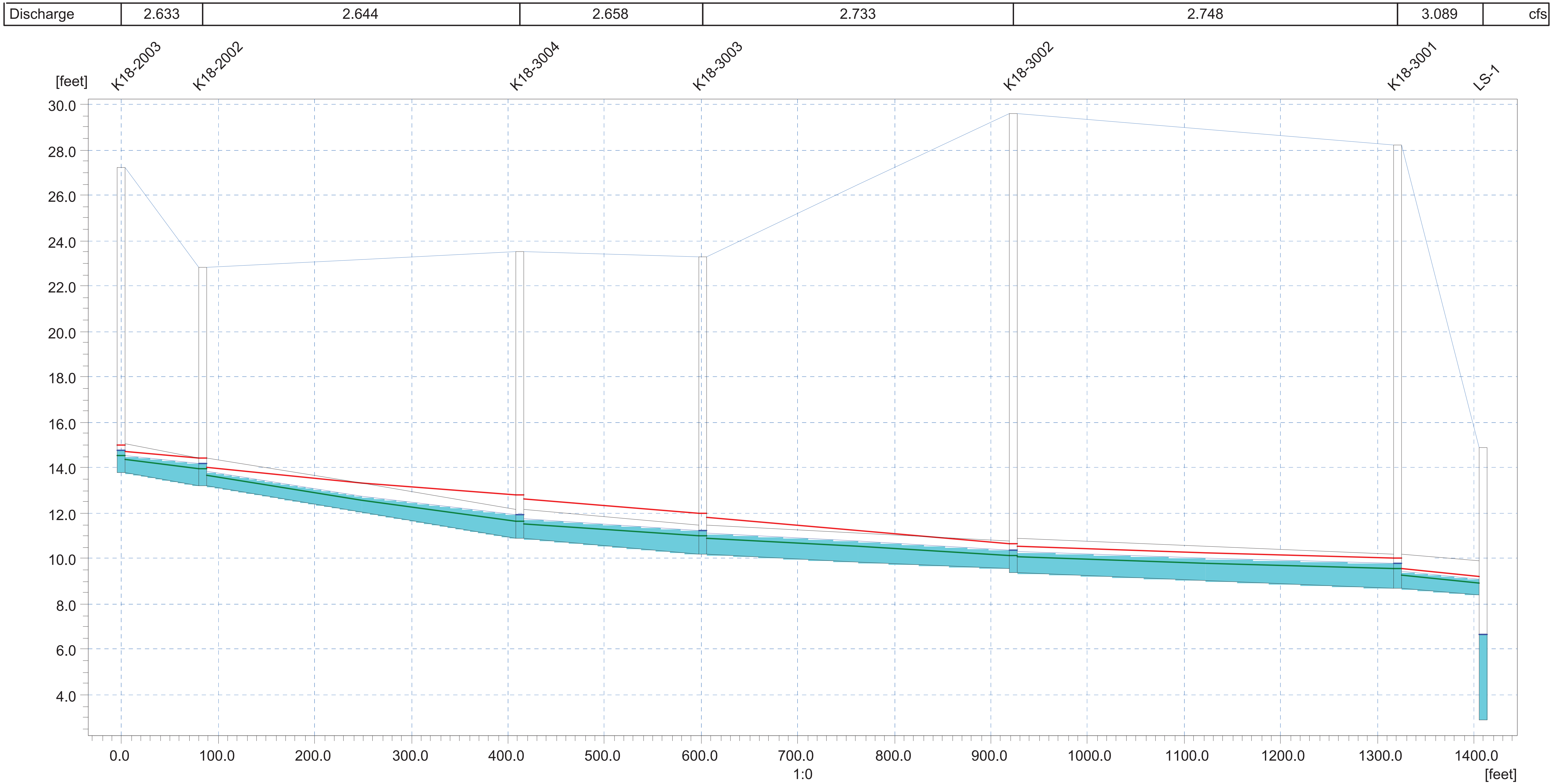
	K18-2012	K18-2011	K18-2008	K18-2007	K18-2006	K18-2005	K18-2004	K18-2003	
Ground Lev.	28.20	27.90	27.00	26.40	27.10	26.60	25.50		[m]
Invert lev.	19.10	16.90	16.10	15.50	14.40	14.10	13.90		[m]

Length	77.24	161.51	192.79	88.51	99.48	155.83	145.33	[m]
Diameter	0.83	1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo	28.48	4.95	3.11	3.16	3.02	1.28	0.69	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

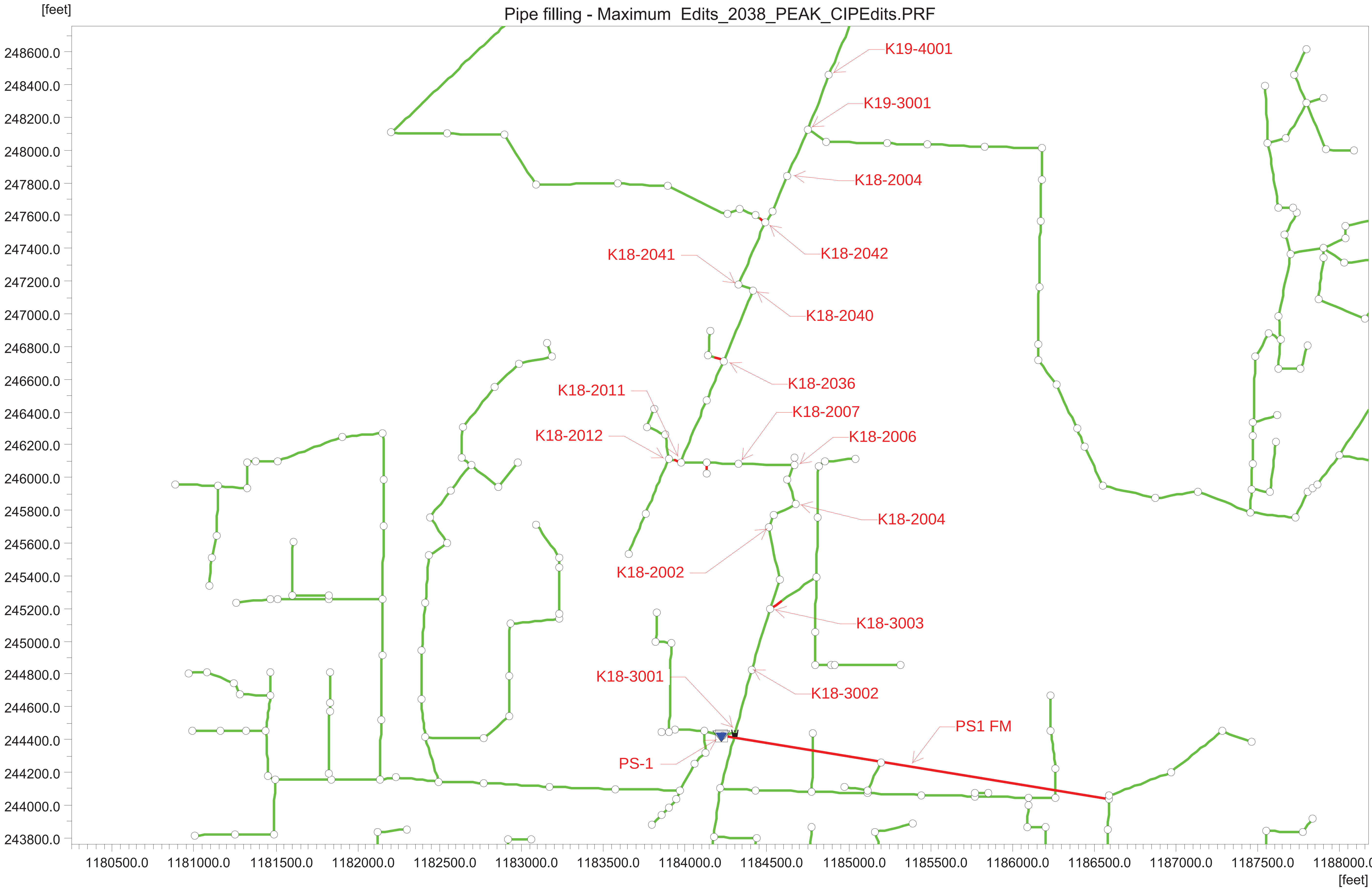
Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF



Ground Lev.	27.20	22.80	23.50	23.30	29.60	28.20		[m]
Invert lev.	13.80	13.20	10.90	10.20	9.40	8.70		[m]
Length	84.43	328.17	189.13	320.91	398.08	88.17		[m]
Diameter	1.25	1.25	1.25	1.25	1.50	1.50		[m]
Slope o/oo	7.11	7.01	3.70	2.06	1.76	3.40		

MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOWS
POST CIP

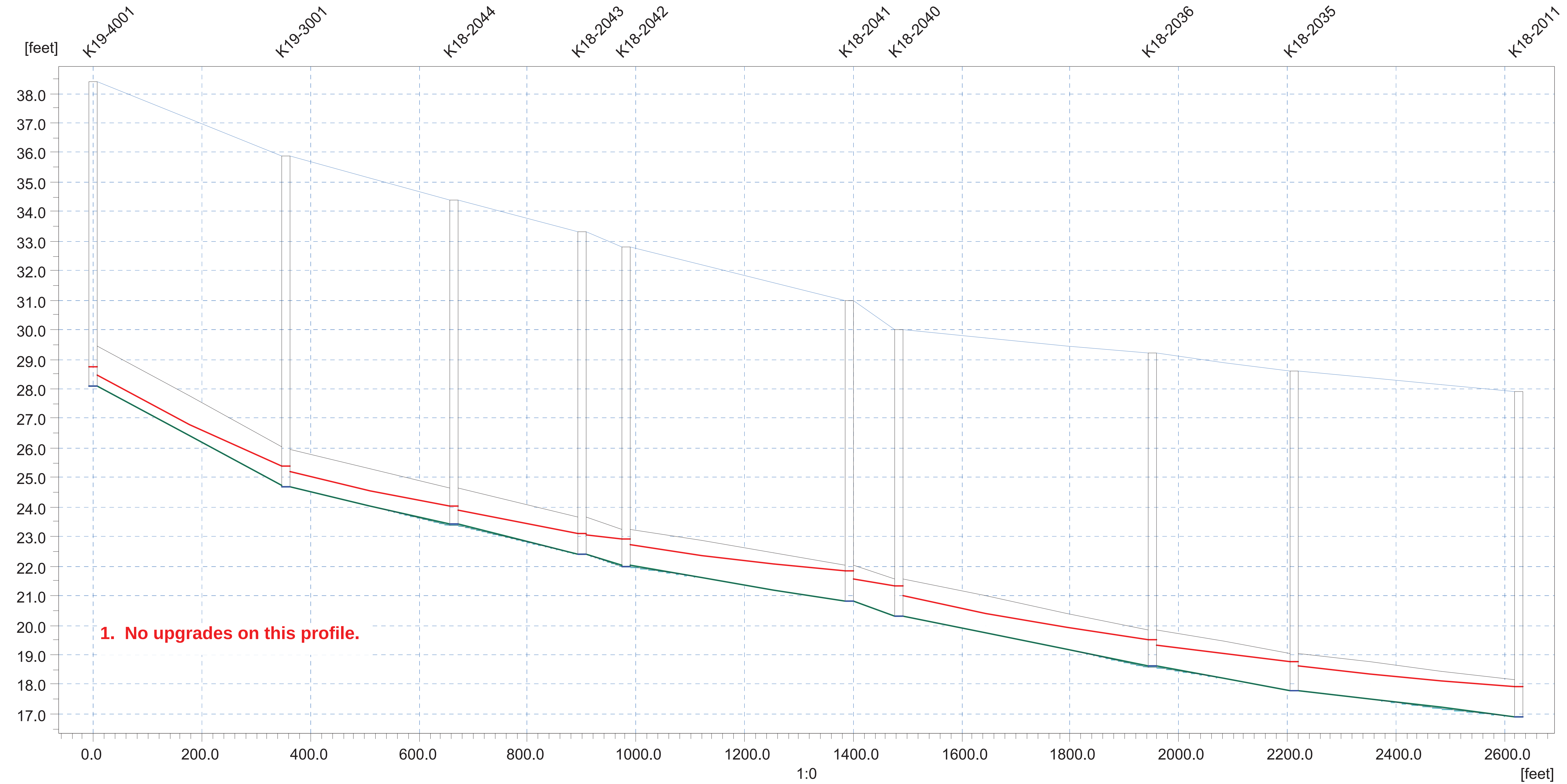


MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	cfs



	K19-4001	K19-3001	K18-2044	K18-2043	K18-2042	K18-2041	K18-2040	K18-2036	K18-2035	K18-2011	
Ground Lev.	38.40	35.90	34.40	33.30	32.80	31.00	30.00	29.20	28.60		[m]
Invert lev.	28.10	24.70	23.40	22.40	22.00	20.80	20.30	18.60	17.80		[m]

Length	354.90	308.82	237.47	79.77	410.98	93.30	466.87	260.95	412.68	[m]
Diameter	1.33	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo	9.50	4.21	4.21	5.01	2.92	5.36	3.64	3.07	2.18	

MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
POST-CIP

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	cfs

	K18-2012	K18-2011	K18-2008	K18-2007	K18-2006	K18-2005	K18-2004	K18-2003	
Ground Lev.	28.20	27.90	27.00	26.40	27.10	26.60	25.50		[m]
Invert lev.	19.10	16.90	16.10	15.50	14.40	14.10	13.90		[m]

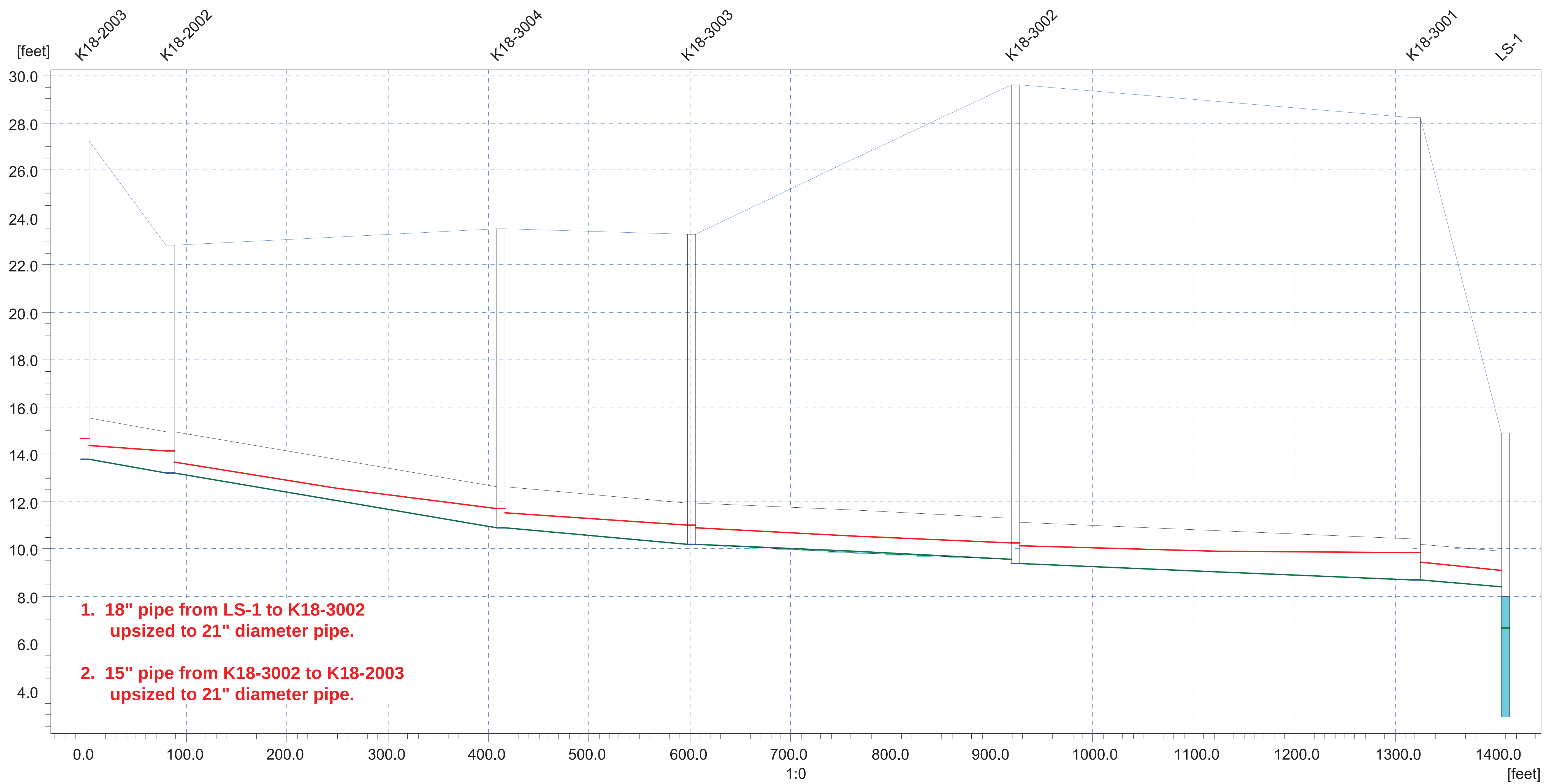
Length	77.24	161.51	192.79	88.51	99.48	155.83	145.33	[m]
Diameter	0.83	1.75	1.75	1.75	1.75	1.75	1.75	[m]
Slope o/oo	28.48	4.95	3.11	3.16	3.02	1.28	0.69	

MYHRE ROAD GRAVITY SEWERS

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	0.001	0.001	0.000	0.000	0.000	0.000	cfs

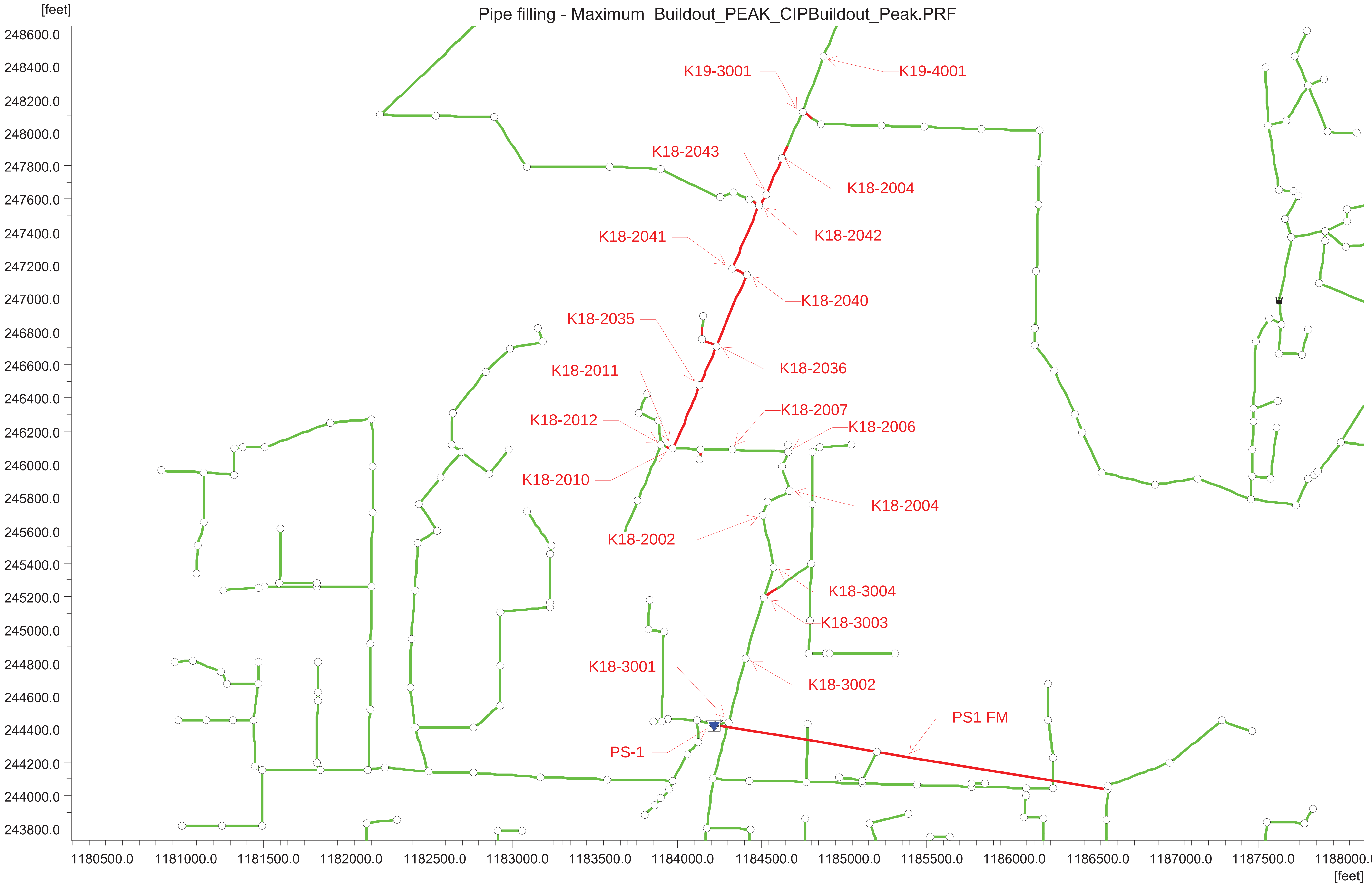


	K18-2003	K18-2002	K18-3004	K18-3003	K18-3002	K18-3001	
Ground Lev.	27.20	22.80	23.50	23.30	29.60	28.20	[m]
Invert lev.	13.80	13.20	10.90	10.20	9.40	8.70	[m]

Length	84.43	328.17	189.13	320.91	398.08	88.17	[m]
Diameter	1.75	1.75	1.75	1.75	1.75	1.50	[m]
Slope o/oo	7.11	7.01	3.70	2.06	1.76	3.40	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOWS
POST CIP

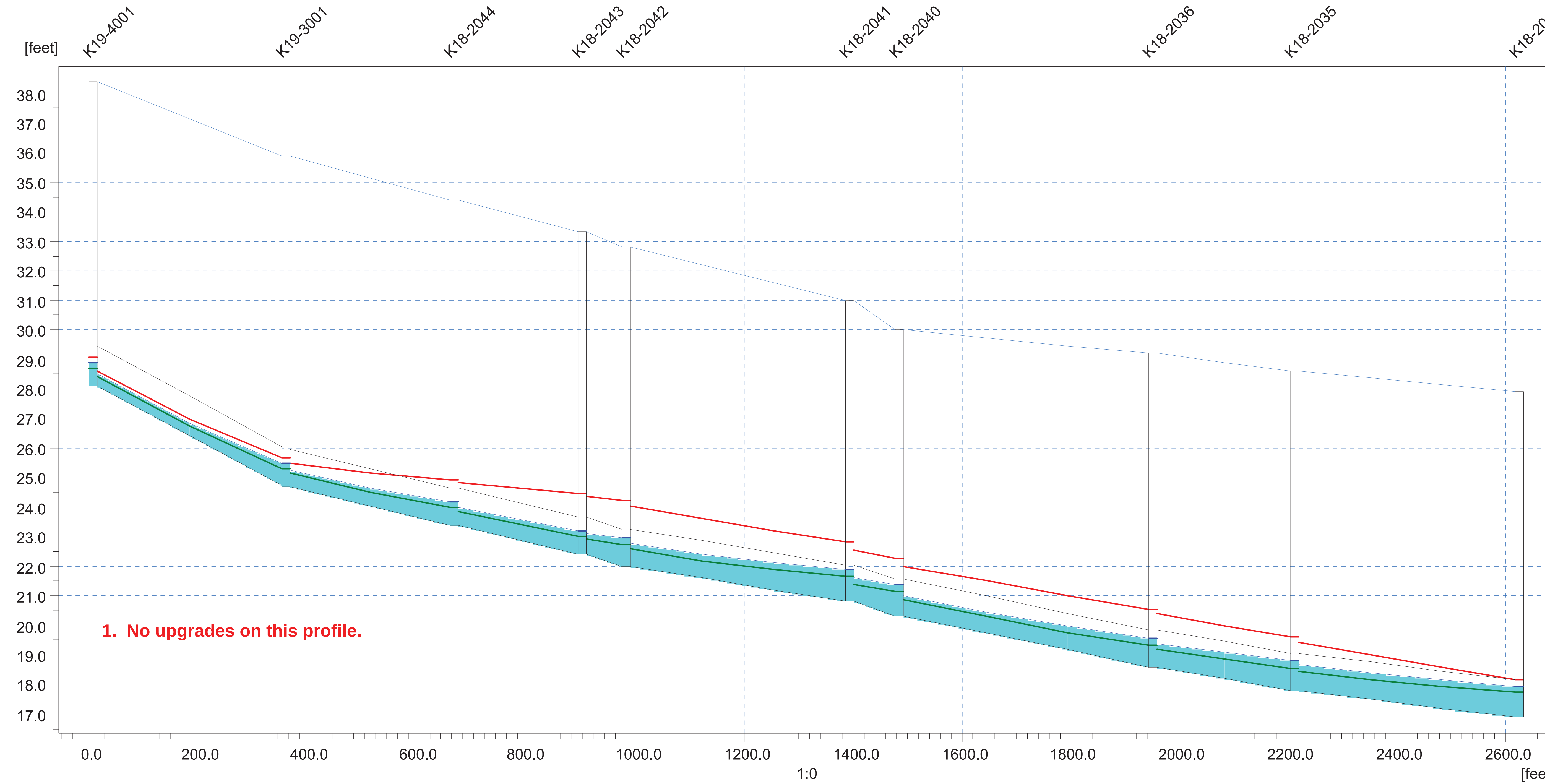


MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	1.615	1.773	1.772	1.776	2.389	2.408	2.435	2.464	2.482	cfs



	K19-4001	K19-3001	K18-2044	K18-2043	K18-2042	K18-2041	K18-2040	K18-2036	K18-2035	K18-2011	
Ground Lev.	38.40	35.90	34.40	33.30	32.80	31.00	30.00	29.20	28.60		[m]
Invert lev.	28.10	24.70	23.40	22.40	22.00	20.80	20.30	18.60	17.80		[m]

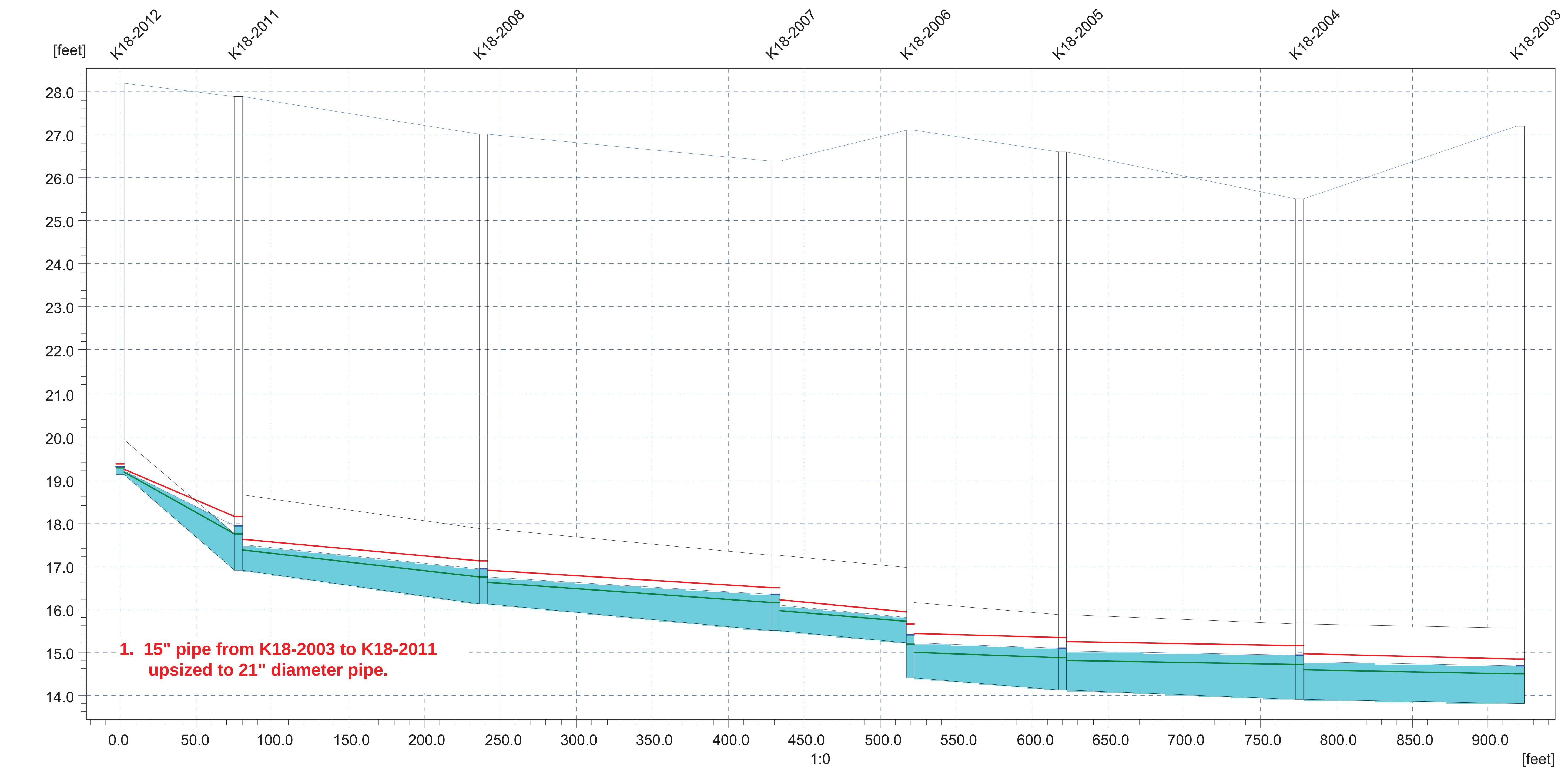
Length	354.90	308.82	237.47	79.77	410.98	93.30	466.87	260.95	412.68	[m]
Diameter	1.33	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo	9.50	4.21	4.21	5.01	2.92	5.36	3.64	3.07	2.18	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	0.084	2.578	2.587	2.594	2.608	2.612	2.621	cfs



	K18-2012	K18-2011	K18-2008	K18-2007	K18-2006	K18-2005	K18-2004	
Ground Lev.	28.20	27.90	27.00	26.40	27.10	26.60	25.50	[m]
Invert lev.	19.10	16.90	16.10	15.50	14.40	14.10	13.90	[m]

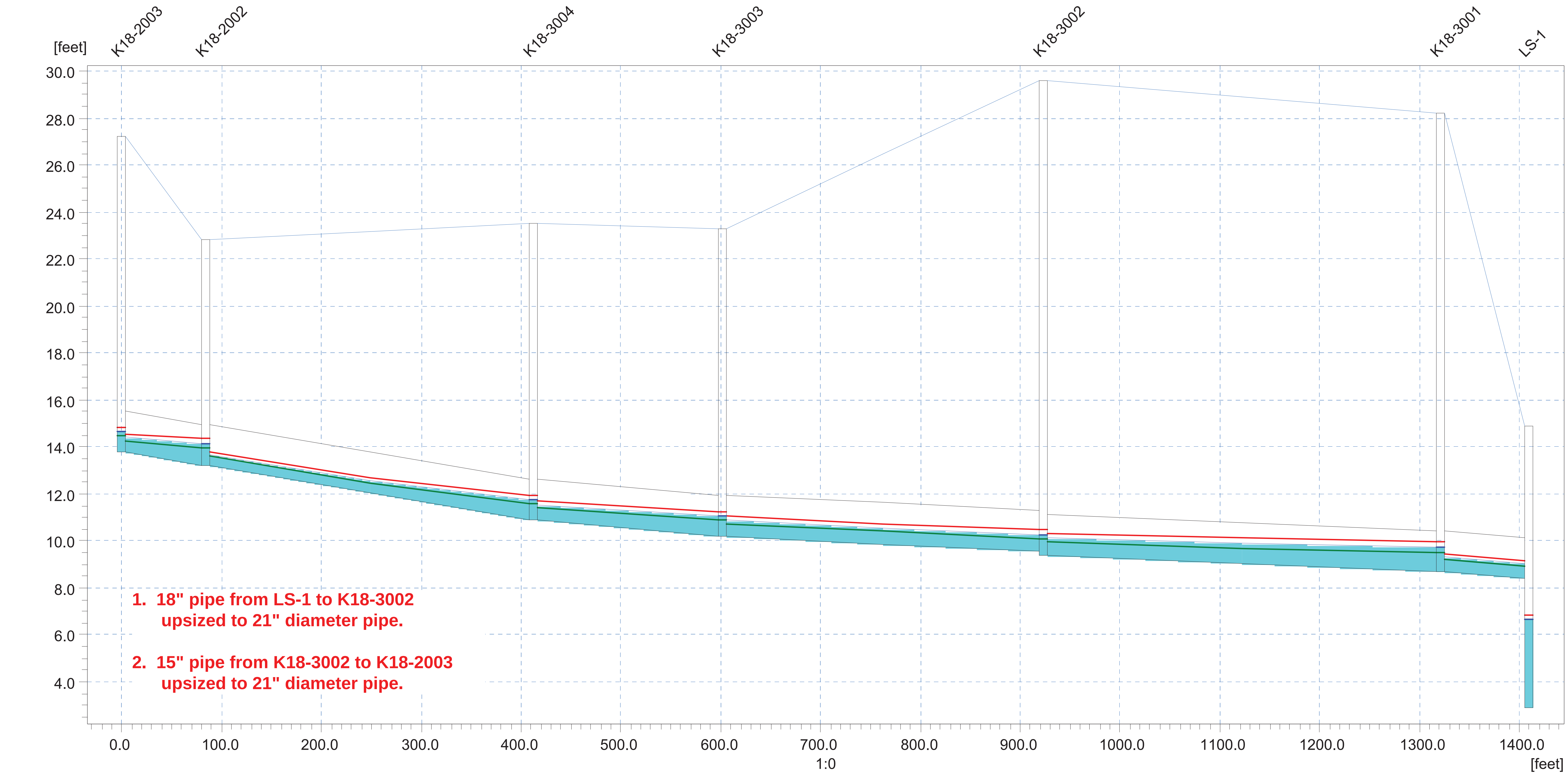
Length	77.24	161.51	192.79	88.51	99.48	155.83	145.33	[m]
Diameter	0.83	1.75	1.75	1.75	1.75	1.75	1.75	[m]
Slope o/oo	28.48	4.95	3.11	3.16	3.02	1.28	0.69	

MYHRE ROAD GRAVITY SEWERS

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge	2.625	2.636	2.649	2.724	2.738	3.079	cfs



	K18-2003	K18-2002	K18-3004	K18-3003	K18-3002	K18-3001	
Ground Lev.	27.20	22.80	23.50	23.30	29.60	28.20	[m]
Invert lev.	13.80	13.20	10.90	10.20	9.40	8.70	[m]

Length	84.43	328.17	189.13	320.91	398.08	88.17	[m]
Diameter	1.75	1.75	1.75	1.75	1.75	1.75	[m]
Slope o/oo	7.11	7.01	3.70	2.06	1.76	3.40	

FREDRICKSON ROAD SEWER UPGRADES

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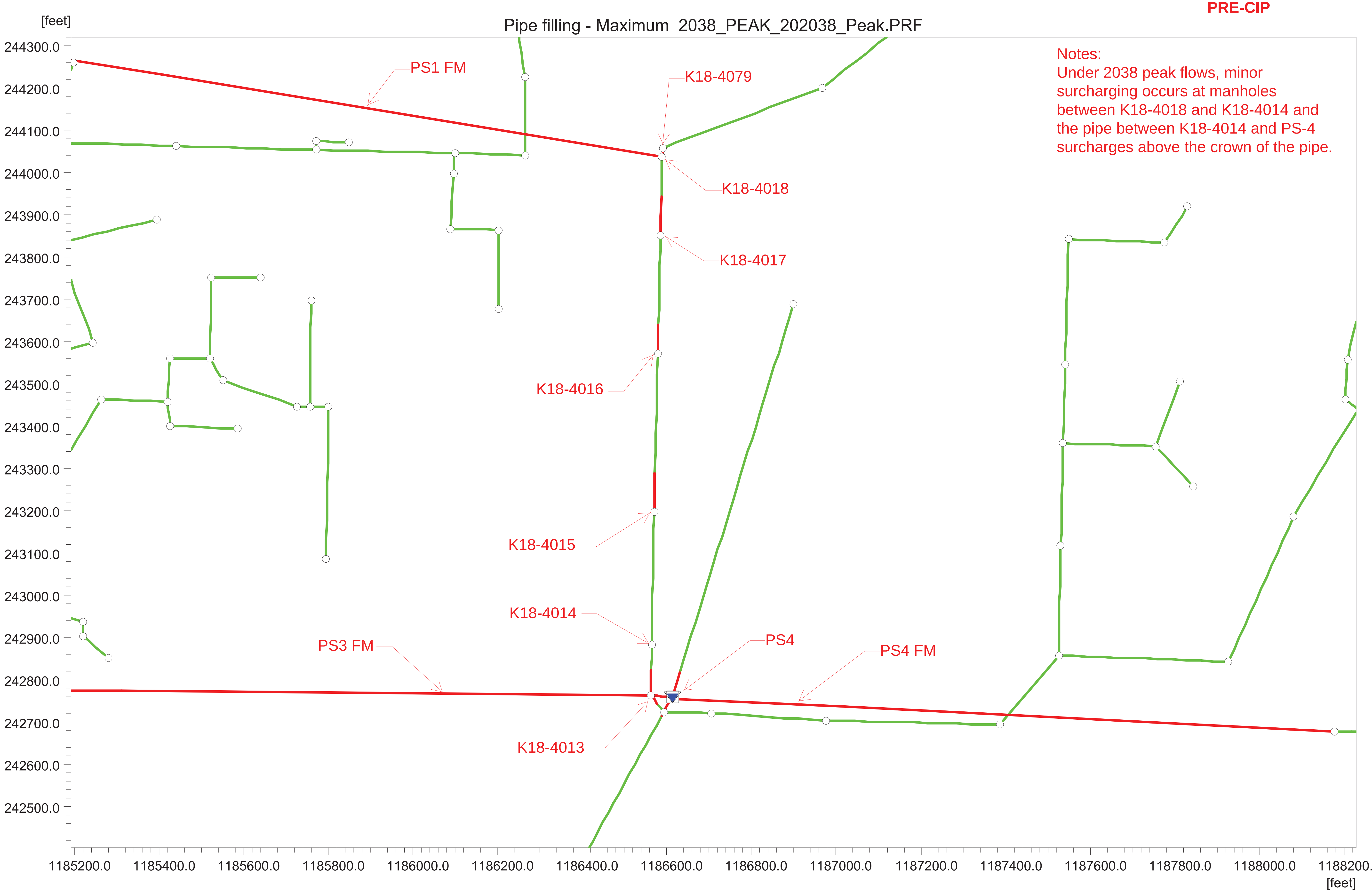
FREDRICKSON ROAD SEWER UPGRADES

2038 PEAK FLOWS
PRE-CIP

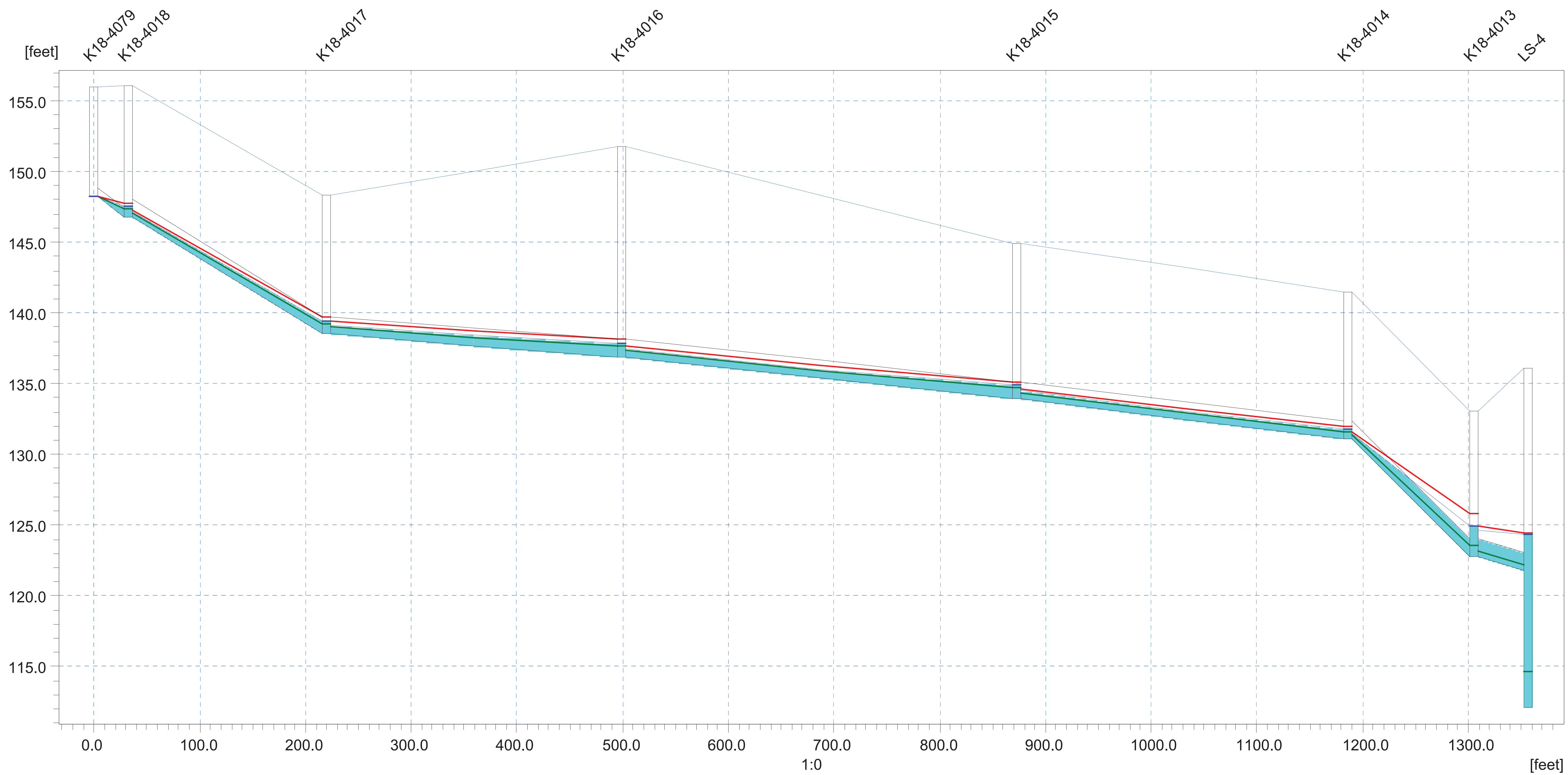
Pipe filling - Maximum 2038_PEAK_202038_Peak.PRF



FREDRICKSON ROAD SEWER UPGRADES

2038 PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF



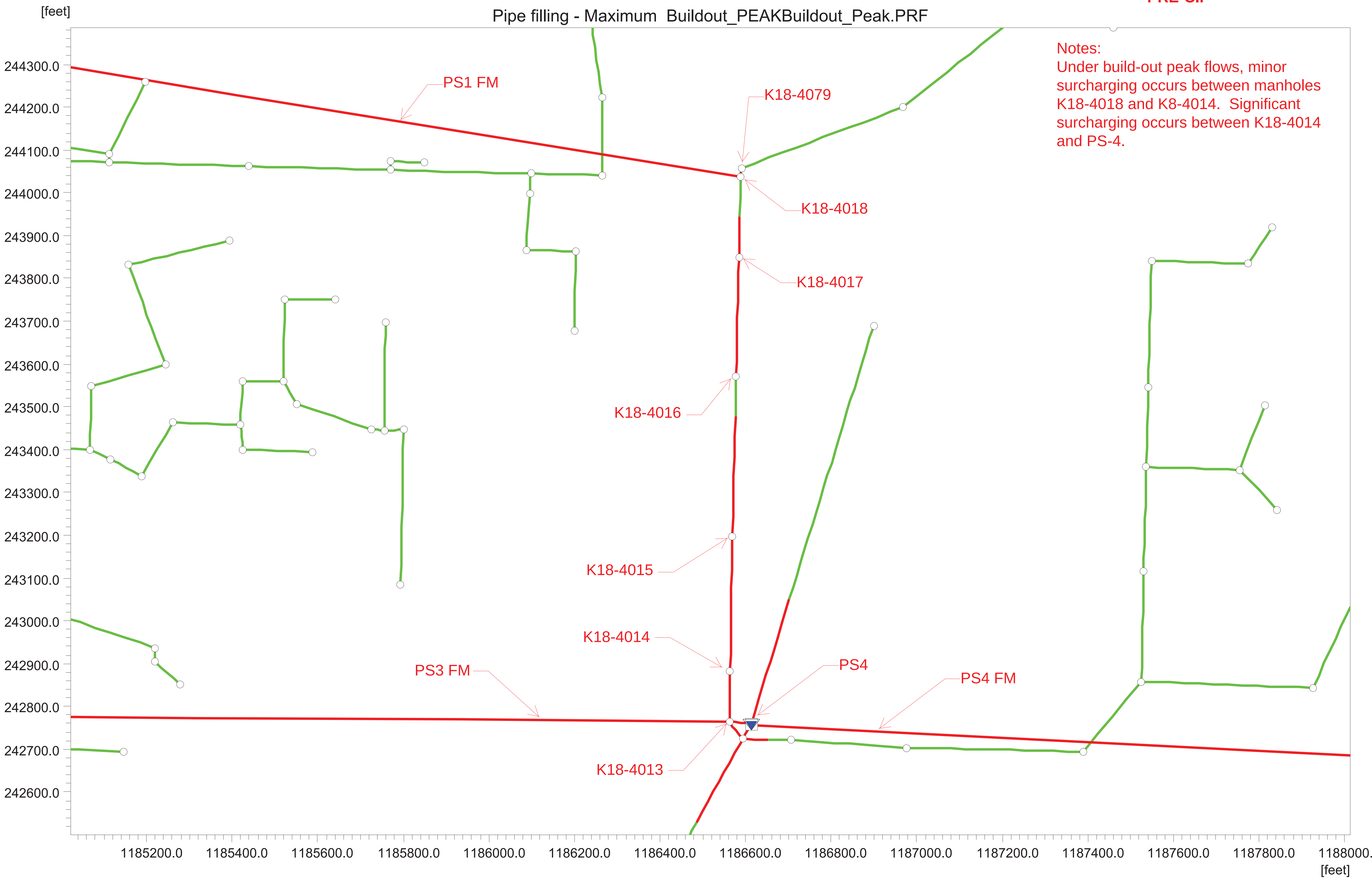
	K18-4079	K18-4018	K18-4017	K18-4016	K18-4015	K18-4014	K18-4013	LS-4	
Ground Lev.	156.00	156.10	148.30	151.80	144.90	141.50	133.10		[m]
Invert lev.	148.20	146.80	138.50	136.90	133.90	131.10	122.80		[m]

		K18-4018 – K18-4017	K18-4017 – K18-4016	K18-4016 – K18-4015	K18-4015 – K18-4014	K18-4014 – K18-4013	K18-4013 – LS-4	
Discharge		2.662	2.669	2.680	2.691	2.702	4.333	cfs
Length		186.58	280.01	373.90	312.94	118.87	50.85	[m]
Diameter		1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo		44.49	5.71	8.02	8.95	69.82	19.67	

FREDRICKSON ROAD SEWER UPGRADES

BUILDOUT PEAK FLOWS PRE-CIP

Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF

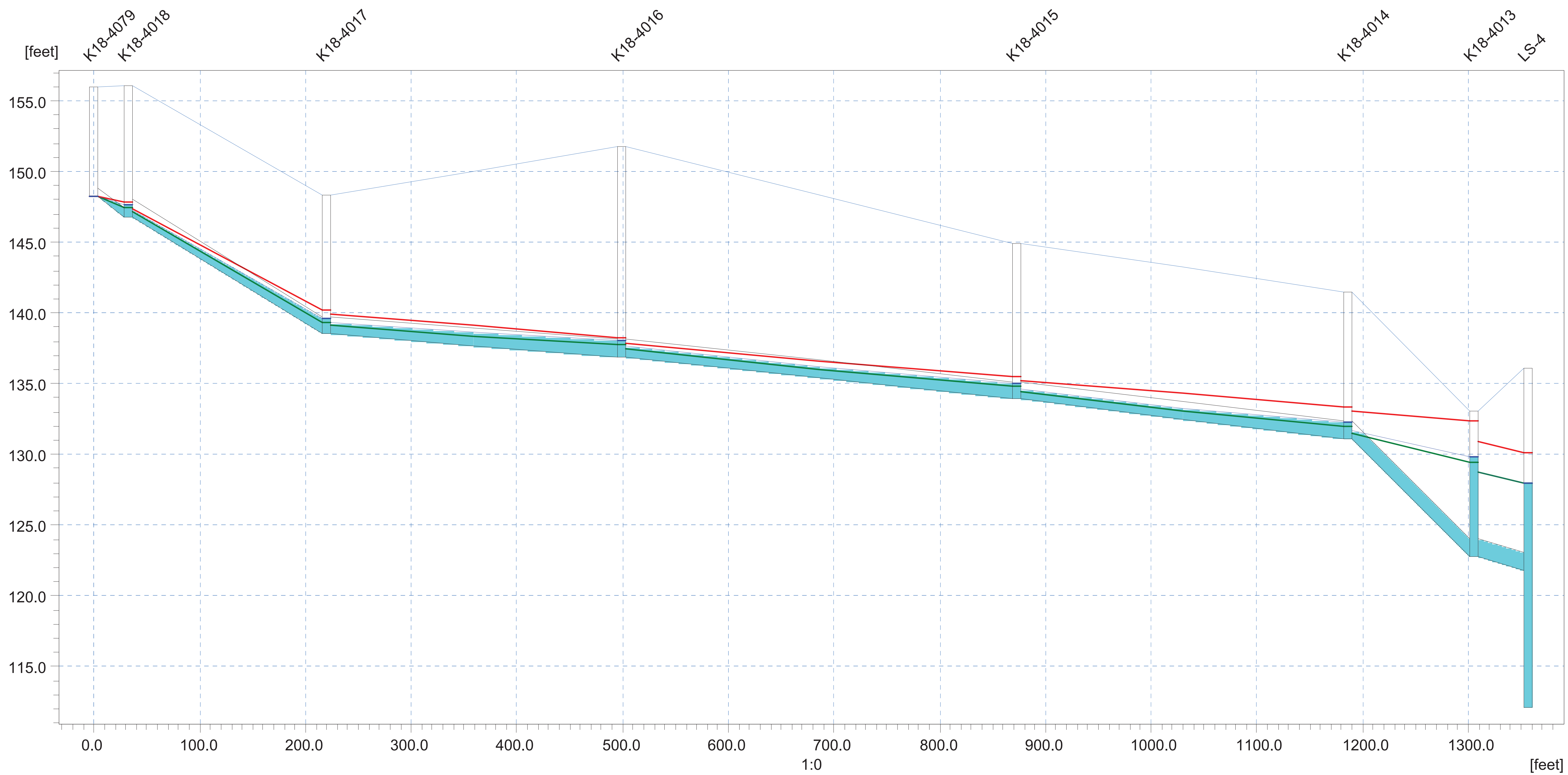


FREDRICKSON ROAD SEWER UPGRADES

BUILDOUT PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge		3.540	3.548	3.559	3.572	3.625	7.930	cfs



	K18-4079	K18-4018	K18-4017	K18-4016	K18-4015	K18-4014	K18-4013	
Ground Lev.	156.00	156.10	148.30	151.80	144.90	141.50	133.10	[m]
Invert lev.	148.20	146.80	138.50	136.90	133.90	131.10	122.80	[m]

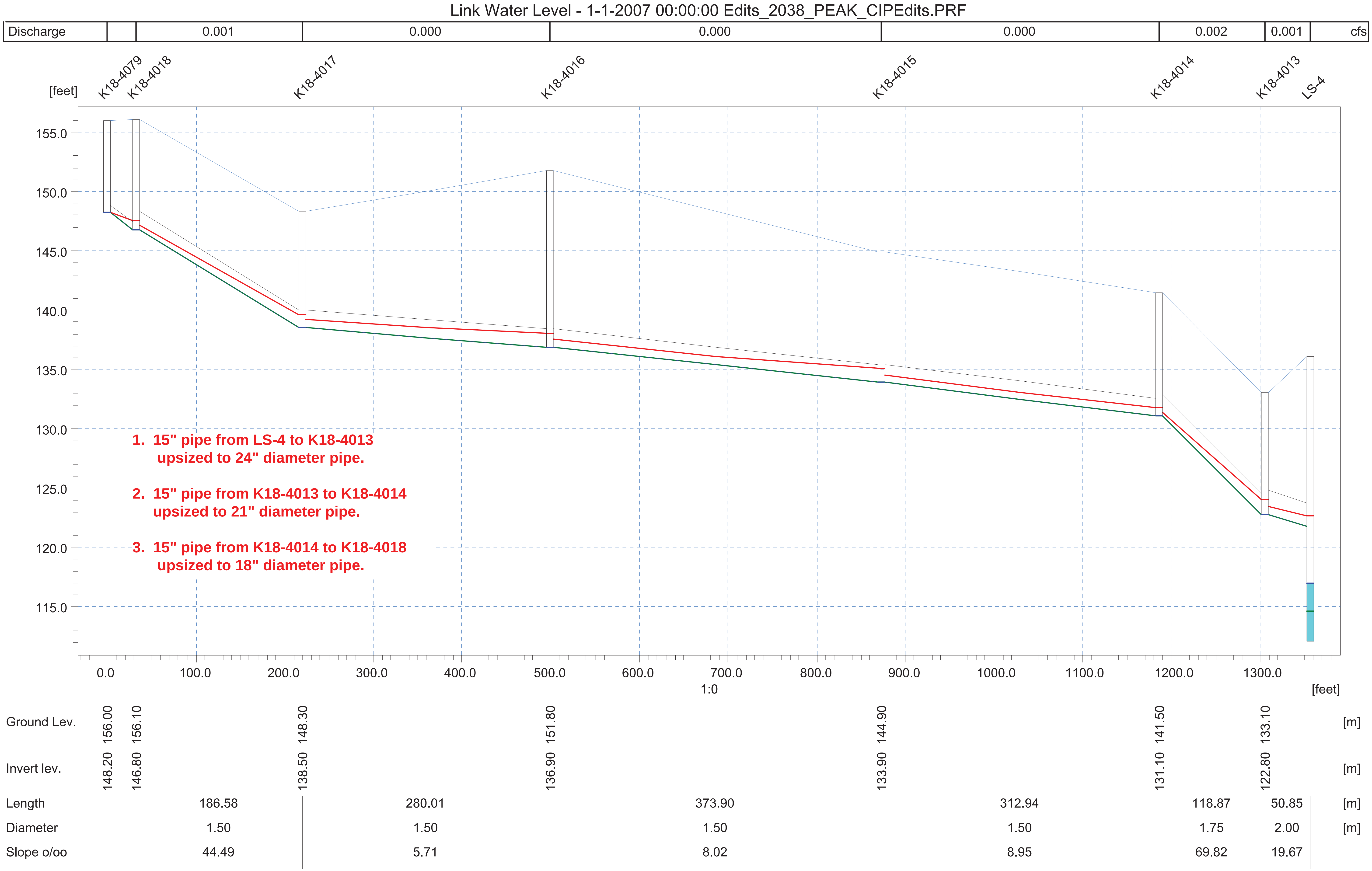
Length		186.58	280.01	373.90	312.94	118.87	50.85	[m]
Diameter		1.25	1.25	1.25	1.25	1.25	1.25	[m]
Slope o/oo		44.49	5.71	8.02	8.95	69.82	19.67	

FREDRICKSON ROAD SEWER UPGRADES

2038 PEAK FLOWS
POST CIP

FREDRICKSON ROAD SEWER UPGRADES

2038 PEAK FLOW CONDITIONS
POST CIP



FREDRICKSON ROAD SEWER UPGRADES

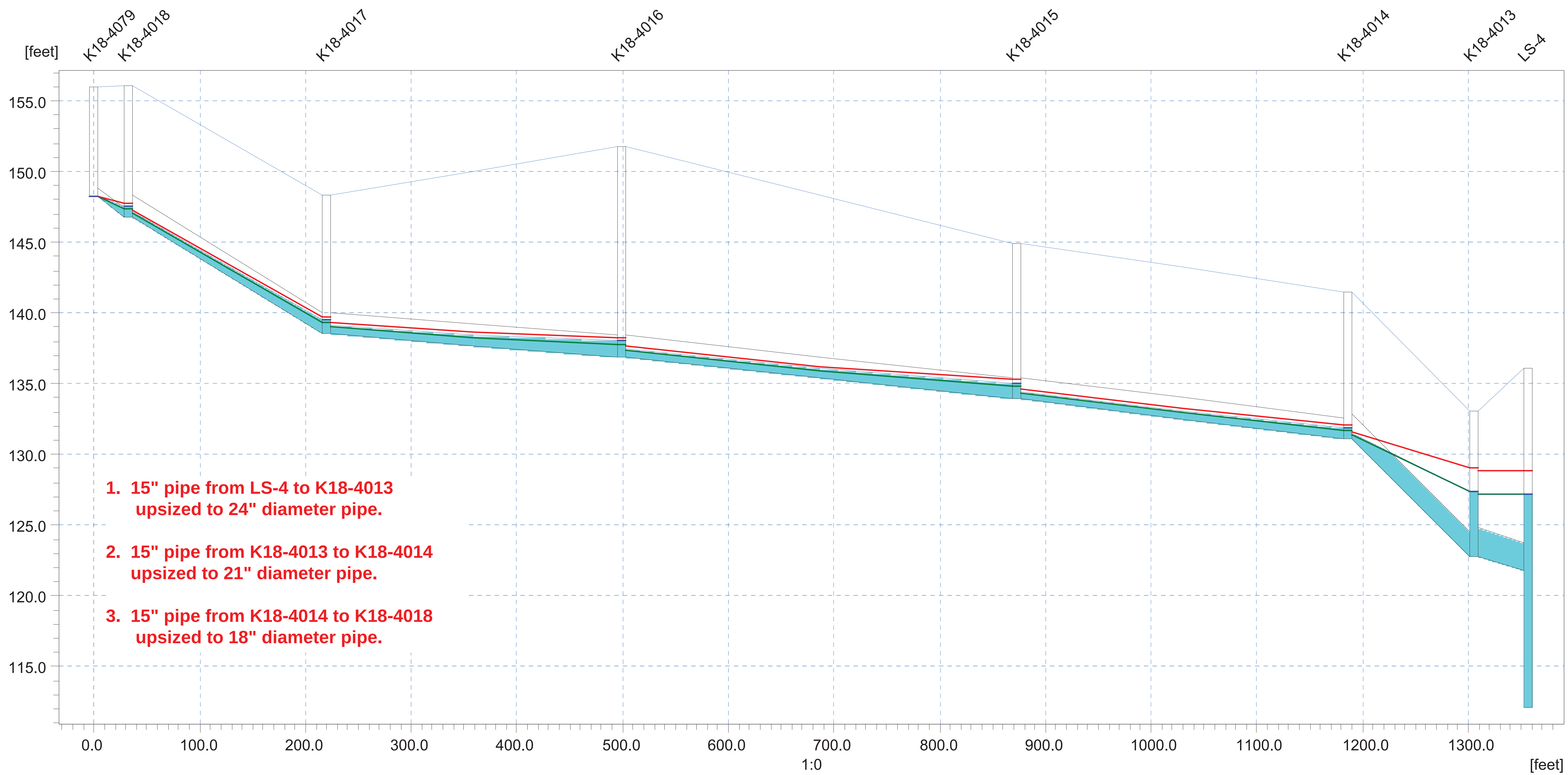
BUILDOUT PEAK FLOWS
POST CIP

FREDRICKSON ROAD SEWER UPGRADES

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

Discharge		3.530	3.538	3.549	3.563	3.569	8.030	cfs



Ground Lev.	156.00	156.10	148.30	151.80	144.90	141.50	133.10	[m]
Invert lev.	148.20	146.80	138.50	136.90	133.90	131.10	122.80	[m]

Length	186.58	280.01	373.90	312.94	118.87	50.85	[m]
Diameter	1.50	1.50	1.50	1.50	1.75	2.00	[m]
Slope o/oo	44.49	5.71	8.02	8.95	69.82	19.67	

LEMOLO PENINSULA SEWER AND INVERTED SIPHON UPGRADES

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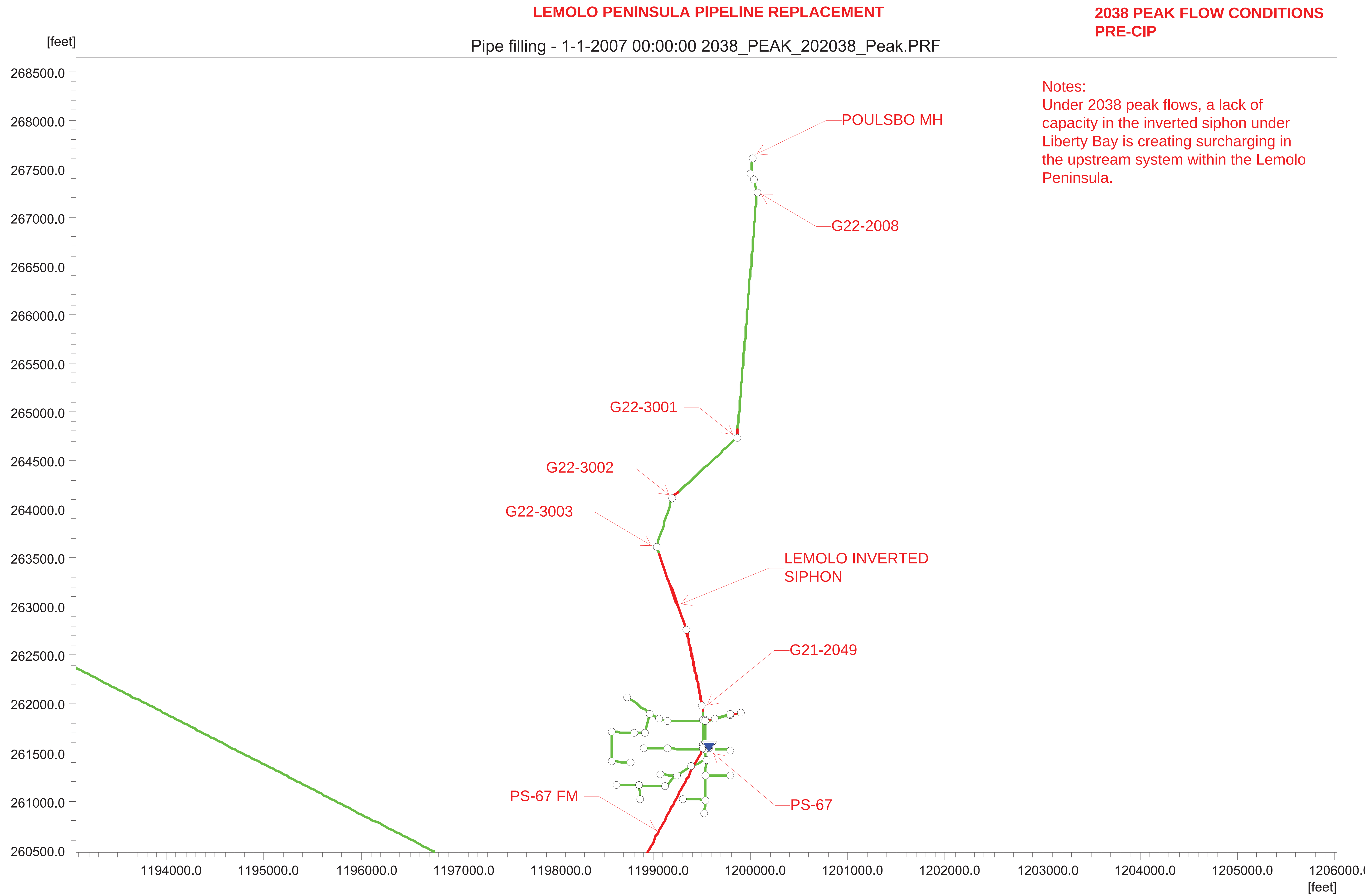


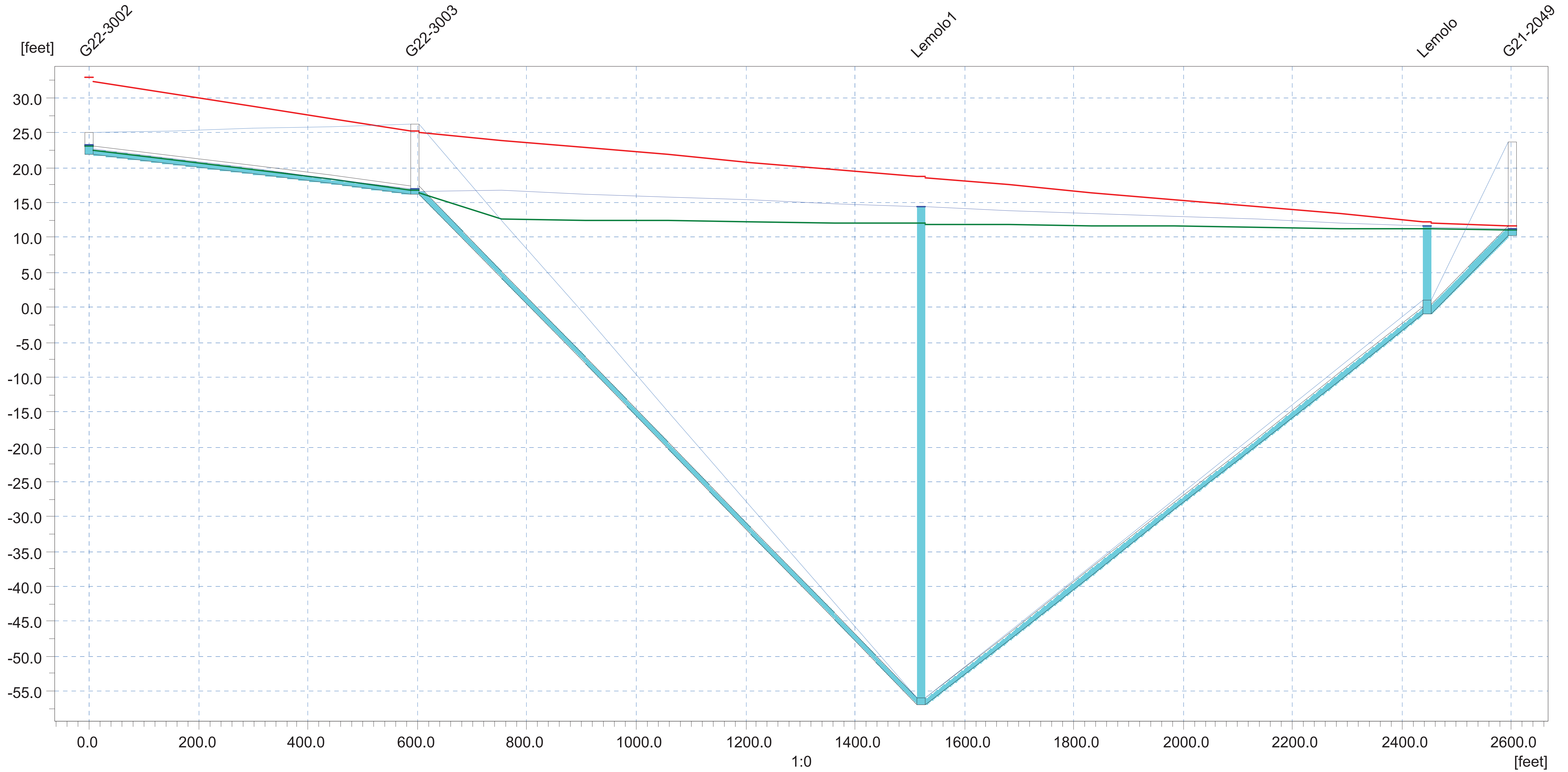
LEMOLO PENINSULA PIPELINE REPLACEMENT
2038 PEAK FLOW CONDITIONS
PRE-CIP
Pipe filling - 1-1-2007 00:00:00 2038_PEAK_202038_Peak.PRF
[feet]
268500.0
268000.0
267500.0
267000.0
266500.0
266000.0
265500.0
265000.0
264500.0
264000.0
263500.0
263000.0
262500.0
262000.0
261500.0
261000.0
260500.0
1194000.0
1195000.0
1196000.0
1197000.0
1198000.0
1199000.0
1200000.0
1201000.0
1202000.0
1203000.0
1204000.0
1205000.0
1206000.0
[feet]
Notes:
Under 2038 peak flows, a lack of capacity in the inverted siphon under Liberty Bay is creating surcharging in the upstream system within the Lemolo Peninsula.
POULSBO MH
G22-2008
G22-3001
G22-3002
G22-3003
LEMOLO INVERTED SIPHON
G21-2049
PS-67 FM
PS-67

LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	3.760	1.934	1.939	3.879	cfs



	G22-3002	G22-3003	Lemolo1	Lemolo	
Ground Lev.	25.00	26.20	-56.00	1.00	[m]
Invert lev.	22.00	16.30	-57.00	-1.00	[m]

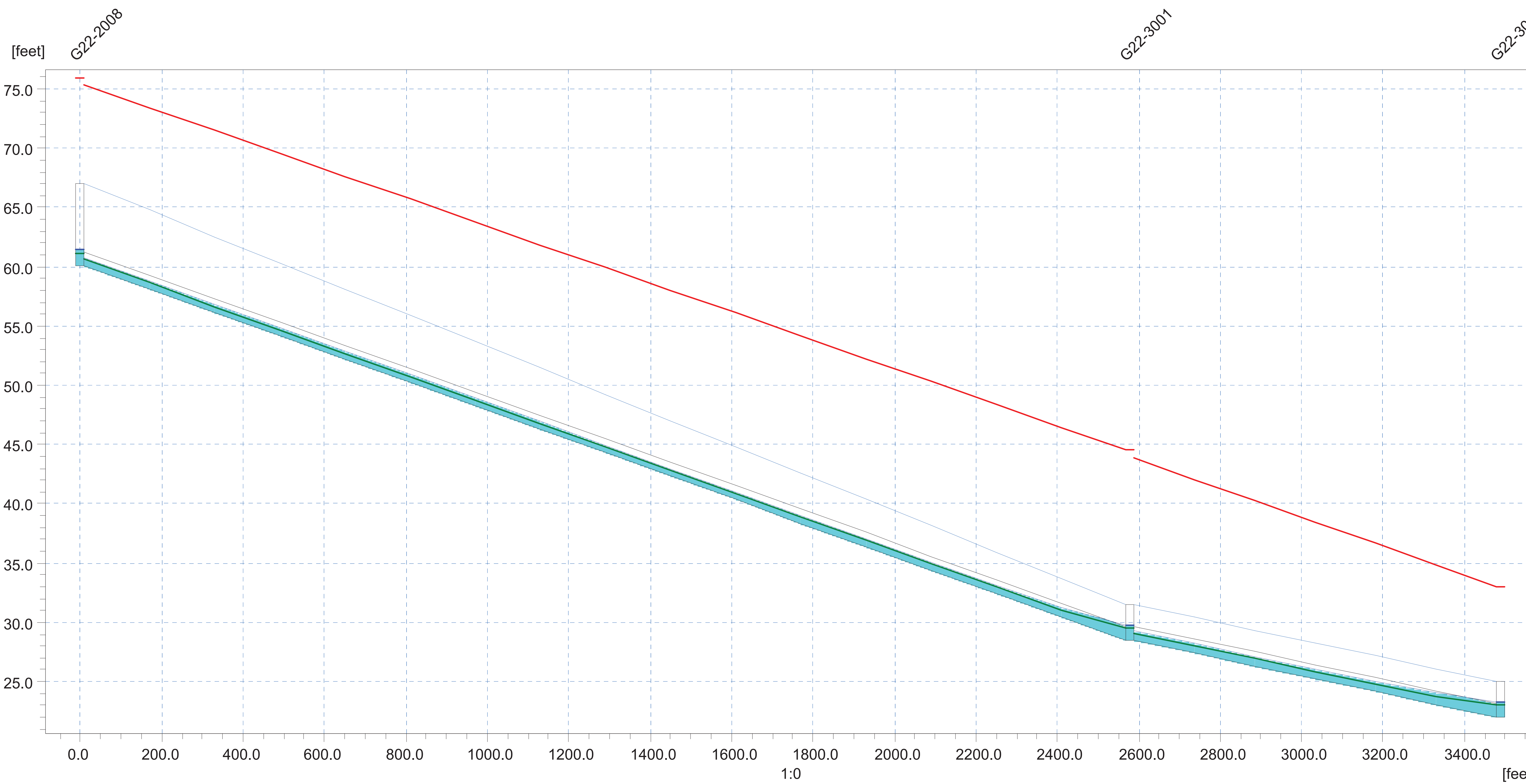
Length	595.15	926.00	926.00	154.00	[m]
Diameter	1.17	1.00	1.00	1.50	[m]
Slope o/oo	9.58	79.16	60.48	72.73	

LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

Discharge	3.708	3.740	cfs



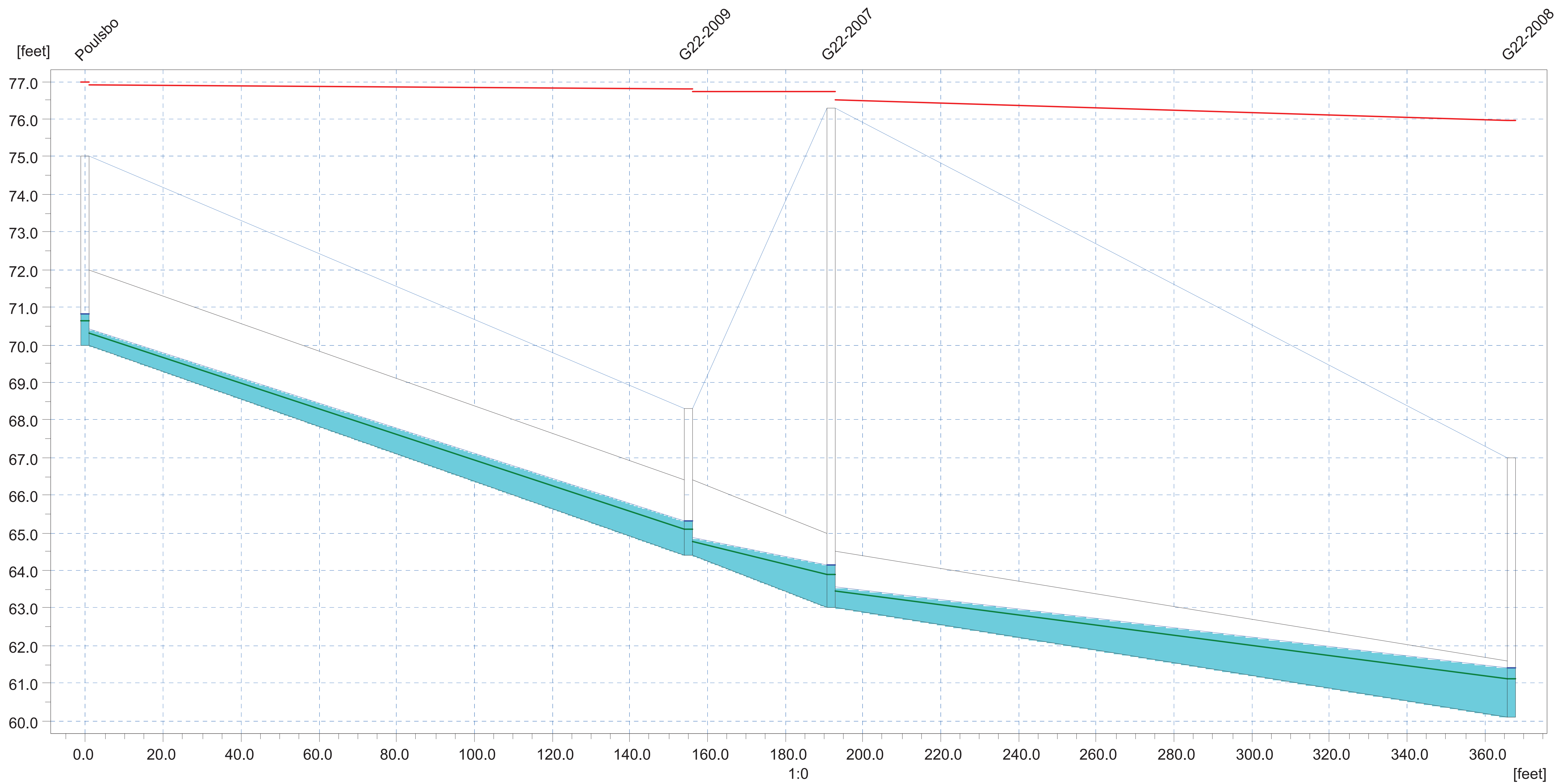
	G22-2008		G22-3001		
Ground Lev.	67.00		31.50		[m]
Invert lev.	60.10		28.50		[m]
Length		2579.70		907.49	[m]
Diameter		1.17		1.17	[m]
Slope o/oo		12.25		7.16	

LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

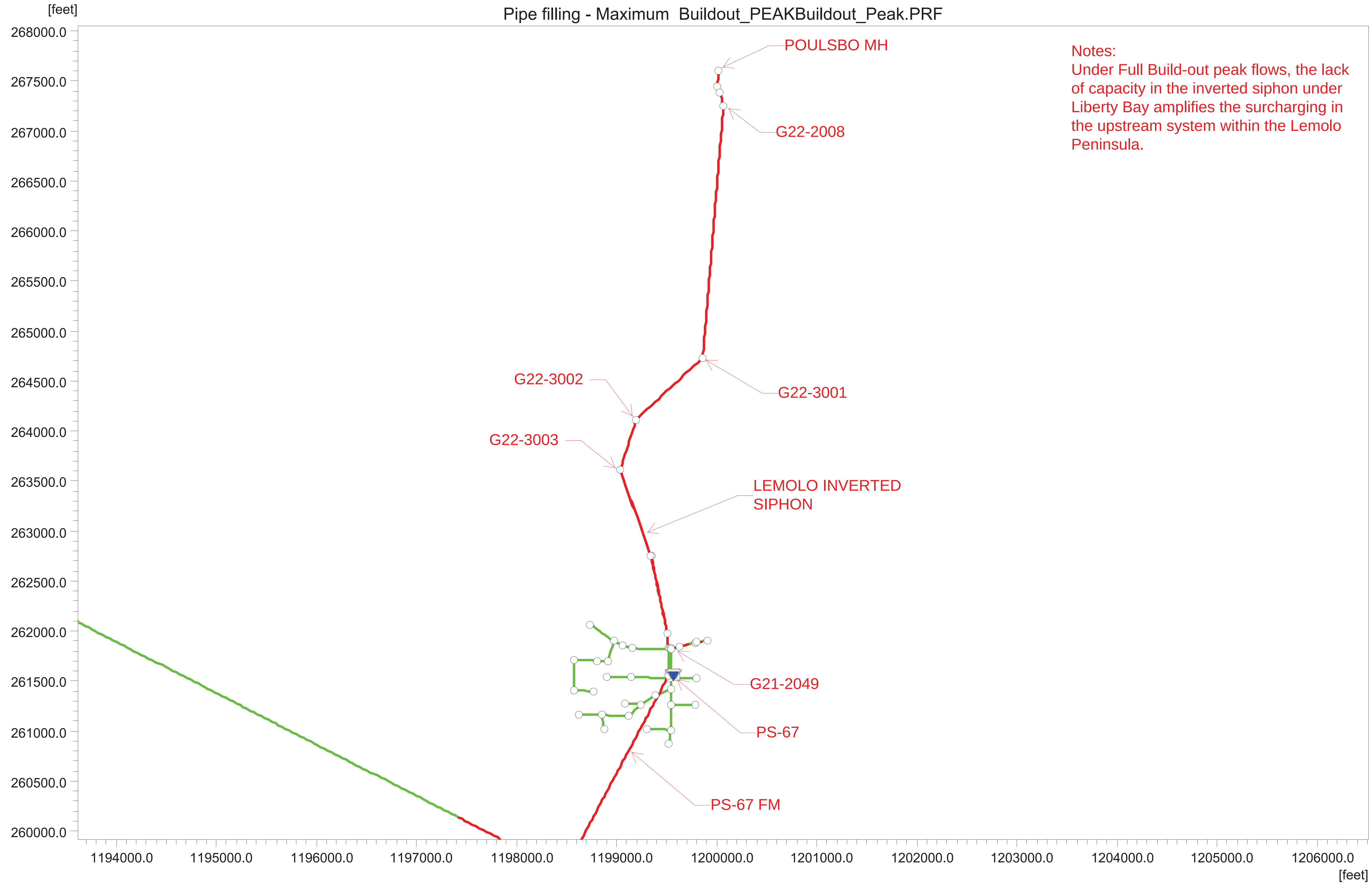
Discharge	3.697	3.701	3.703	cfs



	Poulsbo		G22-2009		G22-2007		
Ground Lev.	75.00		68.30		76.30		[m]
Invert lev.	70.00		64.40		63.00		[m]
Length		155.00		36.62		175.00	[m]
Diameter		2.00		2.00		1.50	[m]
Slope o/oo		36.13		38.23		16.57	

LEMOLO PENINSULA PIPELINE REPLACEMENT

Pipe filling - Maximum Buildout_PEAKBuildout_Peak.PRF

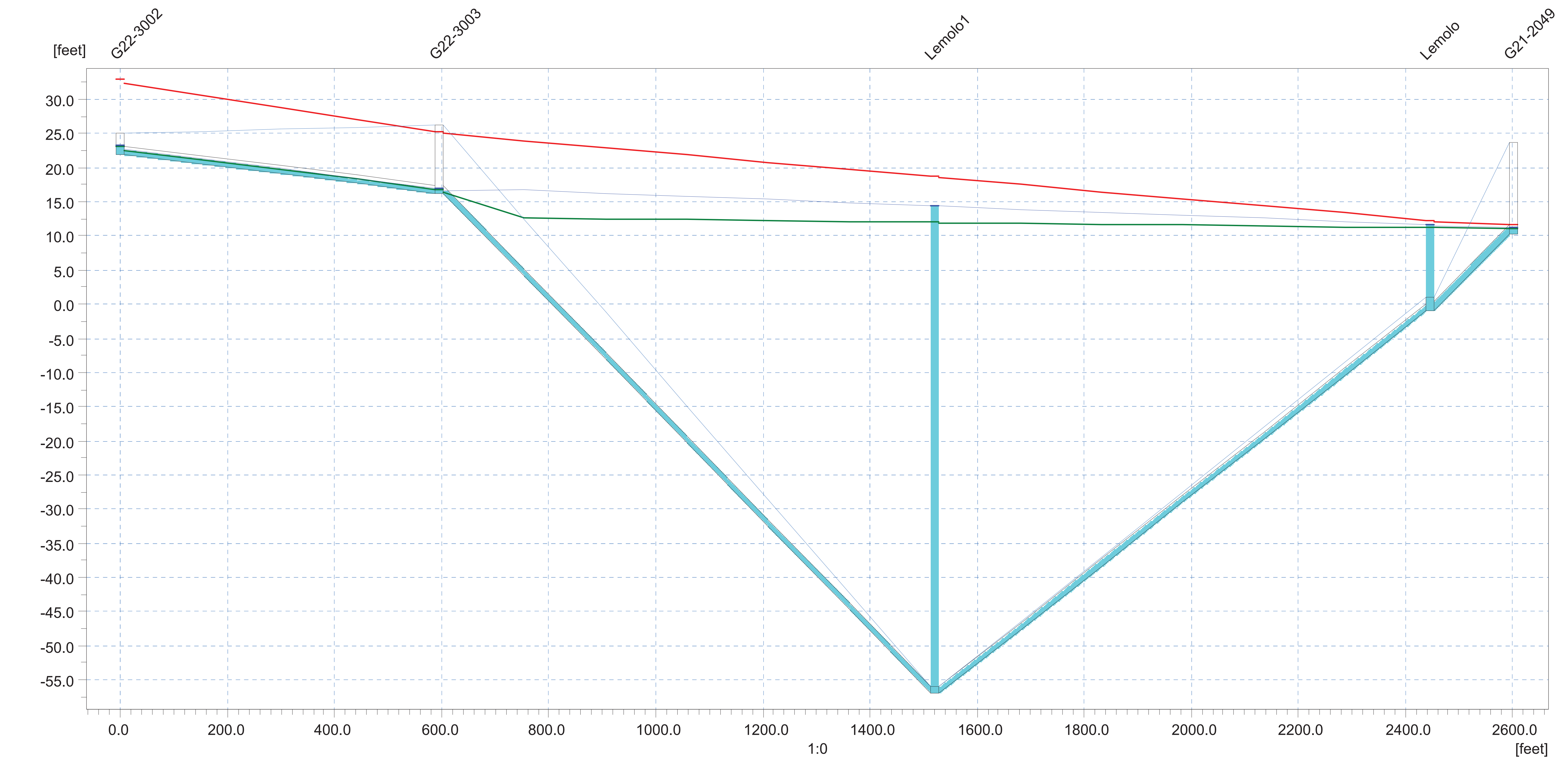


LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	3.760	1.934	1.939	3.879	cfs

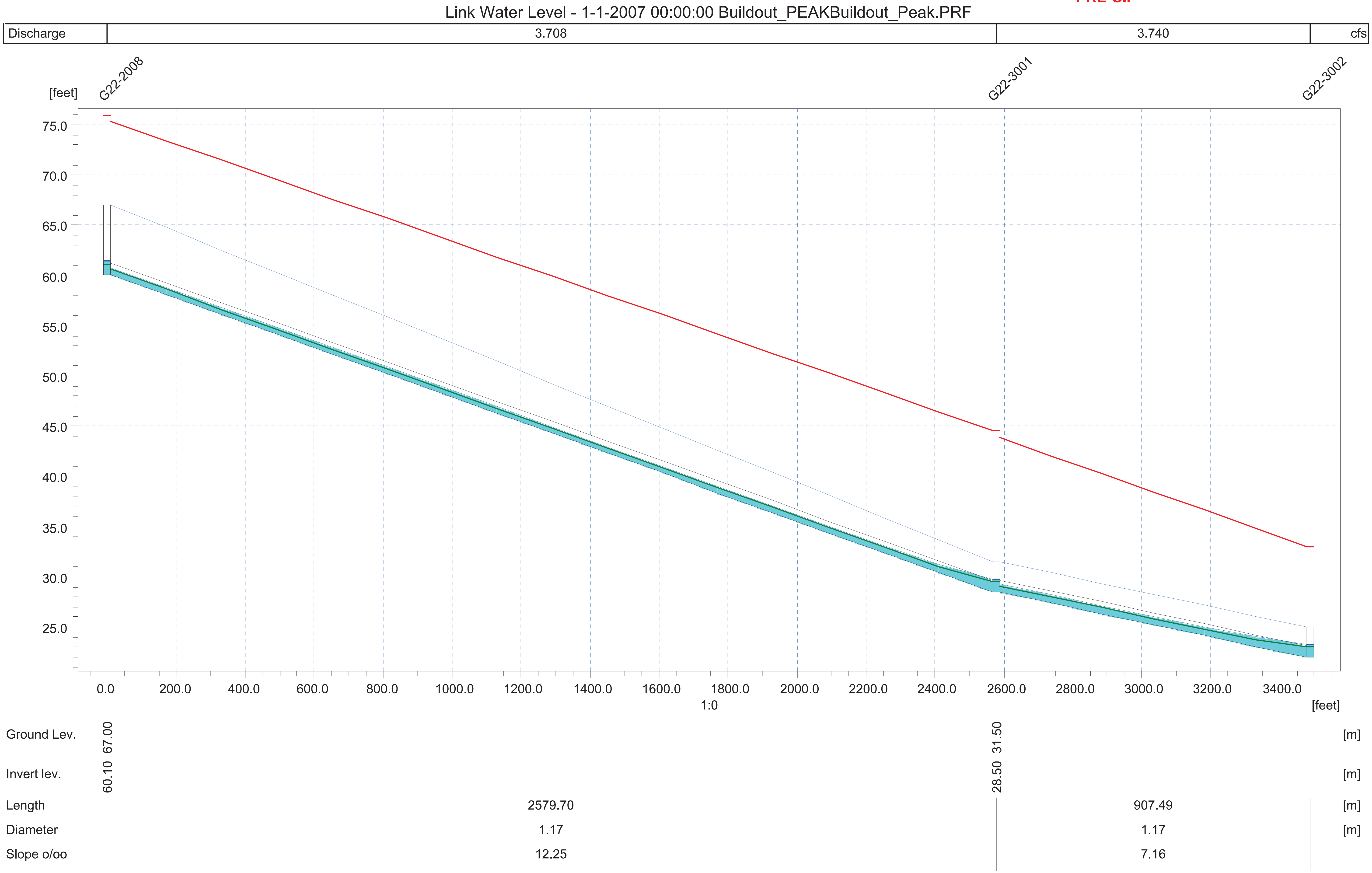


	G22-3002	G22-3003	Lemolo1	Lemolo	
Ground Lev.	25.00	26.20	-56.00	1.00	[m]
Invert lev.	22.00	16.30	-57.00	-1.00	[m]

Length	595.15	926.00	926.00	154.00	[m]
Diameter	1.17	1.00	1.00	1.50	[m]
Slope o/oo	9.58	79.16	60.48	72.73	

LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

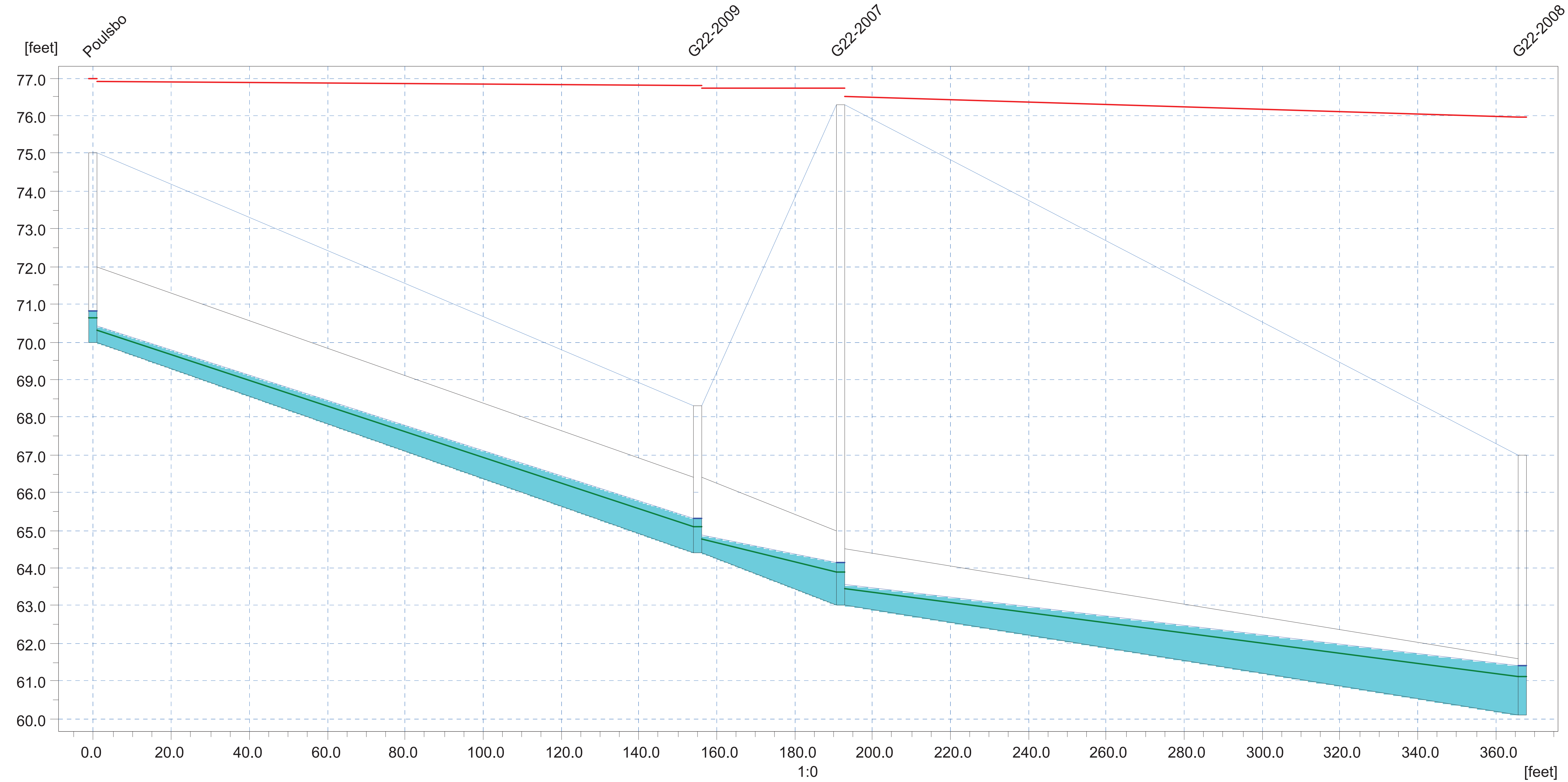


LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
PRE-CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	3.697	3.701	3.703	cfs

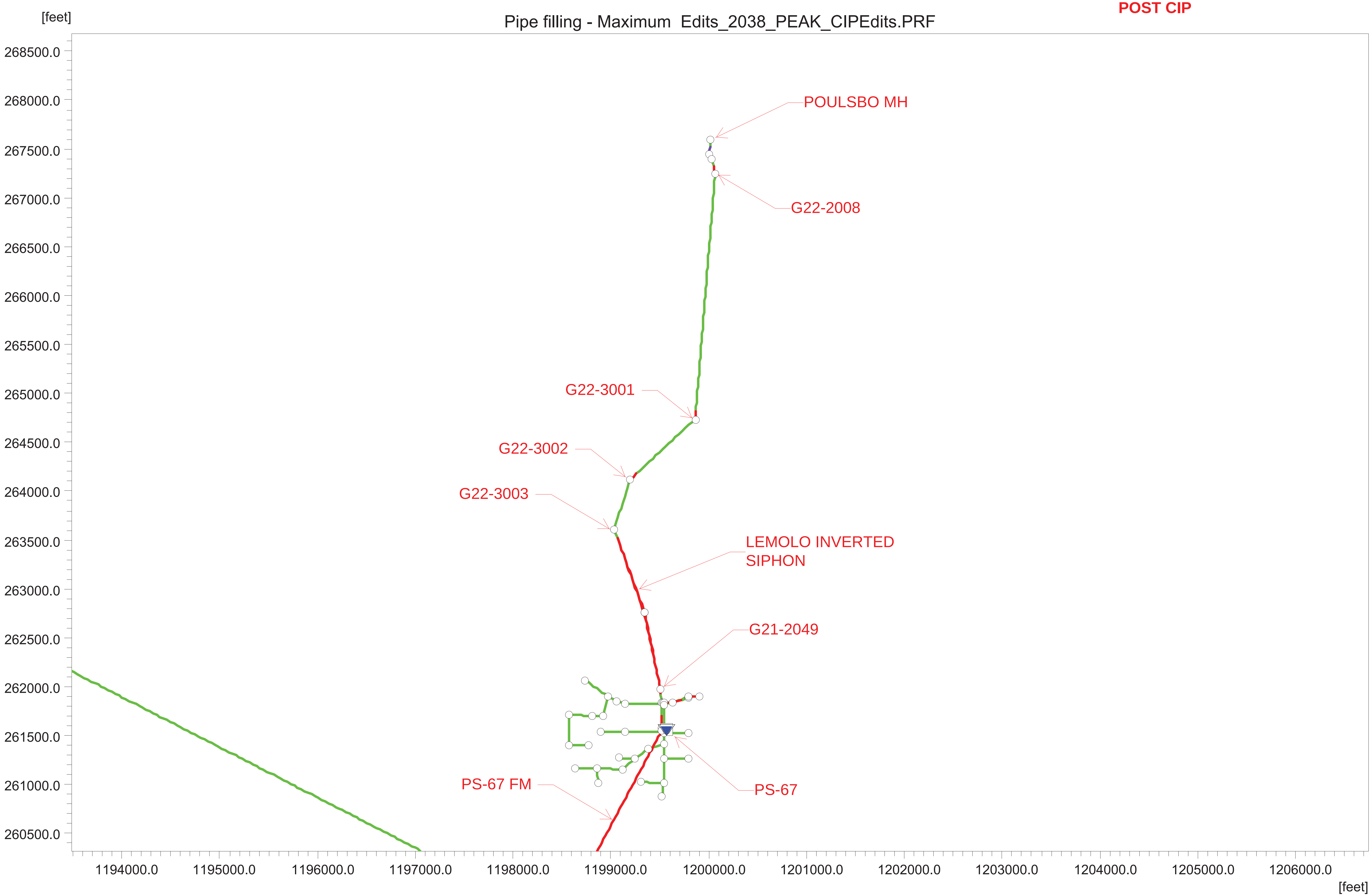


Ground Lev.	75.00	68.30	76.30	[m]
Invert lev.	70.00	64.40	63.00	[m]
Length	155.00	36.62	175.00	[m]
Diameter	2.00	2.00	1.50	[m]
Slope o/oo	36.13	38.23	16.57	

LEMOLO PENINSULA PIPELINE REPLACEMENT

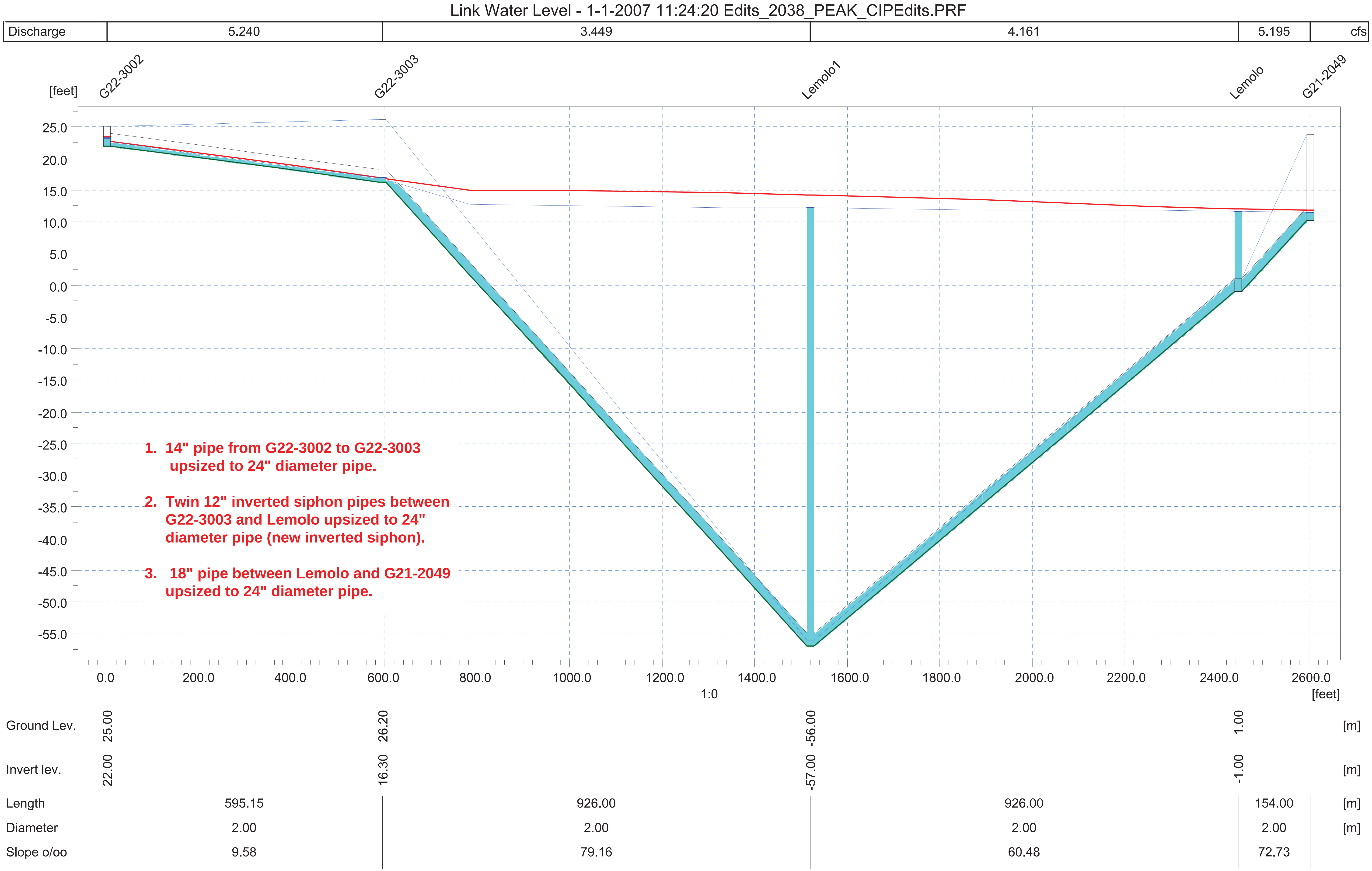
2038 PEAK FLOW CONDITIONS POST CIP

Pipe filling - Maximum Edits_2038_PEAK_CIPEdits.PRF



LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
POST CIP

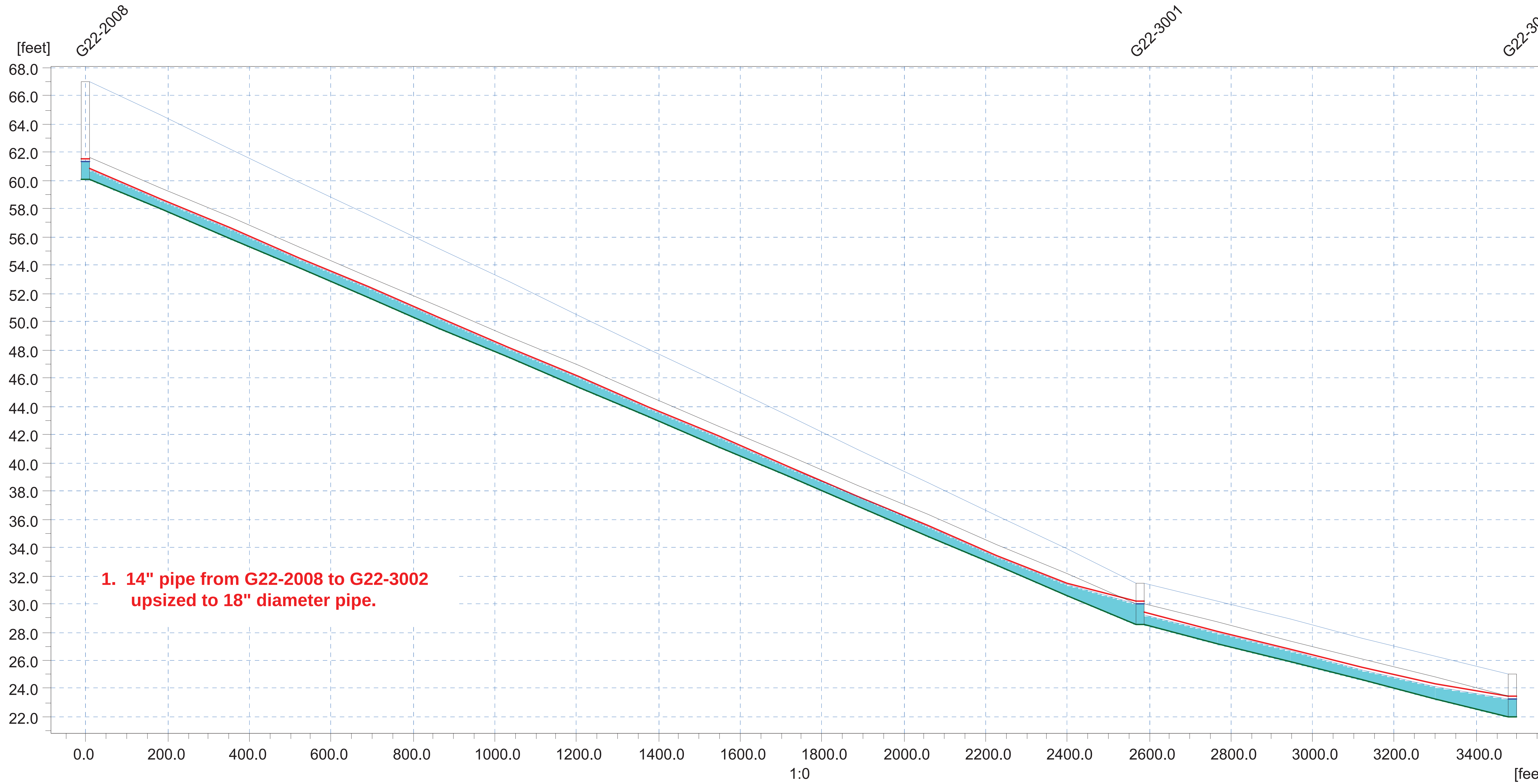


LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 11:25:00 Edits_2038_PEAK_CIPEdits.PRF

Discharge	5.229	5.236	cfs



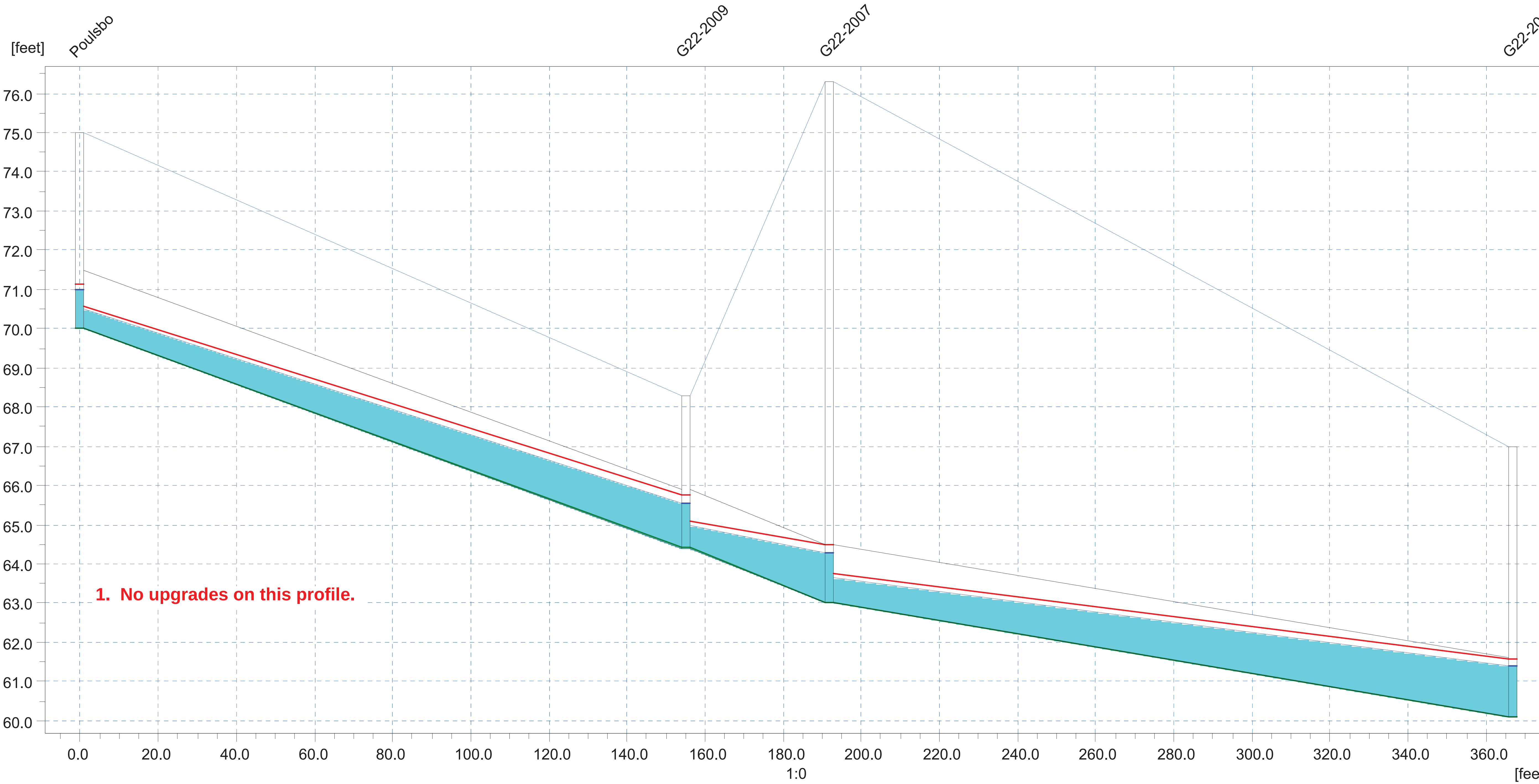
	G22-2008		G22-3001		
Ground Lev.	67.00		31.50		[m]
Invert lev.	60.10		28.50		[m]
Length		2579.70		907.49	[m]
Diameter		1.50		1.50	[m]
Slope o/oo		12.25		7.16	

LEMOLO PENINSULA PIPELINE REPLACEMENT

2038 PEAK FLOW CONDITIONS
Post CIP

Link Water Level - 1-1-2007 11:26:00 Edits_2038_PEAK_CIPEdits.PRF

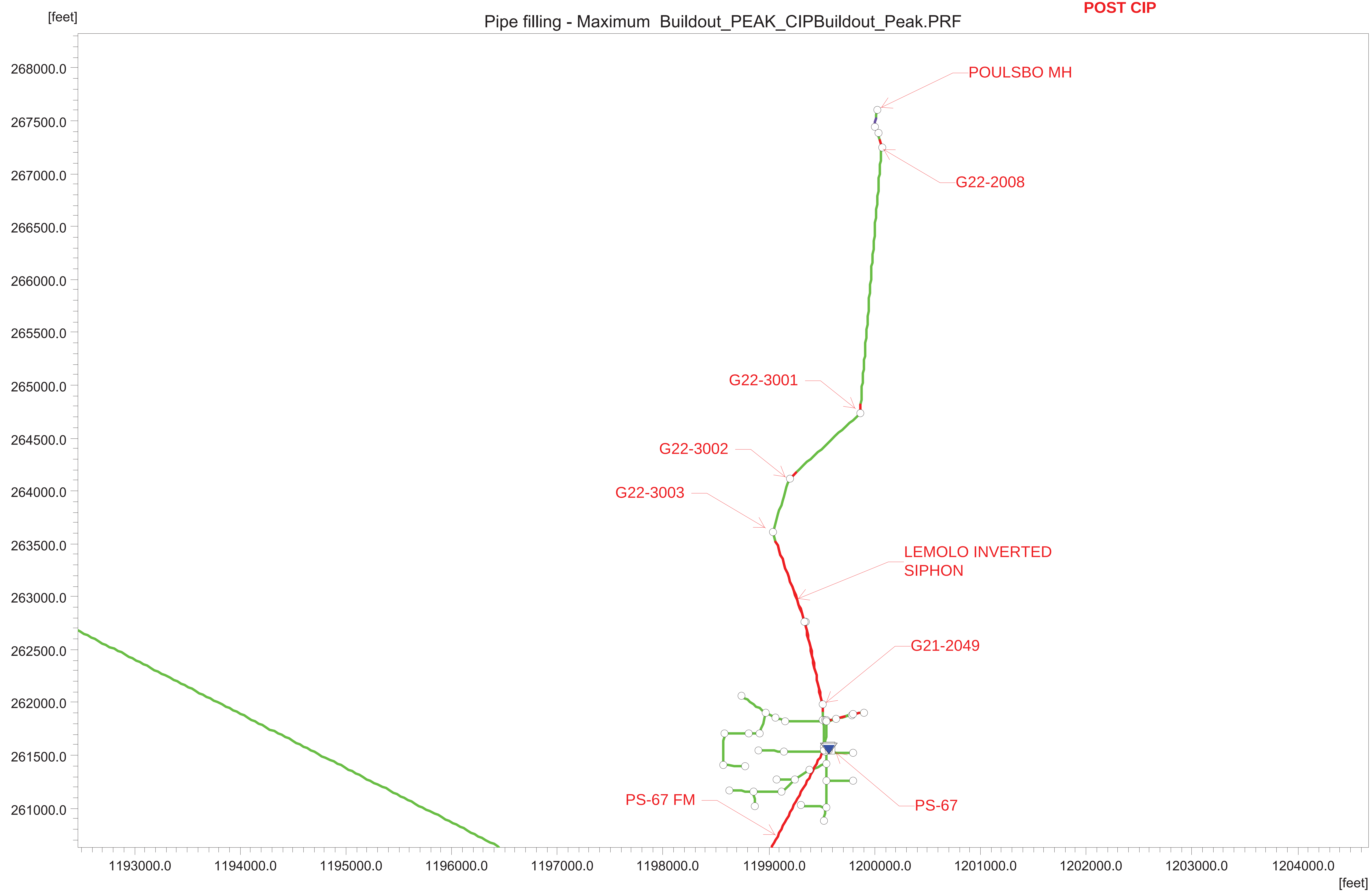
Discharge	5.222	5.223	5.224	cfs



	Poulsbo		G22-2009		G22-2007		G22-2008	
Ground Lev.	75.00		68.30		76.30			[m]
Invert lev.	70.00		64.40		63.00			[m]
Length		155.00		36.62		175.00		[m]
Diameter		1.50		1.50		1.50		[m]
Slope o/oo		36.13		38.23		16.57		

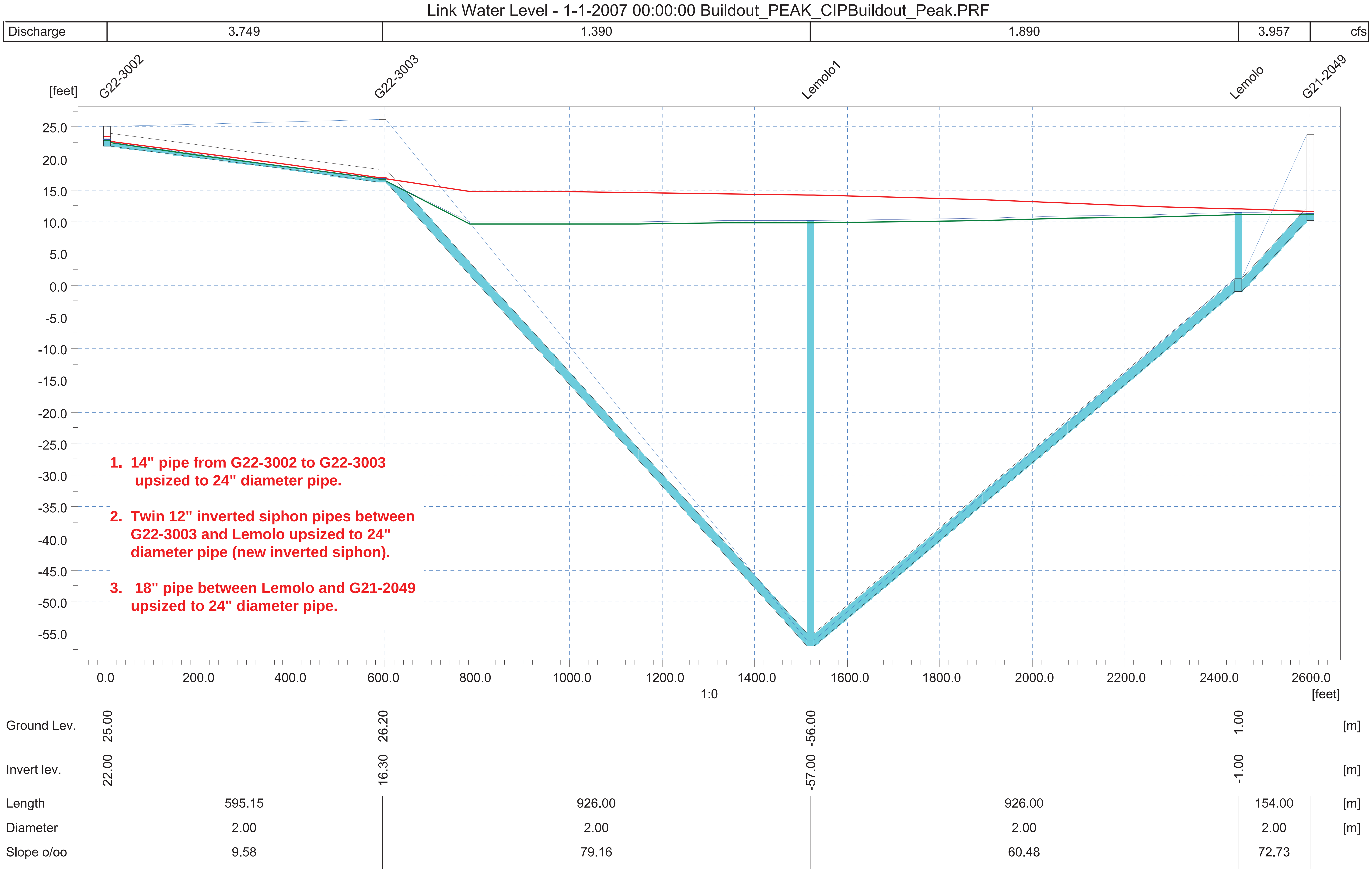
LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
POST CIP



LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

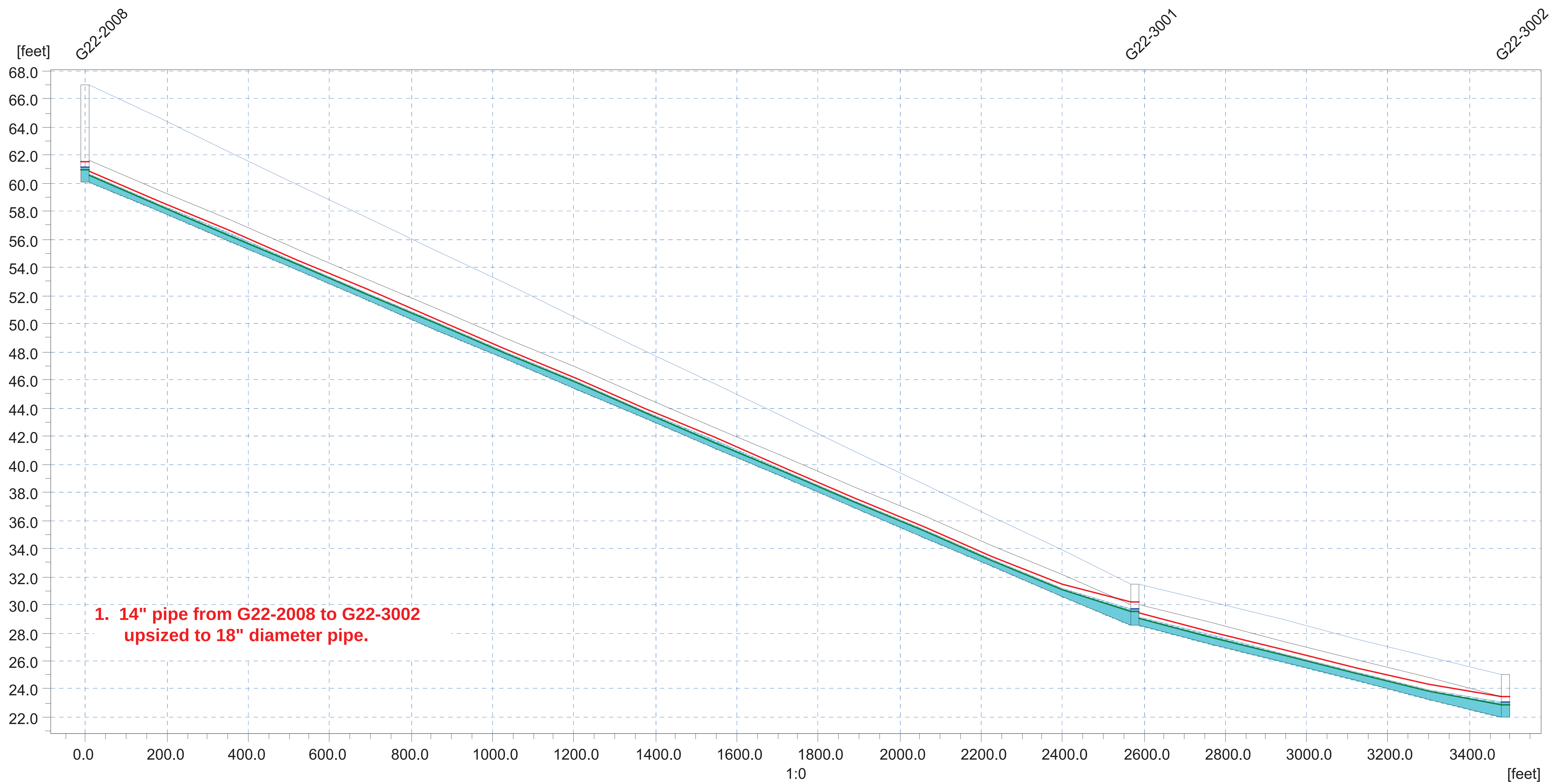


LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAK_CIPBuildout_Peak.PRF

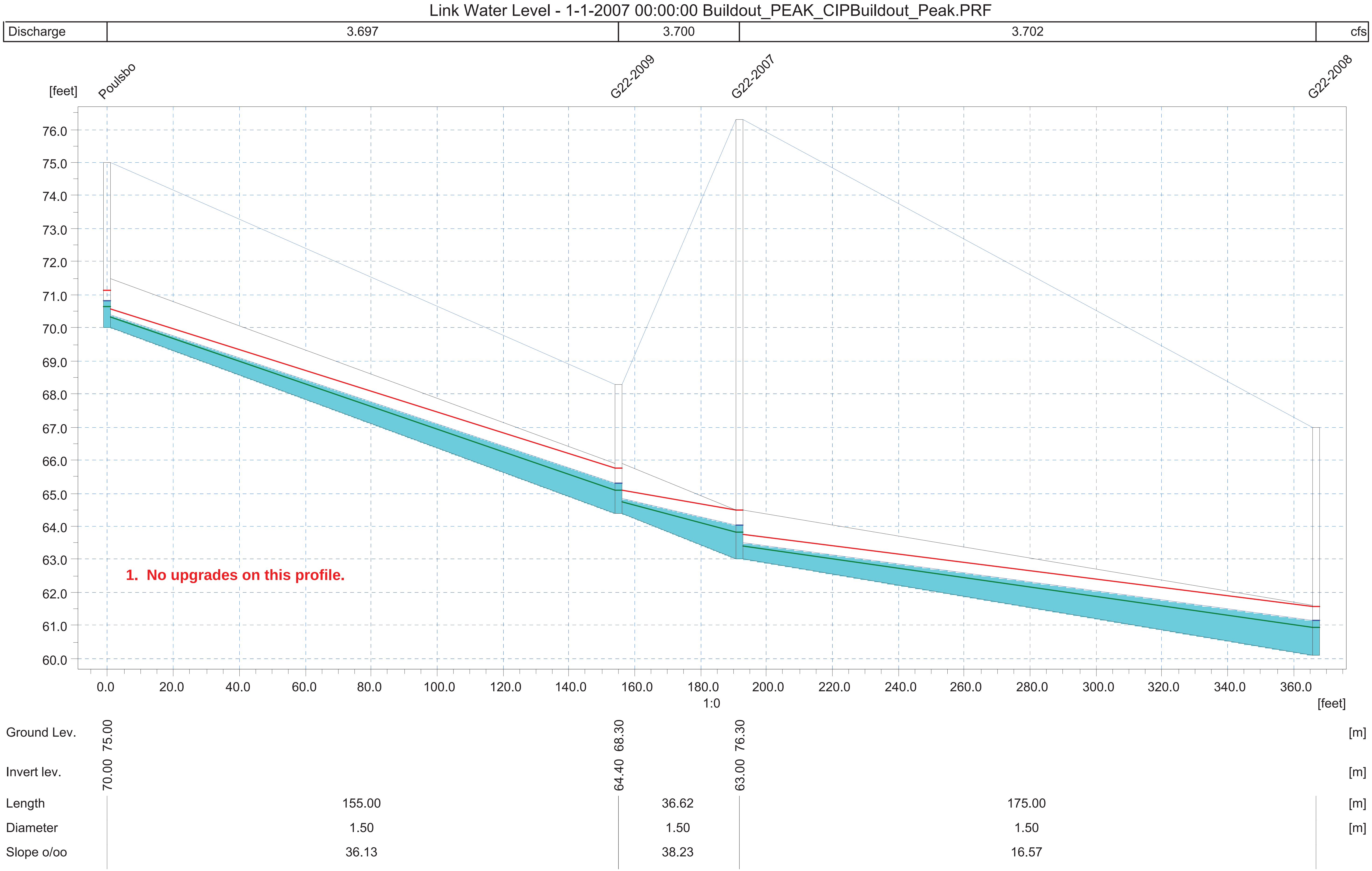
Discharge	3.706	3.735	cfs



	G22-2008		G22-3001		
Ground Lev.	67.00		31.50		[m]
Invert lev.	60.10		28.50		[m]
Length		2579.70		907.49	[m]
Diameter		1.50		1.50	[m]
Slope o/oo		12.25		7.16	

LEMOLO PENINSULA PIPELINE REPLACEMENT

BUILDOUT PEAK FLOW CONDITIONS
POST CIP



APPENDIX C

GEOTECHNICAL ENGINEERING ASSESSMENTS

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PUMP STATION 3
GEOTECHNICAL ASSESSMENT

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Preliminary Site Assessment

TO: Tony Fisher, PE, PMP

FROM: Amy Power, EIT, and Calvin McCaughan, PE

DATE: April 23, 2019

RE: **Preliminary Site Assessment**
Pump Station 3 Upgrades
Silverdale, Washington
Project No. 1073020.010.011

Introduction

This preliminary site assessment summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Kitsap County (County) Pump Station 3 (PS-3) Upgrades project. PS-3 is located approximately 300 feet (ft) southwest of the intersection of Northwest Byron Street and Washington Avenue Northwest in Silverdale, Washington (site; Figure 1).

Geotechnical services were provided in accordance with the scope outlined in Exhibit A of the Subconsultant Services Agreement, authorized February 15, 2018.

Project Understanding and Background

The County plans to increase the capacity of PS-3 and replace outdated pumping equipment to satisfy current design standards. Larger pumps and motors will be installed to accommodate flow increases, and a new conveyance alignment will be added upstream of PS-3. Other conveyance improvements may include upsizing the gravity sewers between Silverdale Way Northwest and PS-3; the new gravity sewers will be installed approximately 8 to 12 ft below ground surface (bgs). A new wet well, odor control room, and mechanical room will also be constructed. The new rectangular wet well structure is estimated to have dimensions of 16 ft by 20 ft by 30 ft (deep).

PS-3 is located in an area frequented by the public, with the Port of Silverdale, parks, and outdoor festivals nearby. Impacts to the shoreline could limit allowable construction methods. As part of this site assessment, LAI reviewed geotechnical information for the Bay Shore Drive and Washington Avenue Sewer Main Replacement project (located immediately north of the site). LAI understands that ground freezing has been selected to shore and dewater the Bay Shore Drive site, thereby limiting impacts to public use and existing infrastructure.

Site Conditions

The site currently consists of the existing pump station and surrounding access area, enclosed by a chain-link fence. The site is bordered by grassy fields to the north and west, and the Puget Sound shoreline to the south. An asphalt parking area and Washington Avenue Northwest abut the eastern boundary of the site. Site topography is generally flat, and slopes gently down to the northeast at a grade of approximately 1 percent (Figure 2).

Geologic Review

Geologic information for the project area was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington* (Polenz et al. 2013). The map indicates that surficial deposits in the vicinity of the site consist of artificial fill (af). In LAI's experience, this unit is highly variable, and may consist of cobbles, pebbles, boulders, silt, clay, organic matter, riprap, concrete, and other debris. The contractor should be prepared to handle such oversized material. Additionally, Vashon recessional alluvial and delta fan deposits (Qgoaf) are mapped adjacent to the site. This unit generally consists of moderately to poorly sorted, stratified pebble gravel, sand, silt, and boulders in a loose condition. Alluvium is deposited in river deltas or where streams emerge from valleys.

Organic silt, peat, and wood fragments were documented in historical borings (Shannon & Wilson, Inc. 2013), and may be encountered at the proposed foundation elevations. These compressible soils extended to approximately 15 ft bgs in historical boring B-1W, and could contribute to long-term settlement of structures. Other soils documented in historical borings B-1W through B-7 are generally consistent with the mapped geology for the site (Attachment 1).

Assessment

LAI concludes that public use of the project area, risk of settlement-related damage to nearby infrastructure, and limitations imposed by site soil and groundwater conditions should be considered when selecting shoring and dewatering methods.

Compressible soils are present throughout the site, and conventional dewatering (well points, etc.) is likely to cause settlement within approximately 50 ft of the excavation areas. Vibrations associated with sheet pile installation could also cause settlement within 50 to 100 ft of the excavations. Additionally, the proximity of the site to Puget Sound could make conventional dewatering difficult.

LAI's preliminary assessment of shoring and dewatering concerns is provided below:

- **Shoring and dewatering.** Ground freezing is proposed to shore and dewater similar soils at the nearby Bay Shore Drive site. Ground freezing technology provides neat shoring and a groundwater cutoff (dewatering). This construction method would limit the risk for dewatering- and vibration-induced settlement of adjacent infrastructure, and could reduce noise and other impacts to public use. Compared with other shoring and dewatering methods, ground freezing limits use of heavy construction equipment and laydown. LAI considers ground freezing the preferred method for installation of the wet well and gravity sewers.

  Other shoring/dewatering options include:

  - For the wet well:

    - Sunken caisson, or drill and advance casing, with a tremie seal. This method may be more economical than ground freezing, but is likely to encounter obstructions that could delay construction.

    - Secant piling. This method is not cost competitive with ground freezing.

        - Sheet pile walls with internal dewatering or tremie seal. This method may be more economical than ground freezing, but carries a significant risk for vibration-related damage and impact to public-use areas.
    - For the gravity sewers:
        - Dewatering with well points plus sheet pile walls or trench box shoring. This method is more economical than ground freezing, but risks damage to nearby infrastructure. Additionally, the noise and vibration caused by sheet pile installation could be considered a public nuisance.

LAI's preliminary assessment of other project elements includes:

- **Foundation support:** Artificial fill and alluvial deposits are likely present within the excavation depths required for the proposed improvements. These soils are typically considered unsuitable foundation material. The proposed 30-ft-deep wet well is anticipated to extend below unsuitable soils; however, a boring should be advanced during final design to obtain site- specific soil and groundwater data. Ancillary structures may need to be designed using a zero net increase in bearing pressure (with lightweight fill below), local overexcavation, and replacement of unsuitable soils, or small-diameter pile foundations (pin piles).
- **Gravity sewers:** During preliminary design of new gravity sewers, the use of lightweight backfill should be assumed. Lightweight backfill will be used to mitigate potential settlement caused by heavier backfill placed over compressible soils.
- **Seismic conditions:** Critical areas maps on the County's graphical interface system (GIS) website indicate that the site is located in a geologically hazardous area, and could be severely impacted by seismic events. In LAI's opinion, the site is at risk for seismic-induced settlement or subsidence and soil liquefaction. Liquefaction could also result in lateral spreading, given the site's proximity to the Puget Sound shoreline. Areas with moderate potential for seismic-induced differential settlement may be present along the project alignment.
- **Groundwater:** The tidal cycles of the nearby Puget Sound are likely to influence groundwater levels at the site, and granular fill and/or alluvial deposits could be highly permeable, and readily transmit groundwater. Groundwater was encountered at 1.4 ft bgs in historical boring B-1W (located approximately 170 ft north of the site).
- **Onsite soils:** Onsite soils are moisture sensitive, and include debris-laden fill. Import soils should be used for structure and utility backfill.
- **Oversized material:** Cobbles, boulders, and debris are often found in artificial fill, and may be encountered during excavation. The contractor should be prepared to handle such oversized material.

Recommendations

This preliminary site assessment is based on review of available maps and historical boring logs, visual surface observations of the site, and LAI's experience with similar projects. Subsurface explorations should be performed prior to final design, and should include at least one soil boring advanced 50 ft bgs at the proposed wet well location. Given the variability of site soils/fills, borings should be advanced at 200-ft intervals along the gravity sewer alignment to Silverdale Way (if applicable). Data gathered during subsurface explorations can be used to address the following:

- Confirm the extent, depth, and composition of artificial fill.
- Determine bearing characteristics and settlement behavior of underlying deposits.
- Determine the probable extent of seismically induced liquefaction settlement and lateral spreading.
- Finalize shoring and dewatering assessments and collect detailed soil gradations for ground freezing and dewatering design considerations.

Use of This Preliminary Site Assessment

Landau Associates, Inc. prepared this preliminary site assessment for the exclusive use of BHC Consultants, LLC and Kitsap County Public Works for specific application to the Pump Station 3 Upgrades project in Silverdale, Washington. Use of this assessment by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been provided in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this assessment.

Closing

We trust that this assessment provides you with the information needed to proceed. If you have questions or comments, or if we may be of further service, please contact the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

Amy Power
Project EIT

Calvin McCaughan, PE
Principal

ALP/CAM/mcs
[Y:\1073\020.010\011\R\PS-3 PRELIMINARY SITE ASSESSMENT.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site Plan
Attachment 1. Historical Boring Logs

References

Kitsap County. GIS website. Available at: https://kitcowa.maps.arcgis.com. Accessed March 7, 2019.

Polenz, M., G.T. Petro, T.A. Contreras, K.A. Stone, G.L. Paulin, and R. Cakir. 2013. *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington.* Washington Division of Geology and Earth Resources Map Series 2013-02.

Shannon & Wilson, Inc. 2013. Boring Logs: Bay Shore Dr. and Washington Ave., Sewer Main Replacement, Silverdale, Washington. July.

Washington State Department of Labor and Industries. 2016. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. May 20.

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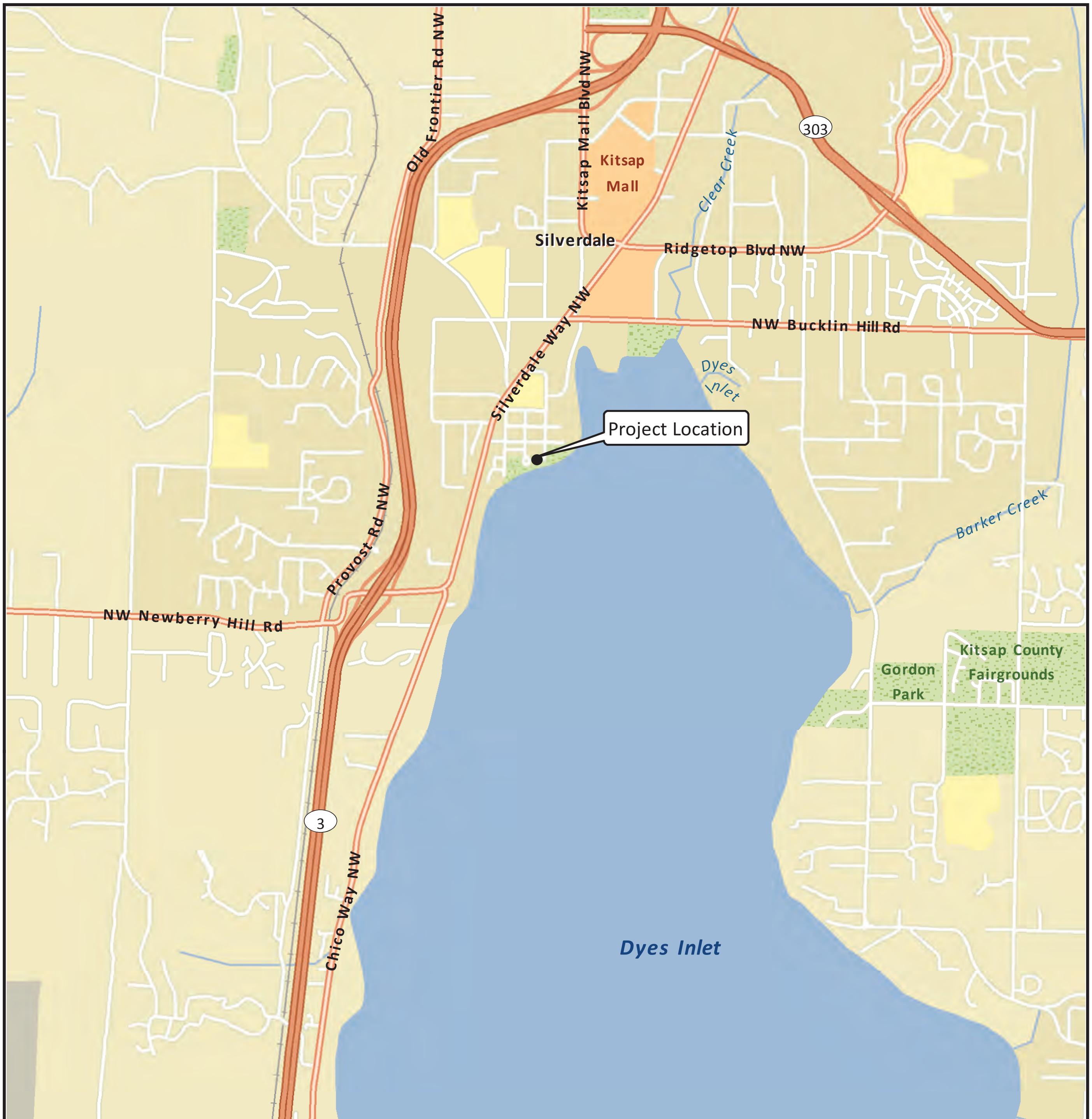

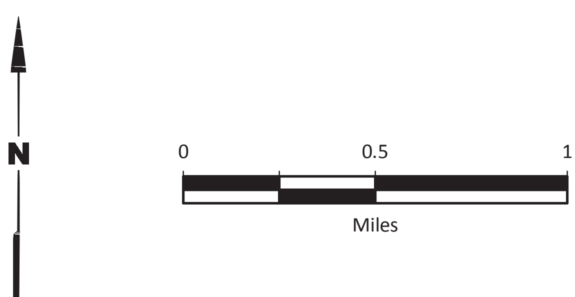

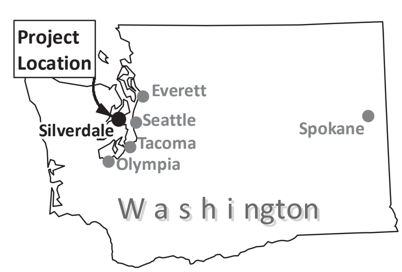

Data Source: Esri 2012

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LANDAU ASSOCIATES

Kitsap County Pump Station 3 Upgrades Silverdale, Washington	**Vicinity Map**	Figure 1

Source: Landau Associates, Inc. 2018

N

Kitsap County
Pump Station 3 Upgrades
Silverdale, Washington

Site Plan

Figure
2

LANDAU ASSOCIATES

ATTACHMENT 1

Historical Boring Logs

Aerial Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Bay Shore Drive and Washington Ave
Sewer Main Replacement
Silverdale, WA

SITE AND EXPLORATION PLAN

September 2014 | 21-1-21829-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2

D:\ USERS\Coral\Setup.mxd 9/5/2014 BRL

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From USACE Tech Memo 3-357)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines.
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTE: No. 4 size = 5 mm; No. 200 size = 0.075 mm

<u>NOTES</u>

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

Bay Shore Dr. and Washington Ave.
Sewer Main Replacement
Silverdale, Washington

SOIL CLASSIFICATION AND LOG KEY

July 2013 21-1-21829-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 2 of 2

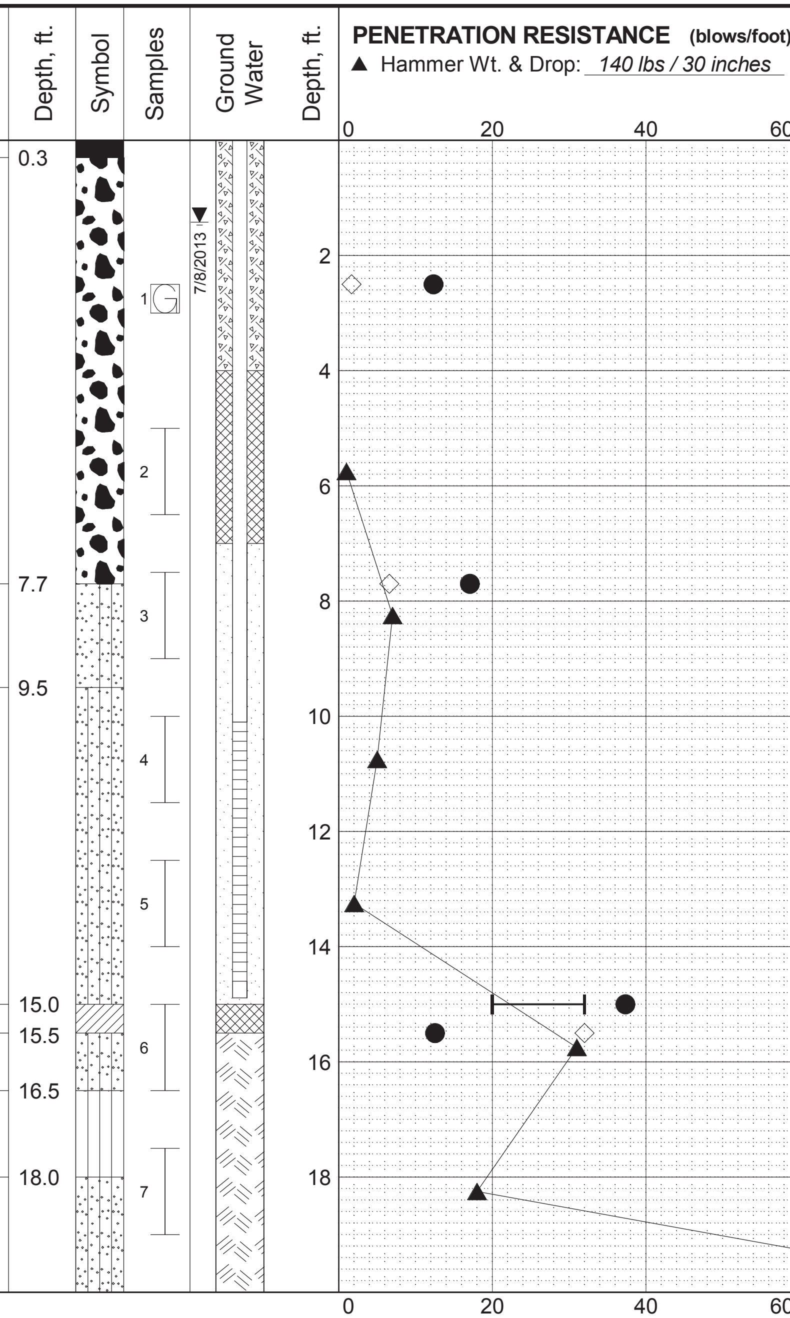
Total Depth:	46.25 ft.	Northing:	240,474 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	12.2 ft.	Easting:	1,181,503 ft.	Drilling Company:	Boart Longyear	Rod Diam.:	2-5/8"
Vert. Datum:	NAVD88	Station:	26+80.68 ft.	Drill Rig Equipment:	Mobile B-59	Hammer Type:	Automatic
Horiz. Datum:	NAD 83	Offset:	9.08L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
ASPHALT.	0.3
Brown, trace of silt to silty, sandy, fine GRAVEL; moist to wet; scattered organics; GW/GM. - Very loose at 5 feet, with abundant wood fragments. - Faint anaerobic odor below 7 feet.	7.7
Loose, gray, slightly silty, slightly fine gravelly SAND; wet; SP-SM.	9.5
Very loose to loose, brown to gray, trace to slightly gravelly, silty SAND; wet; abundant wood fragments and organics; SM.	15.0
Hard, gray, silty CLAY, trace of sand; wet; trace of wood fragments; CL.	15.5
Dense, gray, slightly fine gravelly, silty SAND; moist to wet; SM.	16.5
Medium dense, gray, sandy SILT, trace of gravel and clay; wet; trace of sand seams, scattered wood fibers; ML.	18.0
Medium dense to very dense, gray, trace of	

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Grab Sample
- 2.0" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Bay Shore Dr. and Washington Ave.
Sewer Main Replacement
Silverdale, Washington

LOG OF BORING B-1W

July 2013 21-1-21829-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 3

REV 2

Total Depth:	46.25 ft.	Northing:	240,474 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	12.2 ft.	Easting:	1,181,503 ft.	Drilling Company:	Boart Longyear	Rod Diam.:	2-5/8"
Vert. Datum:	NAVD88	Station:	26+80.68 ft.	Drill Rig Equipment:	Mobile B-59	Hammer Type:	Automatic
Horiz. Datum:	NAD 83	Offset:	9.08L	Other Comments:			

SOIL DESCRIPTION

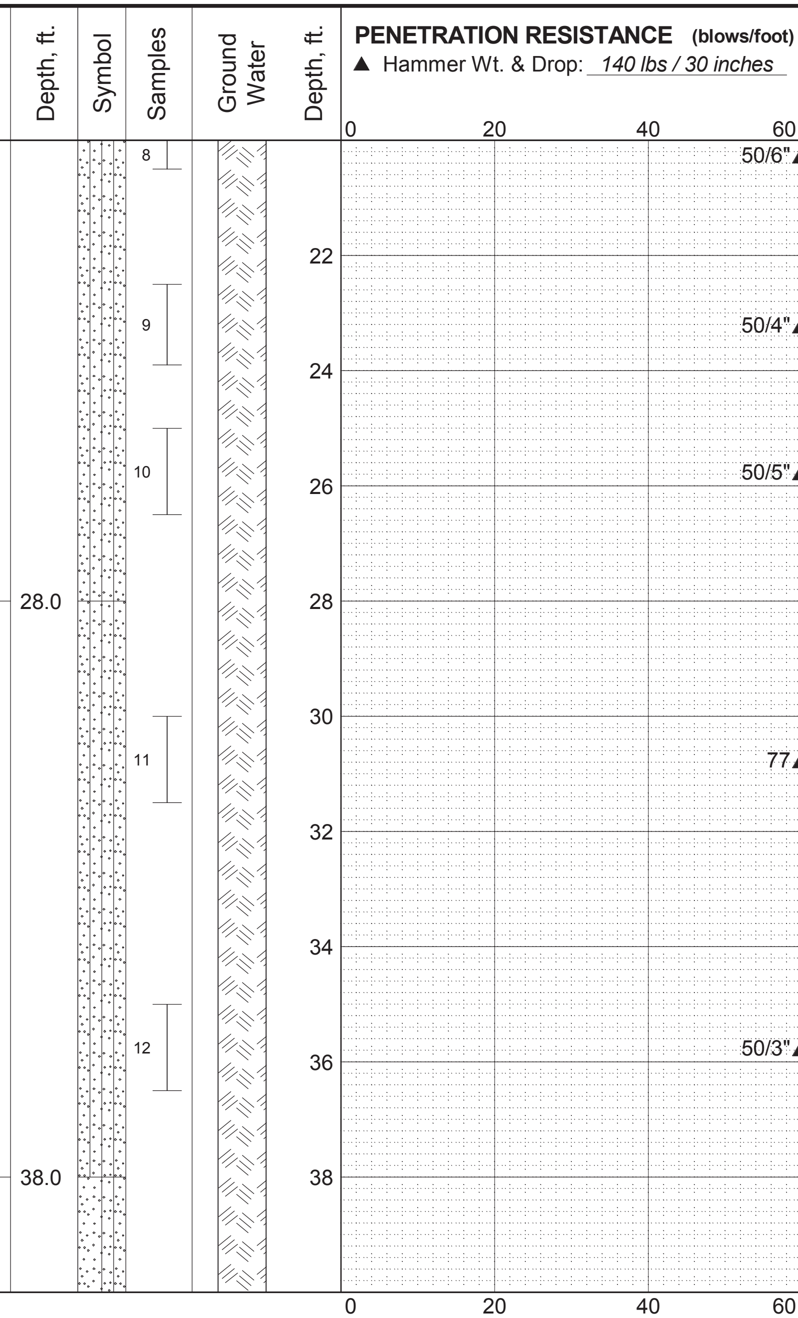
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

gravel to slightly gravelly, silty SAND; moist to wet; SM.

28.0 — Very dense, gray, silty, gravelly SAND to silty, sandy GRAVEL; wet; SM/GM.

38.0 — Very dense, gray, slightly silty, gravelly SAND; wet; SP-SM.

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Grab Sample
- 2.0" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Bay Shore Dr. and Washington Ave.
Sewer Main Replacement
Silverdale, Washington

LOG OF BORING B-1W

July 2013 21-1-21829-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 2 of 3

REV 2

Total Depth:	46.25 ft.	Northing:	240,474 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	12.2 ft.	Easting:	1,181,503 ft.	Drilling Company:	Boart Longyear	Rod Diam.:	2-5/8"
Vert. Datum:	NAVD88	Station:	26+80.68 ft.	Drill Rig Equipment:	Mobile B-59	Hammer Type:	Automatic
Horiz. Datum:	NAD 83	Offset:	9.08L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

0 20 40 60

Sample 13 — 50/4"

42

44

Sample 14 — 50/3"

46

46.3

BOTTOM OF BORING
COMPLETED 4/10/2013

Note: When the auger was extracted from the borehole the soil caved and filled the borehole to approximately 5 feet below the ground surface. The auger was lowered back in the hole and the soil was excavated to a depth of about 15.5 feet. Approximately 6-inches of bentonite seal was seal was placed from about 15 to 15.5 feet.

48

50

52

54

56

58

0 20 40 60

LEGEND

- * Sample Not Recovered
- Grab Sample
- 2.0" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▼ Ground Water Level in Well

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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Bay Shore Dr. and Washington Ave.
Sewer Main Replacement
Silverdale, Washington

LOG OF BORING B-1W

July 2013 21-1-21829-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 3 of 3

REV 2

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 7/19/13 Log: AXT Rev: CIJ Typ: LKN

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PUMP STATION 4
GEOTECHNICAL ASSESSMENT

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Preliminary Site Assessment

TO: Tony Fisher, PE, PMP

FROM: Amy Power, EIT, and Calvin McCaughan, PE

DATE: April 23, 2019

RE: **Preliminary Site Assessment**
Pump Station 4 Upgrades
Silverdale, Washington
Project No. 1073020.010.012

Introduction

This preliminary site assessment summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Kitsap County (County) Pump Station 4 (PS-4) Upgrades project. PS-4 is located at the northeast corner of the intersection of Frederickson Road Northwest and Northwest Bucklin Hill Road in Silverdale, Washington (site; Figure 1).

Geotechnical services were provided in accordance with the scope outlined in Exhibit A of the Subconsultant Services Agreement, authorized February 15, 2018.

Project Understanding

The County plans to increase the capacity of PS-4 by adding a well. To accommodate flow increases and satisfy current design standards, the County will replace outdated pumping equipment with larger pumps and motors; a larger generator; and new power, control, and telemetry panels. Other conveyance improvements include upgrading the gravity sewer along Fredrickson Road Northwest between Northwest Chena Road and Northwest Bucklin Hill Road, and replacing the force main between Northwest Bucklin Hill Road and Nels Nelson Road with a 20-inch-diameter pipe. The new gravity sewer is anticipated to be approximately 8 to 12 feet (ft) deep. The new force main will be installed about 6 to 7 ft below ground surface (bgs). The new rectangular wet well structure is estimated to have dimensions of 20 ft by 34 ft by 30 ft (deep).

Site Conditions

The site is located in a residential neighborhood, and is bordered by coniferous and deciduous trees to the north and asphalt roadways to the west and south. A gravel access road skirts the eastern boundary of the site, and a chain-link fence encloses existing PS-4 and the surrounding access area. The site slopes gently down to the southwest at a grade of approximately 4 percent; the existing building pad was created by cutting and filling a portion of the slope (Figure 2).

Geologic Review

Geologic information for the project area was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington* (Polenz et al. 2013). The map indicates that surficial deposits in the vicinity of the site consist of Vashon lodgment till (Qgt), a mixture of clay, silt, sand, pebbles, cobbles, and isolated boulders. Glacial till is typically unsorted and unstratified, and exhibits high shear strength and little to no permeability. This unit is highly compacted, as it was overridden and deposited directly by glacial ice.

Cobbles and boulders are often present in glacial deposits, and may be encountered throughout the site. The contractor should be prepared to handle such oversized material.

Assessment

Based on LAI's review of available geologic and geotechnical information, site visits, and experience with similar projects, site conditions are suitable for the proposed improvements:

- **Anticipated soils:** Glacial till is mapped at the site, and is likely present within the excavation depths required for the proposed improvements. The till is anticipated to provide adequate support for the wet well replacement and ancillary, on-grade structures. Boulders and cobbles are often present in glacially derived soils, and may be encountered throughout the site.
- **Seismic conditions:** Medium dense to very dense, glacially consolidated soil is mapped at the site. In LAI's opinion, site soil has a low risk of seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.
- **Foundation support:** Medium dense to very dense glacial till will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered.

Construction Considerations

The following should be considered during development of project specifications:

- **Onsite soils:** Glacial till typically has a high fines content and may be moisture sensitive. Earthwork should be avoided during heavy and/or extended periods of precipitation. If reused as structural fill, onsite soils should be moisture conditioned and screened for constituents greater than 6 inches in diameter.
- **Subgrade preparation:** After vegetation has been stripped and subgrade has been excavated to the proposed elevation, the upper 1 ft of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade

areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be overexcavated and replaced with structural fill.

- **Construction dewatering:** Dewatering may be necessary if shallow, perched groundwater is encountered in excavations. Excavations may cross existing utility trenches that contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations, where minor groundwater seepage is encountered. The contractor should be made responsible for the design, monitoring, and maintenance of any dewatering system(s).
- **Temporary excavations:** The soil likely to be exposed in the excavations (glacial till) should be considered Type B with a maximum allowable excavation inclination of 1 horizontal to 1 vertical. Depending on the wet well location and adjacent infrastructure, open cut, temporary excavations could be feasible. Temporary excavations should be completed in accordance with Section 2-09 of the Washington State Department of Transportation's *2018 Standard Specifications for Road, Bridge, and Municipal Construction.* Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor.

Recommendations

This preliminary site assessment is based on review of available maps, visual surface observations of the site, and LAI's experience with similar projects. LAI did not perform a subsurface investigation of the site. LAI recommends that borings be advanced at the proposed wet well location and along the deep gravity sewer extension during final design. The purpose of these borings is to identify subsurface conditions as a basis for contract bidding, and to ensure that unusual quantities of groundwater are not present.

Use of This Preliminary Site Assessment

Landau Associates, Inc. prepared this preliminary site assessment for the exclusive use of BHC Consultants, LLC and Kitsap County Public Works for specific application to the Pump Station 4 Upgrades project in Silverdale, Washington. Use of this assessment by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been provided in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this assessment.

Closing

We trust that this assessment provides you with the information needed to proceed. If you have questions or comments, or if we may be of further service, please contact the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

Amy Power
Project EIT

Calvin McCaughan, PE
Principal

ALP/CAM/mcs
[Y:\1073\020.010\012\R\PS-4 PRELIMINARY SITE ASSESSMENT.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site Plan

References

Polenz, M., G.T. Petro, T.A. Contreras, K.A. Stone, G.L. Paulin, and R. Cakir. 2013. *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington.* Washington Division of Geology and Earth Resources Map Series 2013-02.

Washington State Department of Labor and Industries. 2016. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. May 20.

WSDOT. 2018. *M 41-10: 2018 Standard Specifications for Road, Bridge, and Municipal Construction.* Washington State Department of Transportation. December 1.

Data Source: Esri 2012

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Landau Associates

Kitsap County Pump Station 4 Upgrades Silverdale, Washington	**Vicinity Map**	Figure 1

Source: Landau Associates, Inc. 2018

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Landau Associates

Kitsap County Pump Station 4 Upgrades Silverdale, Washington	**Site Plan**	Figure 2

PUMP STATION 19
GEOTECHNICAL ASSESSMENT

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TO: Tony Fisher, PE, PMP

FROM: Amy Power, EIT, and Calvin McCaughan, PE

DATE: April 23, 2019

RE: **Preliminary Site Assessment**
Pump Station 19 Upgrades
Silverdale, Washington
Project No. 1073020.010.013

Introduction

This preliminary site assessment summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Kitsap County (County) Pump Station 19 (PS-19) Upgrades project. PS-19 is located approximately 50 feet (ft) northeast of the intersection of Northwest Bucklin Hill Road and Nels Nelson Road Northwest in Silverdale, Washington (site; Figure 1).

Geotechnical services were provided in accordance with the scope outlined in Exhibit A of the Subconsultant Services Agreement, authorized February 15, 2018.

Project Understanding

The County plans to replace outdated pumping equipment at PS-19 to satisfy current design standards. At the time of this writing, there are no plans to increase the pumping capacity of PS-19; the existing wet well will be used to house the new pumps, and onsite excavations should be limited. The existing building will be demolished and replaced with a new control building that will also house the check and isolation valves. The deepest excavation will be associated with the onsite piping, and is anticipated to extend approximately 6 to 7 ft below ground surface (bgs).

Site Conditions

The site currently consists of the existing pump station and surrounding access area, enclosed by a chain-link fence. A grassy field slopes gently down to an asphalt-paved access road that abuts the western boundary of the site. This slope is associated with a stormwater detention pond; pond leakage may be contributing to wet site conditions. Site topography continues to slope downward to the east-southeast at a grade of approximately 8 percent. The site is bounded by Northwest Bucklin Hill Road to the south, and a grove of coniferous and deciduous trees separates the site from Highway 303 to the northeast.

Geologic Review

Geologic information for the project area was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington* (Polenz et al. 2013). The map indicates that surficial deposits in the vicinity of the site consist of Vashon lodgment till (Qgt), a mixture of clay, silt, sand, pebbles, cobbles, and isolated boulders. Lodgment till (glacial till) is typically unsorted and unstratified, and exhibits high shear strength and little to no permeability. This unit is highly compacted, as it was overridden and deposited directly by glacial ice. Additionally, Vashon ice-contact (Qgic), Vashon recessional glacial lake deposits (Qgof), and peat deposits (Qp) are mapped adjacent to the site. Peat generally contains a significant amount of organics as well as muck, silt, and clay deposited in wetland areas. Glacial ice-contact deposits are highly variable, and consist of poorly to well-sorted cobble, gravel, sand, and lacustrine material in a loose to dense condition with discontinuous deposits of ablation, flow, and lodgment till. Recessional glacial lake deposits generally consist of loose to moderately stiff, moderately to well-sorted silt, sand, and clay.

Fill was observed in historical boring B-2 (LAI 2018). Fill is highly variable, and consists of cobbles, pebbles, boulders, silt, clay, organic matter, riprap, concrete, and other debris. The soils observed underlying the fill in historical boring B-2 were generally consistent with the mapped geology for the site.

Subsurface Conditions

On April 18, 2018, historical boring B-2 was advanced 20.8 ft bgs at the approximate location shown on Figure 2. A summary exploration log is provided in Attachment 1. The soils underlying existing surface conditions (i.e., asphalt pavement) were categorized into two general units:

- **Fill:** This unit typically consisted of sandy gravel with silt in a medium dense, moist condition. Fill was observed to approximately 3 ft bgs.
- **Ice-contact deposits:** This unit generally consisted of sandy gravel or very silty sand with gravel. Ice-contact deposits ranged from medium dense to very dense and moist to wet. Historical boring B-2 terminated in this unit.

Although not observed in the historical boring, cobbles and boulders are often present in glacial deposits, and may be encountered throughout the site. Additionally, cobbles, boulders, and construction debris may be present in fill. The contractor should be prepared to handle such oversized materials.

During the April 2018 field investigation, groundwater was observed at 5 ft bgs in historical boring B-2. The groundwater conditions reported herein and on the exploration log are for the specific location and date indicated, and may not be representative of other locations and/or times. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring.

Conclusions and Recommendations

Based on review of published geologic maps and historical subsurface data, observation of general site characteristics, and experience with similar projects, LAI concludes that the proposed site improvements are feasible.

The medium dense to very dense ice-contact deposits encountered in historical boring B-2 are likely present within the required excavation depths, and are anticipated to provide adequate support for the proposed improvements. Boulders and cobbles are typically present in glacially derived soils, and may be encountered throughout the site. The contractor should be prepared to handle such oversized material.

Seismic Conditions

Seismic design will be completed using 2018 International Building Code standards (ICC 2017). The parameters listed in Table 1 can be used to compute seismic base shear forces.

Table 1. 2018 International Building Code Seismic Design Parameters

Spectral response acceleration at short periods (S_s) = 1.464g
Spectral response acceleration at 1-second periods (S_1) = 0.518g
Site class = C
Site coefficient (F_a) = 1.2
Site coefficient (F_v) = 1.482

g = force of gravity

Medium dense to very dense, glacially consolidated soil was observed in historical boring B-2. In LAI's opinion, the site soil has a low risk for seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.

Foundation Support

Table 2 provides a summary of design parameters for the structural engineer. The design parameters should be used in conjunction with the complete recommendations provided in this preliminary site assessment.

Table 2. Summary of Design Parameters

Allowable soil bearing pressure = 3,000 psf
Friction coefficient (factored) = 0.35
Passive resistance (factored) = 300 pcf, 140 pcf (buoyant) below 5 ft bgs
Minimum foundation width = 18 inches (continuous), 24 inches (isolated)
Maximum foundation width (for settlement considerations) = 5 ft (continuous), 10 ft (isolated)

ft = feet
pcf = pounds per cubic foot
psf = pounds per square foot

Medium dense to very dense ice-contact deposits will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered.

LAI recommends a net allowable bearing pressure of 3,000 pounds per square foot (psf) for on-grade structures. This net allowable bearing pressure includes a factor of safety of at least 3.0 on the calculated ultimate bearing capacity. Less than ½ inch of total settlement is expected to occur as loads are applied. Post-construction settlement is expected to be negligible. The maximum allowable bearing pressure can be increased by one-third for short-term transient loads.

An allowable coefficient of sliding resistance of 0.35, which includes a factor of safety of 1.5 on the calculated ultimate value, may be used to compute the frictional resistance acting on the base of footings, if applied to vertical dead loads only. The passive resistance of properly compacted structural fill placed against the sides of the foundations can be considered equivalent to a fluid with a density of 300 pounds per cubic foot (pcf). A buoyant value of 140 pcf should be used along portions of structures that extend more than 5 ft bgs. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded from the calculation, unless the foundation perimeter is covered by a slab-on-grade or pavement.

Lateral Earth Pressures

For design of below-grade walls, LAI recommends assuming a design groundwater elevation equal to the ground surface. Below-grade walls are expected to be restrained against rotation during backfilling, and should be designed for an equivalent fluid unit weight of 90 pcf. This assumes level backfill and at-rest, undrained soil conditions. Design of subsurface walls should include appropriate lateral pressures exerted by adjacent surcharge loads.

To achieve uniform surcharge pressures, uniformly distributed lateral pressures, 0.44 times the surcharge pressure, should be added to non-yielding walls. Given their size, wet wells are expected to move with the ground during a seismic event, and unbalanced, dynamic lateral earth pressures need not be incorporated into the pump station design.

Uplift Resistance

LAI recommends assuming a design groundwater elevation equal to the ground surface when evaluating tank-like structures, such as new vaults. The project design should also account for the fact that utilities could experience uplift pressure.

Construction Considerations

The following should be considered during development of project specifications:

- **Onsite soils:** Onsite soils have a high fines content and are considered moisture sensitive. Earthwork should be avoided during heavy and/or extended periods of precipitation.
- **Subgrade preparation:** After vegetation has been stripped and subgrade has been excavated to the proposed elevation, the upper 1 ft of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be overexcavated and replaced with structural fill.
- **Construction dewatering:** Shallow, perched groundwater should be anticipated in excavations; the stormwater pond at the western site boundary likely contributes to perched groundwater. Excavations may also cross existing utility trenches that contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations, where minor groundwater seepage is encountered. The site also has the advantage of topographic relief and nearby ditches, which could allow shallow excavations to drain via open channel. The contractor should be made responsible for the design, monitoring, and maintenance of any dewatering system(s).
- **Temporary excavations:** Temporary excavations should be completed in accordance with Section 2-09 of the Washington State Department of Transportation's *2018 Standard Specifications for Road, Bridge, and Municipal Construction.* Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements outlined in Safety Standards for Construction Work, Part N (Chapter 296-155 of the Washington Administrative Code). The soil likely to be exposed in the excavations should be considered Type C with a maximum allowable excavation inclination of 1½ horizontal to 1 vertical. All applicable local, state, and federal safety codes should be followed. If excavation instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater seepage is present and the excavation is not properly dewatered, the soil may be prone to caving, channeling, and running. Temporary shoring systems should be designed in accordance with the soil parameters presented in Table 3.

Table 3. Recommended Soil Parameters for Design of Temporary Shoring

Soil Unit	Moist Unit Weight (pcf)	Submerged Unit Weight (pcf)	Cohesion (psf)	Internal Angle of Friction (degrees)
Fill	125	63	0	34
Ice contact	130	68	0	36

pcf = pounds per cubic foot
psf = pounds per square foot

Use of This Preliminary Site Assessment

Landau Associates, Inc. prepared this preliminary site assessment for the exclusive use of BHC Consultants, LLC and Kitsap County Public Works for specific application to the Pump Station 19 Upgrades project in Silverdale, Washington. Use of this assessment by others or for another project is at the user's sole risk.

Within the limitations of scope, schedule, and budget, our services have been provided in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this assessment.

LAI anticipates reviewing project plans during design, and finalizing this site assessment without advancing additional geotechnical borings.

Closing

We trust that this assessment provides you with the information needed to proceed. If you have questions or comments, or if we may be of further service, please contact the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

Amy Power
Project EIT

Calvin McCaughan, PE
Principal

ALP/CAM/mcs
[Y:\1073\020.010\013\R\PS-19 PRELIMINARY SITE ASSESSMENT.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site and Historical Boring Plan
Attachment 1. Historical Boring Log

References

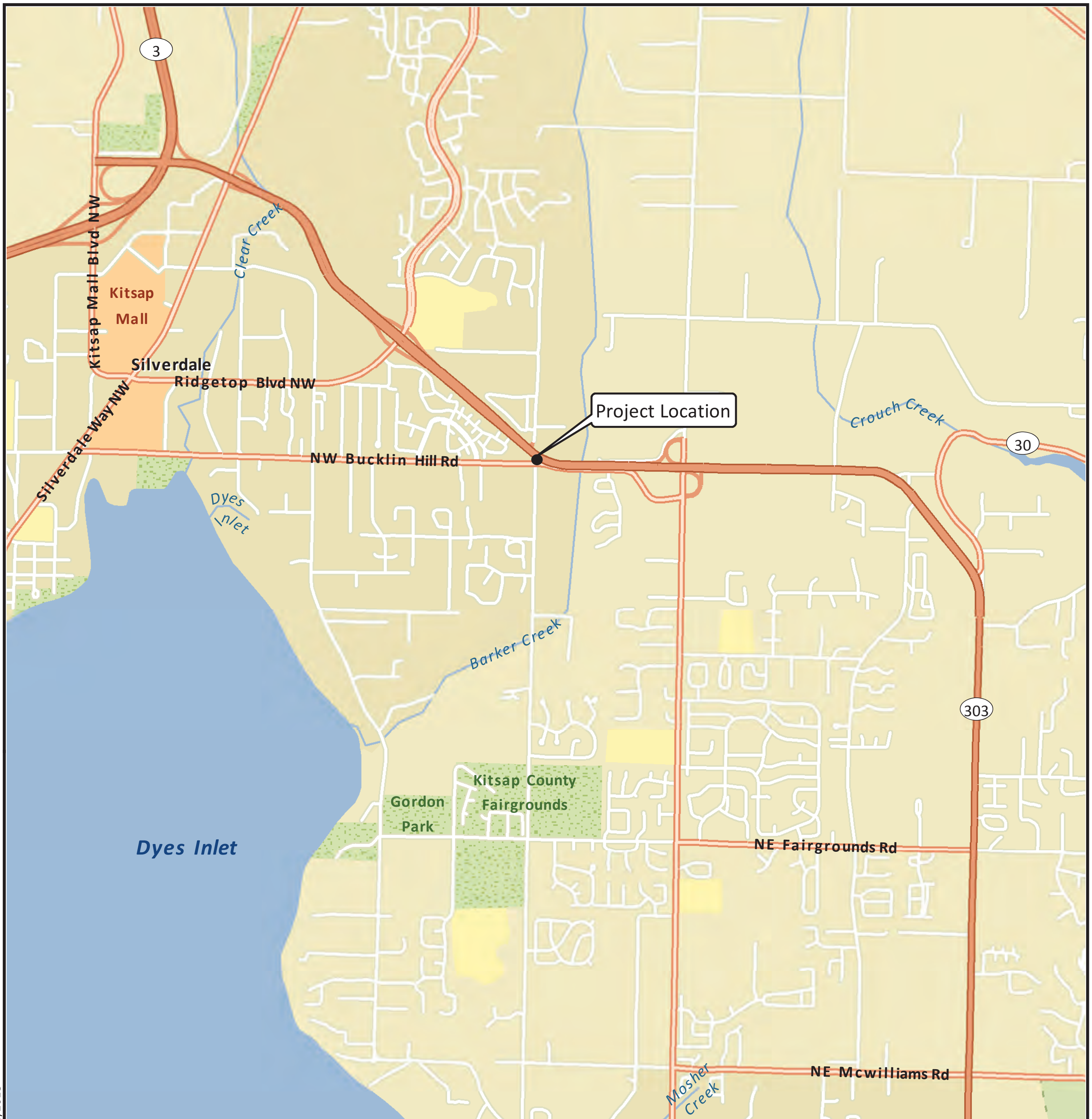
ICC. 2017. 2018 International Building Code. International Code Council. August 31.

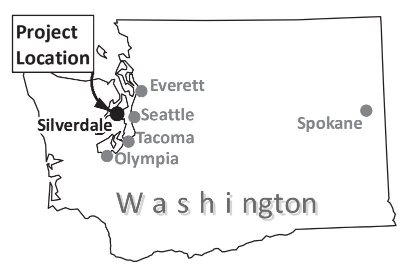
LAI 2018. Draft Geotechnical Report: NW Bucklin Hill Road and Nels Nelson Road NW: Intersection Improvements. Landau Associates, Inc. May 11.

Polenz, M., G.T. Petro, T.A. Contreras, K.A. Stone, G.L. Paulin, and R. Cakir. 2013. *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington.* Washington Division of Geology and Earth Resources Map Series 2013-02.

Washington State Department of Labor and Industries. 2016. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. May 20.

WSDOT. 2018. *M 41-10: 2018 Standard Specifications for Road, Bridge, and Municipal Construction.* Washington State Department of Transportation. December 1.





Data Source: Esri 2012

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LANDAU ASSOCIATES

Kitsap County Pump Station 19 Upgrades Silverdale, Washington	**Vicinity Map**	Figure 1

Approximate Historical Boring Location and Designation

Source: Landau Associates, Inc. 2018

Landau Associates

Kitsap County Pump Station 19 Upgrades Silverdale, Washington	**Site and Historical Boring Plan**	Figure 2

ATTACHMENT 1

Historical Boring Log

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL(1)	TYPICAL DESCRIPTIONS (2)(3)
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:		> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and	≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and	≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and	≤ 15% - "with gravel," "with sand," "with silt," etc.
		≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

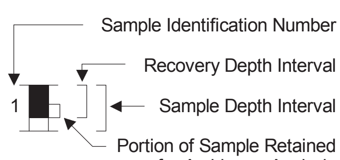
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time other than ATD

LANDAU ASSOCIATES

Kitsap County
Bucklin Hill and Nels Nelson
Intersection Improvements
Silverdale, Washington

Soil Classification System and Key

Figure
A-1

B-2

LAI Project No: 0640030.010

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 95
Drilled By: Holocene Drilling, Inc.
Logged By: BJF   Date: 04/18/18

Moisture Content (%): Plastic Limit — Liquid Limit; 20 40 60 80
▲ SPT N-Value ▲ (△ Non-Standard N-Value △): 20 40 60 80
× Fines Content (%) ×: 20 40 60 80

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0	95					AC	3 inches of asphalt over 9 inches of gravel base **(ASPHALT)**
						GP-GM	Brown, sandy, fine to coarse GRAVEL with silt (medium dense, moist) **(FILL)**
		S-1	b2	13		GP	Brown-gray, sandy, fine to coarse GRAVEL (medium dense, moist) **(ICE CONTACT)**
5	90						-Grades to wet
		S-2	b2	12			
		S-3	b2	69	W = 11 GS	SM	Gray, very silty, fine to coarse SAND with gravel (very dense, wet)
10	85	S-4	b2	50/ 5"			-Grades to moist
15	80	S-5	b2	43			-Grades to dense
20	75	S-6	b2	50/ 4"			-Grades to very dense
25							

Groundwater: ∇ (approx. 5 ft)

Boring Completed 04/18/18
Total Depth of Boring = 20.8 ft.

DRAFT

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Kitsap County
Bucklin Hill and Nels Nelson
Intersection Improvements
Silverdale, Washington

Log of Boring B-2

Figure A-3

PUMP STATION 31
GEOTECHNICAL ASSESSMENT

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Preliminary Site Assessment

TO: Tony Fisher, PE, PMP

FROM: Amy Power, EIT, and Calvin McCaughan, PE

DATE: April 23, 2019

RE: **Preliminary Site Assessment**
Pump Station 31 Upgrades
Silverdale, Washington
Project No. 1073020.010.014

Introduction

This preliminary site assessment summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Kitsap County (County) Pump Station 31 (PS-31) Upgrades project. PS-31 is located in a residential neighborhood, approximately 350 feet (ft) north of the intersection of Larkin Lane Northeast and Northeast Clover Blossom Lane in Silverdale, Washington (site; Figure 1).

Geotechnical services were provided in accordance with the scope outlined in Exhibit A of the Subconsultant Services Agreement, authorized February 15, 2018.

Project Understanding

The County plans to replace outdated pumping equipment at PS-31 to satisfy current design standards. Proposed improvements include installing a three-phase power system, replacing PS-31 with a pre-manufactured pump station structure, and replacing the existing force main with a new force main that extends from the new pump station to the force main associated with County Pump Station No. 8, located on Northeast Clover Blossom Lane. There are no plans to increase the pumping capacity of PS-31. The replacement wet well has an estimated diameter of 6 ft and a depth of 16 ft.

Site Conditions

The site currently consists of the pump station access area, which is enclosed by a chain-link fence. Coniferous and deciduous trees with an understory of vegetation common to the area border the site to the north and west, and Northeast Clover Blossom Lane borders the site to the southeast. The area surrounding the site is generally flat, and slopes down to the northwest at a grade of approximately 15 percent.

Geologic Review

Geologic information for the project area was obtained from the *Geologic Map of the Suquamish 7.5-minute Quadrangle and Part of the Seattle North 7.5'x 15' Quadrangle, Kitsap County, Washington* (Haugerud et al. 2011). The map indicates that surficial deposits in the vicinity of the site consist of Vashon till (Qvt), a material composed of clay, silt, sand, pebbles, cobbles, and isolated boulders.

Glacial till is also mapped in this area, and typically consists of pebbles in a sandy matrix. The till is unsorted and unstratified, and exhibits high shear strength and little to no permeability. This unit is highly compacted, as it was overridden and deposited directly by glacial ice. Additionally, Vashon Drift Esperance Sand (Qve) is mapped adjacent to the site. This material typically consists of sand with small amounts of gravel or silt in a loose condition.

The subsurface conditions observed in LAI's March 2019 exploration were generally consistent with the mapped geology.

Subsurface Conditions

Site subsurface conditions were explored on March 8, 2019 by advancing one hollow-stem auger boring (B-1) at the approximate location shown on Figure 2. Holocene Drilling, Inc., subcontracted by LAI, used a track-mounted drill rig to advance the boring 31.5 ft below ground surface (bgs).

The field investigation was coordinated and monitored by LAI personnel, who also obtained representative soil samples, maintained a detailed record of the subsurface soil and groundwater conditions observed, and used visual and textural examination to describe soils. Subsurface conditions were described using the soil classification system shown on Figure 3, and in general accordance with ASTM International (ASTM) standard test method D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).* A summary log of the exploration is presented on Figure 4. The log represents LAI's interpretation of the subsurface conditions identified during the field investigation. The stratigraphic contacts shown on the log represent approximate boundaries between soil types; actual transitions may be more gradual.

Disturbed soil samples were obtained from the boring at frequent intervals using a 1.5-inch inside-diameter, standard-penetration test, split-spoon sampler. The sampler was driven 18 inches (or a portion thereof) into the undisturbed soil ahead of the auger bit, with a 140-pound automatic hammer falling a distance of approximately 30 inches. The number of blows required to drive the sampler the final 12 inches (or a portion thereof) of soil penetration is noted on the boring log, adjacent to the appropriate sample notation. Samples were taken to LAI's soils laboratory for further examination and testing. Upon completion of drilling and sampling, the borehole was decommissioned in general accordance with the requirements of Washington Administrative Code (WAC) 173-160.

The soils observed underlying existing surface conditions (i.e., topsoil) can be categorized into one general unit:

- **Esperance sand:** This unit typically consists of medium dense to very dense sand with occasional cobbles, gravel, and variable silt content. The esperance sand observed in boring B-1 extended to the maximum depth explored (31.5 ft bgs). Soil in the upper 5 to 10 ft of the exploration was in a medium dense condition, and then transitioned to dense to very dense. Mottling was observed at approximately 13 ft bgs.

Cobbles were observed in boring B-1, and could be present throughout the site. The contractor should be prepared to handle such oversized material.

During the March 2019 field investigation, perched groundwater was observed between 4.5 and 16 ft bgs in boring B-1. The groundwater conditions reported herein and on the exploration log are for the specific location and date indicated, and may not be representative of other locations and/or times. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, groundwater levels in the project area are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring.

Conclusions and Recommendations

Based on the results of the field investigation and engineering analyses, subsurface conditions at the site are suitable for the proposed improvements, provided the following recommendations are incorporated into the project design.

Seismic Conditions

Seismic design will be completed using 2018 International Building Code standards (ICC 2017). The parameters listed in Table 1 can be used to compute seismic base shear forces.

Table 1. 2018 International Building Code Seismic Design Parameters

Spectral response acceleration at short periods (S_s) = 1.51g
Spectral response acceleration at 1-second periods (S_1) = 0.533g
Site class = D
Site coefficient (F_a) = 1.0
Site coefficient (F_v) = site-specific analysis or exception[(a)]

g = force of gravity

(a) A site-specific ground motion analysis (Chapter 21 of American Society of Civil Engineers 7-16) is required for Site Class D structures with S_1 values greater than or equal to 0.2g. Alternatively, Equivalent Lateral Force design (or Modal Response Spectrum Analysis), without a site-specific ground motion analysis, is permitted, provided the value of the seismic response coefficient Cs is determined by Eq. (12.8-2) for values of T≤ 1.5Ts, and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for TL≥T>1.5Ts or Eq. (12.8-4) for T>TL.

Medium dense to very dense, glacially consolidated soil was observed in boring B-1. In LAI's opinion, the site soil has a low risk for seismically induced liquefaction or lateral spreading. Considering the location of the site with respect to the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.

Foundation Support

Table 2 provides a summary of design parameters for the structural engineer. The design parameters should be used in conjunction with the complete recommendations provided in this preliminary site assessment.

Table 2. Summary of Design Parameters

Allowable soil bearing pressure = 3,000 psf
Friction coefficient (factored) = 0.35
Passive resistance (factored) = 300 pcf shallower than 5 ft bgs, 140 pcf (buoyant) below 5 ft bgs
Minimum foundation width = 18 inches (continuous), 24 inches (isolated)
Maximum foundation width (for settlement considerations) = 5 ft (continuous), 10 ft (isolated)

ft = feet
pcf = pounds per cubic foot
psf = pounds per square foot

Medium dense to very dense esperance sand will likely be exposed at the foundation elevation of the proposed structures. Native soils should provide adequate foundation support for on-grade and underground structures, provided the foundation soil remains in a relatively undisturbed condition and excavations are properly dewatered.

Underground structures are anticipated to result in a zero net increase in bearing pressure after the improvements are installed. LAI recommends a net allowable bearing pressure of 3,000 pounds per square foot (psf) for on-grade structures. This net allowable bearing pressure includes a factor of safety of at least 3.0 on the calculated ultimate bearing capacity. Less than ½ inch of total settlement is expected to occur as loads are applied. Post-construction settlement is expected to be negligible. The maximum allowable bearing pressure can be increased by one-third for short-term transient loads.

An allowable coefficient of sliding resistance of 0.35, which includes a factor of safety of 1.5 on the calculated ultimate value, may be used to compute the frictional resistance acting on the base of footings, if applied to vertical dead loads only. The passive resistance of properly compacted structural fill placed against the sides of the foundations can be considered equivalent to a fluid with a density of 300 pounds per cubic foot (pcf). A buoyant value of 140 pcf should be used along portions of structures that extend more than 5 ft bgs. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded from the calculation, unless the foundation perimeter is covered by a slab-on-grade or pavement.

Lateral Earth Pressures

For design of below-grade walls, LAI recommends assuming a design groundwater elevation equal to the ground surface. Below-grade walls are expected to be restrained against rotation during backfilling, and should be designed for an equivalent fluid unit weight of 90 pcf. This assumes level backfill and at-rest, undrained soil conditions. Design of subsurface walls should include appropriate lateral pressures exerted by adjacent surcharge loads.

To achieve uniform surcharge pressures, uniformly distributed lateral pressures, 0.44 times the surcharge pressure, should be added to non-yielding walls. Given its size, the wet well is expected to move with the ground during a seismic event, and unbalanced, dynamic lateral earth pressures need not be incorporated into the pump station design.

Uplift Resistance

Buried, tank-like structures, such as the proposed wet well, will experience an upward, buoyant force when the groundwater level around the outside of the structure is higher than the fluid level inside the structure. Over time, the backfilled excavation may fill with runoff, creating a bathtub effect. The weight of the structure and sidewall soil friction (for concrete exteriors) will resist uplift forces caused by buoyancy. Sidewall soil friction should be reduced or neglected if coatings are applied to the exterior of the wet well. Extending the base of the wet well foundation beyond its outside perimeter would increase the uplift resistance of the structure. LAI recommends assuming a design groundwater elevation equal to the ground surface. The project design should also account for the fact that the lift station and adjacent utilities could experience uplift pressure.

Construction Considerations

The following should be considered during development of project specifications:

- **Onsite soils:** Onsite soils have a high fines content and are considered moisture sensitive. Earthwork should be avoided during heavy and/or extended periods of precipitation. If reused as structural fill, onsite soils should be moisture conditioned and screened for constituents greater than 6 inches in diameter. Onsite soils should be reused only during periods of warm, dry weather.
- **Subgrade preparation:** After vegetation has been stripped and subgrade has been excavated to the proposed elevation, the upper 1 ft of subgrade should be scarified, moisture conditioned, and compacted to a firm, unyielding condition. Accessible subgrade areas should be proof rolled in the presence of a qualified civil or geotechnical engineer. If proof-rolling is not possible, the subgrade may be evaluated with a steel T-probe. Soft/unsuitable subgrade revealed during proof-rolling or probing should be overexcavated and replaced with structural fill.
- **Construction dewatering:** Perched groundwater between approximately 4.5 and 16 ft bgs should be managed with dewatering. Excavations may also cross existing utility trenches that

contain perched water. Temporary excavations should be dewatered to allow construction to be completed in the dry. Conventional sumps and pumps should be sufficient to dewater excavations where minor groundwater seepage is encountered. For the wet well, dewatering will likely require well points or an appreciably sized pump placed at the bottom of the excavation. Sheet piling could be used to seal the wet well excavation from perched groundwater. The contractor should be made responsible for the design, monitoring, and maintenance of any dewatering system(s).

- **Temporary excavations:** Temporary excavations should be completed in accordance with Section 2-09 of the Washington State Department of Transportation's *2018 Standard Specifications for Road, Bridge, and Municipal Construction.* Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements outlined in Safety Standards for Construction Work, Part N (Chapter 296-155 WAC). The soil likely to be exposed in the excavations should be considered Type C with a maximum allowable excavation inclination of 1½ horizontal to 1 vertical. All applicable local, state, and federal safety codes should be followed. If excavation instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater seepage is present and the excavation is not properly dewatered, the soil may be prone to caving, channeling, and running.

  Given the relatively rural location of the pump station and the presence of glacially consolidated soils, open cutting (with dewatering) will likely be used for the wet well, if the site layout permits. A steel casing may be used as temporary shoring, and placed in an open-cut or open-drilled excavation. Temporary shoring systems should be designed in accordance with the soil parameters presented in Table 3.

Table 3. Recommended Soil Parameters for Design of Temporary Shoring

Soil Unit	Moist Unit Weight (pcf)	Submerged Unit Weight (pcf)	Cohesion (psf)	Internal Angle of Friction (degrees)
Esperance Sand	130	68	0	36

pcf = pounds per cubic foot
psf = pounds per square foot

Use of This Preliminary Site Assessment

Landau Associates, Inc. prepared this preliminary site assessment for the exclusive use of BHC Consultants, LLC and Kitsap County Public Works for specific application to the Pump Station 31 Upgrades project in Silverdale, Washington. Use of this assessment by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been provided in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this assessment.

After reviewing updated design drawings, LAI will finalize this site assessment. At that time, laboratory tests may be completed to provide additional information that can be used by the contractor to design a dewatering system.

Closing

We trust that this assessment provides you with the information needed to proceed. If you have questions or comments, or if we may be of further service, please contact the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

Amy Power
Project EIT

Calvin McCaughan, PE
Principal

ALP/CAM/mcs
[Y:\1073\020.010\014\R\PS-31 PRELIMINARY SITE ASSESSMENT.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site Plan
Figure 3. Soil Classification System and Key
Figure 4. Log of Boring B-1

References

ASTM. 2012. D1557-12e1: Standard Test Methods for Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft3 (2,700 kN-m/m3). West Conshohocken, PA: ASTM International.

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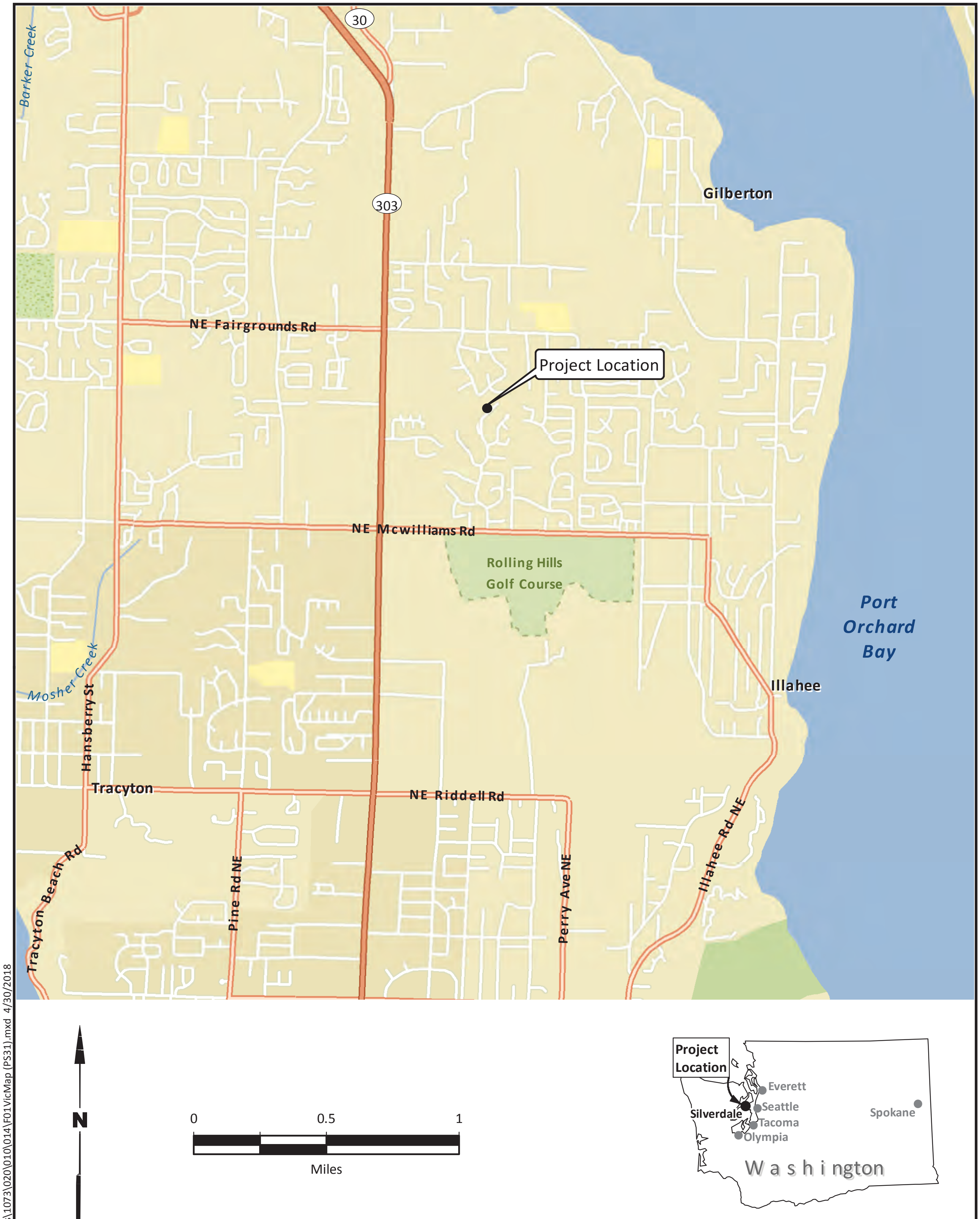

Data Source: Esri 2012

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LANDAU ASSOCIATES

Kitsap County Pump Station 31 Upgrades Silverdale, Washington	**Vicinity Map**	Figure 1

Approximate Boring Location and Designation

Source: Landau Associates, Inc. 2018

N (approx)

LANDAU ASSOCIATES

Kitsap County Pump Station 31 Upgrades Silverdale, Washington	**Site Plan**	Figure 2

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS[2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes: 1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.

2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.

3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents: > 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

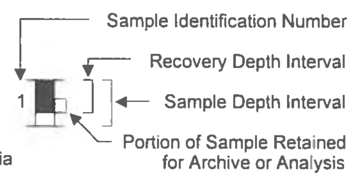
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

∇	Approximate water level at time of drilling (ATD)
▼	Approximate water level at time other than ATD

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Pump Station 31 Upgrades
Silverdale, Washington

Soil Classification System and Key

Figure 3

B-1

LAI Project No: 1073020.010.014

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 316
Drilled By: Holocene Drilling Inc.
Logged By: CAL   Date: 03/08/19

Moisture Content (%) — Plastic Limit / Liquid Limit: 20 40 60 80
▲ SPT N-Value ▲ (△ Non-Standard N-Value △): 20 40 60 80
× Fines Content (%) ×: 20 40 60 80

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S-1	d		
S-2	b2	20	
S-3	b2	33	
S-4	b2	30	
S-5	b2	32	
S-6	b2	43	
S-7	b2	36	
S-8	b2	53	
S-9	b2	60	
S-10	b2	63	
S-11	b2	43	

USCS Symbol	Description
SP	Dark brown to brown, fine to medium SAND with trace silt and organics. Covered in a thin mat of loose leaves, moss, sod, and twigs. (loose, moist to wet) **(TOPSOIL)**
	Brown, fine to medium SAND with gravel and trace silt. Cobbles up to 4 inches in diameter observed. (medium dense to dense, wet) **(ESPERANCE SAND)**
	Gravel observed between 10 and 10.5 ft.
	Grades to fine SAND with silt.
SP/SM	Brown, silty, fine SAND.
	Orange mottling observed throughout. (dense/stiff, wet)
SP	Gray brown, medium to fine SAND. (dense to very dense, moist)
	Grades to coarse to medium.
	Grades to with gravel.
	Grades to coarse to medium without gravel.
	Grades to coarse to fine with trace gravel.

Groundwater: 4.5 ft ATD

Boring Completed 03/08/19
Total Depth of Boring = 31.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

APPENDIX D

STRATEGY FOR CONSTRUCTION TRAFFIC CONTROL MEMORANDUM

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CASSEDAY
CONSULTING
9726 NE 138th Pl
Kirkland, WA 98034
(206) 450-8758
katherine@cassedaytraffic.com

MEMORANDUM

To: Tony Fisher, PE, Project Manager, BHC

From: Katherine Casseday, PE, PTOE

Date: April 9, 2019

Re: Kitsap County Silverdale Sewer System Upgrade, Pump Stations 3, 4and 19 – Strategy for Construction Traffic Control

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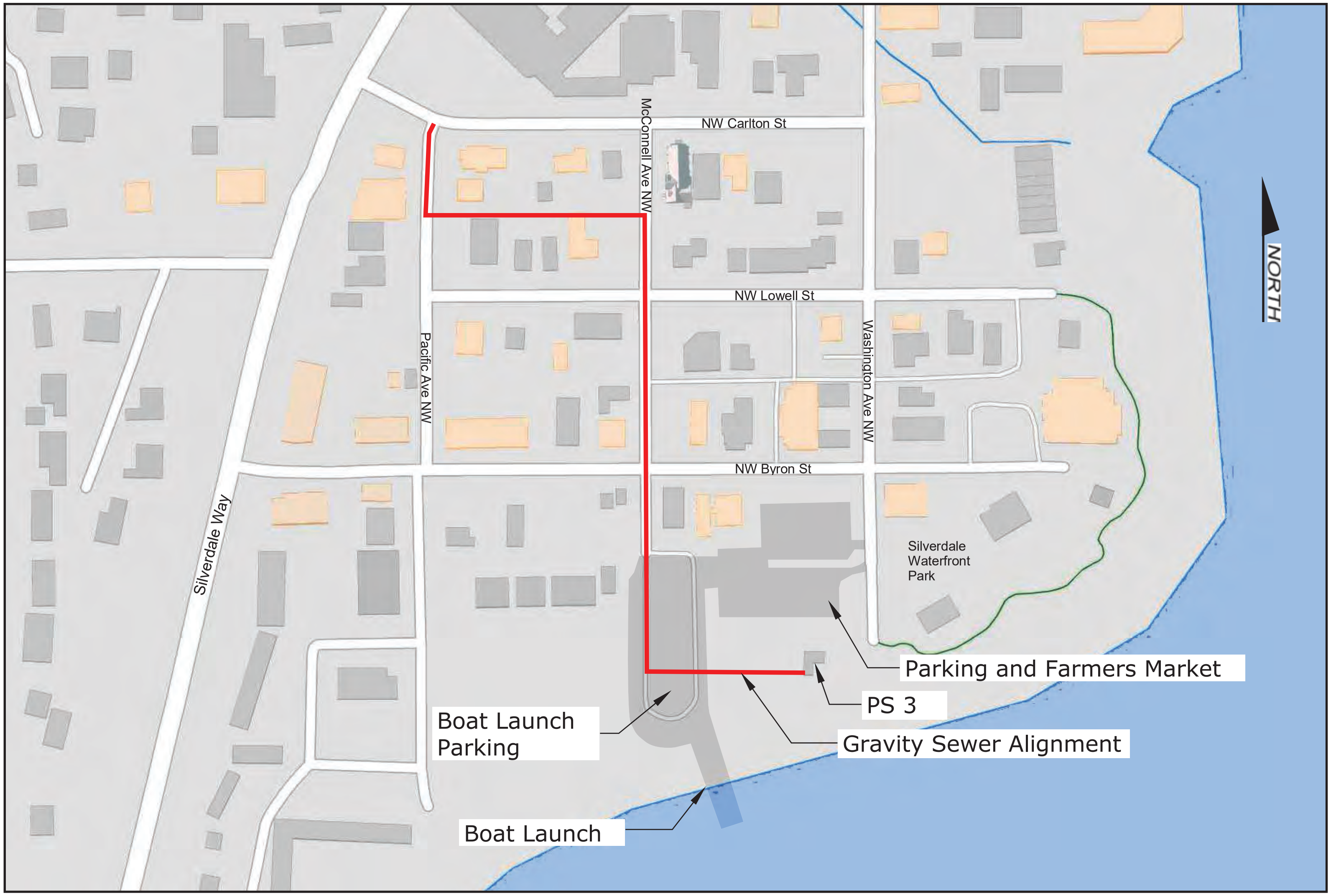
The Silverdale Sewer System Upgrade, Pump Stations 3, 4, 19 and 31 Project will include upgrades at four pump stations and a combination of force main and gravity sewer lines (conveyance) constructed within the public right of way along roadways in Kitsap County. The project will require daytime construction hours (7 AM to 7 PM) on weekdays, with the roadways restored for local access and circulation evenings and weekends. Where possible, streets will remain open to traffic with one 11' travel lane available for alternating traffic throughout the work day. Property access will be maintained by the Contractor with continued access for pedestrian travel, bikes, deliveries and emergency vehicle access.

This technical memorandum provides an overview of the current roadway and traffic conditions in the project vicinity for Pump Stations 3, 4 and 19. A traffic analysis for Pump Station 31 is not included, as this pump station is located in a cul-de-sac with minimal anticipated traffic impacts during construction. This memorandum offers recommendations for traffic control strategy and detours (if and where needed) for the construction stages of the project. What follows covers current conditions of the street network, traffic conditions and an overview of safety plus other considerations for local traffic to be addressed by the Contractor during construction.

Pump Station 3 System Upgrade

Pump Station 3 is located in Old Town Silverdale, near the south end of Washington Ave NW within the Silverdale Waterfront Park. Construction of the new pump station will involve work within the park and the construction to upgrade the gravity sewer line will involve work within the park and along McConnell Ave NW, Pacific Ave NW, an alley south of Carlton Street NW and the parking lot for the boat launch adjacent to the Silverdale Waterfront Park. Figure 1 illustrates the location of Pump Station 3 and provides an overview of the proposed routing for the sewer line conveyance pipe.



CASSEDAY CONSULTING

Pump Station 3 Sewer System Upgrade

Silverdale Sewer System Upgrade - PS 3, PS 4, PS 19

Current roadway and traffic conditions

The upgrades to the gravity sewer conveyance pipes feeding Pump Station 3 are planned to route, as shown in Figure 1, along a half block section of Pacific Ave NW beginning in the intersection with NW Carlton Street and heading south, then turning to the east along an alley between Pacific Ave NW and McConnell Ave NW where it will turn south and continue to the end of McConnell Ave NW and into the parking lot for the boat launch adjacent to Silverdale Waterfront Park. The sewer line will make a final turn to the east within the parking lot and continue to Pump Station 3.

The roadways along the sewer conveyance pipe route lie within Old Town Silverdale which is a small residential and commercial district east of Silverdale Way NW. Speed limit for the streets is 25 miles per hour. Pacific Ave NW is a 2 lane local roadway with 11 foot lanes. There is a sidewalk on the east side of the roadway and businesses with parking immediately adjacent to the roadway on the west side. The alley south of Carlton Street is a one lane right of way with access to both residences and businesses. McConnell Ave NW is a 2 lane local roadway approximately 40 feet wide with parking on both sides. Both sides of the roadway have sidewalks.

The south end of McConnell Ave NW leads to the park and feeds a boat launch and parking lot for the Silverdale Waterfront Park. The lot has parking spaces for 38 vehicle-plus-trailer combinations and spaces for 54 vehicles without trailers. A portion of the park parking lot is used for the Central Kitsap Farmers Market on Tuesday afternoons between May and October. There is an additional entrance and exit to the parking lot from Washington Ave NW, however this access may not be feasible for vehicles with trailers.

Traffic Control Recommendations

The alignment for the gravity sewer line within the right of way has not yet been defined and construction would block at least one travel lane. Where the Contractor may not be able to maintain one 11' lane for alternating traffic, Kitsap County may allow the Contractor to close one block at a time for daytime construction, to be restored for travel and access every evening and night.

If construction of the gravity line blocks the entire roadway in the active work zone, only one block can be closed at a time, allowing traffic to be detoured around the closed block, along the street network. The active work zone shall not block more than one block or intersection at a time. Traffic shall be detoured around the active work zone via the shortest route utilizing the regular grid of roadways in the area. The Contractor shall maintain safe pedestrian and bicycle travel through the work zone and shall maintain access for deliveries, school buses, emergency vehicles. The contractor shall maintain access to properties and businesses at all times. Construction activities shall only occur during daytime hours of 7AM to 7PM and the roadway shall be restored to regular traffic at all other times.
Construction of the gravity line will route through the park and will displace/close some of the vehicle-plus-trailer parking spaces. Access to the boat launch would be affected by construction and Kitsap County could work to limit the number of construction days affecting the boat ramp and trailer parking. Construction along McDowell Avenue NW would close parking and would keep one lane open, for alternating traffic with flagger control – or may involve daytime closures of full blocks to facilitate

construction progress. Traffic control for the work zone will need to manage construction through intersections as well as along blocks – with the goal to maintain local circulation and access.

Pump Station 4, Fredrickson Road Gravity Sewer Upgrade and NW Bucklin Hill Road Force Main Upgrade

Pump Station 4 is located adjacent to the intersection of Fredrickson Road NW and NW Bucklin Hill Road. Improvements to Pump Station 4 will involve site access from Fredrickson Road NW. An upgrade to the gravity sewer line will involve construction in Fredrickson Road NW, from NW Chena Road to NW Bucklin Hill Road. The project will also include upgrades to Pump Station 4's force main in NW Bucklin Hill Road, from Pump Station 4 at Fredrickson Road NW approximately 1250 feet east to a manhole just east of Spinnaker Boulevard (west leg). **Figure 2** illustrates the locations for Pump Stations 4 and 19 along NW Bucklin Hill Road and provides an overview of the planned routing for the gravity sewer on Fredrickson Road and the planned routing for the force main on NE Bucklin Hill Road.

Current roadway and traffic conditions

Fredrickson Road NW is a two lane local roadway serving residential land uses extending from NW Chena Road to NW Bucklin Hill Road. Fredrickson Road NW pavement width is approximately 22 feet with limited shoulders and no curb. Fredrickson Road NW provides access to 22 single family homes sited adjacent to the roadway. Traffic on Fredrickson Road NW has a stop controlled intersection with NW Bucklin Hill Road. At north end the roadway turns east and becomes NW Chena Road. The speed limit along this roadway segment is 25 MPH.

One block east and parallel to Fredrickson Road NW is Richardson Road NW, which has similar characteristics. Connecting these two roadways on the north is NW Chena Road and on the south is NW Bucklin Hill Road, with stop control at NW Bucklin Hill Road.

NW Bucklin Hill Road is an urban minor arterial roadway with one travel lane in each direction and a two-way left turn lane. The project area extends from Fredrickson Road NW (west end) to approximately 250' east of Spinnaker Boulevard (west leg). The speed limit is 35 MPH through the project area. Daily traffic volumes in the project area range from approximately 6000 to 8000 vehicles per day. There are three signed bus stops on the south side of the roadway serving the eastbound Kitsap Transit route 37 Fairgrounds Shuttle. On either side of this roadway segment there are driveways serving from one home to multiple homes and larger neighborhoods. Lighting along this section is extremely limited.

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Pump Station 4 & 19 Sewer System Upgrade

Silverdale Sewer System Upgrade - PS 3, PS 4, PS 19

NW Bucklin Hill Road has a sidewalk on the north side of the roadway, from Myhre Ave NW to east of Spinnaker Boulevard (west leg) and on the south side of the roadway there is a striped shoulder signed for pedestrian access. The westbound travel lane is 12 feet wide. The two-way left turn lane is 12 feet wide. The eastbound travel lane is 10 feet wide and the striped shoulder is 3 feet wide. Near the bus stop at Olson Road NW there is a marked crosswalk with Rectangular Rapid Flashing Beacon (RRFB) display.

To the east of Spinnaker Boulevard (west leg) on NW Bucklin Hill Road, the sidewalk extends for approximately 250’ then transitions to a north shoulder at around 8 feet wide. The two-way left turn lane and the travel lanes are all 11 feet wide. There is little to no shoulder on the south side of the roadway.

Traffic Control Recommendations

Alignment of the gravity sewer line in Fredrickson Road NW has not yet been established. Construction will close at least one travel lane and construction activities may block the entire roadway in the active work zone. The contractor shall maintain access at all times to homes for residents either by providing access through the work zone or by directing them around the active work zone via NW Chena Road and Richardson Road NW to the north, or via NW Bucklin Hill Road and Richardson Road NW to the south. The local streets are not set up for turn-around movements.

Alignment of the proposed force main pipe in NW Bucklin Hill Road has not yet been established. The force main construction is expected to occur in the westbound travel lane or shoulder on the north side of the roadway. For most of the work, the Contractor can maintain two-way traffic by directing westbound traffic into the two-way left turn lane. Occasionally it may be necessary to provide flagger-controlled alternating one-way traffic around an active work zone. At no time will the entire roadway be closed to traffic.

Construction activities shall only occur during daytime hours of 7AM to 7PM and the roadway shall be restored to regular traffic at all other times.

The contractor shall maintain access to local properties at all times, maintaining for safe pedestrian and bicycle traffic through the work zone. The Contractor shall maintain access for Kitsap Transit, deliveries, and emergency vehicles through the work zone. No detours are envisioned for traffic and construction across roadways and driveways will need coordination with residents.

Pump Station 19

As noted above, Figure 2 shows the location of Pump Station 19, located further to the east along NW Bucklin Hill Road, adjacent to the intersection of NW Bucklin Hill Road and Nels Nelson Road NW. Improvements to Pump Station 19 will involve site access from NW Bucklin Hill Road, via existing paved driveways which will be revised to accommodate vacuum truck (vactor truck) access for maintenance of the pump station.

Traffic Control Recommendations

Construction activities shall only occur during daytime hours of 7AM to 7PM and the roadway shall be restored to regular traffic at all other times. Construction of a new traffic signal at this intersection is planned for 2019. Construction activities at Pump Station 19 will need to maintain access through the traffic signal.

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APPENDIX E

PUMP STATION 3 ALTERNATIVE LOCATIONS MEMORANDUM

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DRAFT - MEMORANDUM

Date: September 24, 2018

To: Stella Vakarcs, Barbara Zaroff

From: Tony Fisher, P.E.

CC: Donn Stone, Drew Coombs, Carla Talich

Subject: Pump Station 3 Alternative Locations

PROJECT OVERVIEW

Upgrades to the pumping capacity of Pump Station 3 (PS3) to address growth in its service area were identified in Kitsap County's *Central Kitsap County Wastewater Facility Plan* (hereinafter referred to as "Facilities Plan"). These upgrades, which address capacity limitations and obsolete equipment issues, are planned to occur within the next five years.

In 2015, three options for upgrading PS3 were investigated. These options included: 1) upgrading the station at its existing location; 2) constructing a new pump station in the existing parking lot at the southwest corner of Washington Avenue NW and NW Byron Street and then abandoning the existing station; and 3) constructing a new pump station in a vacant lot near the southwest corner of Washington Avenue NW and NW Carlton Street (Carlton Site) and then abandoning the existing station. After reviewing these options, Kitsap County Public Works selected the existing pump station site (Option 1) as the most cost-effective alternative. Based on that decision, upgrades to the Bay Shore and Washington Improvements Project (Bay Shore Project) were finalized and construction is pending.

The Bay Shore Project includes new sanitary sewer mains, manholes, and hot mix asphalt (HMA) pavement on Washington Avenue NW as well as a new traffic circle lane near the south end of Washington Avenue. The project will set a manhole on the existing gravity sewer main to PS3 that will function as the transition point between the Bay Shore Project and the upgrades to PS3. In addition, a paved driveway for access to the new PS3 at the existing pump station site is planned to be installed near the traffic circle. Construction of the Bay Shore project is slated to start in a few months. Relocating PS3 away from its current location would have impacts to the Bay Shore Project.

During a public meeting on July 26, 2018, a request was made to investigate the feasibility of relocating PS3 further north, toward the HMA-paved parking lot. The new station would be constructed within the grassed area between the parking lot and the current pump station on Parcel 4458-009-009-0001, which is owned by the Port of Silverdale.

The County asked BHC Consultants (BHC) to prepare a technical memorandum evaluating the four options for the new PS3 site. The options are identified as follows:

- <u>Option 1</u> – Upgrade PS3 at its current location on property currently owned by Kitsap County (Parcel #: 4458-010-008-0000);
- <u>Option 2</u> - Upgrade PS3 north of its current location on property currently owned by the Port of Silverdale (Parcel #: 4458-009-009-0001) and on property owned by Kitsap County (Parcel #: 4458-010-008-000);
- <u>Option 3</u> – Upgrade PS3 slightly north of its current location on property owned by Kitsap County (Parcel #: 4458-010-008-0000) and within the existing easement area on property owned by the Port of Silverdale (Parcel #: 4458-009-009-0001); and
- Option 4 – Upgrade PS3 adjacent to the parking lot on property owned by the Port of Silverdale (Parcel #: 4458-009-009-0001).

Common upgrades associated with each option include a new below ground wet well; new valves, fittings, and associated piping; yard piping to connect the new facilities to the existing gravity sewers, force main, and pig launch; new flow metering equipment; a new generator; new telemetry and electrical control panels, and new odor control facilities such as chemical addition equipment or an activated carbon air scrubber.

To address rising tidal concerns associated with global warming, a waterproof membrane will be installed behind the wainscoting around the full exterior perimeter of the existing or new building and fully integrated with the supporting footings below. All windows and exhaust/supply vents will be installed/relocated at least 3’-6” above the finished floor, and heavy-duty jambs and doors will be added that are capable of resisting flooding.

All options assume construction will occur north of the existing riprap wall to the south of the existing building. Consequently, the riprap wall will remain in place with no upgrades, shoreline armoring, or restoration work on the beach.

COMPARISON OF OPTIONS

Option 1 – Upgrade Pump Station 3 at Its Current Location

This option upgrades the existing pump station at its current location and is shown on *Figure 1*. The wet well would be constructed under the paved area north of the existing building, with the only visible features being the access hatches. Modifications to the existing building would include replacing the existing roof with a flat deck and railings to create a public viewing platform; adding a metal stair case and Americans with Disabilities Act (ADA) lift to provide access to the viewing platform; adding brick wainscoting and wood siding around the exterior of the building; and removing all existing equipment inside the building to provide space for the new valves, piping, metering equipment, generator, telemetry panel, and electrical control panels. A new room would be added to the exterior of the building to house the odor control equipment. In addition, new mechanical (HVAC) and building electrical (lighting and outlets) would be installed inside the building.

During construction, a bypass pumping system would be required to accommodate incoming flows while most of the upgrades are constructed since those upgrades would be occurring in the same footprint as the existing station. Operating the station using a temporary bypass pumping system for an extended period increases the risk of sewage spills and results in higher construction costs.

The existing station is located within the shoreline buffer zone, so modifications to the impervious surface area would require additional mitigation measures. The upgrades would disturb approximately 15 square feet of buffer area beyond the area already impacted by the existing station. That area would be restored with shoreline mitigation vegetation along with an additional 745 square feet of landscaping along the west side of the existing building and to the west and north of the new wet well, resulting in 760 square feet of vegetative restoration. About 1,500 square feet of new HMA pavement would replace the existing HMA pavement that is disturbed by construction. No modifications would be required to the sanitary sewer manhole or paved driveway being constructed under the Bay Shore Project.

This option would not improve public access to the beach and many of the Port of Silverdale/park users already view the existing building as intrusive, with respect to the beneficial use of the park/port and aesthetics. The upgrades to the existing building would improve the aesthetics and enhance the beneficial use of the station by providing a public viewing platform.

Because this option would be located on property already owned by Kitsap County, additional property acquisition would not be required, and potential complications associated with grant funding used by the Port of Silverdale to purchase the property to the north of the station may be avoided. The grassy area between the pump station and the parking lot is currently used every Tuesday from early May to early October for the Central Kitsap Farmers Market. The use of this area in the future for this purpose could continue without restrictions.

Option 2 – Upgrade Pump Station 3 North of Its Current Location

This option upgrades the existing pump station by replacing it with a new pump station located in the vacated right of way portion of the grassed area adjacent to and north of the existing pump station and is shown on *Figure 2*. The wet well would be constructed primarily within the existing easement area with a portion of the wet well extending north onto property owned by the Port of Silverdale, and south onto property owned by Kitsap County.

A new building would be constructed west of and adjacent to the new wet well to house the valves, flow metering equipment, generator, telemetry panel, electrical control panels, and odor control equipment. The building would have a flat-decked roof with railings to create a public viewing platform; a metal stair case and ADA lift to provide access to the viewing platform; brick wainscoting; and wood siding around the exterior of the building.

To accommodate the new pump station, portions of the existing gravity sewer, force main, water main, and buried power would need to be relocated. In addition, the interface manhole between the Bay Shore Project and the PS3 Upgrades project would need to be relocated to the north of the proposed wet well location and some modifications to the paved driveway for access to the new pump station may be necessary. These modifications would need to occur before construction of the new wet well could begin.

A significant benefit of this option is that the new station could be constructed while the existing station remains in service. Some minor temporary bypass pumping may be required while making connections or transferring service to the new pump station, but the risks and costs of these efforts would be greatly reduced. Once the new station is operational, the existing building and associated structures would be demolished. Below ground structures that are no longer needed would be abandoned in place. All disturbed areas would then be restored.

This option is also within the shoreline buffer zone, so mitigation would be required. The upgrades would impact about 1,065 square feet of buffer area that would need to be restored with shoreline mitigation vegetation. That restoration would be accomplished in the area where the existing building and HMA pavement is being removed. In addition to the buffer mitigation restoration, this option would include approximately 1,520 square feet of additional landscaping around the north, west, and south sides of the new station and in the remaining area of where the existing HMA paving would be removed, resulting in a total of 2,585 square feet of vegetative restoration. About 2,000 square feet of new HMA pavement would replace the existing HMA pavement that is to remain but is disturbed by construction.

This option may improve public access to the beach by providing additional space between the new pump station and the beach, but the potential increased access would be balanced by the shoreline mitigation/restoration requirements. The new building would be more aesthetically pleasing than the existing building and park use would be enhanced by providing a public viewing platform on top of the new building.

This option would locate the station further from the high-water mark of Dyes Inlet, the beach, and an erodible shoreline. This would provide more space to accommodate berms or other measures to assist in blending the station into the surrounding area and to provide a buffer against rising tide levels.

Because this option is located on property owned by the Port of Silverdale, Kitsap County Public Works would need to negotiate a land swap or land acquisition with the Port. The land swap or acquisition may be challenging as the land appears to have been purchased with grant funds from the Recreation and Conservation Funding Board. That funding has significant restrictions on the use of the land that would need to be addressed.

The grassy area north of the existing pump station is currently used by the Central Kitsap Farmers Market during the summer months. Shifting the station to this location would impact that use by reducing this space. The area where the existing station is located may or may not be available for use by the Farmers Market, depending on the type of shoreline mitigation plantings that are required.

Option 3 – Upgrade Pump Station 3 Within Existing Easement

This option represents a compromise between Options 1 and 2 and would replace the existing pump station with a new pump station located on property owned by Kitsap County Public Works and within an existing easement across property owned by the Port of Silverdale. This option is depicted on *Figure 3*. The wet well would be located within the currently paved access to the existing station. A new building would be constructed within the existing easement and a portion of the existing paved area to house the valves, flow metering equipment, generator, telemetry panel, electrical control panels, and odor control equipment. The new building would have a flat-decked roof with railings to create a public viewing platform; a metal stair case and ADA lift to provide access to the viewing platform; brick wainscoting; and wood siding around the exterior of the new building.

The existing gravity sewer, force main, water main, and buried power in the existing easement would be located under the new building unless those utilities are relocated. The location of the interface manhole between the Bay Shore Project and the PS3 Upgrades project could remain unchanged, but some modifications to the access driveway may be necessary, depending on the final location of the wet well.

A significant benefit of this option, similar to Option 2, is that the new station could be constructed while the existing station remains in service. Some minor temporary bypass pumping may be required while making connections or transferring service to the new pump station, but the risks and costs of these efforts would be greatly reduced. Once the new station is operational, the existing building and associated structures would be demolished. Below ground structures that are no longer needed would be abandoned in place. All disturbed areas would then be restored.

This option is also within the shoreline buffer zone, so mitigation will be required. The upgrades would impact about 330 square feet of buffer area that would need to be restored with shoreline mitigation vegetation. That restoration would be accomplished in the area where the existing building is located and the existing HMA pavement is being removed. The removal of the existing building and a portion of the existing HMA pavement would require an additional 1,550 square feet of landscaping plus another 550 square feet of landscaping around the new building for screening and aesthetics. This would result in a total of 2,430 square feet of landscaping.

Construction would likely substantially disturb the rest of the existing HMA asphalt around the station, resulting in about 1,350 square feet of existing HMA being replaced with new HMA.

Public access to the beach would be improved due to the increased space between the new pump station and the beach. A portion of that space would be dedicated to shoreline mitigation plantings, but sufficient space should remain to improve the public's access to the beach.

This option would locate the station further from the high-water mark of Dyes Inlet, the beach, and an erodible shoreline, but not quite as far away as Option 2. It would bisect the grassed area buffer between the new pump station and existing parking lot that is currently used for the Central Kitsap Farmers Market, which may make the continued use of this area by the Farmers Market more challenging.

Keeping the proposed upgrades on property owned by Kitsap County Public Works and within the easement area may avoid the need for additional land acquisition or a swap of property with the Port of Silverdale. However, the easement is located on property owned by the Port of Silverdale that may have been purchased with grant funds from the Recreation and Conservation Funding Board. That funding has significant restrictions on the use of the land that would need to be addressed. In addition, a review of the easement provisions would be necessary to determine if construction of the pump station facilities is allowed.

Option 4 – Upgrade Pump Station 3 Adjacent to the Parking Lot

This option upgrades the existing pump station by replacing it with a new pump station located in the grassed area immediately adjacent to the edge of the existing parking lot and is shown on *Figure 4*. The wet well and new control building would be constructed just south of the existing parking lot on property owned by the Port of Silverdale. Similar to the other options, the new building would have a flat-decked roof with railings to create a public viewing platform; a metal stair case and ADA lift to provide access to the viewing platform; brick wainscoting; and wood siding around the exterior of the building.

PS3 would be accessed directly from the existing parking lot, thus eliminating the need for a paved driveway off Washington Avenue NW. At least one or two parking slots in the parking lot would need to be stripped to prevent parking so that access to the station is maintained at all times. The interface manhole between the Bay Shore Project and the PS3 Upgrades could remain in its currently proposed location.

A significant benefit of this option, similar to Options 2 and 3, is that the new station could be constructed while the existing station remains in service. Some minor temporary bypass pumping may be required while making connections or transferring service to the new pump station, but the risks and costs of these efforts would be greatly reduced. Once the new station is operational, the existing building and associated structures would be demolished. Below ground structures that are no longer needed would be abandoned in place. All disturbed areas would then be restored.

Most of the new building and wet well would be located outside the shoreline buffer. However, the improvements would still require about 200 square feet of buffer mitigation. This could be accomplished as part of the 5,550 square feet of landscaping needed to restore the area where the existing building and its surrounding HMA pavement are located. Another 610 feet of landscaping would be added around the new building for screening and aesthetics, resulting in a total of 6,100 square feet of vegetative restoration. About 800 square feet of new HMA pavement would be required for the new station.

This option would provide the greatest improvement to public access to the beach. In addition, the new building would be more aesthetically pleasing than the existing building and park use would be enhanced by providing a public viewing platform on top of the building. The station would also be located the furthest from the high-water mark of Dyes Inlet, the beach, and an erodible shoreline, providing more space to accommodate berms or other measures to assist in blending the station into the surrounding area and to provide a buffer against rising tide levels. It would also provide the maximum amount of grassed area between the new station and the beach for the Central Kitsap Farmers Market and park activities.

Because this option is located on property owned by the Port of Silverdale, Kitsap County Public Works would have to negotiate a land swap or land acquisition from the Port. The land swap or acquisition process may be challenging as the land was originally purchased with grant funds from the Recreation and Conservation Funding Board. That funding has significant restrictions on the use of the land that would need to be addressed.

Table 1 contains a summary comparison of each Option.

Table 1 – Comparison of Options

CRITERIA	OPTION 1	OPTION 2	OPTION 3	OPTION 4
1. Re-use Existing Facilities versus. Constructing New Facilities	• Existing building is used to house the valves, flow meter, generator, and electrical control panels. • New wet well is located outside the existing building. • Odor control facilities are located in new building addition. • Modifications to the existing building could trigger seismic upgrades to the structure.	• Requires a new building, which would increase project costs. • Demolishing the existing station requires additional restoration costs. • Impervious area associated with new building may trigger storm water detention/water quality improvements if offset for conversion of existing impervious surfaces to pervious surfaces cannot be credited.	• Requires a new building, which would increase project costs. • Demolishing the existing station requires additional restoration costs. • Impervious area associated with new building may trigger storm water detention/water quality improvements if offset for conversion of existing impervious surfaces to pervious surfaces cannot be credited.	• Requires a new building, which would increase project costs. • Demolishing the existing station requires additional restoration costs. • Impervious area associated with new building may trigger storm water detention/water quality improvements if offset for conversion of existing impervious surfaces to pervious surfaces cannot be credited.
2. Impacts to Other Utilities	• New yard piping would be required to connect the new wet well to the existing gravity sewer and force main. • Relocating other utilities would not be necessary to make room for the upgrades.	• New yard piping would be required to connect the new wet well to the existing gravity sewer and force main. • Several utilities (sewer, water, and power) that are located within an existing easement would need to be relocated to accommodate the proposed facilities.	• New yard piping would be required to connect the new wet well to the existing gravity sewer and force main. • Several utilities (sewer, water, and power) that are located within an existing easement would need to be relocated to accommodate the proposed facilities.	• New yard piping would be required to connect the new wet well to the existing gravity sewer and force main. • Relocating other utilities would not be necessary to make room for the upgrades.
3. Bypass Requirements	• A temporary bypass pumping system would be required for the duration of construction resulting in higher construction risks and costs.	• Existing station could remain in service during construction, reducing bypass pumping requirements and lowering construction risks and costs.	• Existing station could remain in service during construction, reducing bypass pumping requirements and lowering construction risks and costs.	• Existing station could remain in service during construction, reducing bypass pumping requirements and lowering construction risks and costs.
4. Land Swap/ Property Acquisition	• A land swap or property acquisition from the Port of Silverdale would not be required. • No mitigation concerning restrictions on the use of property purchased with grant money is anticipated since the land on which the existing station is located has already undergone that process.	• A land swap or property acquisition from the Port of Silverdale would be required. • The subject property may have been purchased by the Port with grant money, which has significant restrictions on the potential use of those lands, which would need to be mitigated.	• A land swap or property acquisition from the Port of Silverdale would not be required for the new station since it would be located within an existing easement. • The property underlying the easement area may have been purchased by the Port with grant money, which has significant restrictions on the potential use of those lands, which would need to be mitigated.	• A land swap or property acquisition from the Port of Silverdale would be required. • The subject property may have been purchased by the Port with grant money, which has significant restrictions on the potential use of those lands, which would need to be mitigated.
5. Environment Issues, Shoreline Buffer Mitigation, and Restoration Requirements	• The existing site is the closest location to the ordinary high-water mark, beach, and an erodible shoreline, resulting in the least amount of space to address rising tidal concerns due to global warming. • Approximately 15 SF of shoreline buffer mitigation will be required. • Approximately 745 SF of landscape screening is anticipated around the existing building. • No change in the total impervious surface area of approximately 4,090 sf is anticipated, resulting in no anticipated storm water mitigation requirements.	• The new station would be located further away from the ordinary high-water mark, beach, and an erodible shoreline, providing more space to address rising tidal concerns due to global warming. • Approximately 1,060 SF of shoreline buffer mitigation will be required. • Approximately 1,050 SF of partial screening and building façade landscaping will be provided around the existing station. • Approximately 470 SF of additional landscaping beyond the shoreline buffer mitigation landscaping will be needed to restore the area disturbed by the removal of the existing station. • The total impervious area will be decreased to about 3,120 sf, which should allow the project to avoid storm water mitigation requirements.	• The new station would be located further away from the ordinary high-water mark, beach, and an erodible shoreline, providing more space to address rising tidal concerns due to global warming. • Approximately 330 SF of shoreline buffer mitigation will be required. • Approximately 550 SF of partial screening and building façade landscaping will be provided around the existing station. • Approximately 1,550 SF of additional landscaping beyond the shoreline buffer mitigation landscaping will be needed to restore the area disturbed by the removal of the existing station. • The total impervious area will be decreased to about 2,200 sf, which should allow the project to avoid storm water mitigation requirements.	• The new station would be located the furthest away from the ordinary high-water mark, beach, and an erodible shoreline, providing the most space to address rising tidal concerns due to global warming. • Approximately 195 SF of shoreline buffer mitigation will be required. • Approximately 610 SF of partial screening and building façade landscaping will be provided around the existing station. • Approximately 4,200 SF of additional landscaping beyond the shoreline buffer mitigation landscaping will be needed to restore the area disturbed by the removal of the existing station. • The total impervious area will be decreased to about 2,000 sf, which should allow the project to avoid storm water mitigation requirements.
6. Impacts to Public Use	• Remodeling the existing building to provide a viewing platform will enhance the beneficial use of the station. • The pump station would remain intrusive with respect to the public's perception of having a sanitary sewer pump station in a public park. • The pump station's proximity to the existing rock berm provides limited or no pedestrian access between the station and the beach during high tides. • The grassy area between the existing pump station and parking lot could continue to be used for the weekly Central Kitsap Farmers Market and other park uses.	• The new building would be constructed with a public viewing platform that will enhance the beneficial use of the station. • Locating the station further from the beach would provide better public access between the pump station and the existing rock berm, especially during high tides. • Setting the station further away from the beach and screening the area between the new station and the beach with landscaping may improve the visual quality of shoreline. • This location could potentially impact the ability of the Central Kitsap Farmers Market to use the area.	• The new building would be constructed with a public viewing platform that will enhance the beneficial use of the station. • Locating the station further from the beach would provide better public access between the pump station and the existing rock berm, especially during high tides. • Setting the station further away from the beach and screening the area between the new station and the beach with landscaping may improve the visual quality of shoreline. • This location could potentially impact the ability of the Central Kitsap Farmers Market to use the area.	• The new building would be constructed with a public viewing platform that will enhance the beneficial use of the station. • Provides the best pedestrian access to the beach by locating the station the furthest from the beach, especially during high tides. • Setting the station further away from the beach and screening the area between the new station and the beach with landscaping may improve the visual quality of shoreline. • The area between the new station and the beach could be used by the Central Kitsap Farmers Market and other park users, but that area would be more disconnected from the parking lot. • Accessing the new station from the parking lot would require the elimination of one or two parking spots.
7. Impacts to Bay Shore Project	• No modifications to the paved driveway being constructed under the Bay Shore Project would be required. • No modifications to the sanitary sewer system being installed under the Bay Shore Project would be required.	• Might require modifications to the paved driveway being constructed under the Bay Shore Project. • Would require the relocation of a sanitary sewer manhole being installed under the Bay Shore Project.	• Might require modifications to the paved driveway being constructed under the Bay Shore Project. • No modifications to the sanitary sewer system being installed under the Bay Shore Project would be required.	• If access to the new station is provided from the parking lot, then the access driveway being constructed under the Bay Shore Project could be eliminated. • No modifications to the sanitary sewer system being installed under the Bay Shore Project would be required.

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Cost Comparison

Costs were developed to assist in comparing and evaluating the four options. These costs focused on items that varied between each option. Costs such as those related to constructing the new wet well, purchasing and installing the new pumps, pipes, valves, generator, control and telemetry panels, and the odor control facilities (except the structure) were excluded from the analysis as those costs are anticipated to be same for all options. Table 2 summarizes the variable costs for each option.

Table 2 – Cost Comparison of Each Option

Item[1]	Option 1	Option 2	Option 3	Option 4
Demolition[2]	$15,000.00	$15,500.00	$19,000.00	$15,500.00
Temporary Bypass Pumping[3]	$223,000.00	$0.00	$127,000.00	$0.00
Building Upgrades[4]	$303,000.00	$332,000.00	$332,000.00	$332,000.00
Utility Relocation/New Utilities	$26,000.00	$39,000.00	$32,000.00	$30,000.00
Restoration				
Shoreline Mitigation[5]	$500.00	$33,300.00	$10,300.00	$6,300.00
Aesthetic Landscaping[6]	$23,300.00	$47,500.00	$50,400.00	$186,000.00
HMA	$4,270.83	$5,694.44	$3,843.75	$2,277.78
CSTB under HMA	$1,055.56	$1,407.41	$950.00	$562.96
Total	**$596,000.00**	**$473,000.00**	**$575,000.00**	**$573,000.00**

Notes:

1. Costs are for comparative purposes between options and do not capture all costs related to construction. Common costs such as the construction of the new pump station (installation of the new wet well, pumps, pump station pipes and valves, control panels, generator, etc.), removal of the existing diesel tank, and other costs that would be similar under all options are ignored.
2. Demolition includes demolition, haul, and disposal of: existing concrete pads outside the existing building, HMA pavement, chain link fencing, bollards, and the existing concrete wall. Abandonment of the existing wet well, and dry well will be required for all options, so the associated costs would be similar for all options and are therefore ignored for comparison purposes.
3. Temporary bypass pumping costs are the costs that will be incurred while constructing the new pump station. Minor bypass pumping costs required to make connections to the existing system are ignored as those costs would be similar for all options.
4. Building upgrades include all costs associated with demolition of the existing building and/or its roof, depending on the option. These costs also include all costs associated with constructing the new building or the additional room off the existing building for the odor control facilities.
5. Landscaping costs associated with mitigation address the restoration costs required to replace existing permanent vegetation within the shoreline buffer area that is disturbed by construction.
6. Aesthetic landscaping costs include: plant material, soil preparation, topsoil, bark mulch, irrigation, and earthwork berms associated with landscape and building facade screening.
7. All options assume all improvements will occur upland of the existing riprap wall and hence no shoreline armoring, restoration, or beach modification are not included.
8. Costs associated with land swap or property acquisition are not included as these costs may be complicated by the grant funding restrictions and the associated level of effort is unknown.

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FIGURES

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NOTES:

1. THE PROPOSED PUMP STATION 3 (PS3) OPTION 1 LAYOUT IS PRELIMINARY AND MAY CHANGE DURING DETAILED DESIGN PHASE.
2. THE SOURCE OF THE PROPOSED FEATURES FOR THE FUTURE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT IS RH2 ENGINEERING, INC. (MARCH 2018).
3. A NEW PAVED DRIVEWAY WILL BE CONSTRUCTED AND NEW GRAVITY SEWER AND SANITARY SEWER MANHOLE WILL BE INSTALLED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT.
4. PRELIMINARY LAYOUT ASSUMES THE VALVES/GENERATOR/ELECTRICAL CONTROL EQUIPMENT IS LOCATED WITHIN THE EXISTING BUILDING. ODOR CONTROL FACILITIES WILL BE HOUSED IN A NEW ROOM
5. PRELIMINARY LAYOUT ASSUMES THE WET WELL IS LOCATED UNDERGROUND OUTSIDE THE EXISTING BUILDING.
6. PRELIMINARY LAYOUT ASSUMES WET WELL HATCHES TO BE LOCATED IN AREA OF EXISTING ASPHALT RESULTING IN NO LOSS OF PERMANENT VEGETATION.
7. PRELIMINARY LAYOUT RESULTS IN APPROXIMATELY: 13 SF OF MITIGATION (AREA OF GRASS/LAWN IMPACTED); AND 745 SF OF NEW PARTIAL LANDSCAPE SCREENING AND BUILDING FACADE LANDSCAPE.

LEGEND:

- PROPOSED PS3 OPTION 1
- WET WELL (NO ABOVE GRADE BUILDING)
- BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT PROPOSED FEATURES
- EXISTING UTILITY EASEMENT
- EXISTING ASPHALT
- EXISTING VEGETATION
- LANDSCAPE SCREENING/ BUILDING FACADE LANDSCAPE

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Option 1 - PS3
Locate at Existing Site
Pump Station 3, 4, 19 and 31 Upgrades
September 2018

Figure
1

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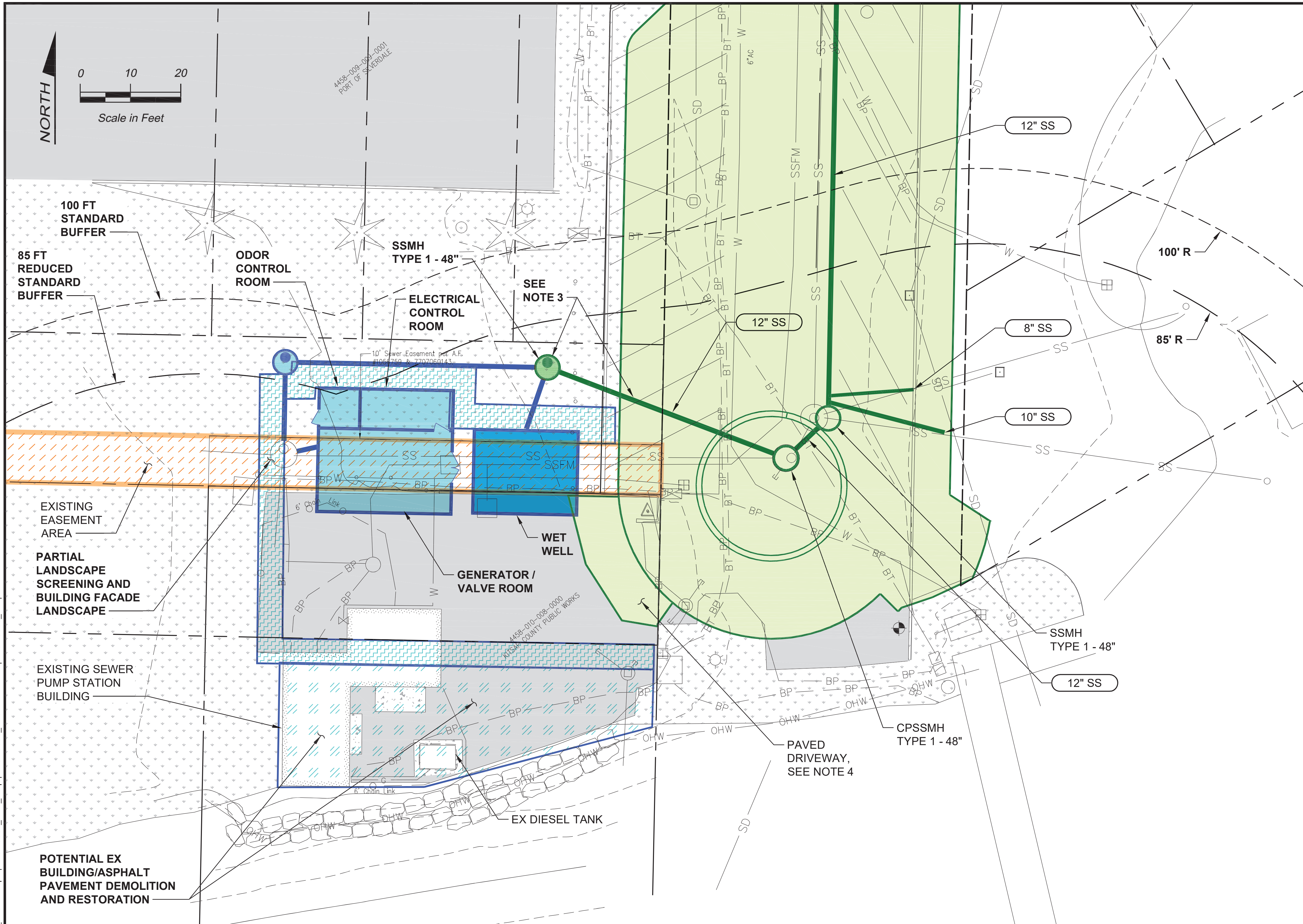

NOTES:

1. THE PROPOSED PUMP STATION 3 (PS3) OPTION 2 LAYOUT IS PRELIMINARY AND MAY CHANGE DURING DETAILED DESIGN PHASE.
2. THE SOURCE OF THE PROPOSED FEATURES FOR THE FUTURE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT IS RH2 ENGINEERING, INC. (MARCH 2018).
3. OPTION 2 WOULD REQUIRE RELOCATION OF THE NEW SANITARY SEWER MANHOLE AND RE-ALIGNMENT OF THE NEW GRAVITY SEWER TO BE INSTALLED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
4. OPTION 2 WOULD LIKELY REQUIRE MODIFICATION OF THE PROPOSED PAVED DRIVEWAY TO BE CONSTRUCTED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
5. PRELIMINARY LAYOUT ASSUMES THE VALVES/GENERATOR/ELECTRICAL CONTROL/ODOR CONTROL EQUIPMENT ARE LOCATED IN A NEW BUILDING IN AN AREA OF EXISTING PERMANENT VEGETATION (APPROXIMATELY 1,040 SF) THAT WILL REQUIRE MITIGATION.
6. PRELIMINARY LAYOUT RESULTS IN APPROXIMATELY: 1,065 SF OF MITIGATION (AREA OF GRASS/LAWN IMPACTED); 1,055 SF OF NEW PARTIAL LANDSCAPE SCREENING AND BUILDING FACADE LANDSCAPE; AND 1,525 SF OF POTENTIAL EXISTING BUILDING/ASPHALT PAVEMENT DEMOLITION AND RESTORATION.

LEGEND:

- PROPOSED PS3 OPTION 1
- WET WELL (NO ABOVE GRADE BUILDING)
- BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT PROPOSED FEATURES
- EXISTING UTILITY EASEMENT
- EXISTING ASPHALT
- EXISTING VEGETATION
- LANDSCAPE SCREENING/ BUILDING FACADE LANDSCAPE

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KITSAP COUNTY WASHINGTON 18 57

Option 2 - PS3
Locate North of Existing Site
Pump Station 3, 4, 19 and 31 Upgrades
September 2018

Figure
2

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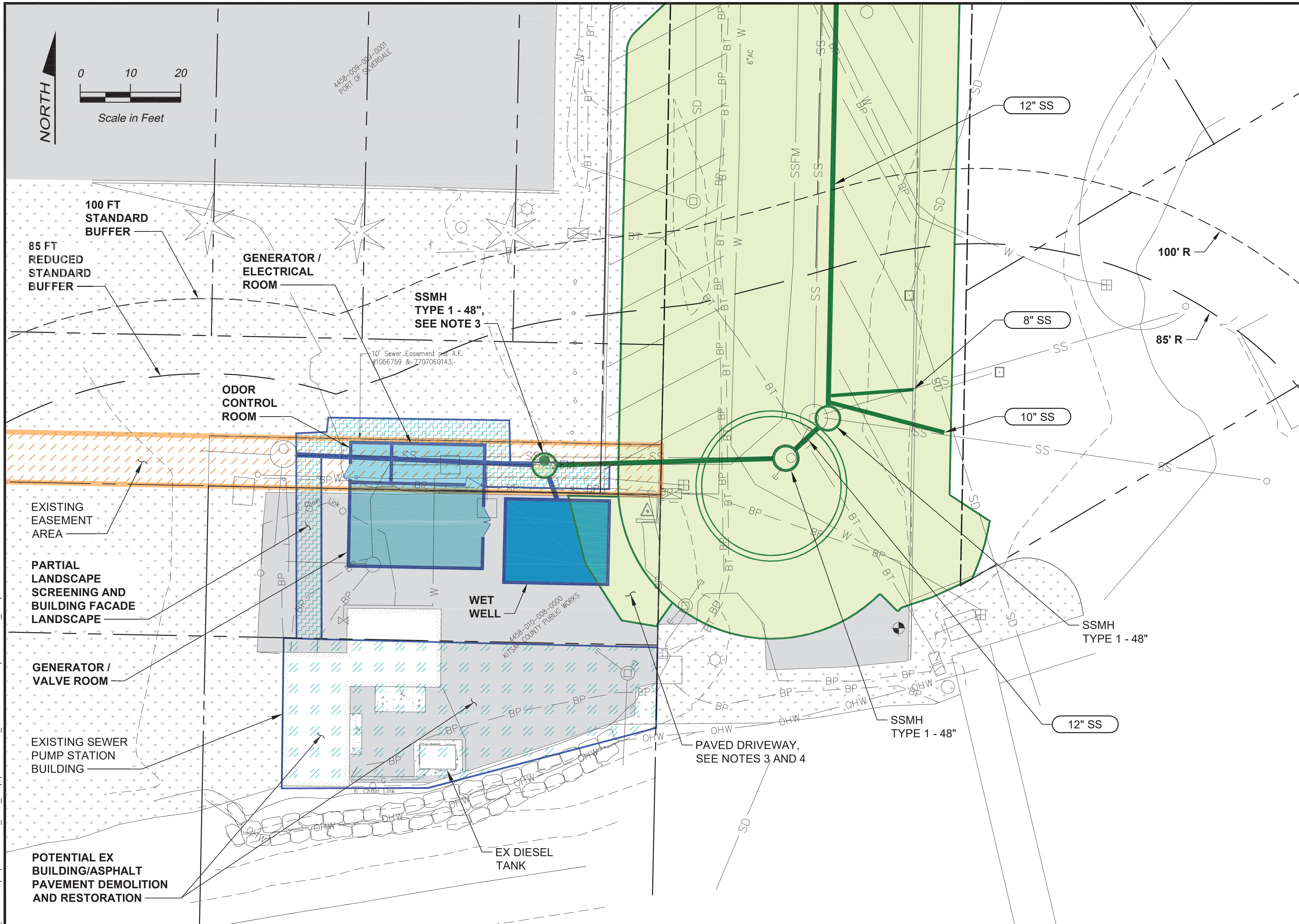


NOTES:

1. THE PROPOSED PUMP STATION 3 (PS3) OPTION 3 LAYOUT IS PRELIMINARY AND MAY CHANGE DURING DETAILED DESIGN PHASE.
2. THE SOURCE OF THE PROPOSED FEATURES FOR THE FUTURE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT IS RH2 ENGINEERING, INC. (MARCH 2018).
3. OPTION 3 WOULD REQUIRE RELOCATION OF THE NEW SANITARY SEWER MANHOLE AND RE-ALIGNMENT OF THE NEW GRAVITY SEWER TO BE INSTALLED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
4. OPTION 3 WOULD LIKELY REQUIRE MODIFICATION OF THE PROPOSED PAVED DRIVEWAY TO BE CONSTRUCTED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
5. PRELIMINARY LAYOUT ASSUMES THE VALVES/GENERATOR/ELECTRICAL CONTROL/ODOR CONTROL EQUIPMENT ARE LOCATED WITHIN A NEW BUILDING IN AN AREA OF EXISTING PERMANENT VEGETATION (APPROXIMATELY 315 SF) THAT WILL REQUIRE MITIGATION.
6. PRELIMINARY LAYOUT RESULTS IN APPROXIMATELY: 330 SF OF MITIGATION (AREA OF GRASS/LAWN IMPACTED); 550 SF OF NEW PARTIAL LANDSCAPE SCREENING AND BUILDING FACADE LANDSCAPE; AND 1,885 SF OF POTENTIAL EXISTING BUILDING/ASPHALT PAVEMENT DEMOLITION AND RESTORATION.

LEGEND:

- PROPOSED PS3 OPTION 1
- WET WELL (NO ABOVE GRADE BUILDING)
- BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT PROPOSED FEATURES
- EXISTING UTILITY EASEMENT
- EXISTING ASPHALT
- EXISTING VEGETATION
- LANDSCAPE SCREENING/ BUILDING FACADE LANDSCAPE

DRAFT
09-2018

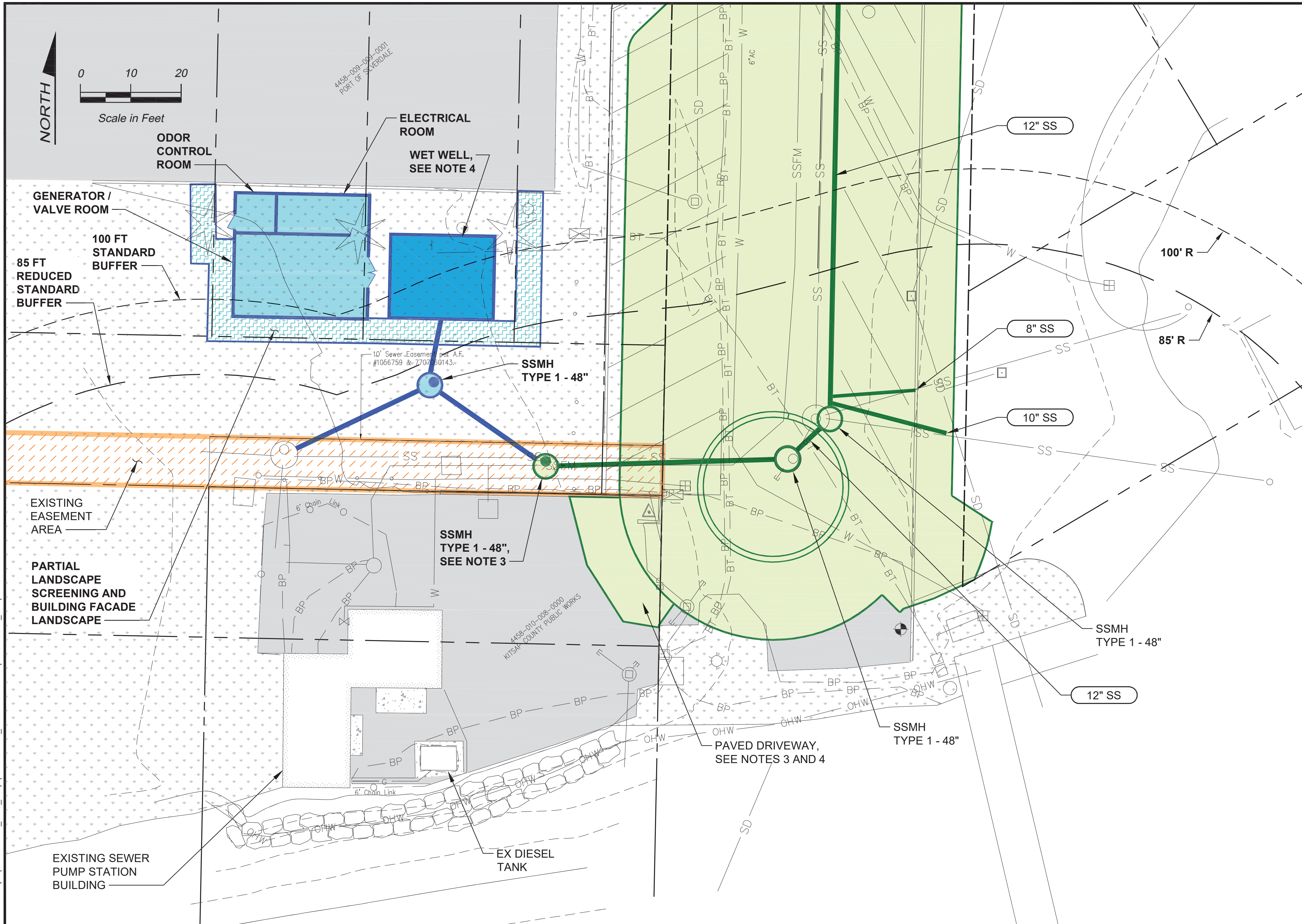
Path: S:\Cad\Kitsap County\18-10530 PS-3-4-19-31\tech memo\d Filename: F18-10530_PS3 Fig_03 Plot date: Sep 20, 2018-09:54:00am CAD User: acariaso.
Xref Filename: | X18-10530_PS3 Ex Topo | X18-10530_RH2_Prop | X18-10530_PS3 Ex Hatches | X18-10530_LAI |

BHC CONSULTANTS

KITSAP COUNTY 18 57 WASHINGTON

Option 3 - Upgrade PS3 Within Existing Easement
Pump Station 3, 4, 19 and 31 Upgrades
September 2018

Figure
3



NOTES:

1. THE PROPOSED PUMP STATION 3 (PS3) OPTION 4 LAYOUT IS PRELIMINARY AND MAY CHANGE DURING DETAILED DESIGN PHASE.
2. THE SOURCE OF THE PROPOSED FEATURES FOR THE FUTURE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT IS RH2 ENGINEERING, INC. (MARCH 2018).
3. OPTION 4 WOULD REQUIRE RELOCATION OF THE NEW SANITARY SEWER MANHOLE AND RE-ALIGNMENT OF THE NEW GRAVITY SEWER TO BE INSTALLED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
4. OPTION 4 WOULD LIKELY REQUIRE MODIFICATION OF THE PROPOSED PAVED DRIVEWAY TO BE CONSTRUCTED AS PART OF THE BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT DESIGN.
5. PRELIMINARY LAYOUT ASSUMES THE VALVES/GENERATOR/ELECTRICAL CONTROL/ODOR CONTROL EQUIPMENT ARE LOCATED IN A NEW BUILDING IN AN AREA OF EXISTING PERMANENT VEGETATION (APPROXIMATELY 200 SF) THAT WILL REQUIRE MITIGATION.
6. PRELIMINARY LAYOUT RESULTS IN APPROXIMATELY: 200 SF OF MITIGATION (AREA OF GRASS/LAWN IMPACTED); AND 610 SF OF NEW PARTIAL LANDSCAPE SCREENING AND BUILDING FACADE LANDSCAPE.

LEGEND:

- PROPOSED PS3 OPTION 1
- WET WELL (NO ABOVE GRADE BUILDING)
- BAY SHORE & WASHINGTON IMPROVEMENTS PROJECT PROPOSED FEATURES
- EXISTING UTILITY EASEMENT
- EXISTING ASPHALT
- EXISTING VEGETATION
- LANDSCAPE SCREENING/ BUILDING FACADE LANDSCAPE

DRAFT
09-2018

BHC CONSULTANTS

Option 4 - Upgrade PS3 Adjacent to the Parking Lot

Pump Station 3, 4, 19 and 31 Upgrades
September 2018

Figure 4

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APPENDIX F

FLYGT PUMP DATA

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PUMP STATION 3
MANUFACTURER DATA

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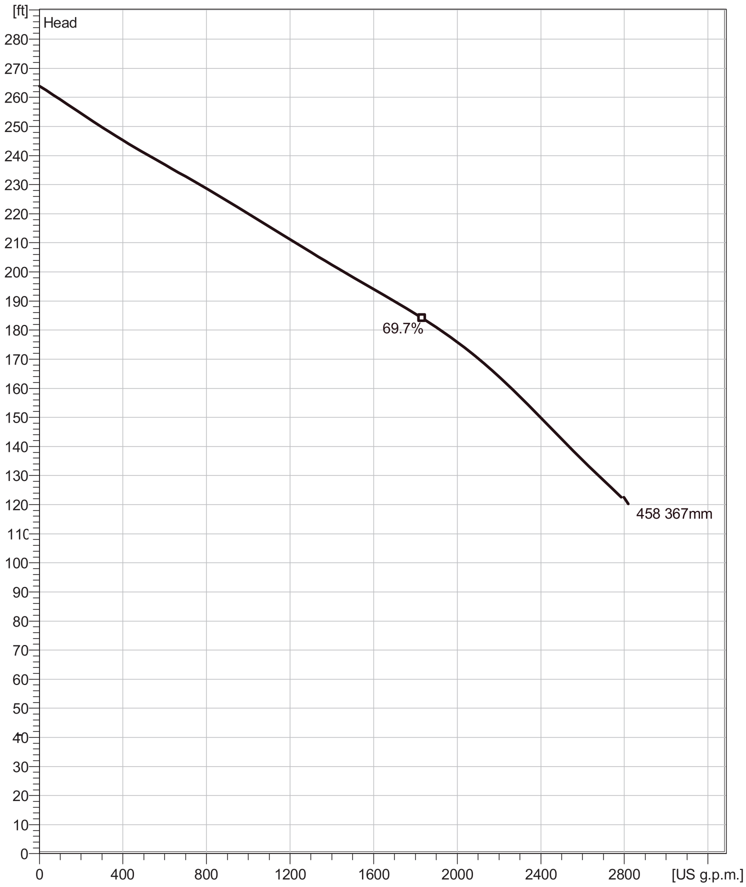
Pump Station 3

NP 3315 HT 3~ 458

Technical specification



Water, pure *Curve ISO*

Note: Picture might not correspond to the current configuration.

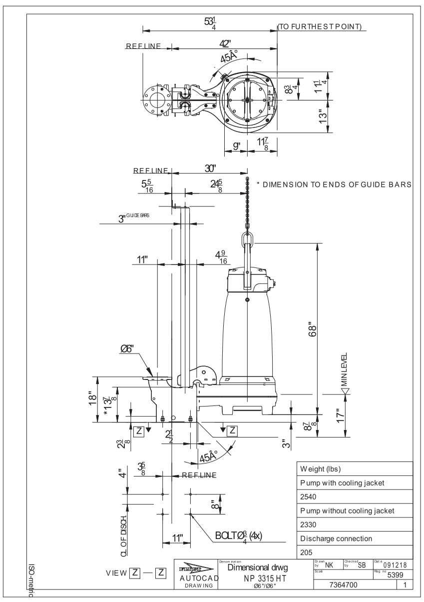
General

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

Impeller

Impeller material	Hard-Iron ™
Discharge Flange Diameter	5 7/8 inch
Suction Flange Diameter	5 7/8 inch
Impeller diameter	367 mm
Number of blades	3

Installation: P - Semi permanent, Wet



Motor

Motor #	N3315.095 35-45-4AA-W 160hp FM
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	160 hp
Rated current	190 A
Starting current	1120 A
Rated speed	1780 rpm
Power factor	
1/1 Load	0.83
3/4 Load	0.78
1/2 Load	0.68
Motor efficiency	
1/1 Load	94.7 %
3/4 Load	95.4 %
1/2 Load	95.6 %

Configuration

Project	Project ID	Created by	Created on	Last update
			10/30/2018	

Pump Station 3

NP 3315 HT 3~ 458

Performance curve

Pump

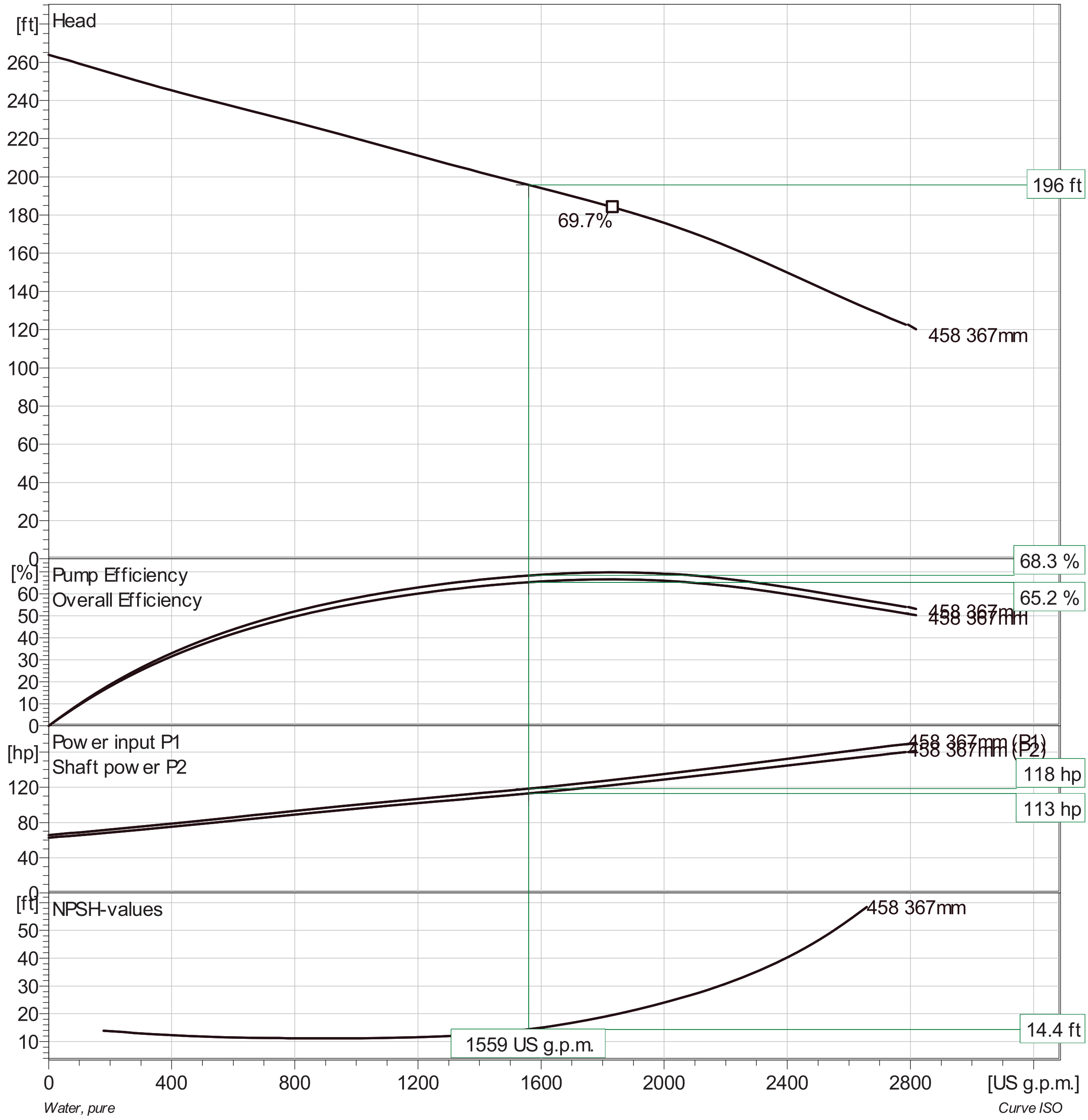
Discharge Flange Diameter	5 7/8 inch
Suction Flange Diameter	150 mm
Impeller diameter	14 7/16"
Number of blades	3

Motor

Motor #	N3315.095 35-45-4AA-W 160hp
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	160 hp
Rated current	190 A
Starting current	1120 A
Rated speed	1780 rpm

Power factor	
1/1 Load	0.83
3/4 Load	0.78
1/2 Load	0.68

Motor efficiency	
1/1 Load	94.7 %
3/4 Load	95.4 %
1/2 Load	95.6 %

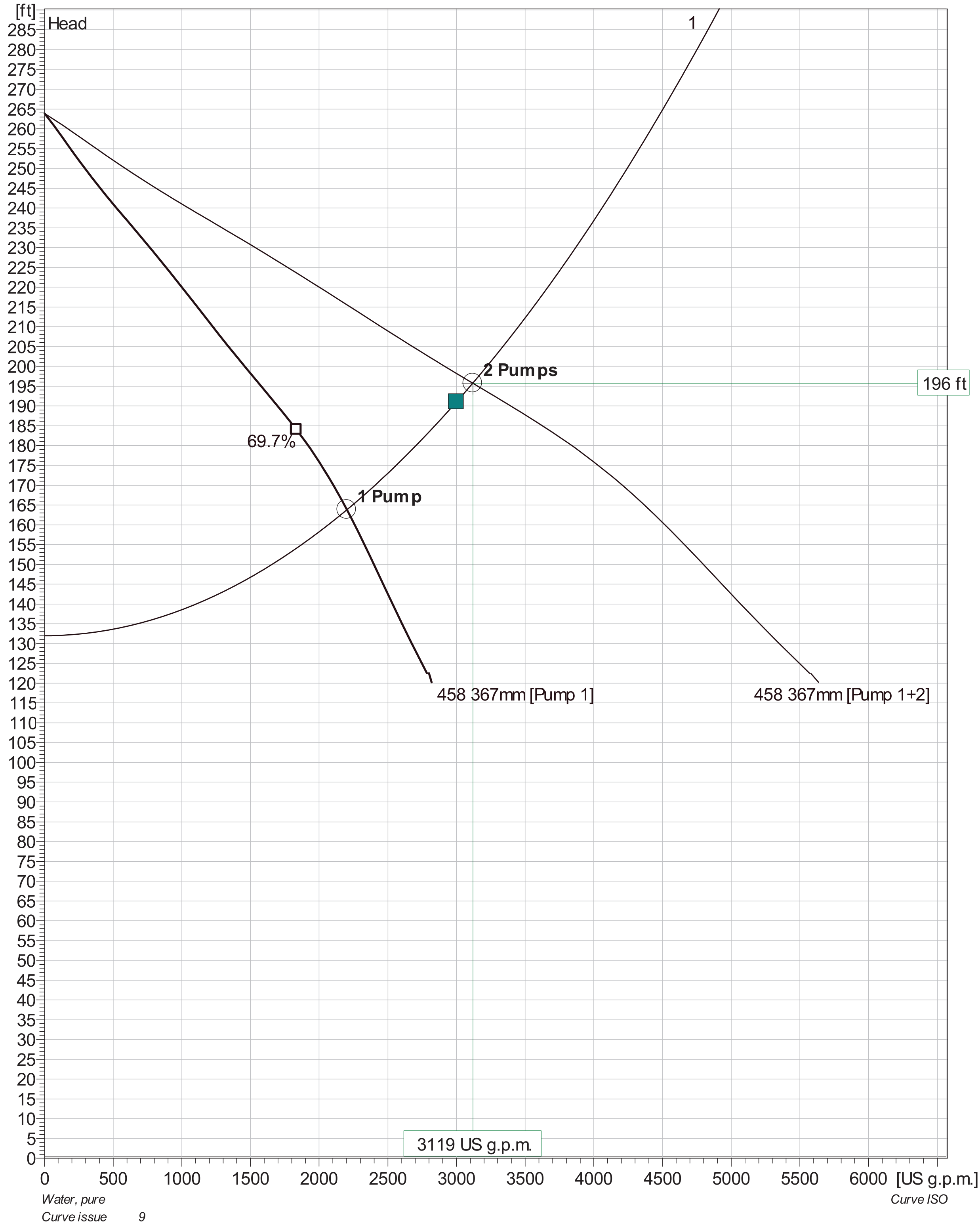


Project	Project ID	Created by	Created on	Last update
			10/30/2018	

NP 3315 HT 3~ 458

Duty Analysis

FLYGT



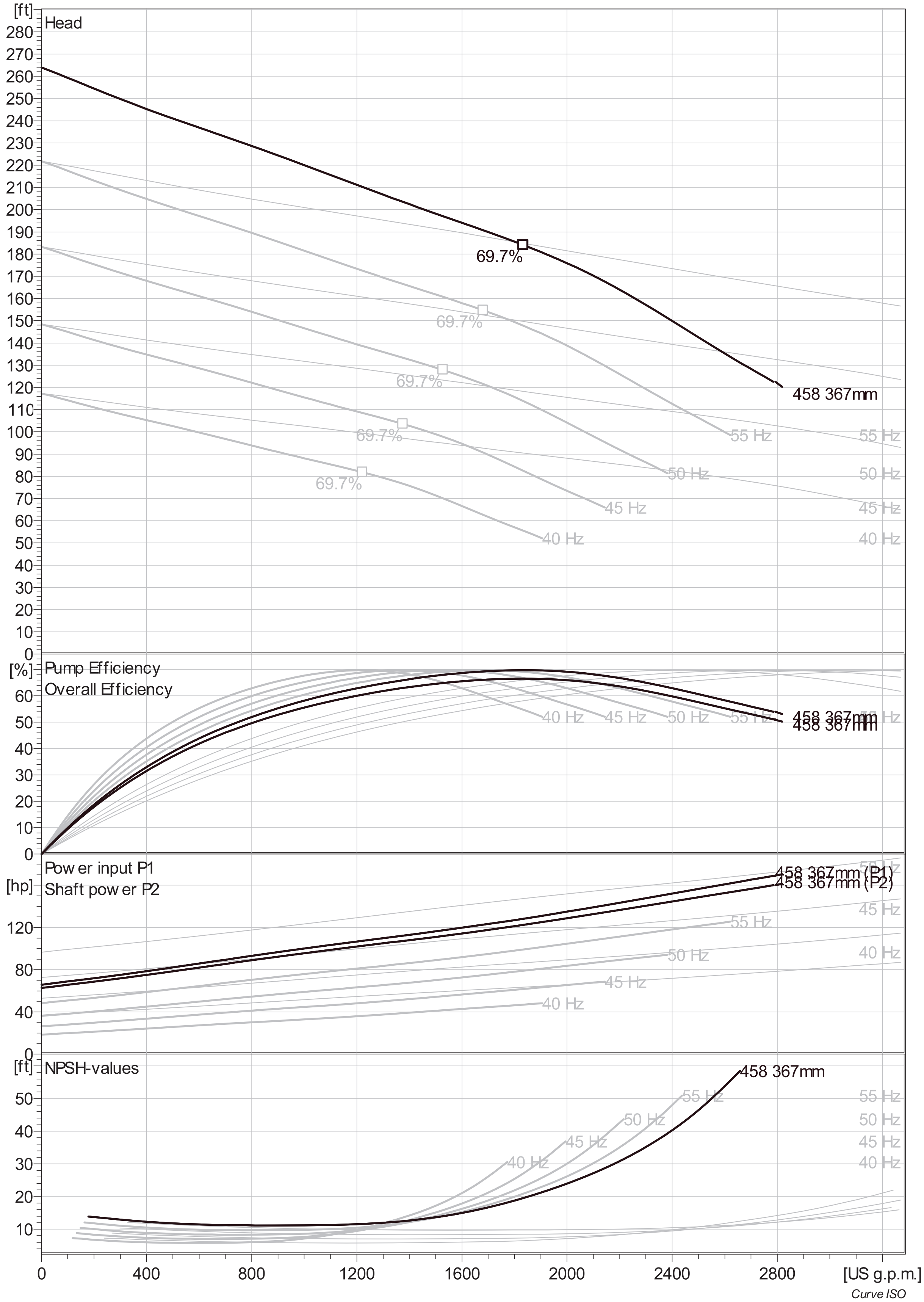
	Individual pump			Total					
Pumps running /System	Flow	Head	Shaft power	Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
2 / 1	1560 US g.p.m.	196 ft	113 hp	3120 US g.p.m.	196 ft	226 hp	68.3 %	944 kWh/US MG	14.4 ft
1 / 1	2200 US g.p.m.	164 ft	137 hp	2200 US g.p.m.	164 ft	137 hp	66.8 %	810 kWh/US MG	30.9 ft

Project	Project ID	Created by	Created on	Last update
			10/30/2018	

Pump Station 3

NP 3315 HT 3~ 458

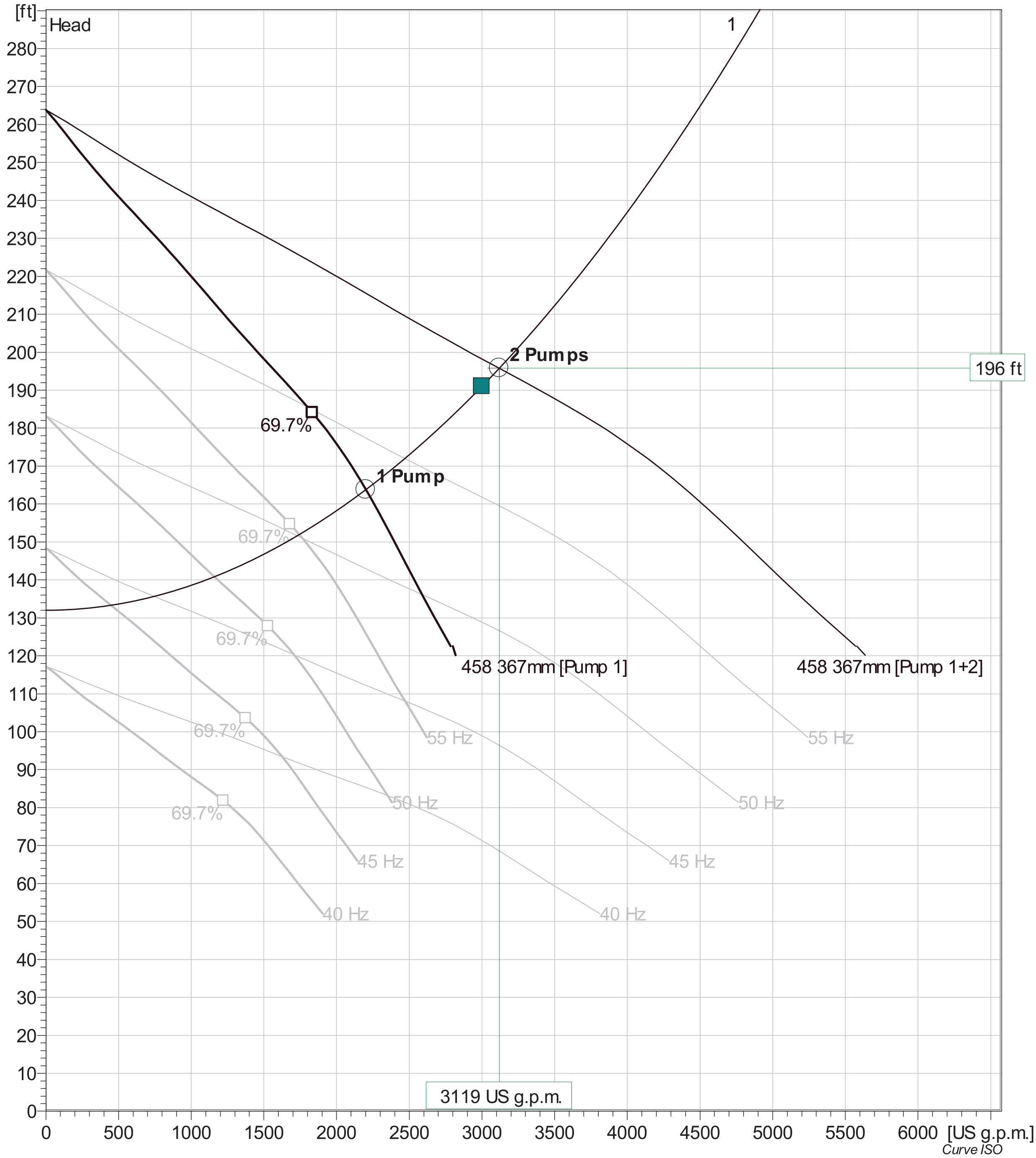
VFD Curve



Project	Project ID	Created by	Created on	Last update
			10/30/2018	

NP 3315 HT 3~ 458
VFD Analysis

Pump Station 3



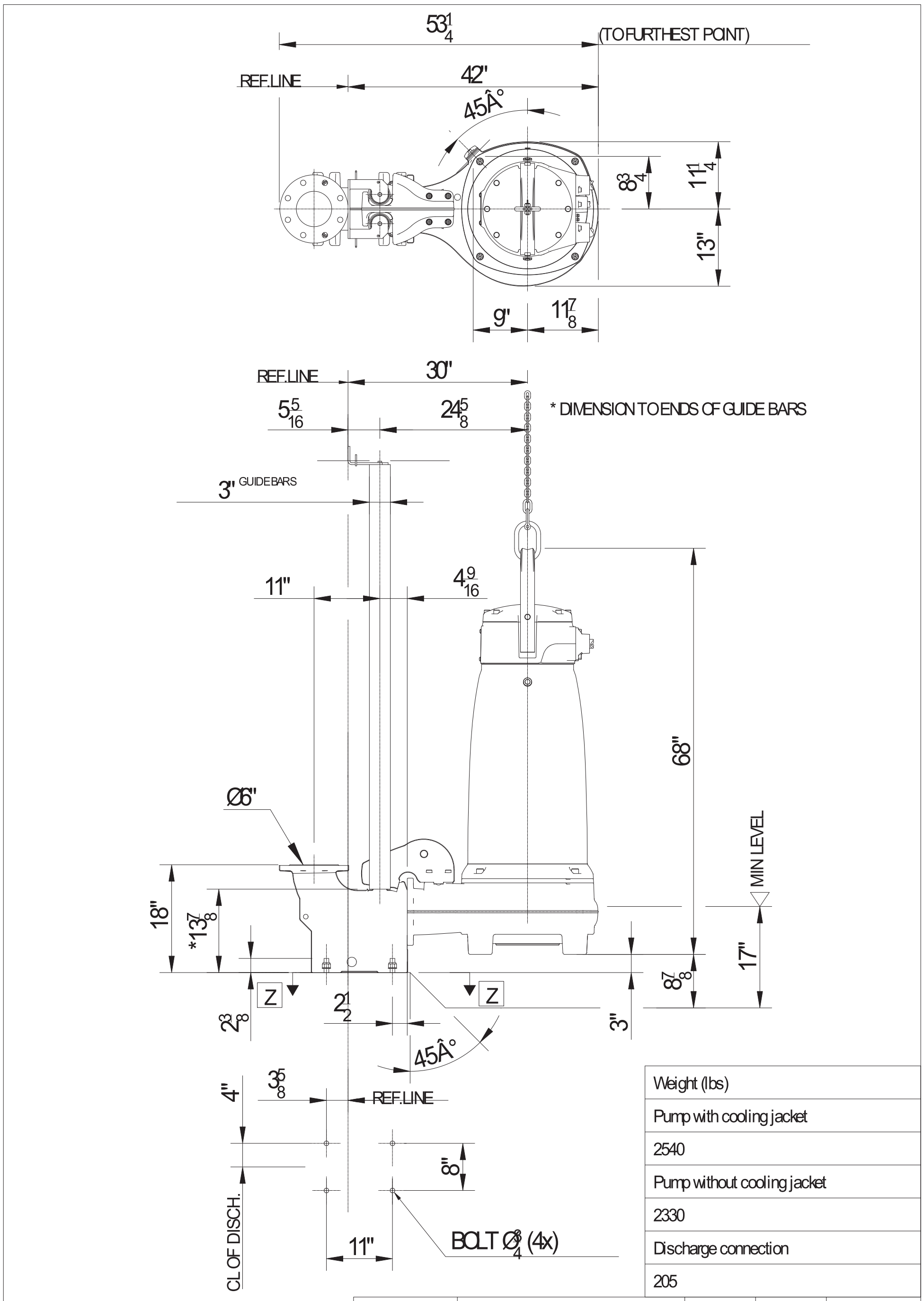
Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
2 / 1	60 Hz	1560 US g.p.m.	196 ft	113 hp	3120 US g.p.m.	196 ft	226 hp	68.3 %	944 kWh/US MG	14.4 ft
2 / 1	55 Hz	1240 US g.p.m.	172 ft	82 hp	2470 US g.p.m.	172 ft	164 hp	65.5 %	864 kWh/US MG	10.7 ft
2 / 1	50 Hz	865 US g.p.m.	152 ft	56.1 hp	1730 US g.p.m.	152 ft	112 hp	59.2 %	845 kWh/US MG	8.38 ft
2 / 1	45 Hz	373 US g.p.m.	136 ft	33.1 hp	745 US g.p.m.	136 ft	66.2 hp	38.6 %	1180 kWh/US MG	7.45 ft
2 / 1	40 Hz									
1 / 1	60 Hz	2200 US g.p.m.	164 ft	137 hp	2200 US g.p.m.	164 ft	137 hp	66.8 %	810 kWh/US MG	30.9 ft
1 / 1	55 Hz	1740 US g.p.m.	152 ft	96.3 hp	1740 US g.p.m.	152 ft	96.3 hp	69.6 %	718 kWh/US MG	18.5 ft
1 / 1	50 Hz	1160 US g.p.m.	141 ft	62.4 hp	1160 US g.p.m.	141 ft	62.4 hp	66.2 %	701 kWh/US MG	9.4 ft
1 / 1	45 Hz	448 US g.p.m.	133 ft	34.6 hp	448 US g.p.m.	133 ft	34.6 hp	43.7 %	1020 kWh/US MG	7.24 ft
1 / 1	40 Hz									

Project	Project ID	Created by	Created on	Last update
			10/30/2018	

NP 3315 HT 3~ 458

Dimensional drawing

FLYGT



Weight (lbs)
Pump with cooling jacket
2540
Pump without cooling jacket
2330
Discharge connection
205

FLYGT AUTOCAD DRAWING	Denomination: Dimensional drwg NP 3315 HT Ø6"/Ø6"	Drawn by NK	Checked by SB	Date 091218
		Scale		Reg no 5399
		7364700		1

Project	Project ID	Created by	Created on	Last update
			10/30/2018	

PUMP STATION 4
MANUFACTURER DATA

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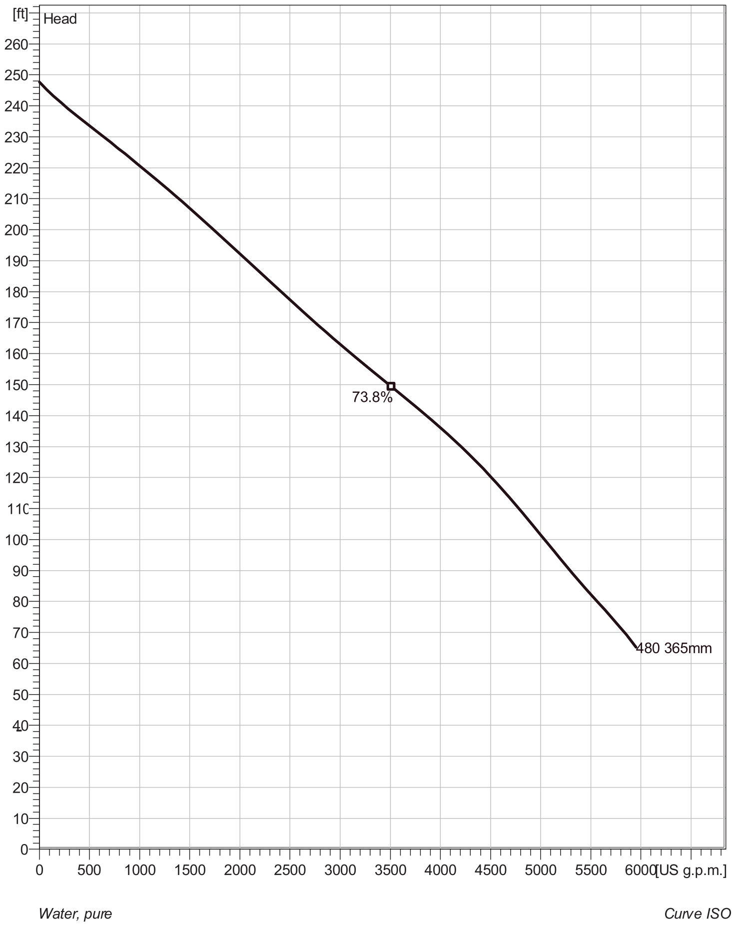
NP 3231/745 3~ 480

Technical specification



Note: Picture might not correspond to the current configuration.

General
Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Modular based design with high adaptation grade.

Impeller

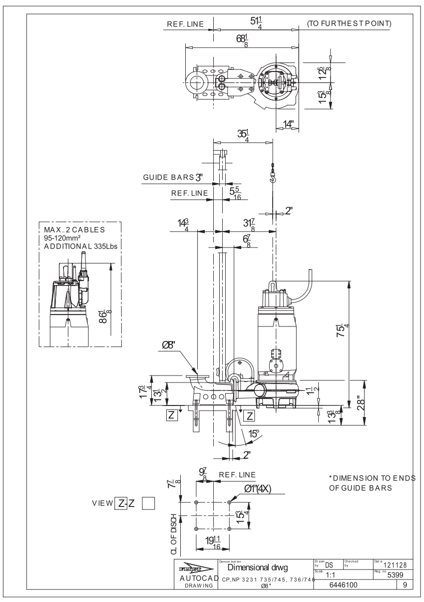
Impeller material	Hard-Iron ™
Discharge Flange Diameter	7 7/8 inch
Suction Flange Diameter	9 13/16 inch
Impeller diameter	365 mm
Number of blades	3

Motor

Motor #	N0745.000 43-44-4AA-W 250hp FM
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	250 hp
Rated current	284 A
Starting current	2030 A
Rated speed	1780 rpm
Power factor	
1/1 Load	0.88
3/4 Load	0.84
1/2 Load	0.76
Motor efficiency	
1/1 Load	93.5 %
3/4 Load	94.0 %
1/2 Load	93.0 %

Configuration

Installation: P - Semi permanent, Wet



Project	Project ID	Created by	Created on	Last update
			10/31/2018	

Pump Station 4

NP 3231/745 3~ 480

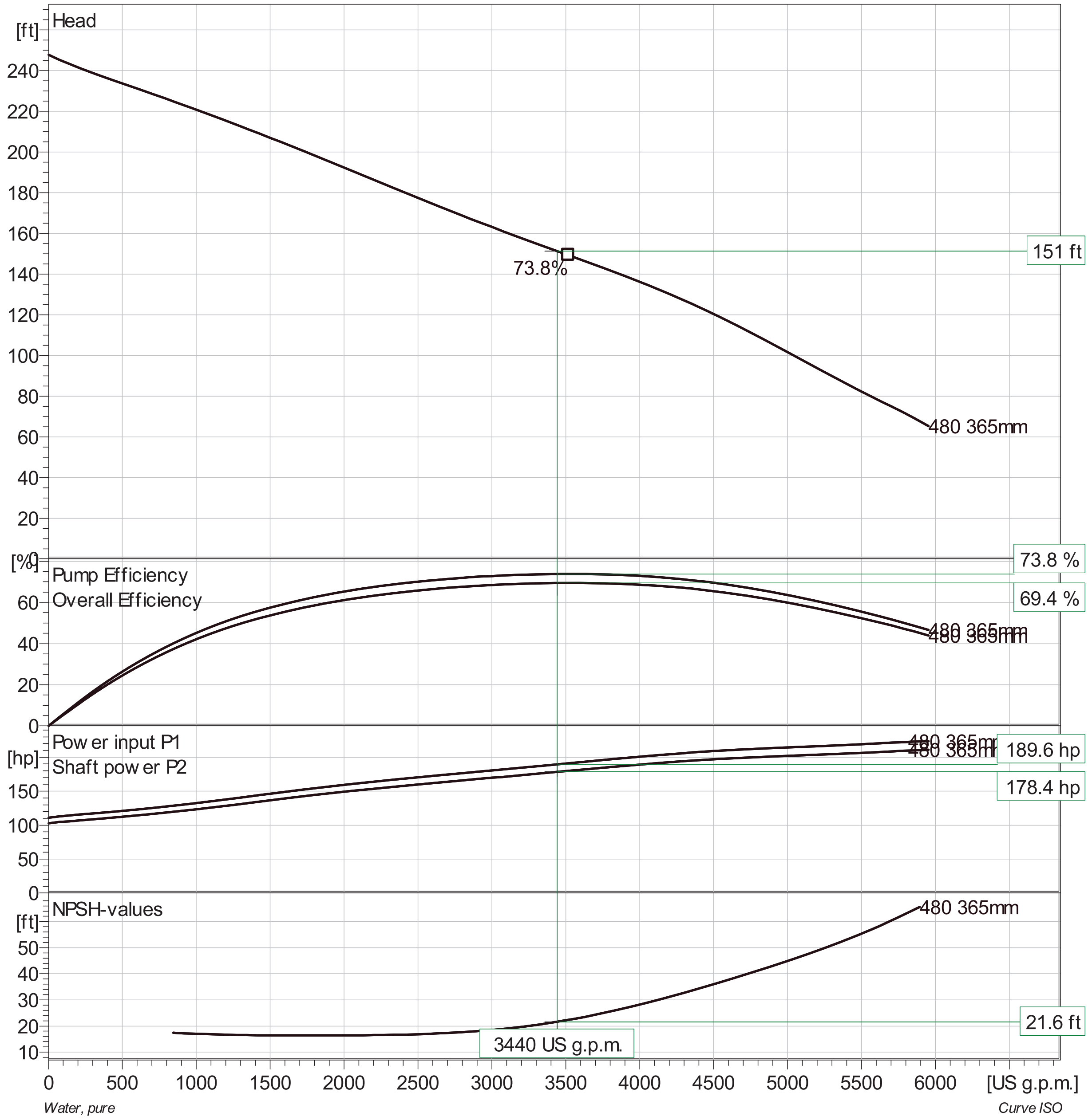
Performance curve

Pump	
Discharge Flange Diameter	7 7/8 inch
Suction Flange Diameter	250 mm
Impeller diameter	14 3/8"
Number of blades	3

Motor	
Motor #	N0745.000 43-44-4AA-W 250hp
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	250 hp
Rated current	284 A
Starting current	2030 A
Rated speed	1780 rpm

Power factor	
1/1 Load	0.88
3/4 Load	0.84
1/2 Load	0.76

Motor efficiency	
1/1 Load	93.5 %
3/4 Load	94.0 %
1/2 Load	93.0 %

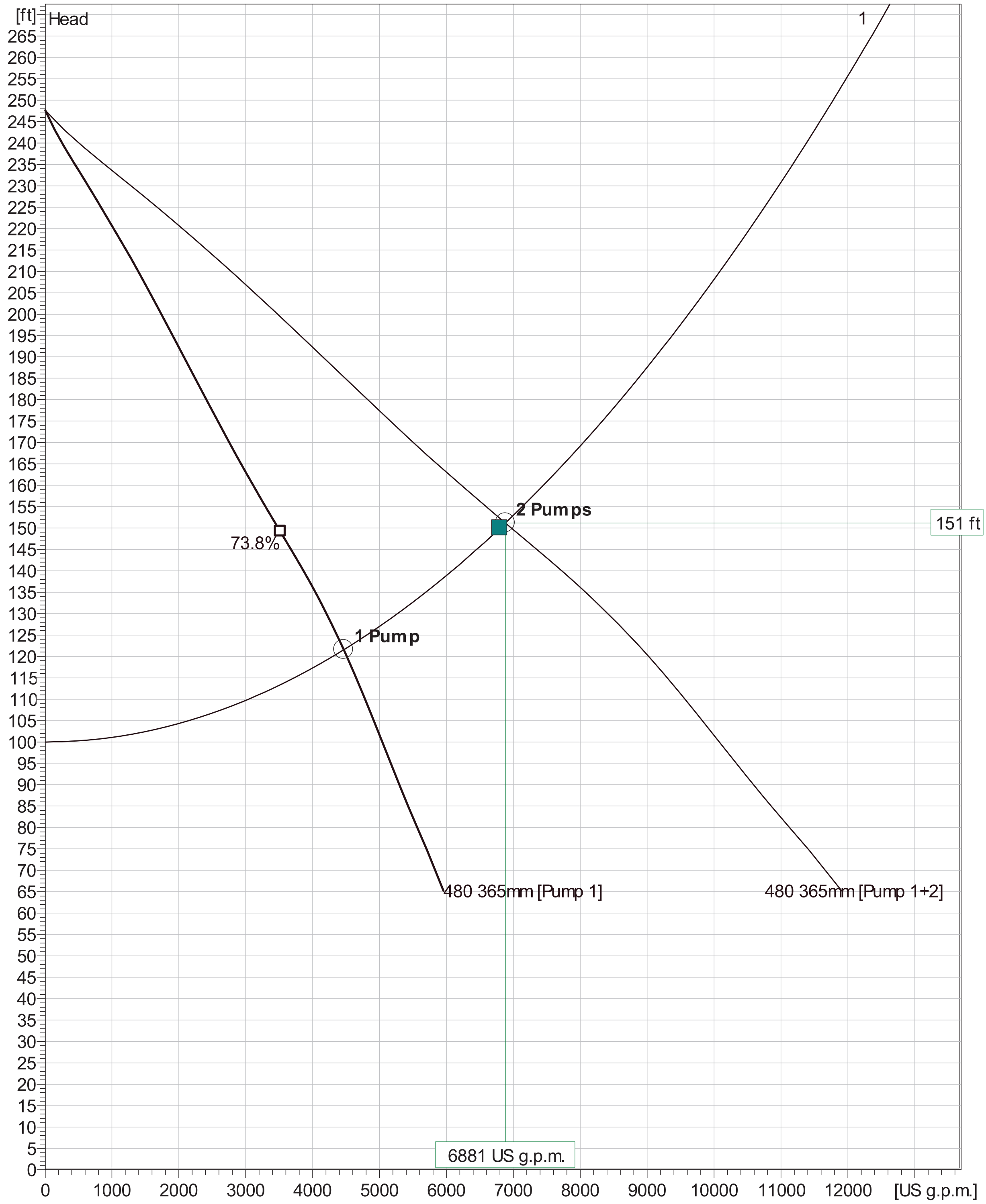


Project	Project ID	Created by	Created on	Last update
			10/31/2018	

Pump Station 4

NP 3231/745 3~ 480

Duty Analysis



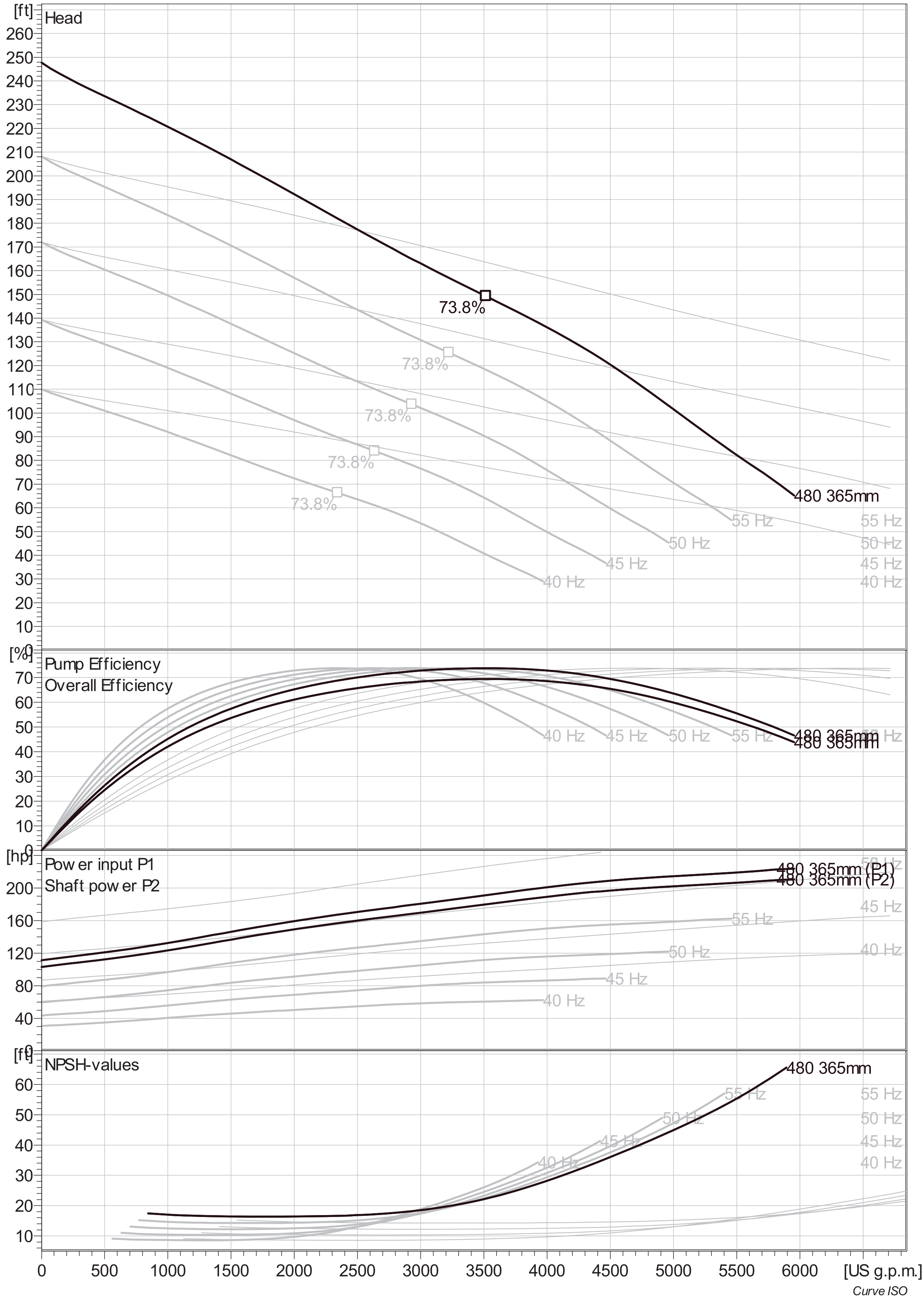
Pumps running /System	Individual pump Flow	Head	Shaft power	Total Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
2 / 1	3440 US g.p.m.	151 ft	178 hp	6880 US g.p.m.	151 ft	357 hp	73.8 %	685 kWh/US MG	21.6 ft
1 / 1	4460 US g.p.m.	122 ft	197 hp	4460 US g.p.m.	122 ft	197 hp	69.8 %	581 kWh/US MG	35.4 ft

Project	Project ID	Created by	Created on	Last update
			10/31/2018	

Pump Station 4

NP 3231/745 3~ 480

VFD Curve

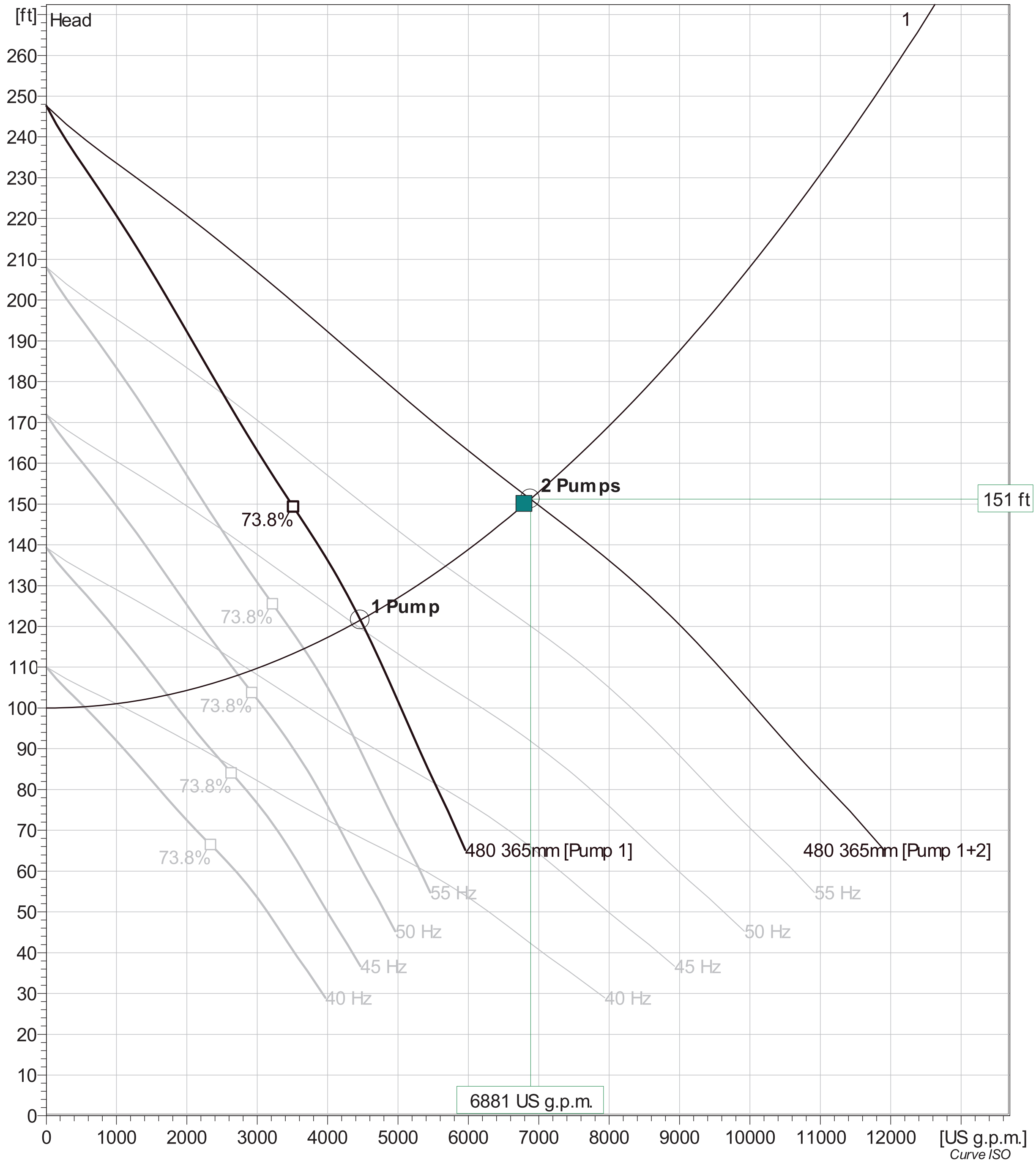


Project	Project ID	Created by	Created on	Last update
			10/31/2018	

Pump Station 4

NP 3231/745 3~ 480

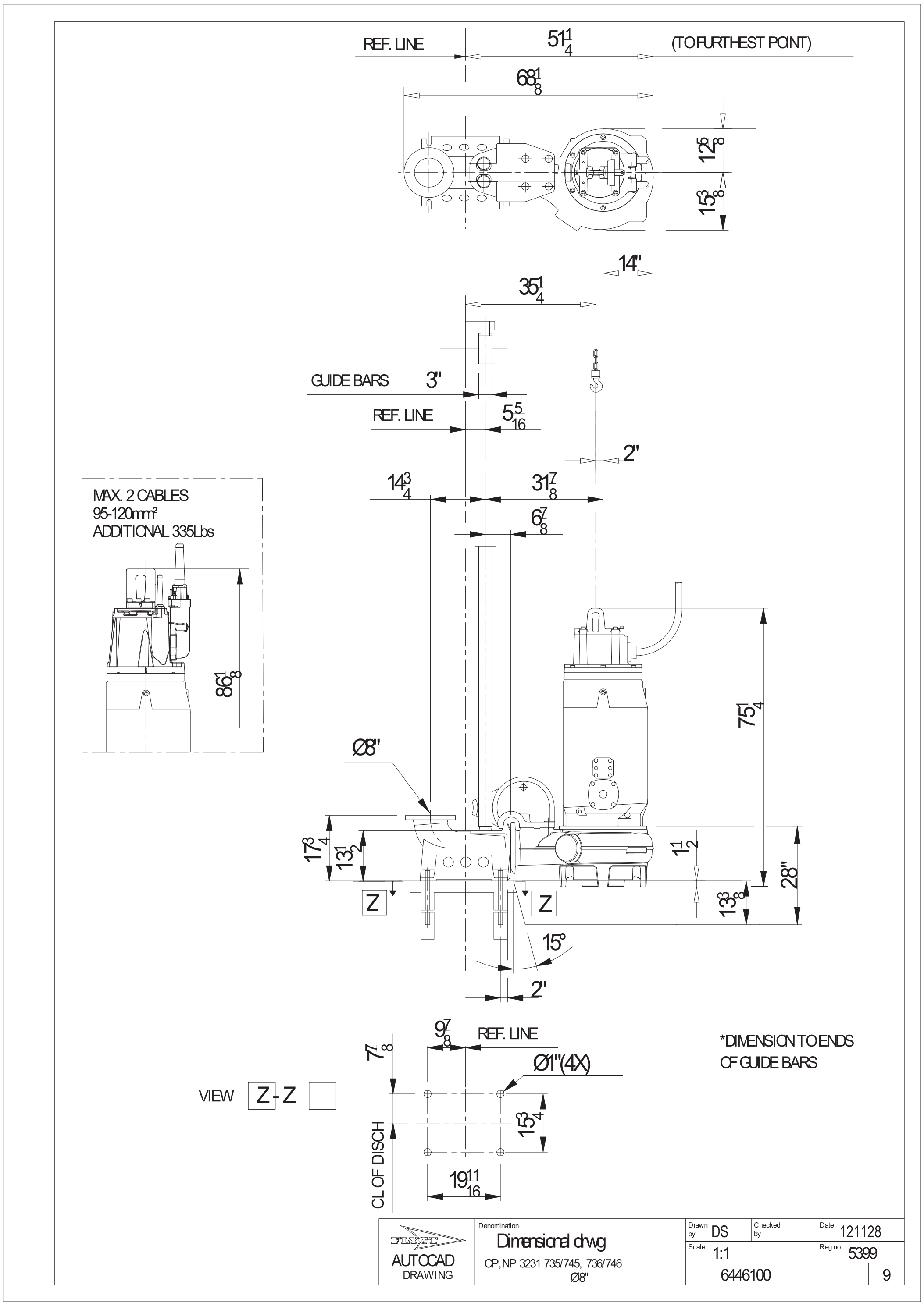
VFD Analysis



Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
2 / 1	60 Hz	3440 US g.p.m.	151 ft	178 hp	6880 US g.p.m.	151 ft	357 hp	73.8 %	685 kWh/US MG	21.6 ft
2 / 1	55 Hz	2840 US g.p.m.	135 ft	132 hp	5670 US g.p.m.	135 ft	264 hp	73.2 %	621 kWh/US MG	16.5 ft
2 / 1	50 Hz	2190 US g.p.m.	121 ft	94 hp	4370 US g.p.m.	121 ft	188 hp	70.9 %	579 kWh/US MG	12.8 ft
2 / 1	45 Hz	1450 US g.p.m.	109 ft	62.3 hp	2910 US g.p.m.	109 ft	125 hp	64.5 %	591 kWh/US MG	10.3 ft
2 / 1	40 Hz	496 US g.p.m.	101 ft	34.8 hp	992 US g.p.m.	101 ft	69.5 hp	36.5 %	1040 kWh/US MG	
1 / 1	60 Hz	4460 US g.p.m.	122 ft	197 hp	4460 US g.p.m.	122 ft	197 hp	69.8 %	581 kWh/US MG	35.4 ft
1 / 1	55 Hz	3660 US g.p.m.	114 ft	146 hp	3660 US g.p.m.	114 ft	146 hp	72.9 %	528 kWh/US MG	24.5 ft
1 / 1	50 Hz	2730 US g.p.m.	108 ft	101 hp	2730 US g.p.m.	108 ft	101 hp	73.6 %	499 kWh/US MG	15.1 ft
1 / 1	45 Hz	1720 US g.p.m.	103 ft	65.7 hp	1720 US g.p.m.	103 ft	65.7 hp	68.4 %	524 kWh/US MG	10.5 ft
1 / 1	40 Hz	539 US g.p.m.	100 ft	35.2 hp	539 US g.p.m.	100 ft	35.2 hp	38.9 %	968 kWh/US MG	

Project	Project ID	Created by	Created on	Last update
			10/31/2018	

NP 3231/745 3~ 480
Dimensional drawing



PUMP STATION 19
MANUFACTURER DATA

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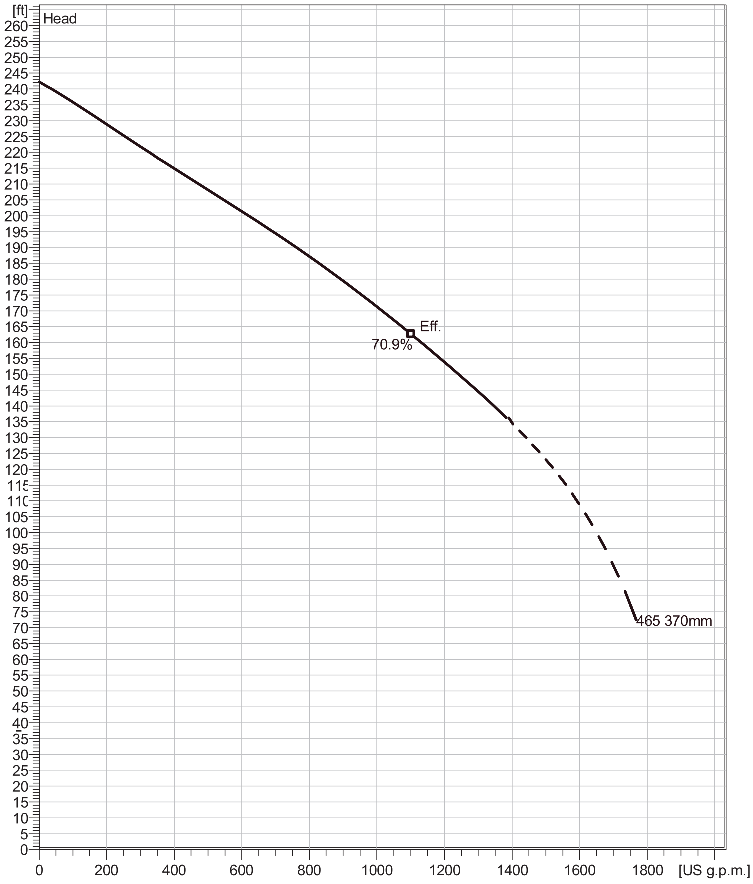
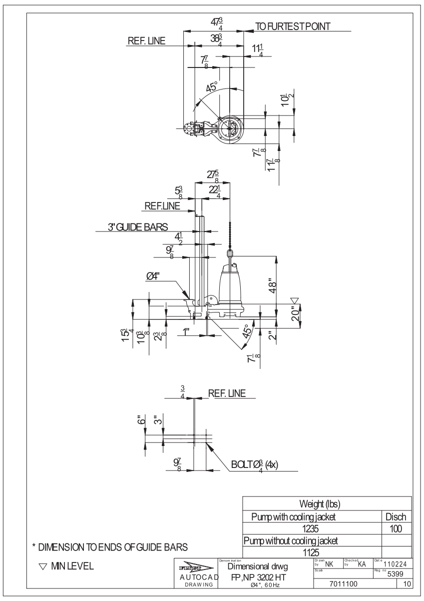
NP 3202 HT 3~ 465

Technical specification



Water, pure *Curve ISO*

Installation: P - Semi permanent, Wet



Note: Picture might not correspond to the current configuration.

General

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

Impeller

Impeller material	Hard-Iron ™
Discharge Flange Diameter	3 15/16 inch
Suction Flange Diameter	7 7/8 inch
Impeller diameter	370 mm
Number of blades	2

Motor

Motor #	N3202.095 30-29-4AA-W 70hp FM
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	70 hp
Rated current	79 A
Starting current	550 A
Rated speed	1775 rpm
Power factor	
1/1 Load	0.90
3/4 Load	0.87
1/2 Load	0.80
Motor efficiency	
1/1 Load	92.5 %
3/4 Load	93.0 %
1/2 Load	93.0 %

Configuration

Project	Project ID	Created by	Created on	Last update
			7/3/2018	

Pump Station 19

NP 3202 HT 3~ 465

Performance curve

Pump

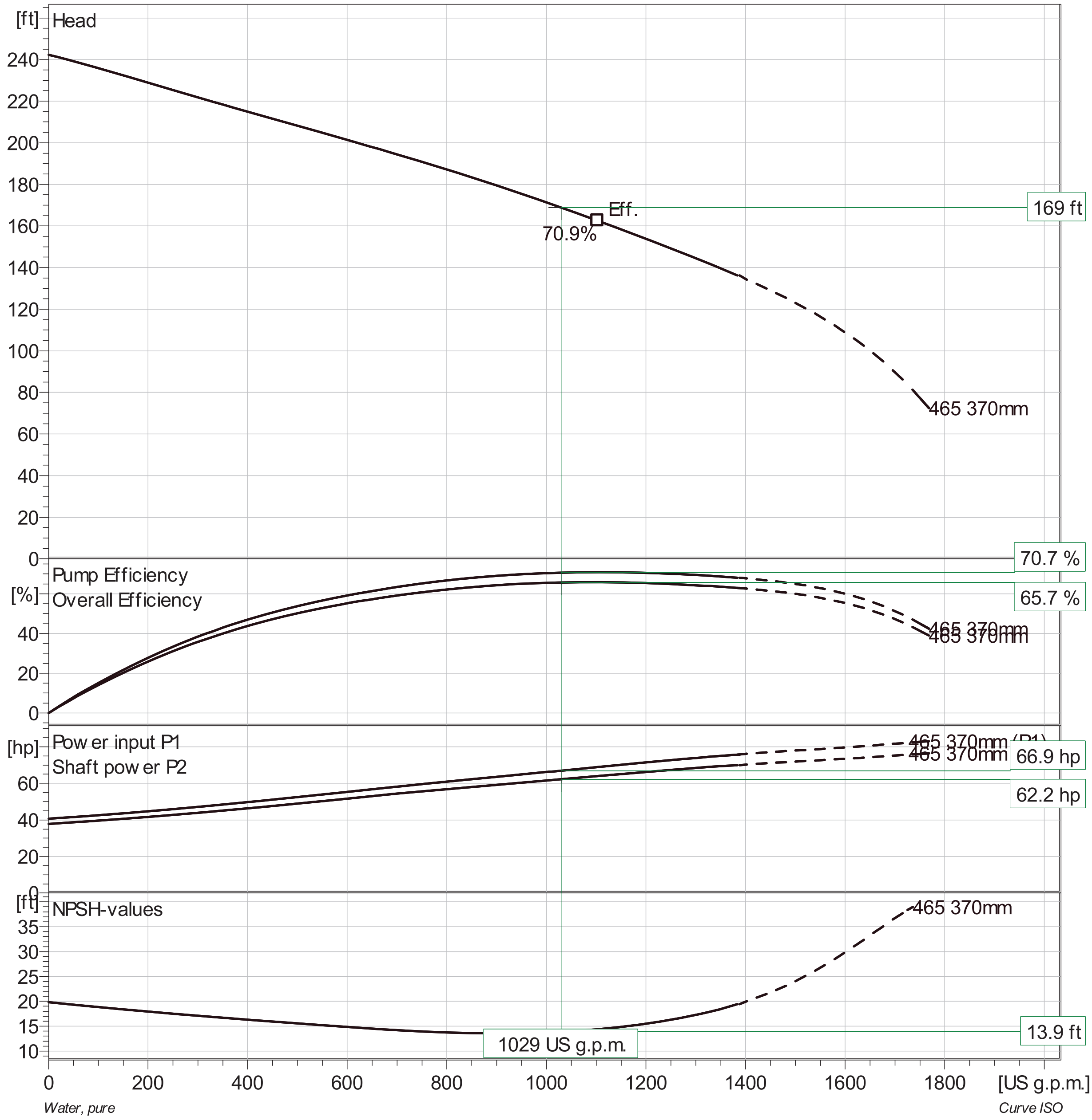
Discharge Flange Diameter	3 15/16 inch
Suction Flange Diameter	200 mm
Impeller diameter	14 9/16"
Number of blades	2

Motor

Motor #	N3202.095 30-29-4AA-W 70hp
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	70 hp
Rated current	79 A
Starting current	550 A
Rated speed	1775 rpm

Power factor	
1/1 Load	0.90
3/4 Load	0.87
1/2 Load	0.80

Motor efficiency	
1/1 Load	92.5 %
3/4 Load	93.0 %
1/2 Load	93.0 %



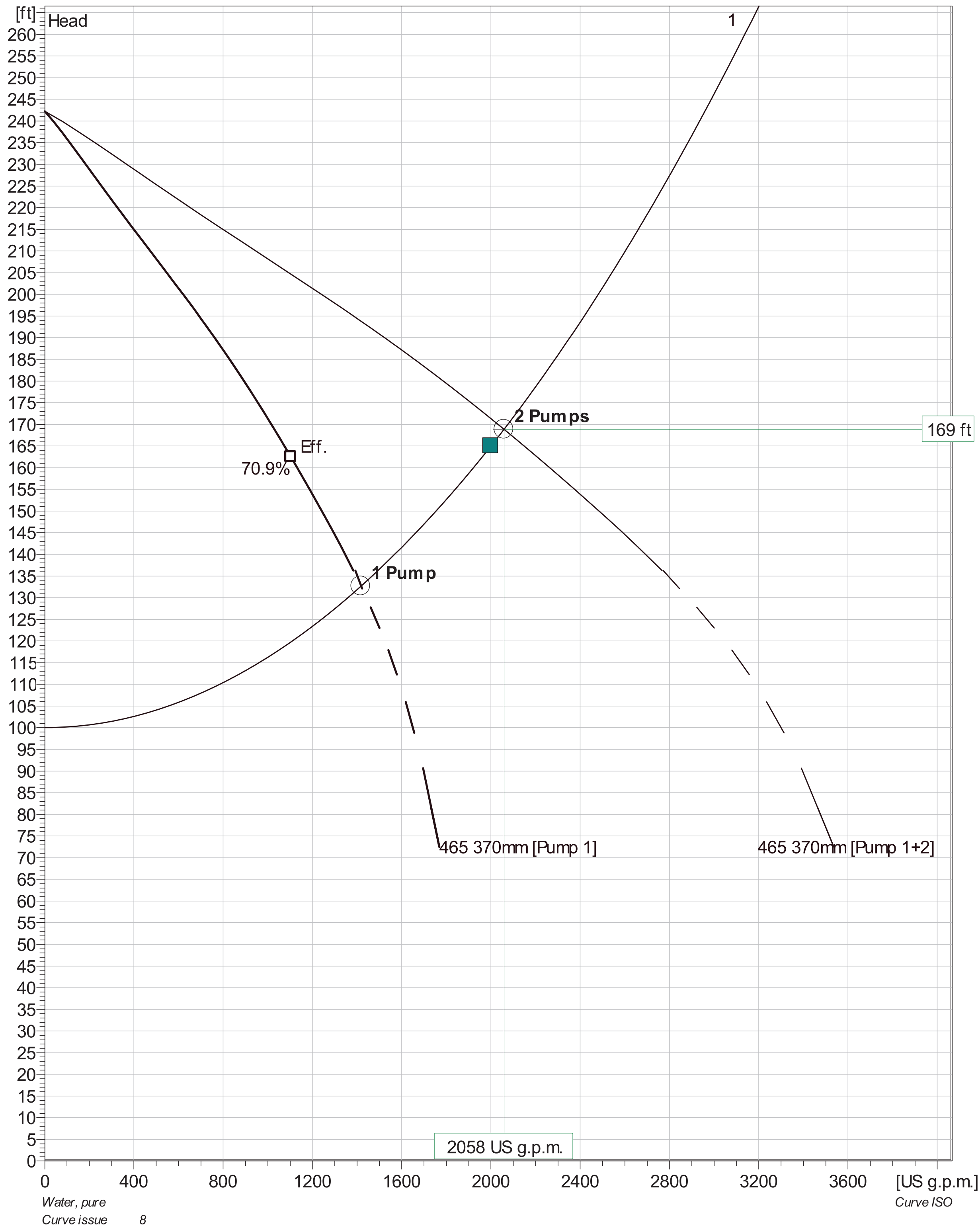
Duty point		**Guarantee**
Flow	**Head**	
1000 US g.p.m.	165 ft	No

Project	Project ID	Created by	Created on	Last update
			7/3/2018	

Pump Station 19

NP 3202 HT 3~ 465

Duty Analysis



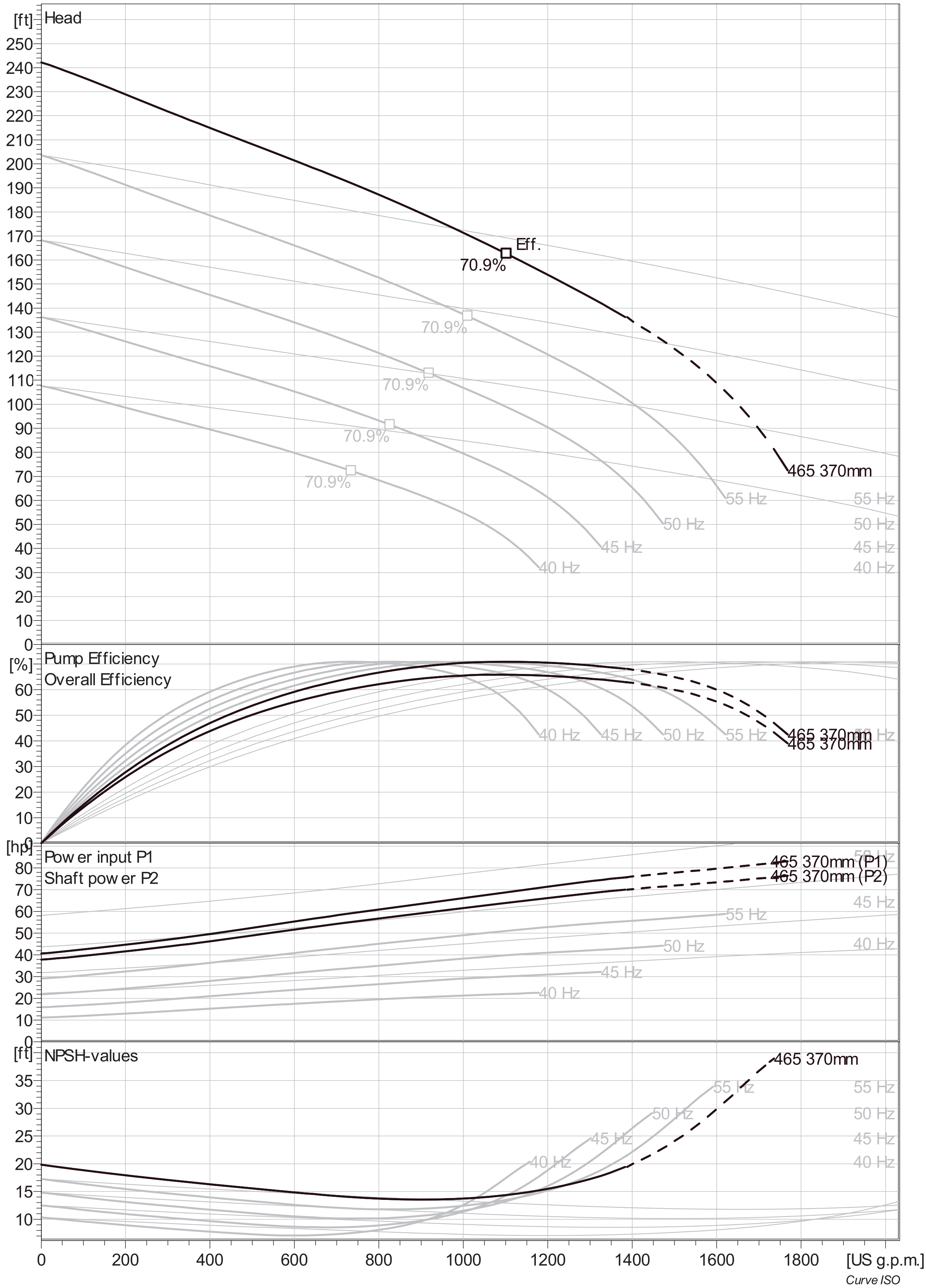
Pumps running /System	Individual pump Flow	Head	Shaft power	Total Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
2 / 1	1030 US g.p.m.	169 ft	62.2 hp	2060 US g.p.m.	169 ft	124 hp	70.7 %	808 kWh/US MG	13.9 ft
1 / 1	1420 US g.p.m.	133 ft	70.6 hp	1420 US g.p.m.	133 ft	70.6 hp	67.4 %	670 kWh/US MG	20.6 ft

Project	Project ID	Created by	Created on	Last update
			7/3/2018	

NP 3202 HT 3~ 465

VFD Curve

FLYGT

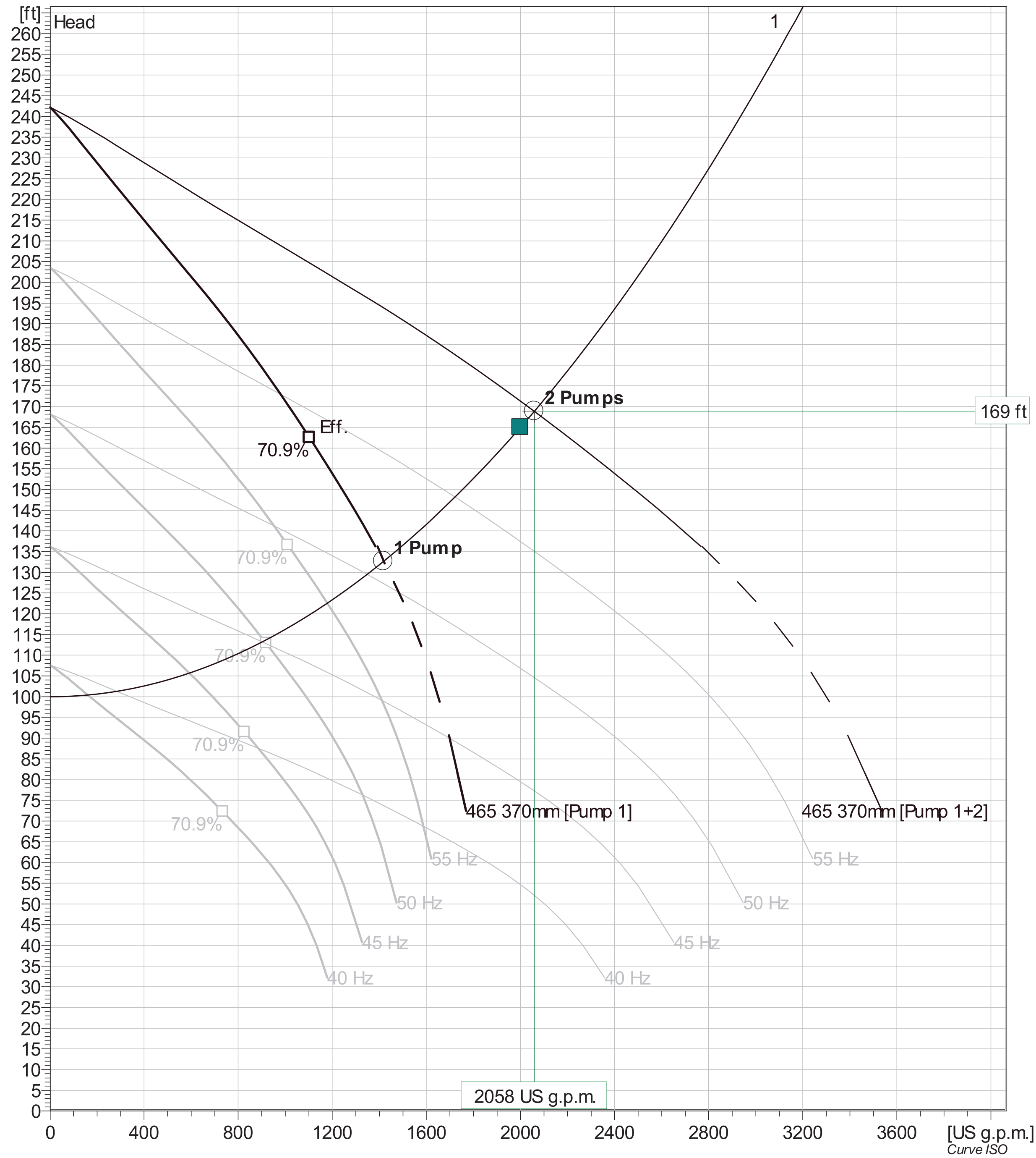


Project	Project ID	Created by	Created on	Last update
			7/3/2018	

Pump Station 19

NP 3202 HT 3~ 465

VFD Analysis

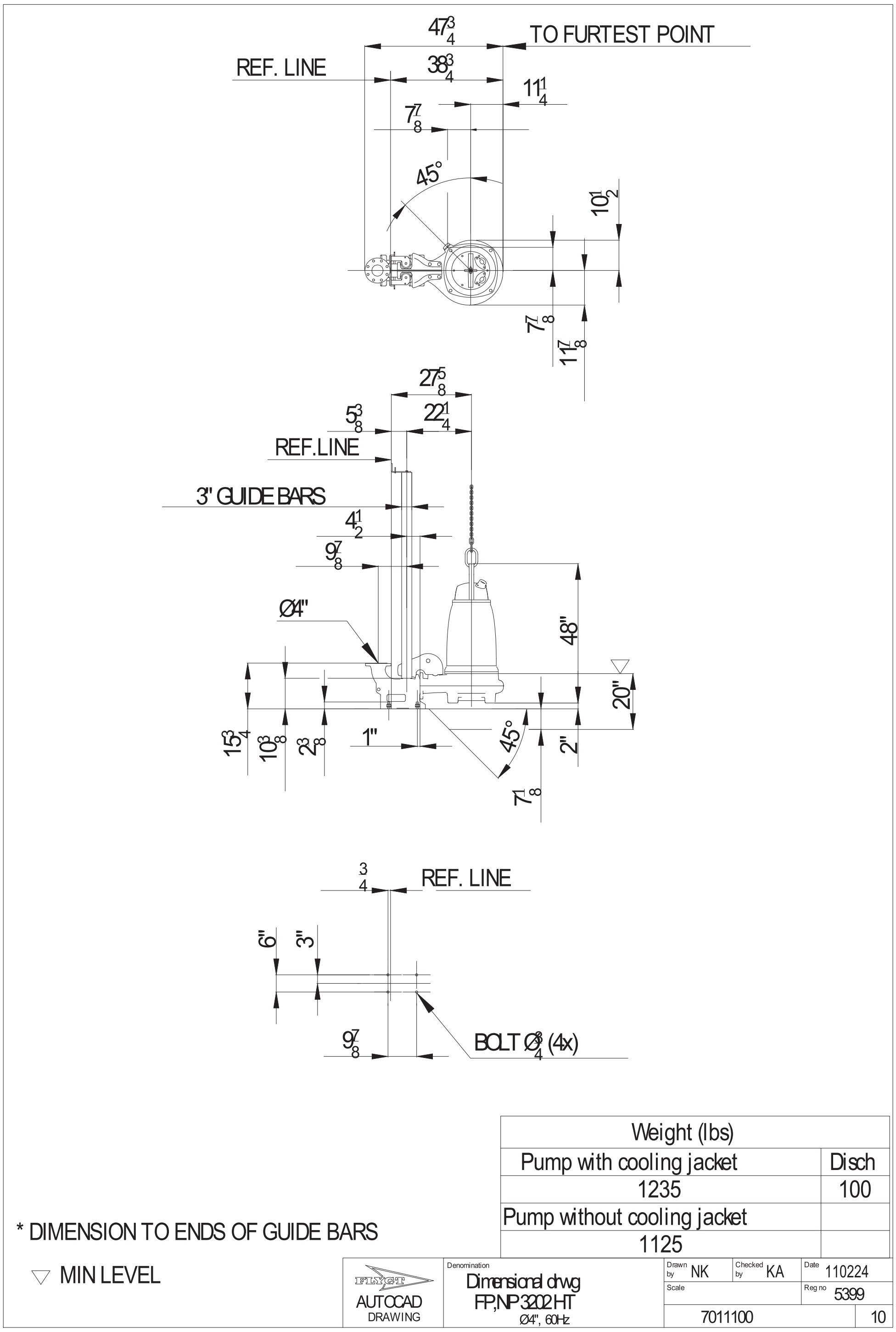


Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
2 / 1	60 Hz	1030 US g.p.m.	169 ft	62.2 hp	2060 US g.p.m.	169 ft	124 hp	70.7 %	808 kWh/US MG	13.9 ft
2 / 1	55 Hz	861 US g.p.m.	148 ft	46.3 hp	1720 US g.p.m.	148 ft	92.6 hp	69.7 %	717 kWh/US MG	11.8 ft
2 / 1	50 Hz	674 US g.p.m.	130 ft	33 hp	1350 US g.p.m.	130 ft	66 hp	66.9 %	656 kWh/US MG	10.2 ft
2 / 1	45 Hz	451 US g.p.m.	113 ft	21.8 hp	902 US g.p.m.	113 ft	43.6 hp	59.2 %	655 kWh/US MG	9.37 ft
2 / 1	40 Hz	142 US g.p.m.	101 ft	12.4 hp	284 US g.p.m.	101 ft	24.9 hp	29.3 %	1240 kWh/US MG	9.31 ft
1 / 1	60 Hz	1420 US g.p.m.	133 ft	70.6 hp	1420 US g.p.m.	133 ft	70.6 hp	67.4 %	670 kWh/US MG	20.6 ft
1 / 1	55 Hz	1180 US g.p.m.	123 ft	52.5 hp	1180 US g.p.m.	123 ft	52.5 hp	69.7 %	593 kWh/US MG	14.7 ft
1 / 1	50 Hz	911 US g.p.m.	113 ft	36.9 hp	911 US g.p.m.	113 ft	36.9 hp	70.9 %	542 kWh/US MG	10.7 ft
1 / 1	45 Hz	592 US g.p.m.	106 ft	23.9 hp	592 US g.p.m.	106 ft	23.9 hp	66.4 %	544 kWh/US MG	8.69 ft
1 / 1	40 Hz	161 US g.p.m.	100 ft	12.6 hp	161 US g.p.m.	100 ft	12.6 hp	32.4 %	1110 kWh/US MG	9.18 ft

Project	Project ID	Created by	Created on	Last update
			7/3/2018	

NP 3202 HT 3~ 465

Dimensional drawing



Weight (lbs)	
Pump with cooling jacket	Disch
1235	100
Pump without cooling jacket	
1125	

Project	Project ID	Created by	Created on	Last update
			7/3/2018	

PUMP STATION 31
MANUFACTURER DATA

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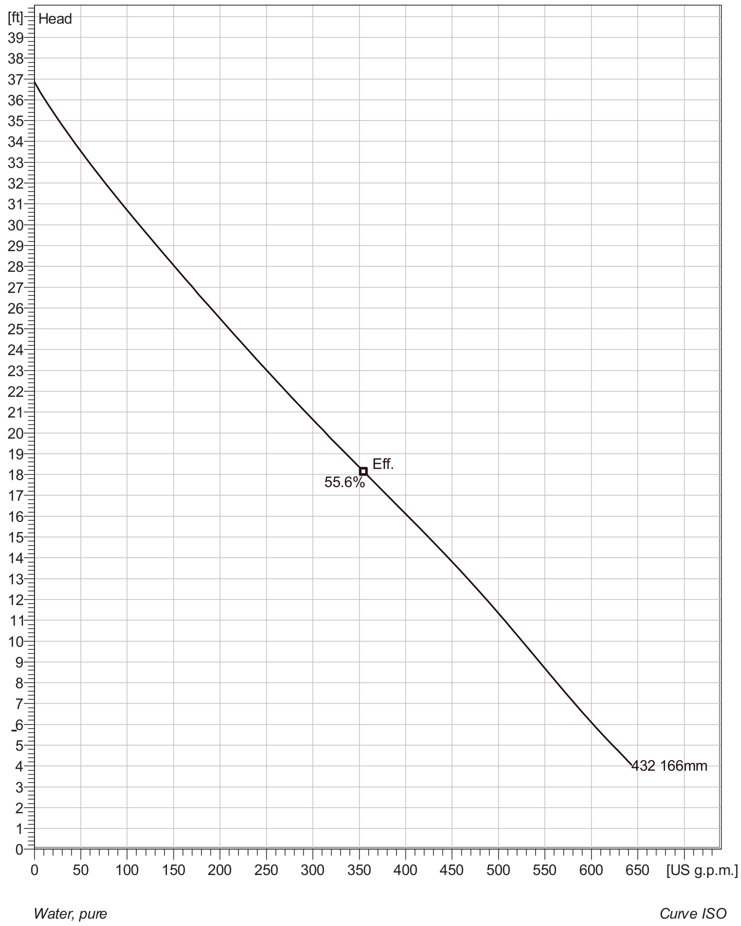
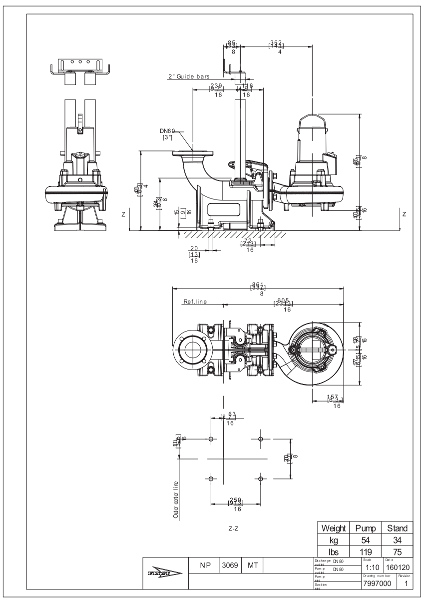
NP 3069 MT 3~ Adaptive 432

Technical specification



Installation: P - Semi permanent, Wet



Note: Picture might not correspond to the current configuration.

General

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

Impeller

Impeller material	Hard-Iron ™
Discharge Flange Diameter	3 1/8 inch
Suction Flange Diameter	4 7/16 inch
Impeller diameter	166 mm
Number of blades	2

Motor

Motor #	N3069.070 13-10-4BB-W 3.2hp FM
Stator variant	13
Frequency	60 Hz
Rated voltage	230 V
Number of poles	4
Phases	3~
Rated power	3.2 hp
Rated current	9.4 A
Starting current	43 A
Rated speed	1655 rpm
Power factor	
1/1 Load	0.87
3/4 Load	0.80
1/2 Load	0.67
Motor efficiency	
1/1 Load	73.7 %
3/4 Load	76.3 %
1/2 Load	75.6 %

Configuration

Pump Station 31

NP 3069 MT 3~ Adaptive 432

Performance curve

Pump

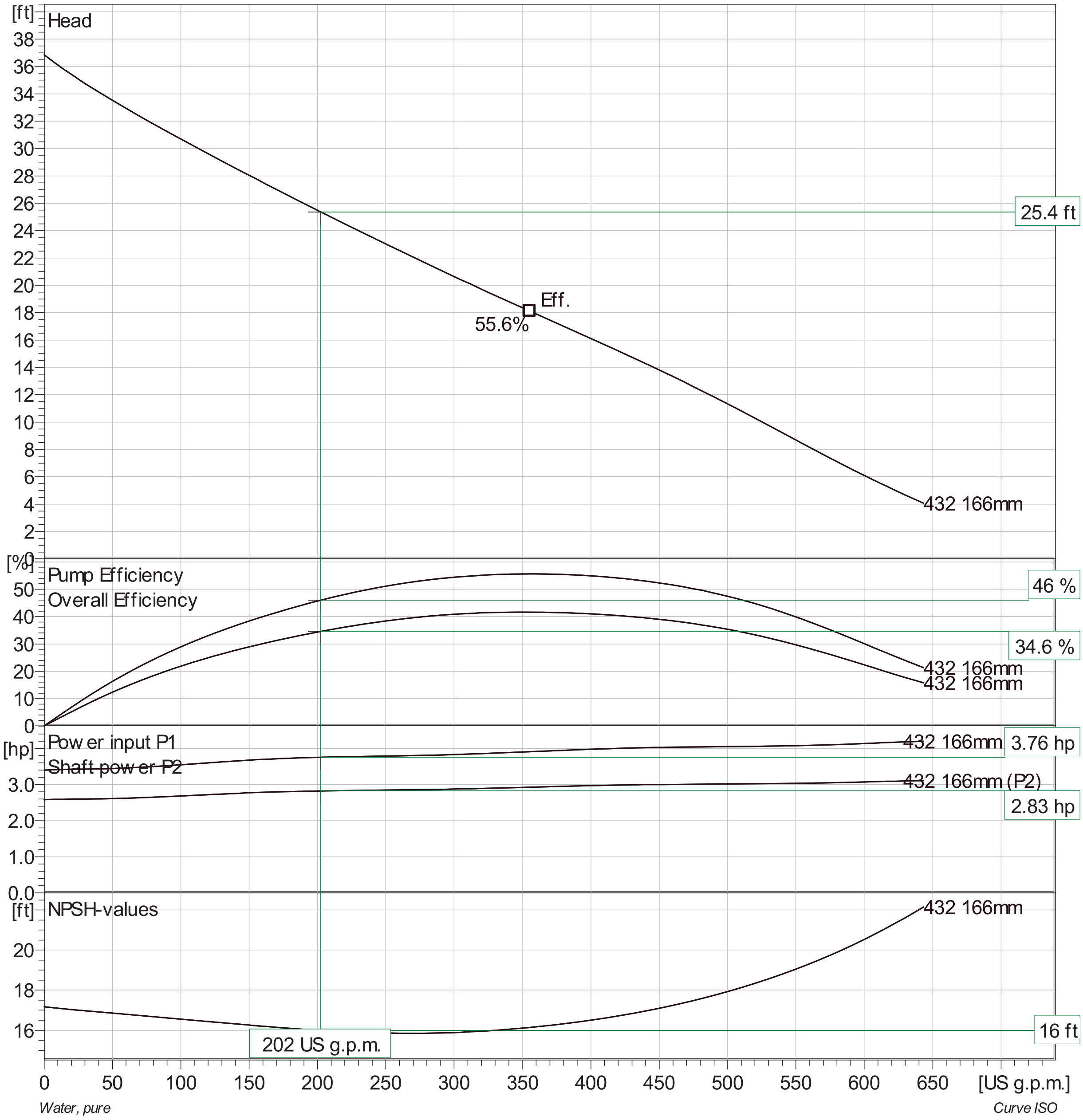
Discharge Flange Diameter	3 1/8 inch
Suction Flange Diameter	113 mm
Impeller diameter	6 9/16"
Number of blades	2

Motor

Motor #	N3069.070 13-10-4BB-W 3.2hp
Stator variant	13
Frequency	60 Hz
Rated voltage	230 V
Number of poles	4
Phases	3~
Rated power	3.2 hp
Rated current	9.4 A
Starting current	43 A
Rated speed	1655 rpm

Power factor	
1/1 Load	0.87
3/4 Load	0.80
1/2 Load	0.67

Motor efficiency	
1/1 Load	73.7 %
3/4 Load	76.3 %
1/2 Load	75.6 %

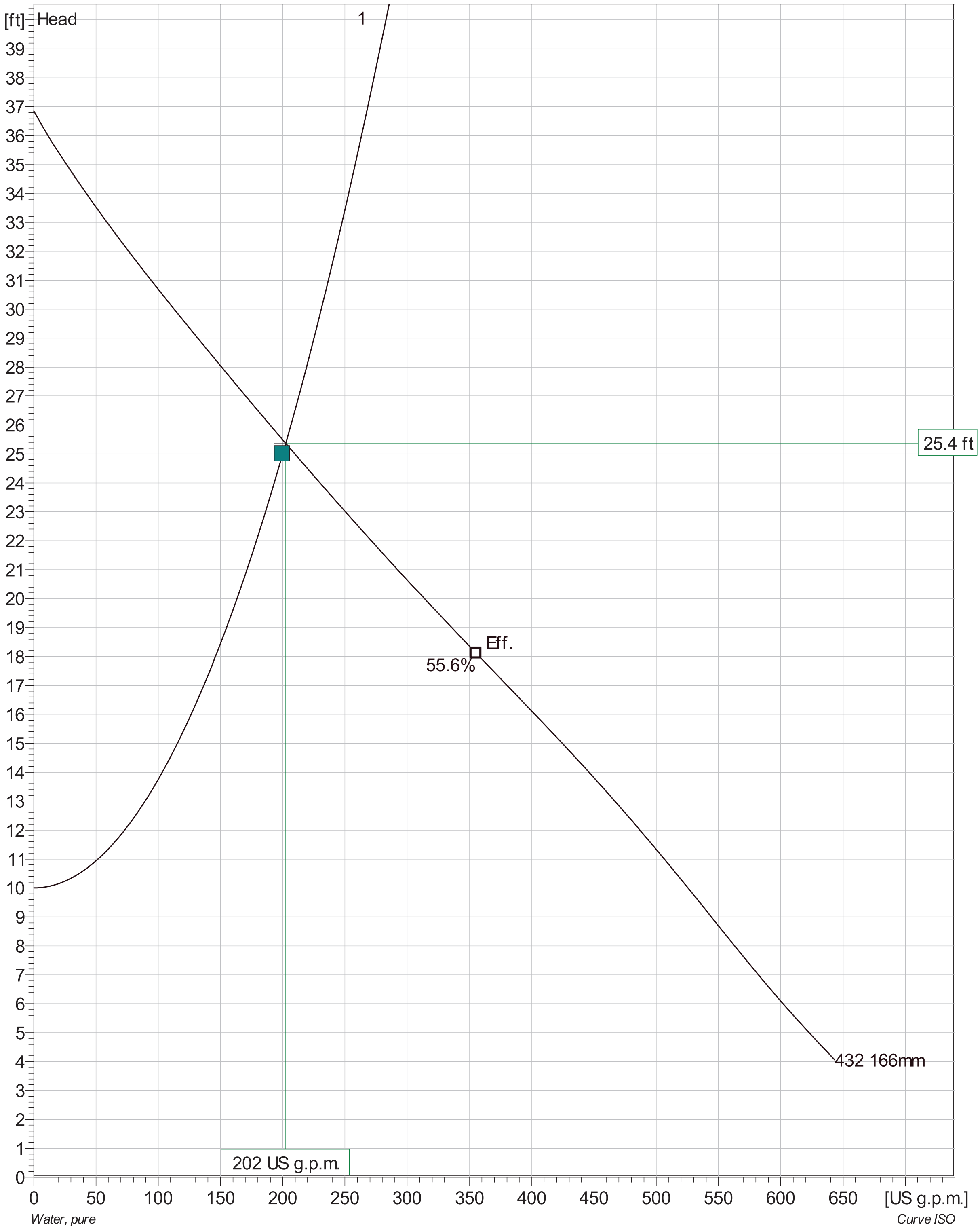


Duty point		Guarantee
Flow	**Head**	
200 US g.p.m.	25 ft	No

Project	Project ID	Created by	Created on	Last update
			7/18/2018	

Pump Station 31

NP 3069 MT 3~ Adaptive 432
Duty Analysis

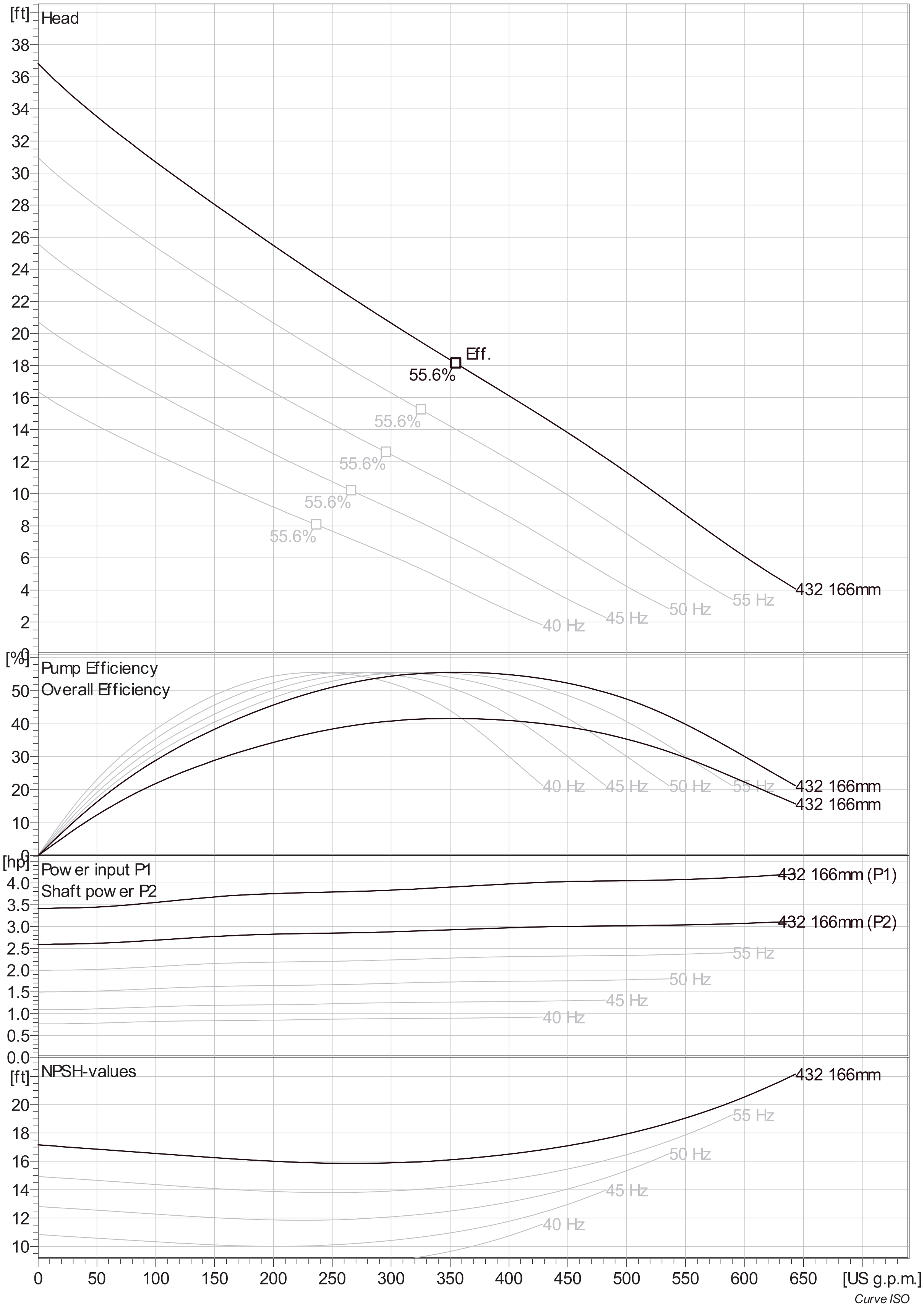


Pumps running /System	Individual pump Flow	Head	Shaft power	Total Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
1	202 US g.p.m.	25.4 ft	2.83 hp	202 US g.p.m.	25.4 ft	2.83 hp	46 %	231 kWh/US MG	16 ft

Project	Project ID	Created by	Created on	Last update
			7/18/2018	

Pump Station 31

NP 3069 MT 3~ Adaptive 432
VFD Curve

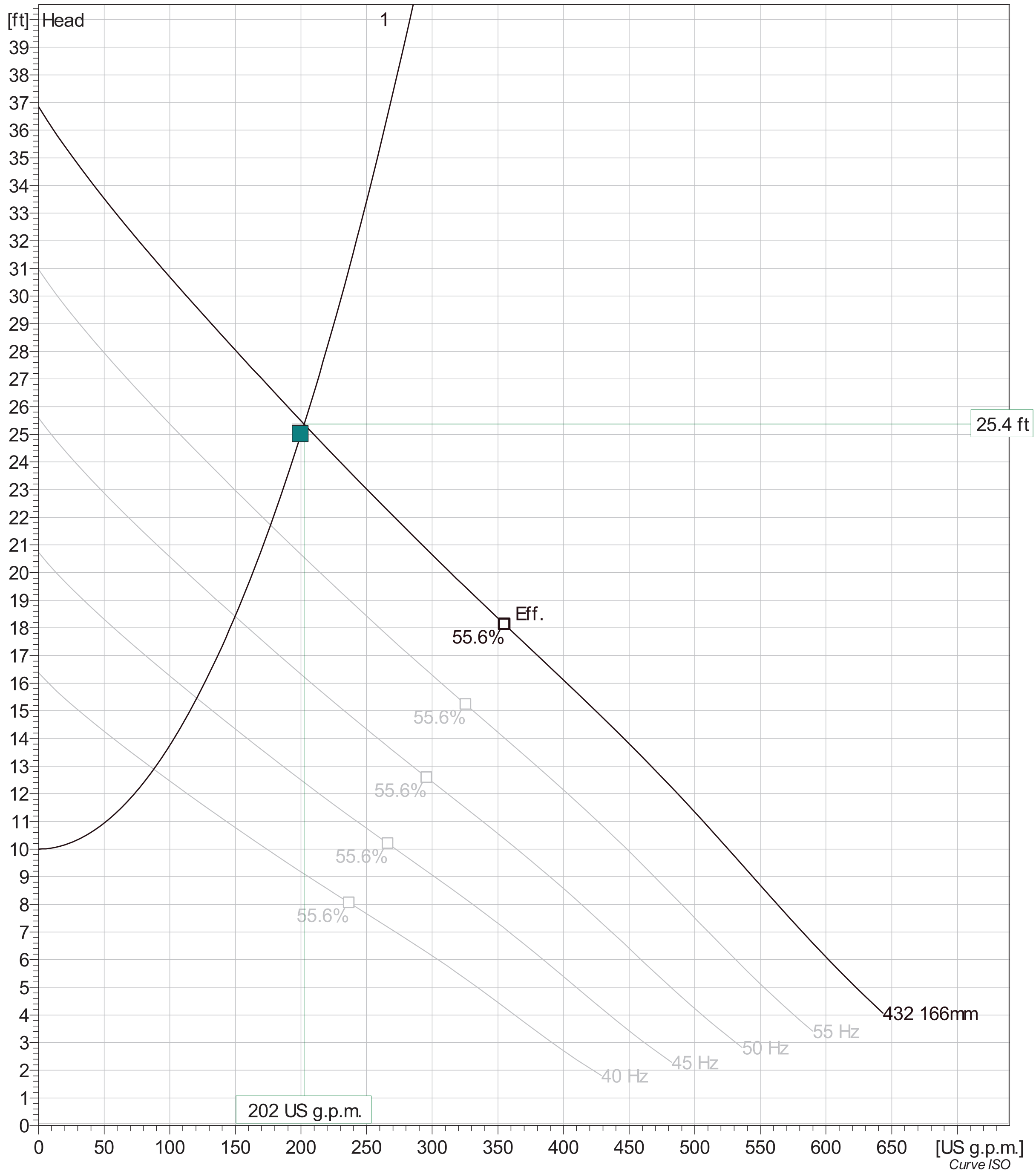


Project	Project ID	Created by	Created on	Last update
			7/18/2018	

NP 3069 MT 3~ Adaptive 432

VFD Analysis

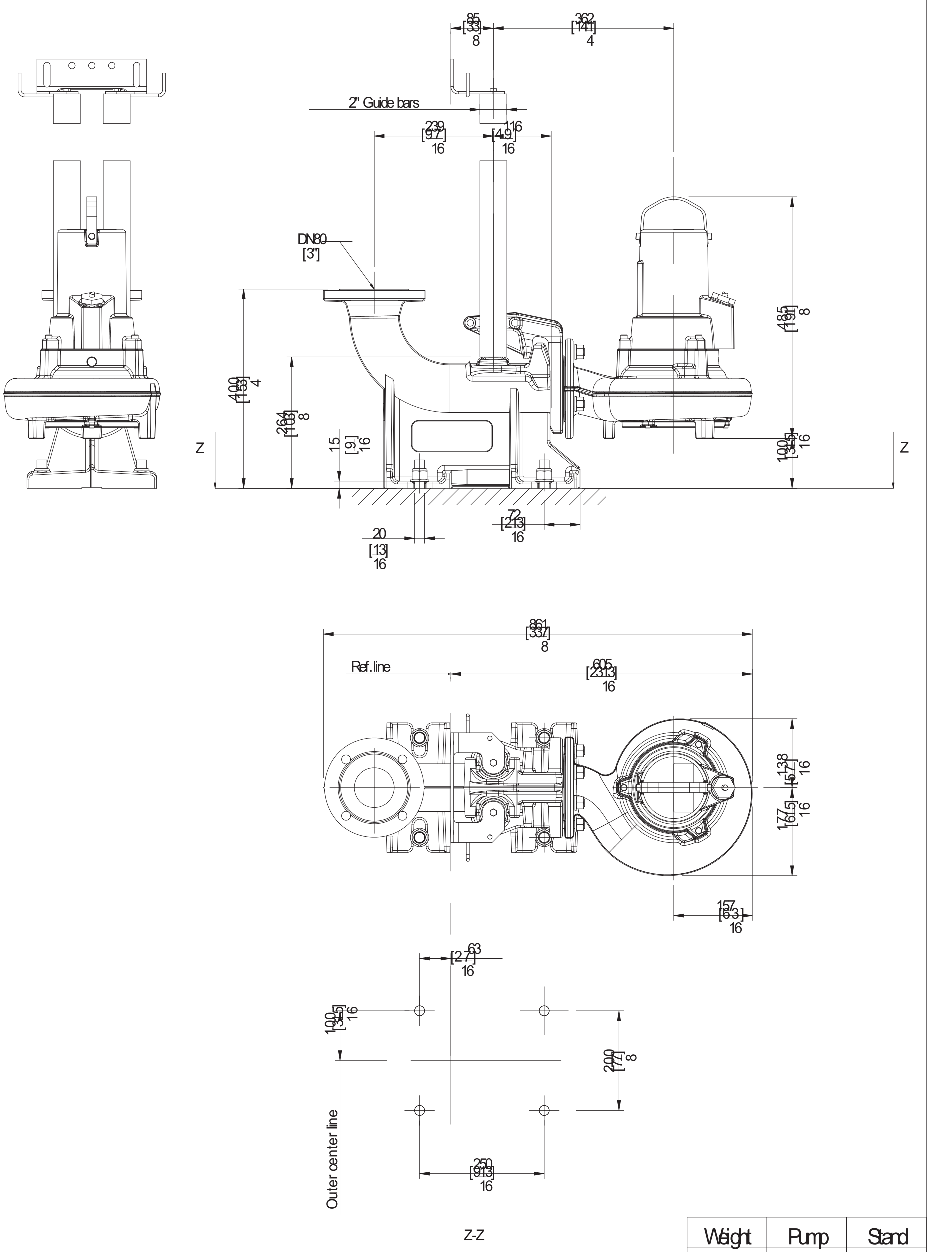
FLYGT



Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
1	60 Hz	202 US g.p.m.	25.4 ft	2.83 hp	202 US g.p.m.	25.4 ft	2.83 hp	46 %	231 kWh/US MG	16 ft
1	55 Hz	177 US g.p.m.	21.7 ft	2.17 hp	177 US g.p.m.	21.7 ft	2.17 hp	44.7 %	200 kWh/US MG	14 ft
1	50 Hz	150 US g.p.m.	18.4 ft	1.63 hp	150 US g.p.m.	18.4 ft	1.63 hp	42.9 %	178 kWh/US MG	12 ft
1	45 Hz	121 US g.p.m.	15.5 ft	1.18 hp	121 US g.p.m.	15.5 ft	1.18 hp	40.1 %	167 kWh/US MG	10.2 ft
1	40 Hz	87.8 US g.p.m.	12.9 ft	0.813 hp	87.8 US g.p.m.	12.9 ft	0.813 hp	35.2 %	172 kWh/US MG	8.55 ft

NP 3069 MT 3~ Adaptive 432

Dimensional drawing



Weight	Pump	Stand
kg	54	34
lbs	119	75

NP	3069	MT	
Discharge outlet DN 80	Scale 1:10	Date 160120	
Pump outlet DN 80			
Pump inlet	Drawing number 7997000	Revision 1	
Suction inlet			

APPENDIX G

SURGE ANALYSIS MEMORANDUM

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TECHNICAL MEMORANDUM

Date: December 4, 2019

To: Tony Fisher

From: Dave Harms

Subject: Kitsap County Lift Stations 3, 4, 19 & 31 Preliminary Design Hydraulic Surge Analysis

---

David C. Harms, PE
BHC Consultants, LLC

1. Introduction

A preliminary hydraulic pressure surge analysis was performed for the subject Kitsap County preliminary lift station design project. The purpose of this analysis was to investigate and identify potential surge conditions that could occur as a result of lift station operation. The analysis utilized InfoSurge software by Innovyze, to simulate pump operations and surge conditions.

Surge pressures, also referred to as pressure transients or water hammer, occur when steady state flow conditions are changed in a pipeline. Examples of such conditions include pump startup, sudden closure of a valve, or loss of power to the pumps. The impacts of these conditions are not significant for most transients and specific surge control facilities or other modifications for protection are unnecessary. In some specific cases however, pressure surges that may result in damage to pipelines and appurtenances may occur if adequate protection measures are not provided.

Surge events may result in extremely low pressures that lead to vapor cavity formation and potential collapse of pipe walls. Vapor cavities occur when negative pressures are lower than the vapor pressure of the fluid. When this situation occurs, the fluid will vaporize to stabilize the negative pressure, which can be quite damaging, as cavitation can result in loss of the pipe material. In addition, very high pressures can occur when the vapor cavity subsequently collapses, and the two water columns rejoin. Extremely high pressures resulting either from vapor cavity collapse or from other surge events could burst the pipe if the pressures exceed the capacity of the pipe material.

The most critical surge condition associated with lift stations often results from a total station power failure (pump trip) when the largest flow is occurring. This condition was analyzed for Lift Stations 3, 4, 19, and 31 (LS 3, LS 4, LS 19, & LS 31). The lift station and piping systems were initially evaluated based on pumps and piping configurations identified in the preliminary design without surge protection. If the model predicted potentially damaging transients, then surge mitigation devices may be needed, and the system should be analyzed further during final design after the pumping conditions are more defined.

InfoSurge, a hydraulic computer model, was used to determine the magnitude of the pressure surges and impacts of various transient control facilities or modifications at each station. InfoSurge solves the basic equations of fluid mechanics for the transient flow of an incompressible fluid in a pipe. The assumptions that were made to simplify the equations and to solve for the pressure and flow as a function of time at various locations in the system are described in the following paragraphs.

2. Analysis Assumptions

To perform the surge analysis, InfoSurge used the physical data that describes each lift station (piping, valves, fittings, etc.) and their respective force mains (pipe diameter, length, fittings, etc.) as well as the pumping conditions (boundary conditions) assumed for each station. The data used and a discussion of the impacts that could result from variations in the data are as follows:

2.1 Boundary Conditions

The magnitude of surge pressures depends on the flow rate of sewage in the force mains. Higher flow rates will result in more significant changes in flow velocity and therefore greater potential surge pressures. Consequently, the surge model for each lift station was setup for maximum discharge prior to the power outage (pump trip) event.

2.2 Sonic Velocities

The magnitude of the transients also depends on the speed at which pressure waves propagate through the system. The wave speed is equal to the speed of sound in the pipe (sonic velocity), which is related to the pipe material, diameter, wall thickness, and fluid characteristics. Higher wave speeds increase the potential for pressure surges. Wave speeds used for the surge analysis at each station ranged from 1,030 ft/sec for PVC pipe to 4,180 ft/sec for ductile iron pipe.

2.3 Physical Characteristics

Physical system information such as pipe sizes, lengths, friction factors, local loss coefficients for fittings and valves, and invert elevations were entered in the model. Some of this data is still preliminary and could change during the final design. Therefore, some variations may occur during the final design phase and the model should be updated and re-ran to verify surge conditions. If an existing force main has an air-vac valve, model simulations were run with and without the valve. Hazen Williams 'C' values (friction factors for the modeled piping) are shown in Table 1.

Table 1
Hazen Williams 'C' Values

Pipe Material	'C'
Newer Ductile Iron pipe	145
Older Ductile Iron pipe	140
PVC pipe	145

2.4 Pump Characteristics

Data for the pumps was based on preliminary pump design data obtained from Whitney Equipment Company, Inc. (WECI) for the proposed Flygt pumps. Pump and motor rotational moments of inertia were calculated in the model, based on rated pump flow and pressure, pump speed, and efficiency. Pump characteristics for each lift station are summarized in Table 2.

Table 2
Pump Characteristics

Lift Station	Q (gpm)	TDH (feet)	Speed (rpm)	Power (HP)	Impellor Size (inches)	Efficiency	Pump/Motor Inertia ($lb\text{-}ft^2$)
3	2,200	165	1,780	160	14.45	69.7%	55
4	5,030	120	1,780	250	14.37	73.8%	75
19	1,240	92	1,775	70	14.57	70.9%	16
31	168	20	1,655	3.2	6.54	55.6	< 1

2.5 Number of Pumps Running

The greatest flow will occur when the maximum number of pumps are operating, which will also result in the highest potential surge pressures. For LS 3, LS 4, and LS 19, this equates to two pumps operating in parallel. For LS 31, only one pump would operate at a time.

3. Analysis Results

3.1 Lift Station 3

Rapid shut down conditions at LS 3 during a pump trip resulted in a maximum pressure of about 75 psi and a minimum pressure of approximately negative 15 psi (see Figure 1 for the maximum and minimum pressure envelope along the force main). Figure 2 illustrates the pressure at LS 3 during a pump trip. Both figures indicate that minimum pressures are at or near vapor pressures for a brief period after the pump trip. The minimum pressure occurs along the majority of the force main.

3.2 Lift Station 4

Rapid shut down conditions at LS 4 during a pump trip resulted in a maximum pressure of about 54 psi and a minimum pressure of approximately negative 12 psi (see Figure 3 for the maximum and minimum pressure envelope along the force main). Figure 4 illustrates the pressure at LS 4 during a pump trip. The lowest of the minimum pressures occur near the lift station, but the minimum pressures increase gradually further downstream of the lift station.

3.3 Lift Station 19

Rapid shut down conditions at LS 19 during a pump trip resulted in a maximum pressure of about 44 psi and minimum pressures were at vapor pressure (cavitation) for an extended length of the force main, downstream of the lift station (see Figure 5 for the maximum and minimum pressure envelope along the force main). Figure 6 illustrates the pressure in the force main downstream of LS 19 during a pump trip. Model results indicate that cavitation occurs along approximately 3,000 feet of the force main, downstream of the lift station. Pressures also drop to cavitation levels at two other locations further downstream in the force main.

3.4 Lift Station 31

Rapid shut down conditions at LS 31 during a pump trip resulted in a maximum pressure of about 22 psi and a minimum pressure of approximately negative 5 psi. The LS 31 force main discharges to the LS 8 force main system. Maximum pressures along the LS 31 force main occur when the LS 8 force main system is experiencing maximum head conditions of approximately 55 feet. During these maximum head conditions however, pressure at LS 31 does not change during a pump trip, because the pressurized LS 8 force main buffers pressure changes caused by the pump trip. The minimum pressure of negative 5 psi occurs during a pump trip, when the LS 8 force main system is not surcharged. Figure 7 illustrates the minimum pressure at LS 31 during a pump trip.

4. Recommendations

4.1 Lift Station 3

The preliminary surge analysis indicated that mitigation measures may be necessary for LS 3. Potential mitigation measures include a surge tank, adding a flywheel to each pump/motor or additional air-vacuum relief valves to the force main. Changing the material of the onsite piping would change the speed at which pressure waves propagate through the system and could be an option as well. A flywheel would slow down the speed at which the pumps ramp down after a pump trip and is an effective method for mitigating cavitation but is not feasible for a submersible pump installation.

The force main profile would suggest that an air-vacuum valve may be located near the high point where Lift Station 2's force main connects to LS 3's force main. However, a review of the record drawings for LS 3's force main did not reveal an air vacuum valve at this location. A field check of the force main in this location during the design phase should be made to determine if an air-vacuum valve does exist as air-vacuum valves are effective mitigation measures for surge pressures.

The surge analysis should be updated during the final design stage as more information is available on lift station piping and the pump selection is refined. Results of the refined analysis will confirm whether surge mitigation is necessary and identify a mitigation measure.

4.2 Lift Station 4

The preliminary surge analysis indicated that mitigation measures may be necessary for LS 4. Potential mitigation measures include a surge tank, adding a flywheel to each pump/motor or additional air-vacuum relief valves to the force main. Changing the material of the onsite piping would change the speed at which pressure waves propagate through the system and could be an option as well. A flywheel would slow down the speed at which the pumps ramp down after a pump trip and is an effective method for mitigating cavitation but is not feasible for a submersible pump installation.

The surge analysis should be updated during the final design stage as more information is available on lift station piping and the pump selection is refined. Results of the refined analysis will confirm whether surge mitigation is necessary and identify a mitigation measure.

4.3 Lift Station 19

The preliminary surge analysis indicated that mitigation measures will be necessary for LS 19. Adding a flywheel to each pump/motor would slow down the speed at which the pumps ramp down after a pump trip and would mitigate the potential for cavitation at the lift station. However, installing flywheels on submersible pumps is not feasible. Model results indicate that the existing air-vacuum valves along Paulson Road mitigate cavitation at those local high points in the force main; however, additional surge control measures may be necessary along the force main, to further mitigate cavitation. The surge analysis should be refined during the final design stage as more information is available on the lift station piping and the pump selection is refined. The force main will also be updated in the model to include additional detail.

4.4 LIft Station 31

The preliminary surge analysis for LS 31 indicated that mitigation measures will likely be unnecessary. Model results indicate that the pressurized LS 8 force main system buffers potential surge pressures caused by a pump trip at LS 31, thereby holding pressures constant during the pump trip event. If the LS 8 force main system is not pressurized during a pump trip, a pressure of about negative 5 psi is experienced at LS 31. This negative pressure is not low enough to cause cavitation under these conditions, but the surge analysis should be refined during the final design stage to verify preliminary results.

5. Attachments

- Figure 1 – Lift Station 3 Force Main Pressure Envelope During Pump Trip
- Figure 2 – Pressure at Lift Station 3 During Pump Trip
- Figure 3 – Lift Station 4 Force Main Pressure Envelope During Pump Trip
- Figure 4 – Pressure at Lift Station 4 During Pump Trip
- Figure 5 – Lift Station 19 Force Main Pressure Envelope During Pump Trip (Paulson Alignment)
- Figure 6 – Pressure Downstream of Lift Station 19 During Pump Trip (Paulson Alignment)
- Figure 7 – Pressure at Lift Station 31 During Pump Trip <Pending>

Attachments

Figure 1: Lift Station 3 Force Main Pressure Envelope During Pump Trip

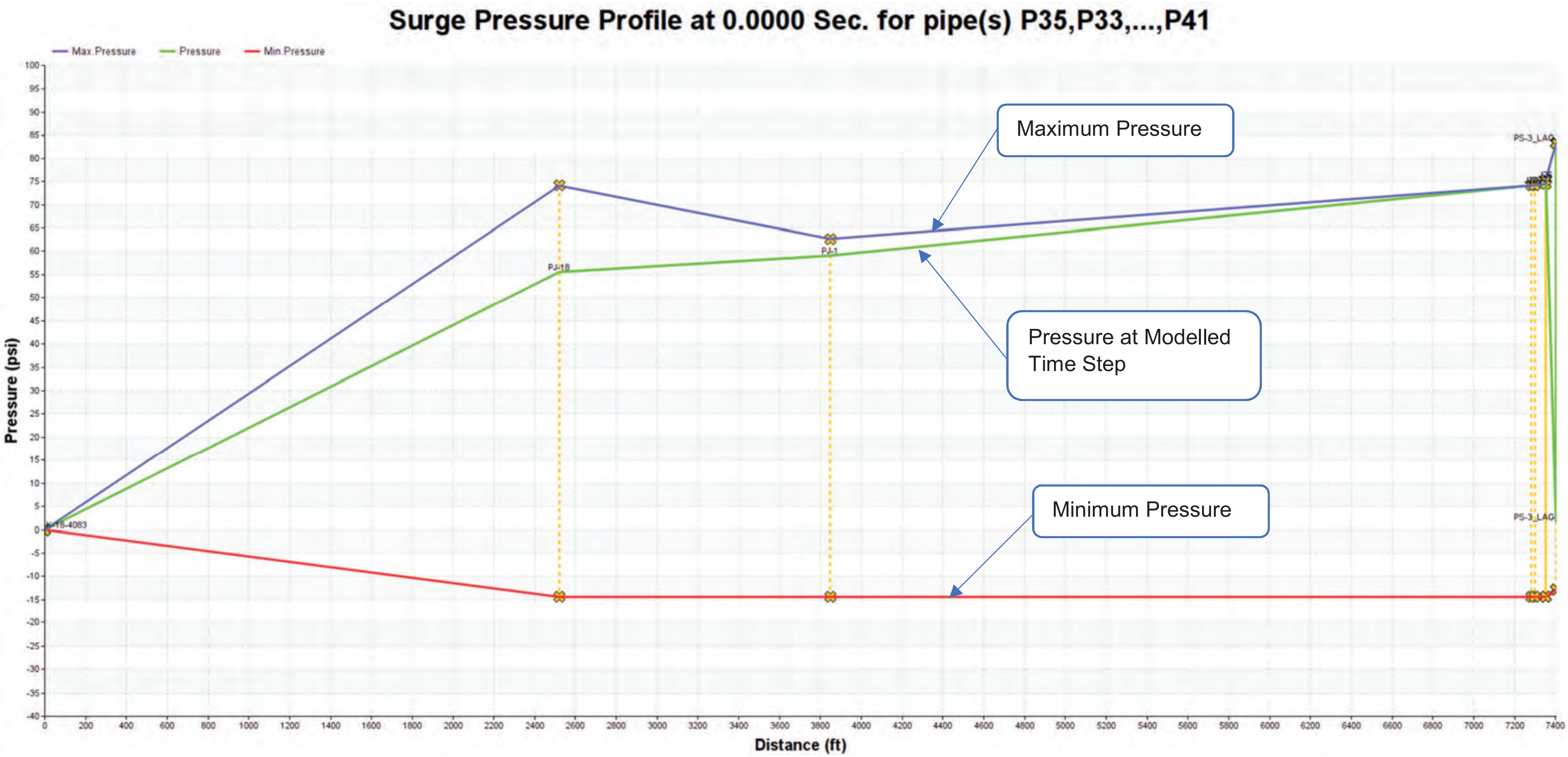


Figure 2: Pressure at Lift Station 3 During Pump Trip

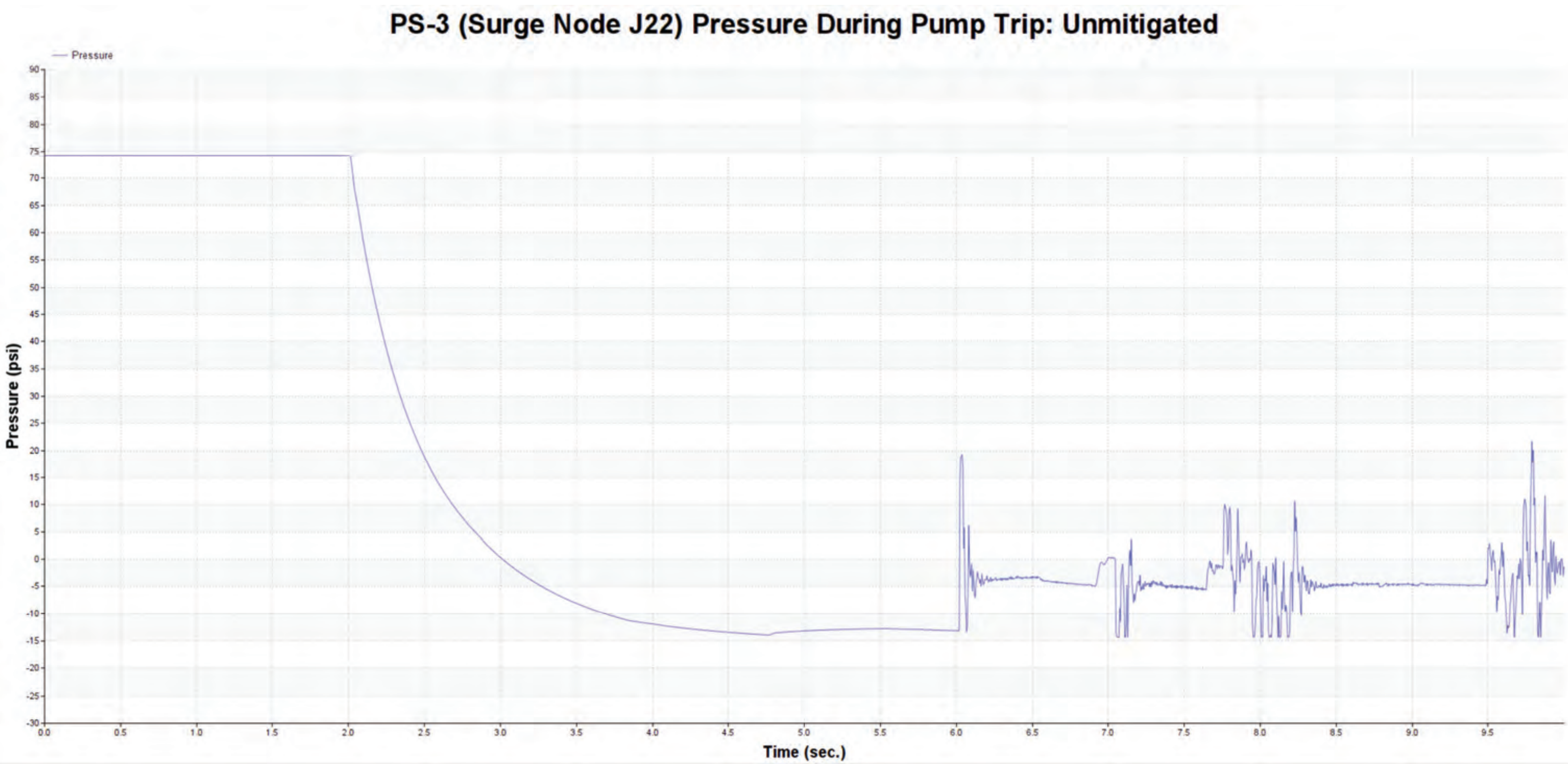


Figure 3: Lift Station 4 Force Main Pressure Envelope During Pump Trip

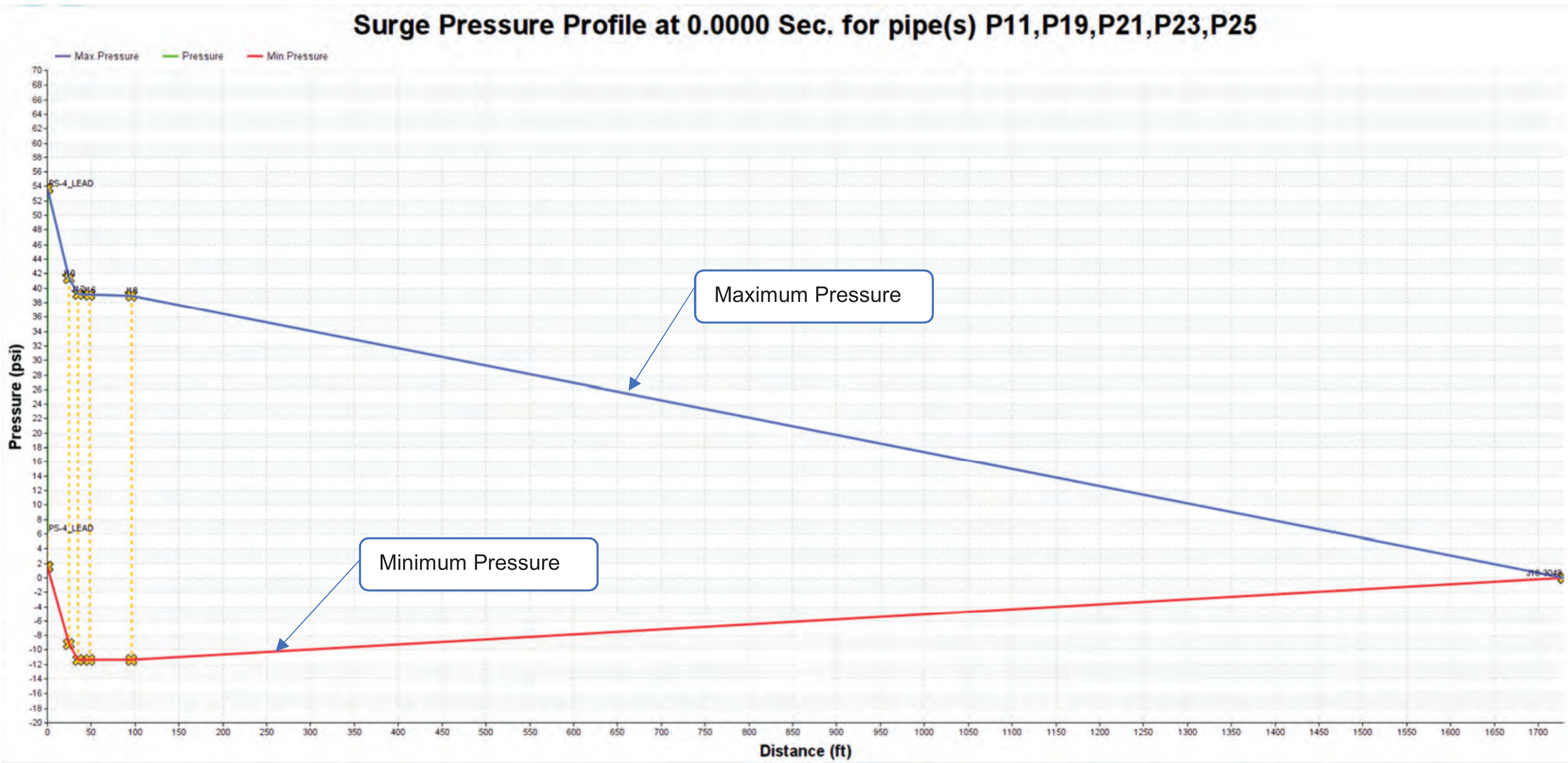


Figure 4: Pressure at Lift Station 4 During Pump Trip

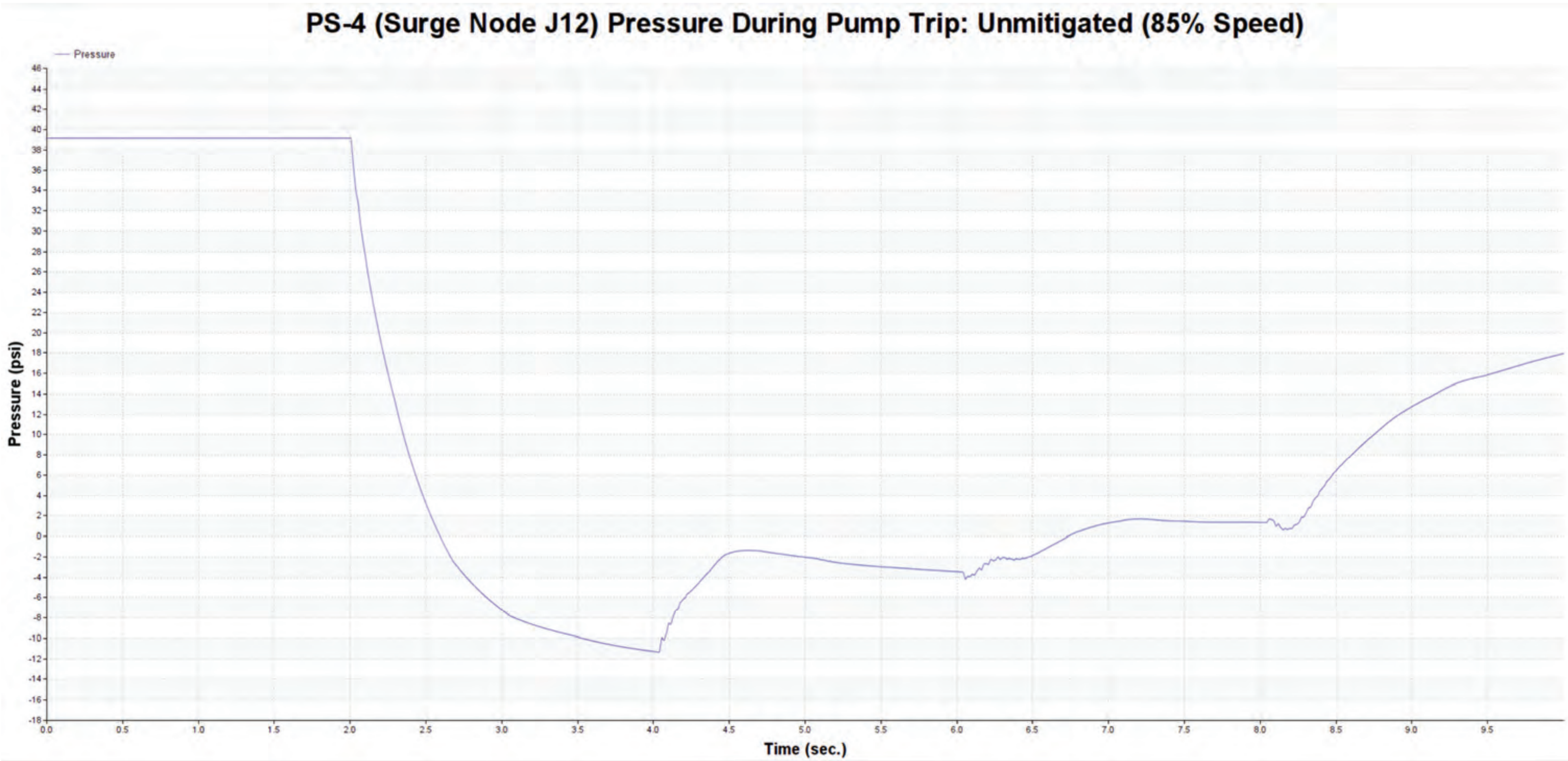


Figure 5 – Lift Station 19 Force Main Pressure Envelope During Pump Trip (Paulson Alignment)

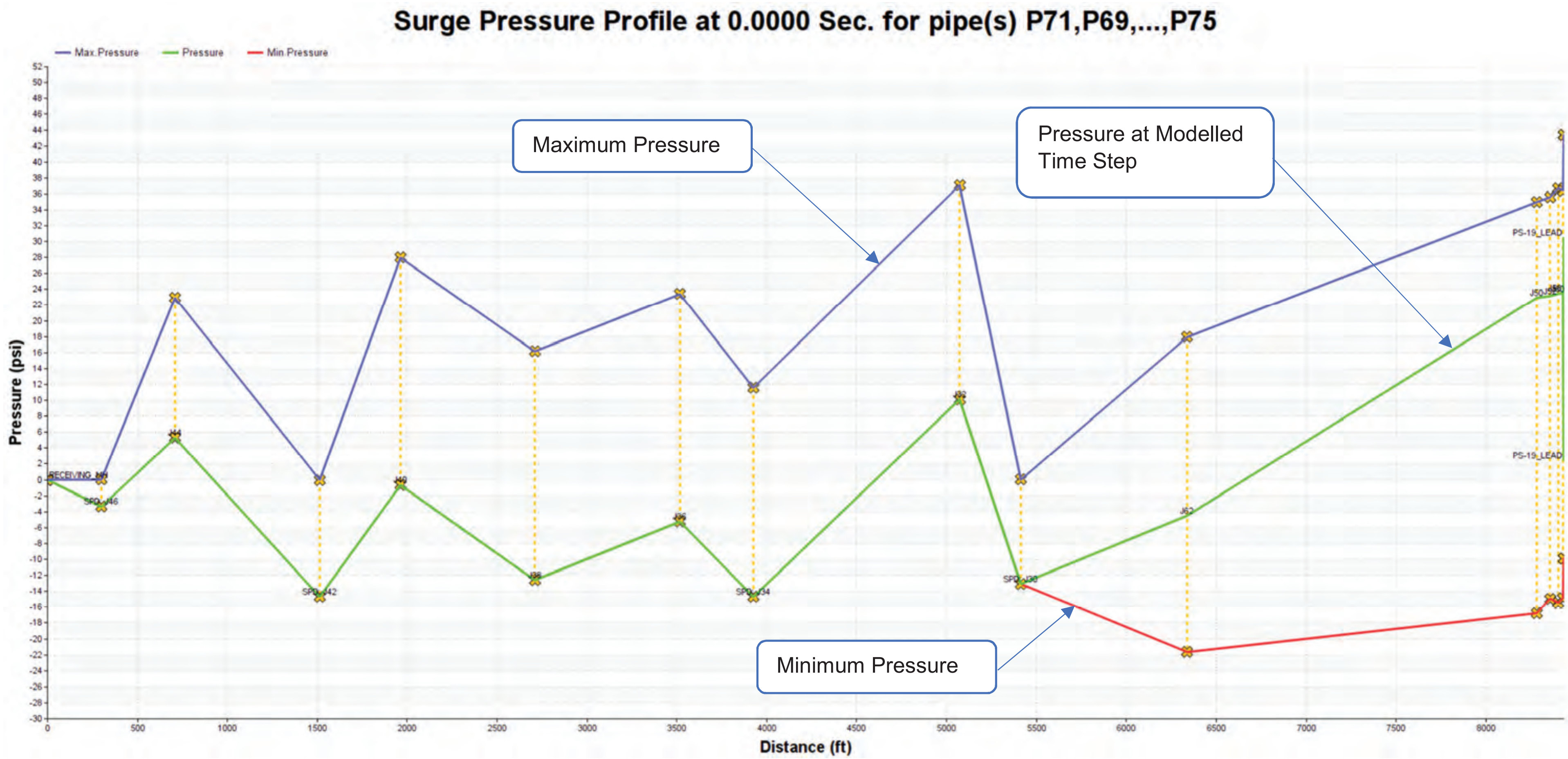


Figure 6 – Pressure Downstream of Lift Station 19 During Pump Trip (Paulson Alignment)

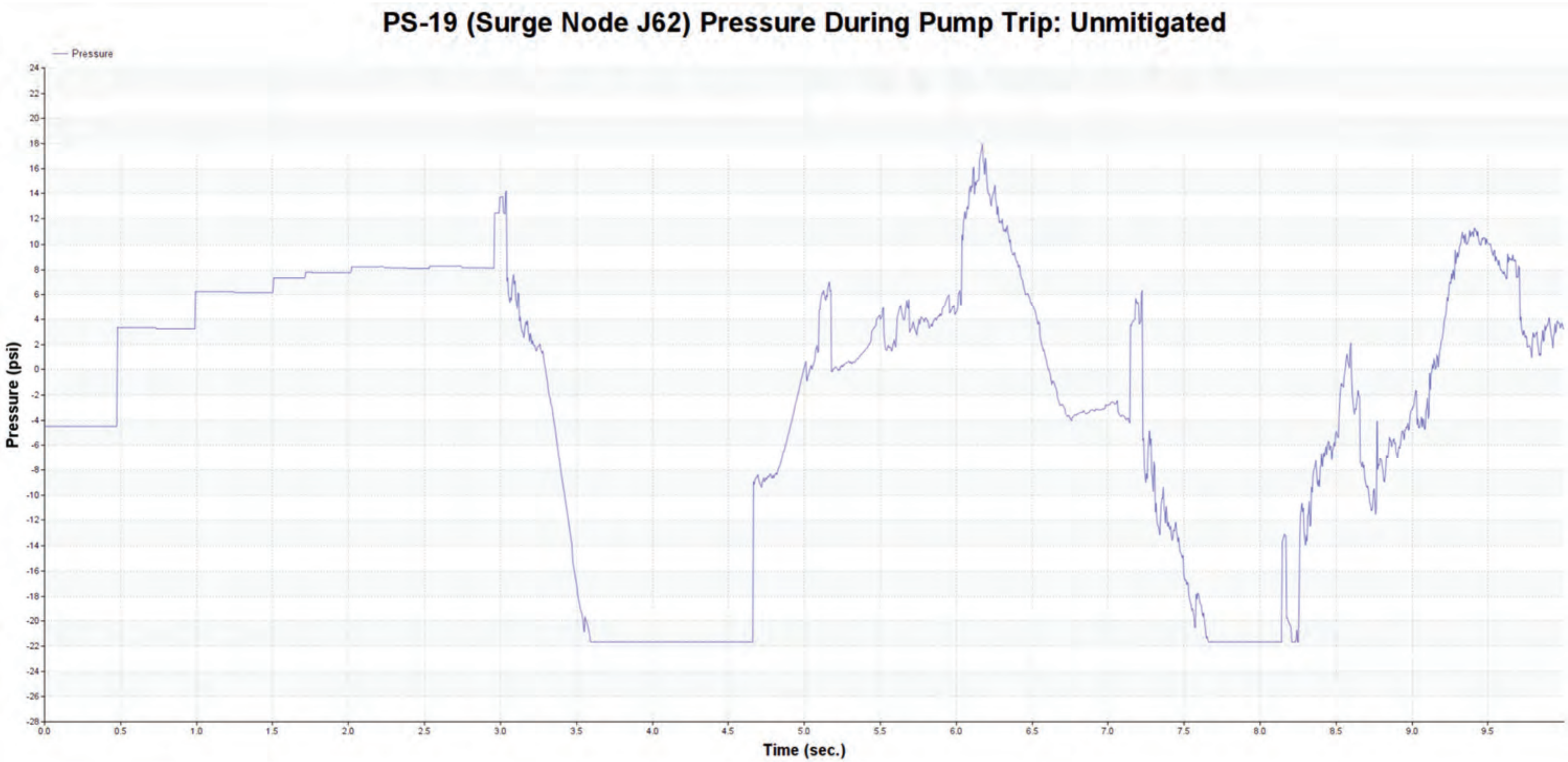
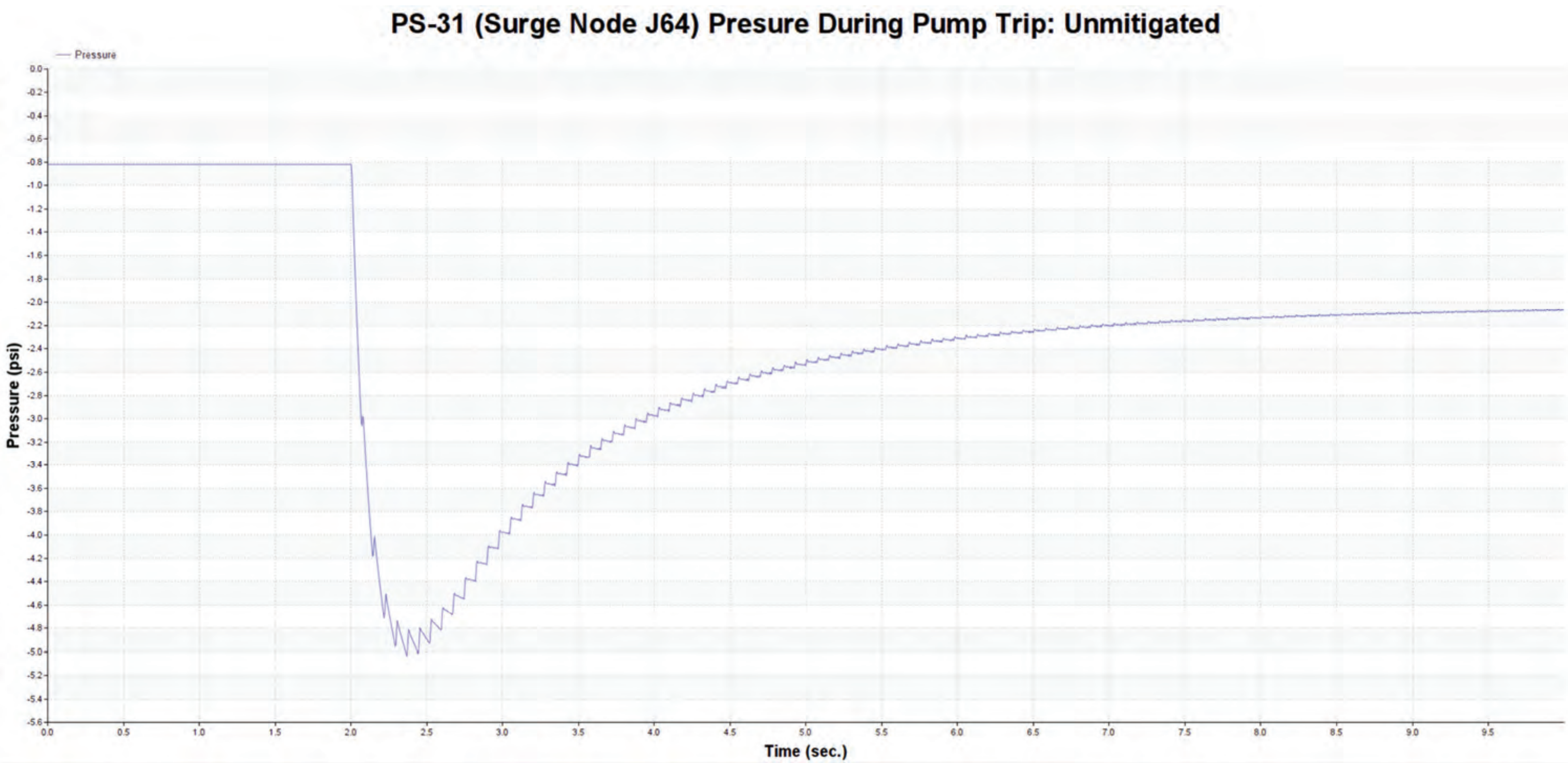


Figure 7: Pressure at Lift Station 31 During Pump Trip



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APPENDIX H

PHASE 1 CULTURAL RESOURCES ASSESSMENT

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Washington State
Public Works Board
Post Office Box 42525
Olympia, Washington 98504-2525

January 23, 2019

Barbara Zaroff
Kitsap County
614 Division Street, MS#23
Port Orchard, WA 98366

Re: Final Determination: Executive Order 05-05
Pre-Construction Project Title: Silverdale Pump Station Upgrades-Preliminary Engineering
PWB Contract: PR18-96103-050

Dear Ms. Zaroff,

The Public Works Board (PWB) has concluded Kitsap County successfully completed compliance requirements for the Executive Order 05-05 (EO 05-05) for the project stated above. The Suquamish Tribe did request that you conduct a cultural resource assessment of each of the four proposed pump station construction areas once the engineering plans have been completed. This is an eligible activity under this pre-construction loan, if you have funding available.

The Department of Archaeology & Historic Preservation reviewed your project and found it was exempt from the GEO 05-05 process.

If you have any questions about the EO 05-05 process, please contact me at 360-725-3088 or via e-mail connie.rivera@commerce.wa.gov. Thank you for your attention to this matter.

Sincerely,

Connie Rivera
Public Works Board Program Manager & Tribal Liaison

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CASCADIA ARCHAEOLOGY

February 18, 2019

BHC Consultants, LLC
1601 5th Avenue, Suite 500
Seattle, WA 98101

Attn: Tony Fisher

MEMORANDUM

RE: Phase 1 Archaeological investigation for 4 Pump Station upgrades (PS 3, Ps 4, PS 19 and PS 31), Kitsap County

Introduction

This memorandum provides a summary of the Phase 1 archaeological investigation of the above-referenced project. The sources consulted included archaeological site files, historic register files, historic property files, Traditional Cultural Property files, cemetery files, and cultural resources report files available online at the Washington Department of Archaeology and Historic Preservation (DAHP) in their WISAARD database. Also consulted were local histories and homestead records; ethnographies; maps (t-sheets; General Land Office; Metsker, Kroll, and Anderson Map Co.; USGS, etc.); historic aerials; and soils maps.

The Study Areas for this Phase 1 assessment are defined as extending approximately one mile from the boundaries of potential disturbance for the four pump stations, PS 3 (T. 25 N., R. 1 E., Section 20); PS 4 and PS 19 (T. 25 N., R. 1 E., Section 15); and PS 31 (T. 25 N., R. 1 E., Section 25). PS 4 and PS 19 are combined into one Study Area because of their proximity. The findings are summarized below, followed by conclusions and recommendations.

Recorded Sites

Archaeology:
Files available at DAHP list one archaeological site within the PS 3 Study Area, none in the PS 4-PS 19 Study Area, and none within the PS 31 Study Area. The recorded site is 45KP225, in T. 25 N., R. 1 E., Section 20,. It is a historic site consisting of a concrete culvert and unidentified adjacent concrete structure, possibly associated with flood/erosion control on Strawberry Creek (Dellert 2011). The structures are estimated to date between World War I and the 1940s.

Historic Properties and Cemeteries:
Historic properties are those listed in DAHP's Historic Property Inventory; they are mostly structures but can also include parks, roadways or other elements of the "built environment", and are usually over 50 years old. A total of 31 historic properties and two cemeteries are recorded within the study areas. Five are in both the PS 3 and PS 4-19 study areas; they are listed under both in Table 1. Eighteen historic properties are in the PS 3 Study Area, nine historic properties and one cemetery are in the PS 4-19 Study Area; and nine historic properties and one cemetery are in the PS 31 Study Area. The properties include residences, barns and other farm buildings, commercial and community structures, and railroad features. It should be noted that all the houses in the PS 31 Study Area listed in the HPI inventory are less than 50 years old, although they will be within the next five to six years.

Table 1. Historic Properties and Cemeteries in Study Areas.

ID #;	Name/property type	Comments
PS 3		
700150; 45KP128	Jackson Hall Memorial Community Hall	9161 Washington Ave., Silverdale Date: 1936. On NRHP and WHR (1995)
717555; 45KP306	Charles (or Christian) Braenlein Farm Barn	9151 Tracyton Blvd NW, Bremerton Date: 1915. On WHBR
715088	Barn	9506 Mickelberry Rd NW, Silverdale Date: 1920. Rec'd Not Eligible for hist. register
715087	Chicken Coop	9506 Mickelberry Rd NW, Silverdale Date: 1940. Rec'd Not Eligible for hist. register
715085	House	9506 Mickelberry Rd NW, Silverdale Date: 1912. Rec'd Not Eligible for hist. register
708319	Alternative High School	10120 Frontier Pl NW, Silverdale Date: 1958. Rec'd Not Eligible for hist. register
708318	Central Kitsap Middle School	Date: 1959-89. Rec'd Not Eligible for hist. register
708317	Central Kitsap High School	Date: 1942-94. Rec'd Not Eligible for hist. register
708214	House	3890 NW Windy Ridge Ln, Silverdale Date: 1962. Rec'd Not Eligible for hist. register
674383	Dahl Glass Co. Building	9536 Silverdale Wy, Silverdale Date: 1948. Not evaluated
669670	NBK Bangor Railroad trestle, Facility 645	W. Anderson, Silverdale Date: 1944. Rec'd Not Eligible for hist. register
184462	Old Town Pub (modern name)	3473 NW Byron St., Silverdale Date: 1913. Rec'd Not Eligible for hist. register
156984	Commercial building	9220 Bay Shore Dr., Silverdale Date: 1946. Rec'd Not Eligible for hist. register
97200	Not listed	9729 Silverdale NW, Silverdale Date: not listed. Det. Not Eligible for hist. register
97199	Silverdale Lutheran Church	9729 Silverdale Wy NW, Silverdale Date: 1958. Determined Not Eligible for hist. register
91401	Not listed	9723 Silverdale Wy NW, Silverdale Date::not listed. Determined Not Eligible for hist. register
717018	Silverdale United Methodist Church	9982 Silverdale Wy NW, Silverdale Date: 1962. Not evaluated for hist. register
672329	NBK Shelton-Bangor Railroad Bridge No. 2-3 (41.41)	NW Anderson Hill Rd., Silverdale Date: 1944. No other info.

P.O. Box 51058 Seattle, WA 98115-1058 Phone: 206-366-0337 Fax: 206-363-5303

PS4 andPS19		
717555; 45KP306	Charles (or Christian) Braenlein Farm Barn	9151 Tracyton Blvd NW, Bremerton Date: 1915. On WHBR. Also in PS3 Study Area
700714, 45KP279	Wheeler Farm Barn	NW Paulson Rd., Poulsbo Date: 1938. On WHBR, Rec'd eligible to NRHP.
717018	Silverdale United Methodist Church	9982 Silverdale Wy NW, Silverdale Date: 1962. Not evaluated for hist. register. Also in PS 3 Study Area
715088	Barn	9506 Mickelberry Rd NW, Silverdale Date: 1920. Rec'd Not Eligible for hist. register. Also in PS 3 Study Area
715087	Chicken Coop	9506 Mickelberry Rd NW, Silverdale Date: 1940. Rec'd Not Eligible for hist. register. Also in PS 3 Study Area
715085	House	9506 Mickelberry Rd NW, Silverdale Date: 1912. Rec'd Not Eligible for hist. register. Also in PS 3 Study Area
97130	House	1531 NW Bucklin Rd, Bremerton Date: Not listed. Det. Not Eligible for hist. register
9983	Central Valley School	10051 Central Valley Rd. NW, Bremerton Date: not listed. Not evaluated for hist. register.
9982	Community Meeting Hall	10180 Central Valley Rd NE, Bremerton. Date: not listed. Not evaluated for hist. register.
2893; 45KP229	Paulson Children Graves	Paulson Rd., Poulsbo 2 or 3 family burials, early 20th century
PS 31		
114062	House? Not provided, no photos.	8890 Roy Rd. NE, Bremerton Date: 1974. Not evaluated for hist. register.
114063	House	2791 NE Strand Rd., Bremerton Date: 1975. Det. Not Eligible for hist. register
114064	House	8825 Boundary Ln NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114061	House	9088 Roy Rd. NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114060	House	9068 Roy Rd. NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114059	House	9048 Roy Rd. NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114057	House	8835 Boundary Ln NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114047	House	8811 Boundary Ln NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
114046	House	8801 Boundary Ln NE, Bremerton Date: 1974. Det. Not Eligible for hist. register
647; 45KP171	Brownsville Cemetery	Brownsville/Gilberton. Date: ca. 1903; abandoned pre-1960. About 34 burials.

NRHP: National Register of Historic Places
WHR: Washington Heritage Register
WHBR: Washington Heritage Barn Register

Register Properties:
One historic property, the Jackson Hall Memorial Community Hall (45KP128) is listed on the National Register of Historic Places (NRHP) and is also on the Washington Heritage Register (WHR). It is within the PS 3 Study Area. The hall was built in 1936 and served as a central focus of social and community activities. Its construction was partially funded by the WPA.

Two historic barns, the Christian (or Charles; records differ) Braendlein Farm Barn (45KP306), and the Wheeler Farm Barn (45KP279), are listed in the Washington Heritage Barn Register (WHBR). The Braendlein Barn is in the PS 3 and PS 4-19 study areas, and the Wheeler Barn is in the PS 4-19 Study Area.

The Braendlein Barn was built in 1915 on property purchased by Christian (Charles) Braendlein in 1888. He grew potatoes for market and sold meat to the Bremerton Naval Shipyard. He also worked with the Department of Agriculture on local agricultural production, and served on the school board, as a county commissioner, and as coroner (Perry 1977:88, cited in Montgomery et al. 2013). The family later sold the farm and it was subsequently owned by M.E. Doll, and then leased to the Takuji Yamashita family until they were interned during World War II. Mr. Yamashita was a hotel owner in Silverdale and Bremerton, and was earlier involved in two legal cases as a result of anti-Asian discrimination. One of the first graduates of the UW law school, he was not admitted to the State Bar because of the law denying citizenship to Asians, a case that was decided by the Washington Supreme Court in 1902 (he was granted honorary admittance to the State Bar posthumously). Later, he went to court because he was barred from forming a corporation to own property; that case went to the U.S. Supreme Court, where it lost (Wilma 2000). After the Yamashita family left Silverdale, the farm changed hands and was occupied by the Nyland family and then by the Preus/DeGroot family.

The Wheeler Barn was built in 1938. Reportedly, its original use was as an auction house. The farm has been in the Wheeler family since the 1950s.

Traditional Cultural Properties:
No Traditional Cultural Properties (TCPs) are listed within any of the study areas in DAHP files or have been noted in cultural resource reports consulted for this project.

Ethnographic Sites:
The study areas are in the ethnographically recorded territory of the Suquamish, a Southern Lushootseed-speaking group of the Southern Coast Salish (Suttles and Lane 1990). A number of sites on Dyes Inlet were used by the Suquamish; on inner Dyes Inlet there were clam and oyster collecting places, and salmon were caught on Clear Creek (Lane 1974:22).

Several ethnographic place names are recorded within or close to the study areas, most near the head of Dyes Inlet. The following names refer to locations in or close to the PS

3 and PS 4-19 study areas; they were recorded by the linguist T.T. Waterman in the early twentieth century (Hilbert et al. 2001).

- *Swa'*^{3}*aq*^{3}*t,* for a tiny bay just north of Silverdale. The term is the diminutive of another place name (*Sxaq*^{3}*t*, "way back in") for a small bay near Silverdale.
- *Ba'xwabaqwobs*, meaning "prairies, open spaces", the present-day site of Silverdale.
- *Blssqwe*^{l}*qwats*^{3}, "where a certain rush grows," for a creek just south of Silverdale. Rush stems were used in making mats.
- *Duwe'iq*, the creek east of Silverdale, probably Clear Creek. According to Waterman, the word evokes a creek located at the head of a bay or estuary; it was described as "mouth of a creek way back in a pocket" by one of his contacts (Hilbert et al. 2001:208).
- *Qo'qwaxad*, meaning "coot"; also known as *xuda'a:b*, a term for a particular ceremonial performance. This referred to a lake with an island in it, where "black tamanous" ceremonies were held. This is apparently Island Lake, about 1.5 miles north of the PS 4-19 Study Area.

Warren Snyder also recorded place names of the Suquamish (Snyder 1968:132): The first listed is in or close to the PS 3 and PS 4-19 study areas; the other two are in the PS 31 Study Area:

Sáqad, or "spear it". This was the name of a camping site at the mouth of Clear Creek as well as the creek and the entirety of Dyes Inlet. According to Snyder, none of the people he interviewed remembered there being a winter village there, so it was probably a seasonal camp. Silver salmon was the main species in the creek, and clams and oysters were collected from the adjacent beach area.

- *qq*^{w}*áptb,* which means "someone was bit on the buttocks". The Suquamish camped there (Gilberton-University Point vicinity) and fished for smelt in the fall. The location was named for the story of a woman who was said to have been bitten by a shark there.
- *syabálqu?,* meaning "high class water side". There was a spring on the beach there. According to Snyder, people did not camp there but went inland to collect salal and huckleberries.

Previous Archaeological Investigations

DAHP's online data base lists 13 archaeological investigations within the PS 3 Study Area since 1995, 16 in the PS 4-19 Study Area, and one in the PS 31 Study Area. They were done for proposed projects such as roadway and stormwater improvements, cell tower construction, and trail construction. None of the projects identified precontact (prehistoric) or potentially significant historic archaeological resources. Historic buildings were identified on four projects; in one case a property was considered significant (the Wheeler Barn, which is on the Washington Heritage Barn Register), but a finding of No Effect to the barn from the proposed project (cell tower) was recommended. The reports are listed in Table 2, along with brief descriptions of the type of investigation and results.

Table 2. Archaeological Investigations within One Mile.

Reference	Type of Investigation	Results	Comments
PS 3			
Baker 2015	Survey, no shovel probes (paved)	No CR identified	For cell tower
Berger and McNett 2016	Survey, shovel probes	No archaeology; 5 buildings recorded	School remodel/rebuild. Historic structures recommended not eligible to hist. register.
Dellert 2015	Monitoring	No significant CR	Bucklin Hill Rd. project
Diedrich et al. 2012	Survey	No significant CR	Water system/transmission main
Forsman et al. 1997	Survey, shovel probes	No significant CR	Bucklin Hill Rd. project
Kassa 2016	Survey, 1 shovel probe	No CR identified	Silverdale Wy. Project
Kelly 2012a	Survey, shovel probes	No CR identified	Stormwater control
Kelly 2012b	Survey, no shovel probes (paved)	No CR identified	Stormwater control
Kelly and Montgomery 2013	Survey, shovel probes	2 houses with outbuildings, 1 partly burned house	Trail improvement project. Buildings recorded; not eligible for hist. register
Luttrell 2004	Survey, shovel probes	No CR identified	Waaga Wy road project
Mather et al. 2005	Survey, shovel probes	No significant CR	Waaga Wy road project
Montgomery et al. 2013	Survey	No CR identified	Bucklin Hill Rd. project
Schumacher 2008a	Survey, shovel probes	Silverdale Lutheran Church; rec'd not eligible to hist. register	Community Center campus; Building originally a church, built 1958
PS 4-19			
Baker 2015	Survey, no shovel probes (paved)	No CR identified	For cell tower Also in PS 3 Study Area.
Baker and McReynolds 2015	Survey, no shovel probes (graded)	Wheeler Barn within visual APE	For cell tower. Eligible historic property in visual APE but No effect.
Berger 2007	Survey, shovel turnovers	No CR identified	Subdivision, Silverdale Wy/ Waaga Wy
Berger 2014	Survey, shovel probes	No CR identified	Clear Ck. floodplain restoration
Bundy 2007	Survey, shovel probes	No CR identified	
Dellert 2015	Monitoring	No significant CR	Bucklin Hill Rd. project. Also in PS 3 Study Area.
Diedrich et al. 2012	Survey	No significant CR	Water system/transmission main. Also in PS 3 Study Area.
Forsman et al. 1997	Survey, shovel probes	No significant CR	Bucklin Hill Rd. project Also in PS 3 Study Area.
Kassa 2017	Survey, shovel probes	No CR identified	Transit Center project
Kelly 2012a	Survey, shovel probes	No CR identified	Stormwater control
Kelly 2012b	Survey, no shovel probes (paved)	No CR identified	Stormwater control
Kelly 2012c	Survey, no shovel probes (disturbed/fill)	No CR identified	Stormwater control
Luttrell 2004	Survey, shovel probes	No CR identified	Waaga Wy road project. Also in PS 3 Study Area.

Montgomery et al. 2013	Survey	No CR identified	Bucklin Hill Rd. project. Also in PS 3 Study Area.
Schumacher 2004	Survey, shovel probes	No significant CR	Bicycle trail
Schumacher 2008b	Survey, shovel probes	1915 house; rec'd not eligible to hist. register	Stormwater control
PS 31			
Schumacher 2008c	Survey, no shovel probes	No significant CR	Road improvement project

CR=cultural resources (historic or prehistoric)
APE=Area of Potential Effects

Historic Settlement

The first recorded Euroamerican settlement of the Silverdale vicinity took place in 1854, when loggers arrived and began harvesting timber, much of which was initially milled at Enetai (Port Orchard) and sent to California (Hinchliff 2011). The first Euroamerican settler may have been Daniel J. Sackman, who obtained several land patents around Silverdale, from which he harvested timber to supply a mill he and others had built at Enetai (present-day Port Orchard) (Perry 1977:2).

In the 1880s, Scandinavian immigrants claimed homesteads and by ca. 1890 had established farms, including through the Farmers' Cooperative, to sell their surplus products. Mosquito Fleet boats transported produce and other goods, as well as people, to Seattle, Bremerton, and other places on Puget Sound. Over time, the city of Silverdale grew to its current population of about 15,000.

Brownsville was also settled starting in the 1880s. Like Silverdale and other Kitsap County towns, early transportation to and from the community was mostly by water; a dock was built to accommodate Mosquito Fleet steamboats in the early twentieth century. Use of the area increased as people began vacationing and building summer cabins there, but populations have remained relatively small compared to neighboring places such as Bremerton and Silverdale.

The 1858 General Land Office (GLO) cadastral plat of T. 25 N., R. 1 E. shows no structures in any of the study areas, but it does show a road on the northwest side of Dye's Inlet in the NE ¼ of Section 20, which heads west-northwest, and two trails. One starts at the shoreline in the NE ¼ of Section 20 and goes north between Clear Creek and the creek to its west; the other starts at the shoreline in Section 21 (NE ¼) and goes north on the east side of Clear Creek, crossing the east branch in Section 9.

The U.S. Coast and Geodetic Survey t-sheet from 1881 shows Dye's Inlet and Burke's Bay (present-day Brownsville area), but no structures, towns, agricultural fields, or roads are shown (U.S. Coast and Geodetic Survey 1881).

GLO land patent records for Section 20 (PS 3) list Herod Wells as receiving a cash-entry patent for 32 acres in 1870. Thaddeus Ridgeway received a cash entry patent for 80 acres in the S ½ SW Section 15 (encompassing the PS 4-19 location), in 1891. Adjacent parcels were patented by David Williams and William Cagle. Daniel Sackman also obtained land in Section 15.

In Section 25 (PS 31), Peter Hansberry received a cash entry patent for 120 acres in the NW ¼, in 1890; Malcomb McMillan a cash entry patent for 160 acres in the NE ¼ in 1891; Aiden Williams a cash entry patent for 160 acres in the SE SW ¼ and SW SE ¼ in 1891; and James Duncan Moorhead a homestead entry patent for 160 acres in the SW NW ¼ and the NW SW ¼ in 1890. PS 31 and the associated force main are within the boundaries of Hansberry's homestead.

County atlases from the early to middle twentieth century show increased infrastructure and subdivision of parcels over time. Tiny parcels were platted in some waterfront locations and increased in number. By 1909 there was a street grid in Section 20 in the vicinity of PS 3, and a dock on the shoreline with four adjacent buildings. Three are labeled, one as a bank and store; one as the Post Office; and one as a store (Anderson Map Co. 1909). The landowner in the S ½ SW ¼ Section 15 (PS 4-19) was Jacob Kreselheimer (spelling varies in different atlases; transcribed as shown in atlas); in the NE SW ¼ Section 25, Ella M. Lyle and A.A. Breeze had separate parcels.

In 1926, Kreilscheimer still held the same parcel he had in 1909 in Section 15. In Section 25, the parcel previously owned by Breeze was held by the Scandinavian American Bank while, Lyle still owned the parcel she had in 1909. Owners of lots in the street grid in Section 20 were listed: Their names included Thuesen, Madison, Bixby and Wyatt, Wyatt and Chandler, Page, Finley, Hedman, Carlson, Chase, Radovich, Anderson, Holt, and Rudin (Metsker Map Co. 1926).

The 1940 atlas shows the dock in Section 20; J. Kreielsheimer in Section 15; and in Section 20, R.L. Bender and R.H. Parker held the parcels previously owned by Lyle and Breeze (Kroll Map Co. 1940).

Soils

PS 3:
Three soil types are mapped in the PS 3 project location (encompassing the PS and associated sewer line): Indianola loamy sand; Neilton gravelly loamy sand; and Urban land-Alderwood complex. Indianola loamy sand is typically situated on glacial landforms (eskers, kames, terraces) and is derived from sandy glacial outwash. The A horizon is about 6 in. thick in a typical profile, the B1 horizon down to 17 in., B2 to 27 in., and glacial (BC and C) at 27 to 37 in. below surface (NRCS 2019). Neilton gravelly loamy sand is usually present on terraces and is derived from gravelly and sandy glacial outwash. Urban land-Alderwood complex consists primarily of altered urban land; the Alderwood component is typically composed of very gravelly ashy sandy loam. It is found on till plains and moraines and forms in basal till.

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PS 4-19:
Mapped soils are mostly Alderwood gravelly sandy loam, with a small area of Norma fine sandy loam. Alderwood soils are derived from glacial drift and/or outwash over dense glaciomarine deposits and are typically present on 0-8 percent hills. The A horizon in a typical profile extends to 7 in., followed by the B1 horizon to 21 in., B2 to 30 in., and C (glacial) at 35 in. (NRCS 2019). Norma fine sandy loam is derived from alluvium with volcanic ash mixed in; it is typically situated in depressions and is poorly drained.

PS 31:
Soils in the PS 31 vicinity are mapped as Alderwood gravelly sandy loam.

Conclusions

Probability of Historic Properties being affected:
The likelihood that any historic properties would be affected by the Project is considered low as the work will replace existing facilities with similar ones or take place underground with no new surface expression. In addition, most of development in the PS 4-19 and PS 31 areas is recent; historic aerials indicate that most residential subdivisions and other development took place between 1981 and 1994 (NETROnline 2019). The PS 3 Project area has been developed since the late nineteenth to early twentieth century. The specific ages of all the buildings in this area have not been recorded, but no permanent effects from the proposed project are expected.

The following properties are located along the roads where new force main or gravity sewer pipelines will be upgraded.

<u>PS 3:</u>
One historic property on file at DAHP is within or directly adjacent to the PS 3 Project, the Old Town Pub, which is at the corner of NW Byron St. and McConnell Ave. NW. It was recommended not eligible to a historic register, although a formal evaluation by the State Historic Preservation Officer (SHPO) has not been undertaken.

<u>PS 4-19:</u>
One historic property on file at DAHP is within or directly adjacent to the PS 4-19 project boundaries, a house on Bucklin Hill Road. That house was determined Not Eligible to a historic register so no further consideration is necessary.

<u>PS 31:</u>
None of the historic properties inventoried at DAHP that are within the PS 31 Study Area are in or directly adjacent to the Project location.

Archaeological Probability:
In the statewide archaeological predictive model lists five levels of “Risk”, i.e, potential that archaeological resources are present that could be disturbed by a project. The model is based primarily on environmental factors such as proximity to water, landform type, and slope, and does not take into account previous disturbance, smaller-scale topographic

factors, etc., so additional information about specific project location and parameters is factored into the recommendations. Over most of the four project areas, soils are mostly glacial, so cultural material would likely be near the surface or in the upper two to three feet. One small area of alluvial soils is mapped, in the PS 4-19 project area, and cultural material could be more deeply buried there. However, that area may have been heavily disturbed by road construction, as discussed below.

PS 3:

The predictive model identifies the PS 3 project location as being "Very High Risk" to "High Risk"; for both these levels, "Survey [is] Highly Advised". Given its location (proximity to the shoreline, head of the bay, etc.), the potential for precontact and historic archaeological resources is considered high, and survey is recommended for any areas of potential new disturbance (i.e., relocated or expanded trenches, expanded pump station excavations). If this is not practical, i.e., the area of potential disturbance is covered by asphalt, concrete, etc., then archaeological monitoring of construction of any areas where native soils could be disturbed (below fill) and above unaltered glacial sediments is recommended.

PS 4-19:

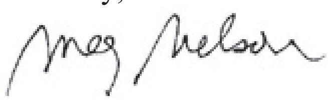
This area is considered to have Moderate or Moderately Low potential for archaeological resources in the predictive model. Survey is recommended for Moderate risk areas and contingent on project parameters for Moderately Low risk areas. The fact that no archaeological resources have been identified in any of the surveys conducted in the Study Area, along with the likelihood that the Project location has been extensively disturbed by previous construction for Waaga Way (Hwy 303) and Bucklin Hill Road suggests that it is unlikely that significant archaeological resources are present in the area of potential disturbance. The majority of the project is on a slope except at the eastern edge, which is in the Barker Creek valley. Presently, the creek is approximately 1,000 ft. away, although it could have been closer in the past. That area, which is mapped as having alluvial soils, has a greater potential for sites than the slope, and survey of that area that includes subsurface probing is recommended if there is a possibility that native sediments could be disturbed. However, that area is where the two roads intersect and native soils may not be reachable in a survey. If that is the case, construction excavations at that location should be monitored.

PS 31:

This area has a Moderately Low potential for archaeological resources in the state predictive model. It is located on a relatively flat landform above two small creeks, which could have drawn people to that general area to collect plant resources or hunt, although there doesn't appear to be anything about the specific location that would have made it more desirable than others in the general vicinity. However, if project activities could affect native sediments that have not been disturbed previously, archaeological survey is recommended.

Note that a field survey of the project locations has not been undertaken for this Phase 1 assessment. Recommendations are based on historic information and could be revised based on specific project elements not currently finalized or by a field visit. If you have any questions about the results of this assessment, please contact me.

Sincerely,



Meg Nelson
Senior Archaeologist, Project Manager

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APPENDIX I

OPINIONS OF PROBABLE PROJECT COSTS

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Cost Estimate

Kitsap County **Job:** **17-10530.01**
Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design **Date:** **12/05/19**
Engineer's Projection of Probable Construction Cost - CIP Budget **By:** **Tony F.**
Old Town Silverdale Sewer Upgrades **Checked:**

Bid Item No.	Ref. Section	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	1-04	Preconstruction Work Phase	$7,800.00	1	LS	$7,800.00
2	1-04	Final Cleanup and Restoration	$34,800.00	1	LS	$34,800.00
3	1-05	Surveying	$6,600.00	1	LS	$6,600.00
4	1-05	Project Record Drawings	$3,400.00	1	LS	$3,400.00
5	1-08	Type B Schedules	$500.00	2	MONTH	$1,000.00
6	1-09	Minor Changes & Additions (Allowance)	$20,000.00	1	FA	$20,000.00
7	1-09	Mobilization & Demobilization	$27,300.00	1	LS	$27,300.00
8	1-10	Project Temporary Traffic Control	$10,450.00	1	LS	$10,450.00
9	2-02	Removal of Structures and Obstructions	$5,000.00	1	LS	$5,000.00
10	2-09	Trench Safety Systems	$5.00	850	LF	$4,250.00
11	2-09	Gravel Backfill for Foundation (Allowance)	$30.00	30	TN	$900.00
12	4-04	Crushed Surfacing Top Course	$27.00	170	TN	$4,590.00
13	4-04	Crushed Surfacing Base Course	$27.00	340	TN	$9,180.00
14	5-04	Temporary HMA Pavement	$150.00	90	TN	$13,500.00
15	5-04	Permanent HMA Pavement	$150.00	335	TN	$50,250.00
16	7-05	Type 1 Manhole, 54-inch Dia.	$7,500.00	3	EA	$22,500.00
17	7-08	Imported Trench (Subsequent) Backfill	$26.00	1,885	TN	$49,010.00
18	7-08	Controlled Density Fill (CDF) (Allowance)	$130.00	20	CY	$2,600.00
19	7-08	Dewatering	$4,500.00	1	LS	$4,500.00
20	7-08	Extra Trench Excavation (Allowance)	$65.00	50	CY	$3,250.00
21	7-17	6-inch Gravity Sewer	$86.00	160	LF	$13,760.00
22	7-17	15-inch Gravity Sewer	$118.00	690	LF	$81,420.00
23	8-01	Temporary Erosion and Sediment Control	$12,000.00	1	LS	$12,000.00
		Subtotal				$388,060.00
		Contingency	30%			$116,500.00
		Subtotal				$504,560.00
		Sales Tax	9.0%			$45,500.00
		Total Estimated Construction Cost				**$550,060.00**
		Allied Costs	50%			$275,100.00
		Total Estimated Project Cost				**$825,160.00**

The opinion of probable construction cost herein is based on our perception of current conditions at the project location. This opinion reflects our professional opinion of costs at this time and is subject to change as the project design matures. BHC has no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. BHC cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

USE	**$825,500**

Kitsap County

Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design

Engineer's Projection of Probable Construction Cost

Preliminary Design

Pump Station 3

December 5, 2019

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$42,000.00	1	LS	$42,000.00
2	Final Cleanup and Restoration	$6,500.00	1	LS	$6,500.00
3	Surveying	$13,000.00	1	LS	$13,000.00
4	Project Record Drawings	$17,400.00	1	LS	$17,400.00
5	Type B Schedules	$500.00	12	Month	$6,000.00
6	Minor Changes (Allowance)	$125,000.00	1	FA	$125,000.00
7	Mobilization and Demobilization	$173,300.00	1	LS	$173,300.00
8	Operation and Maintenance Manuals	$3,000.00	1	LS	$3,000.00
9	Dewatering	$48,000.00	1	LS	$48,000.00
10	Bypass Pumping	$88,000.00	1	LS	$88,000.00
11	Trench Safety Systems	$251,000.00	1	LS	$251,000.00
12	Gravel Backfill for Foundations (Allowance)	$30.00	10	TN	$300.00
13	Crushed Surfacing Base Course	$27.00	100	TN	$2,700.00
14	Crushed Surfacing Top Course	$27.00	50	TN	$1,350.00
15	HMA Pavement	$150.00	50	TN	$7,500.00
16	Temporary Erosion and Sediment Control	$6,000.00	1	LS	$6,000.00
17	Pumps	$270,000.00	1	LS	$270,000.00
18	Mechanical Work	$553,500.00	1	LS	$553,500.00
19	Electrical Work	$434,000.00	1	LS	$434,000.00
20	Structures (Slab on Wet Well)	$238,000.00	1	LS	$238,000.00
21	Miscellaneous Site Work	$197,500.00	1	LS	$197,500.00
	Subtotal				**$2,484,050.00**
	Contingency	30%			$745,300.00
	Subtotal				$3,229,350.00
	Sales Tax	9.0%			$290,700.00
	Total Estimated Construction Cost				**$3,520,050.00**
	Allied Costs	50%			$1,760,025.00
	Total Estimated Project Cost				**$5,280,075.00**

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USE	**$5,280,500**

Cost Estimate

Kitsap County **Job:** **17-10530.01**
Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design **Date:** **12/05/19**
Engineer's Projection of Probable Construction Cost - CIP Budget **By:** **Tony F.**
Fredrickson Road Sewer Upgrades **Checked:**

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$17,800.00	1	LS	$17,800.00
2	Final Cleanup and Restoration	$34,800.00	1	LS	$34,800.00
3	Surveying	$8,300.00	1	LS	$8,300.00
4	Project Record Drawings	$4,700.00	1	LS	$4,700.00
5	Type B Schedules	$500.00	2	MONTH	$1,000.00
6	Minor Changes & Additions (Allowance)	$44,000.00	1	FA	$44,000.00
7	Mobilization & Demobilization	$61,900.00	1	LS	$61,900.00
8	Project Temporary Traffic Control	$15,800.00	1	LS	$15,800.00
9	Removal of Structures and Obstructions	$5,000.00	1	LS	$5,000.00
10	Trench Safety Systems	$5.00	1,940	LF	$9,700.00
11	Gravel Backfill for Foundation (Allowance)	$30.00	65	TN	$1,950.00
12	Crushed Surfacing Top Course	$27.00	685	TN	$18,495.00
13	Crushed Surfacing Base Course	$27.00	530	TN	$14,310.00
14	Temporary HMA Pavement	$150.00	220	TN	$33,000.00
15	Permanent HMA Pavement	$150.00	1,105	TN	$165,750.00
16	Type 1 Manhole, 54-inch Dia.	$7,500.00	7	EA	$52,500.00
17	Imported Trench (Subsequent) Backfill	$26.00	5,035	TN	$130,910.00
18	Controlled Density Fill (CDF) (Allowance)	$130.00	20	CY	$2,600.00
19	Dewatering	$10,000.00	1	LS	$10,000.00
20	Extra Trench Excavation (Allowance)	$65.00	50	CY	$3,250.00
21	6-inch Gravity Sewer	$88.00	600	LF	$52,800.00
22	18-inch Gravity Sewer	$120.00	1,160	LF	$139,200.00
23	21-inch Gravity Sewer	$137.00	120	LF	$16,440.00
24	24-inch Gravity Sewer	$148.00	60	LF	$8,880.00
23	Temporary Erosion and Sediment Control	$26,500.00	1	LS	$26,500.00
	Subtotal				$879,585.00
	Contingency	30%			$263,900.00
	Subtotal				**$1,143,485.00**
	Sales Tax	9.0%			$103,000.00
	Total Estimated Construction Cost				**$1,246,485.00**
	Allied Costs	50%			$623,300.00
	Total Estimated Project Cost				**$1,869,785.00**

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USE	**$1,870,000**

Cost Estimate

Kitsap County
Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design
Engineer's Projection of Probable Construction Cost - CIP Budget
Pump Station 4 Force Main Upgrade

Job: 17-10530.01
Date: 12/05/19
By: Tony F.
Checked:

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$15,600.00	1	LS	$15,600.00
2	Final Cleanup and Restoration	$34,800.00	1	LS	$34,800.00
3	Surveying	$7,700.00	1	LS	$7,700.00
4	Project Record Drawings	$5,400.00	1	LS	$5,400.00
5	Type B Schedules	$500.00	2	MONTH	$1,000.00
6	Minor Changes & Additions (Allowance)	$39,000.00	1	FA	$39,000.00
7	Mobilization & Demobilization	$54,400.00	1	LS	$54,400.00
8	Project Temporary Traffic Control	$19,800.00	1	LS	$19,800.00
9	Removal of Structures and Obstructions	$10,000.00	1	LS	$10,000.00
10	Trench Safety Systems	$5.00	1,570	LF	$7,850.00
11	Gravel Backfill for Foundation (Allowance)	$30.00	50	TN	$1,500.00
12	Crushed Surfacing Top Course	$27.00	660	TN	$17,820.00
13	Crushed Surfacing Base Course	$27.00	280	TN	$7,560.00
14	Temporary HMA Pavement	$150.00	150	TN	$22,500.00
15	Permanent HMA Pavement	$150.00	385	TN	$57,750.00
16	Imported Trench (Subsequent) Backfill	$26.00	2,160	TN	$56,160.00
17	Controlled Density Fill (CDF) (Allowance)	$130.00	20	CY	$2,600.00
18	Dewatering	$8,000.00	1	LS	$8,000.00
19	Extra Trench Excavation (Allowance)	$65.00	50	CY	$3,250.00
20	20-inch C905 PVC Force Main	$240.00	1,570	LF	$376,800.00
21	Temporary Erosion and Sediment Control	$23,500.00	1	LS	$23,500.00
	Subtotal				$772,990.00
	Contingency	30%			$231,900.00
	Subtotal				**$1,004,890.00**
	Sales Tax	9.0%			$90,440.00
	Total Estimated Construction Cost				**$1,095,330.00**
	Allied Costs	50%			$547,700.00
	Total Estimated Project Cost				**$1,643,030.00**

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USE	$1,643,500

Kitsap County

Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design

Engineer's Projection of Probable Construction Cost

Preliminary Design

Pump Station 4

December 5, 2019

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$42,000	1	LS	$42,000
2	Final Cleanup and Restoration	$6,500	1	LS	$6,500
3	Surveying	$13,000	1	LS	$13,000
4	Project Record Drawings	$17,400	1	LS	$17,400
5	Type B Schedules	$500	12	Month	$6,000
6	Minor Changes (Allowance)	$150,000	1	FA	$150,000
7	Mobilization and Demobilization	$220,200	1	LS	$220,200
8	Operation and Maintenance Manuals	$3,000	1	LS	$3,000
9	Dewatering	$36,000	1	LS	$36,000
10	Bypass Pumping	$95,000	1	LS	$95,000
11	Trench Safety Systems	$397,000	1	LS	$397,000
12	Gravel Backfill for Foundations (Allowance)	$30	10	TN	$300
13	Crushed Surfacing Base Course	$27	170	TN	$4,590
14	Crushed Surfacing Top Course	$27	90	TN	$2,430
15	HMA Pavement	$150	80	TN	$12,000
16	Temporary Erosion and Sediment Control	$6,000	1	LS	$6,000
17	Pumps	$500,000	1	LS	$500,000
18	Mechanical Work	$797,100	1	LS	$797,100
19	Electrical Work	$456,000	1	LS	$456,000
20	Structures (Slab on Wet Well)	$188,000	1	LS	$188,000
21	Miscellaneous Site Work	$204,300	1	LS	$204,300
	Subtotal				**$3,156,820**
	Contingency	30%			$947,100.00
	Subtotal				**$4,103,920.00**
	Sales Tax	9.0%			$369,350
	Total Estimated Construction Cost				$4,473,270.00
	Allied Costs	50%			$2,236,700.00
	Total Estimated Project Cost				$6,709,970.00

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USE	**$6,710,000**

Kitsap County

Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design

Engineer's Projection of Probable Construction Cost

Preliminary Design

Pump Station 19

December 5, 2019

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$42,000	1	LS	$42,000
2	Final Cleanup and Restoration	$6,500	1	LS	$6,500
3	Surveying	$13,000	1	LS	$13,000
4	Project Record Drawings	$17,400	1	LS	$17,400
5	Type B Schedules	$500	12	Month	$6,000
6	Minor Changes (Allowance)	$105,000	1	FA	$105,000
7	Mobilization and Demobilization	$146,600	1	LS	$146,600
8	Operation and Maintenance Manuals	$3,000	1	LS	$3,000
9	Dewatering	$35,000	1	LS	$35,000
10	Bypass Pumping	$186,000	1	LS	$186,000
11	Trench Safety Systems	$1,000	1	LS	$1,000
12	Gravel Backfill for Foundations (Allowance)	$30	10	TN	$300
13	Crushed Surfacing Base Course	$27	110	TN	$2,970
14	Crushed Surfacing Top Course	$27	60	TN	$1,620
15	HMA Pavement	$150	60	TN	$9,000
16	Temporary Erosion and Sediment Control	$6,000	1	LS	$6,000
17	Pumps	$225,000	1	LS	$225,000
18	Mechanical Work	$474,700	1	LS	$474,700
19	Electrical Work	$434,000	1	LS	$434,000
20	Structures (Slab on Wet Well)	$203,500	1	LS	$203,500
21	Miscellaneous Site Work	$182,100	1	LS	$182,100
	Subtotal				**$2,100,690**
	Contingency	30%			$630,300.00
	Subtotal				**$2,730,990.00**
	Sales Tax	9.0%			$245,800
	Total Estimated Construction Cost				$2,976,790.00
	Allied Costs	50%			$1,488,400.00
	Total Estimated Project Cost				$4,465,190.00

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USE	**$4,465,500**

Kitsap County

Silverdale PS 3, 4, 19, & 31 Upgrades - Preliminary Design

Engineer's Projection of Probable Construction Cost

Preliminary Design

Pump Station 31

December 5, 2019

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	Preconstruction Work Phase	$64,500	1	LS	$64,500
2	Final Cleanup and Restoration	$9,500	1	LS	$9,500
3	Surveying	$17,500	1	LS	$17,500
4	Project Record Drawings	$14,700	1	LS	$14,700
5	Type B Schedules	$500	10	Month	$5,000
6	Minor Changes (Allowance)	$37,000	1	FA	$37,000
7	Mobilization and Demobilization	$51,700	1	LS	$51,700
8	Operation and Maintenance Manuals	$1,000	1	LS	$1,000
9	Dewatering	$21,000	1	LS	$21,000
10	Bypass Pumping	$5,500	1	LS	$5,500
11	Trench Safety Systems	$1,600	1	LS	$1,600
12	Gravel Backfill for Foundations (Allowance)	$30	10	TN	$300
13	Crushed Surfacing Base Course	$27	20	TN	$540
14	Crushed Surfacing Top Course	$27	10	TN	$270
15	HMA Pavement	$150	10	TN	$1,500
16	Temporary Erosion and Sediment Control	$4,000	1	LS	$4,000
17	Pumps	$40,000	1	LS	$40,000
18	Mechanical Work	$280,000	1	LS	$280,000
19	Electrical Work	$157,000	1	LS	$157,000
20	Miscellaneous Site Work	$28,800	1	LS	$28,800
	Subtotal				**$741,410**
	Contingency	30%			$222,500
	Subtotal				**$963,910**
	Sales Tax	9.0%			$86,800
	Total Estimated Construction Cost				$1,050,710
	Allied Costs	50%			$525,400
	Total Estimated Project Cost				$1,576,110

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USE	**$1,576,500**

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APPENDIX J

BASELINE PROJECT DESIGN SCHEDULE – LS 19 & LS 31

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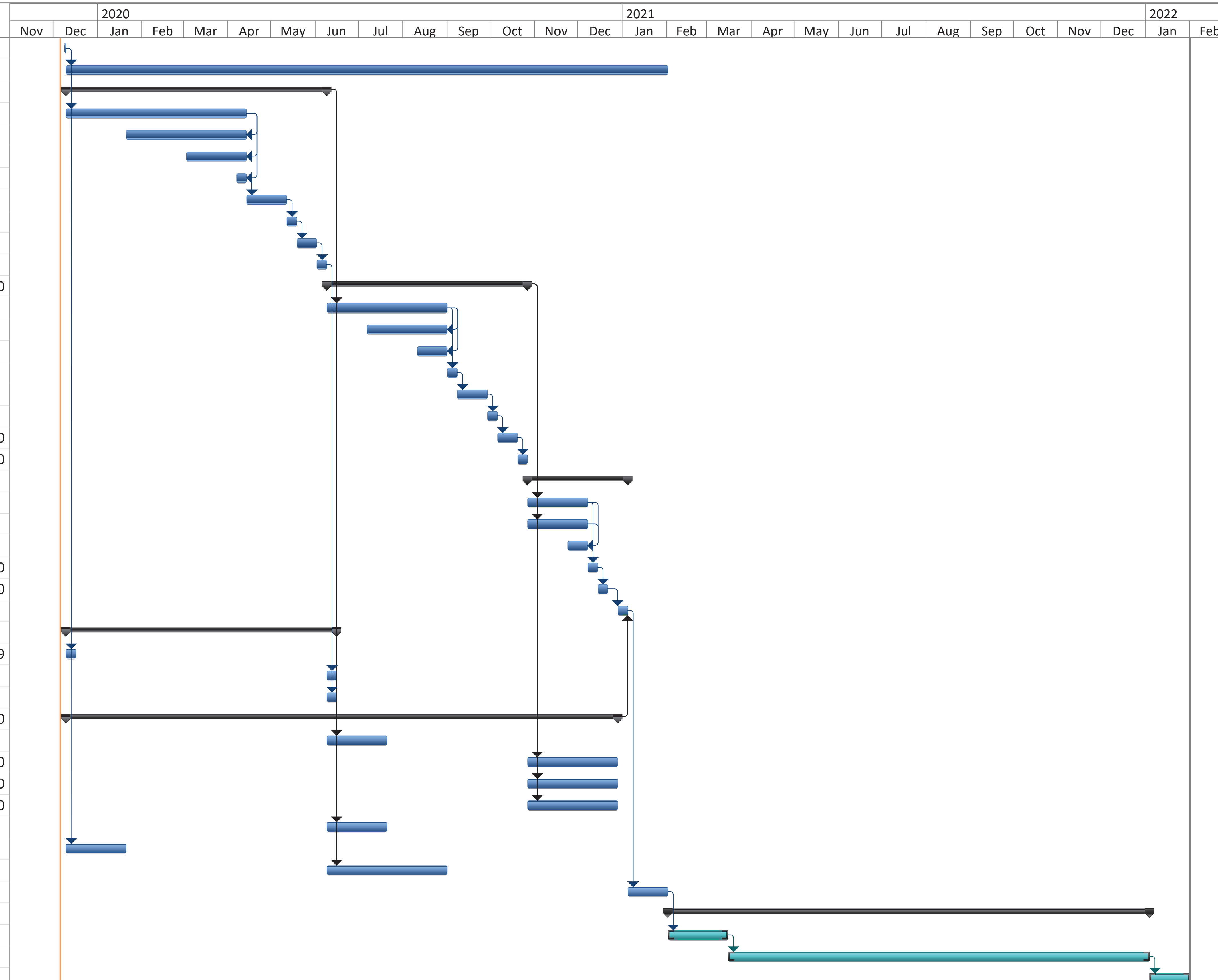
SILVERDALE PUMP STATIONS 19 & 31 UPGRADES

EXHIBIT D

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	1 day	Mon 12/9/19	Mon 12/9/19
2	Project Management	300 days	Tue 12/10/19	Mon 2/1/21
3	60% Design	130 days	Tue 12/10/19	Mon 6/8/20
4	Draft Drawings	90 days	Tue 12/10/19	Mon 4/13/20
5	Draft Specifications	60 days	Tue 1/21/20	Mon 4/13/20
6	Draft OPCC	30 days	Tue 3/3/20	Mon 4/13/20
7	Internal QA/QC	5 days	Tue 4/7/20	Mon 4/13/20
8	Address Internal Comments	20 days	Tue 4/14/20	Mon 5/11/20
9	60% Submittal	5 days	Tue 5/12/20	Mon 5/18/20
10	Client Review	10 days	Tue 5/19/20	Mon 6/1/20
11	Review Meeting	5 days	Tue 6/2/20	Mon 6/8/20
12	90% Design	100 days	Tue 6/9/20	Mon 10/26/20
13	Draft Drawings	60 days	Tue 6/9/20	Mon 8/31/20
14	Draft Specifications	40 days	Tue 7/7/20	Mon 8/31/20
15	Draft OPCC	15 days	Tue 8/11/20	Mon 8/31/20
16	Internal QA/QC	5 days	Tue 9/1/20	Mon 9/7/20
17	Address Internal Comments	15 days	Tue 9/8/20	Mon 9/28/20
18	90% Submittal	5 days	Tue 9/29/20	Mon 10/5/20
19	Client Review	10 days	Tue 10/6/20	Mon 10/19/20
20	Review Meeting	5 days	Tue 10/20/20	Mon 10/26/20
21	Final Design	50 days	Tue 10/27/20	Mon 1/4/21
22	Draft Drawings	30 days	Tue 10/27/20	Mon 12/7/20
23	Draft Specifications	30 days	Tue 10/27/20	Mon 12/7/20
24	Draft OPCC	10 days	Tue 11/24/20	Mon 12/7/20
25	Internal QA/QC	5 days	Tue 12/8/20	Mon 12/14/20
26	Address Internal Comments	5 days	Tue 12/15/20	Mon 12/21/20
27	Final Submittal (Bid Docs)	5 days	Tue 12/29/20	Mon 1/4/21
28	Public Outreach	135 days	Tue 12/10/19	Mon 6/15/20
29	Web Article	5 days	Tue 12/10/19	Mon 12/16/19
30	Web Article Update	5 days	Tue 6/9/20	Mon 6/15/20
31	Public Meeting	5 days	Tue 6/9/20	Mon 6/15/20
32	Permitting	275 days	Tue 12/10/19	Mon 12/28/20
33	SEPA	30 days	Tue 6/9/20	Mon 7/20/20
34	SDAP	45 days	Tue 10/27/20	Mon 12/28/20
35	Building Permit	45 days	Tue 10/27/20	Mon 12/28/20
36	NPDES/SWPPP	45 days	Tue 10/27/20	Mon 12/28/20
37	PSE Application	30 days	Tue 6/9/20	Mon 7/20/20
38	Critical Areas Report	30 days	Tue 12/10/19	Mon 1/20/20
39	Critical Areas Permit	60 days	Tue 6/9/20	Mon 8/31/20
40	Bid Services	20 days	Tue 1/5/21	Mon 2/1/21
41	Construction	**240 days**	**Tue 2/2/21**	**Mon 1/3/22**
42	Preconstruction Phase	30 days	Tue 2/2/21	Mon 3/15/21
43	Final Construction	210 days	Tue 3/16/21	Mon 1/3/22
44	Construction Record Drawings	20 days	Tue 1/4/22	Mon 1/31/22



Baseline Schedule
Date: Fri 12/6/19

Task | Milestone ◆ | Summary

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APPENDIX K

LIFT STATION 17 FORCE MAIN HYDRAULICS MEMORANDUM

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TECHNICAL MEMORANDUM

Date: December 20, 2019

To: Barbara Zaroff

From: Tony Fisher

CC: Stella Vakarcs

Subject: Lift Station 17 Force Main Sizing/HGL

Project No: 10530.01

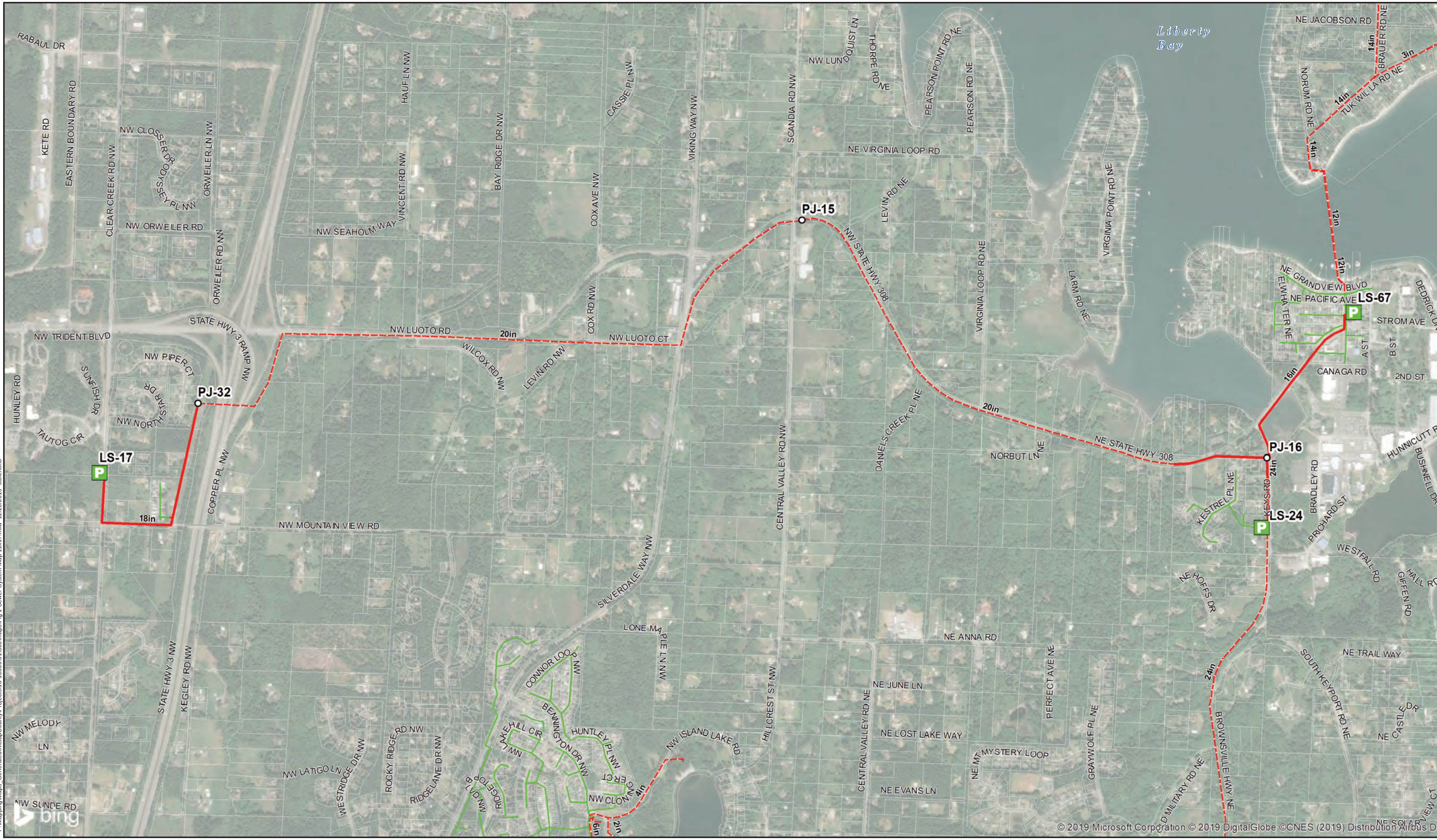
At the request of Kitsap County (County), BHC Consultants, LLC (BHC) reviewed the profile of the sewer system between Lift Station 17 and Lift Station 24 to determine the sections of pipe that remain full under the modeled flow conditions. The County also asked BHC to investigate whether decreasing the size of the piping would provide additional protection from corrosion by extending the length of pipe that is typically submerged and flowing full.

A review of the sanitary sewer system between Lift Station 17 and Lift Station 24 indicates that the system acts as a force main between Lift Station 17 and Node PJ-32. Downstream of Node PJ-32, the sewage flows by gravity to Lift Station 24 where it is subsequently pumped to the Central Kitsap Wastewater Treatment Plant (CKTP) for treatment. The 24-inch pipe between Lift Station 24 and Node PJ-16, which has a length of about 1000 feet, remains fully submerged at all times as Node PJ-16 is located at a lower elevation than the invert into Lift Station 24. The hydraulic grade line in this segment of pipe is driven by pumped flows from Lift Station 67 combined with the Lift Station 17 pumped flows and creates a backwater affect in the 20-inch pipe between Node PS-16 and Node PJ-15. The backwater extends west into the 20-inch pipe for about 1,300 feet. Figure 1 depicts the sanitary sewer system between Lift Station 17, Lift Station 67, and Lift Station 24.

The 20-inch pipe between Node PJ-32 and Node PJ-16 appears to have sufficient capacity to convey the current, future (2038), and buildout flows (See appendix for model results) and may even be slightly oversized. However, this main is experiencing corrosion issues and needs to be replaced. As previously mentioned, corrosion in pipelines typically occurs at the water surface line where hydrogen sulfide in the sewage reacts with moisture in the air to make sulfuric acid. One means of minimizing the amount of pipe that is subject to this corrosion is to submerge more of the pipe. However, the pipeline grades would require the pipes to be substantially deeper to significantly increase the amount of submerged pipe and that is not practical.

Another means of increasing the length of submerged pipe is to decrease the diameter of the pipe, resulting in more frictional head loss and a higher hydraulic grade line. Increasing the hydraulic grade line in the pipe between Lift Station 24 and Node PJ-16 would directly impact the pumping capacity at Lift Station 67 and is not recommended as that could trigger an upgrade to the station. Decreasing the diameter of the pipe between Node PJ-16 and Node PJ-32, while physically possible, would provide little benefit as the minimum amount of submerged pipe would be dictated by the lowest flows, which occurs when the pumps at Lift Station 67 and Lift Station 17 are off. This condition would essentially result in a relatively flat hydraulic grade line that is set by the invert elevation of the pipe entering Lift Station 24. Decreasing the diameter of the pipe between Node PJ-16 and PJ-32 would not significantly change that elevation. Decreasing the diameter of the pipe between those two nodes would increase the hydraulic grade line in that segment of the system when the pumps at Lift Station 17 are operating but would have little to no benefit at low flows.

Lowering the pipe or decreasing its diameter would require the pipe to be replaced. When the pipe is replaced, PVC or HDPE should be used for the pipe material as either option is more resistant to corrosion and is less expensive than ductile iron or steel pipe. Since the pipe would need to be replaced anyway, decreasing the diameter or increasing the depth of the pipe would offer little benefit and could potentially create a future bottleneck at full buildout flows, depending on how growth occurs and whether any contributing areas undergo zoning changes. Therefore, the recommendation is to maintain the existing grade and diameter of this pipe when it is replaced, while using corrosion resistant materials such as HDPE or PVC pipe.



P:\Mapping\Maps_Generated\KitsapCounty\Projects\18-10530.01\500\maps\Fig 1 Sewer System Map 11x17.mxd 12/20/2019 ctolentino

BHC CONSULTANTS

Sewer System: Kitsap County.
GIS Base data: Kitsap County.
Data sources supplied may not reflect current or actual conditions. This map is a geographic representation based on information available. It does not represent survey data. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.
BHC Consultants LLC., assumes no responsibility for the validity of any information presented herein, nor any responsibility for the use or misuse of the data.

Legend

- P Pump Station
- Force Main (Under Gravity Flow)
- Gravity Main
- Force Main (Fully Submerged/Full Pipe)

N

0 600 1,200 Feet

KITSAP COUNTY 18 57 WASHINGTON

Sewer System Map

PS 3, 4 19 & 31 Upgrades
Kitsap County, Washington
December 2019

Figure
1

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APPENDIX – MODEL RESULTS

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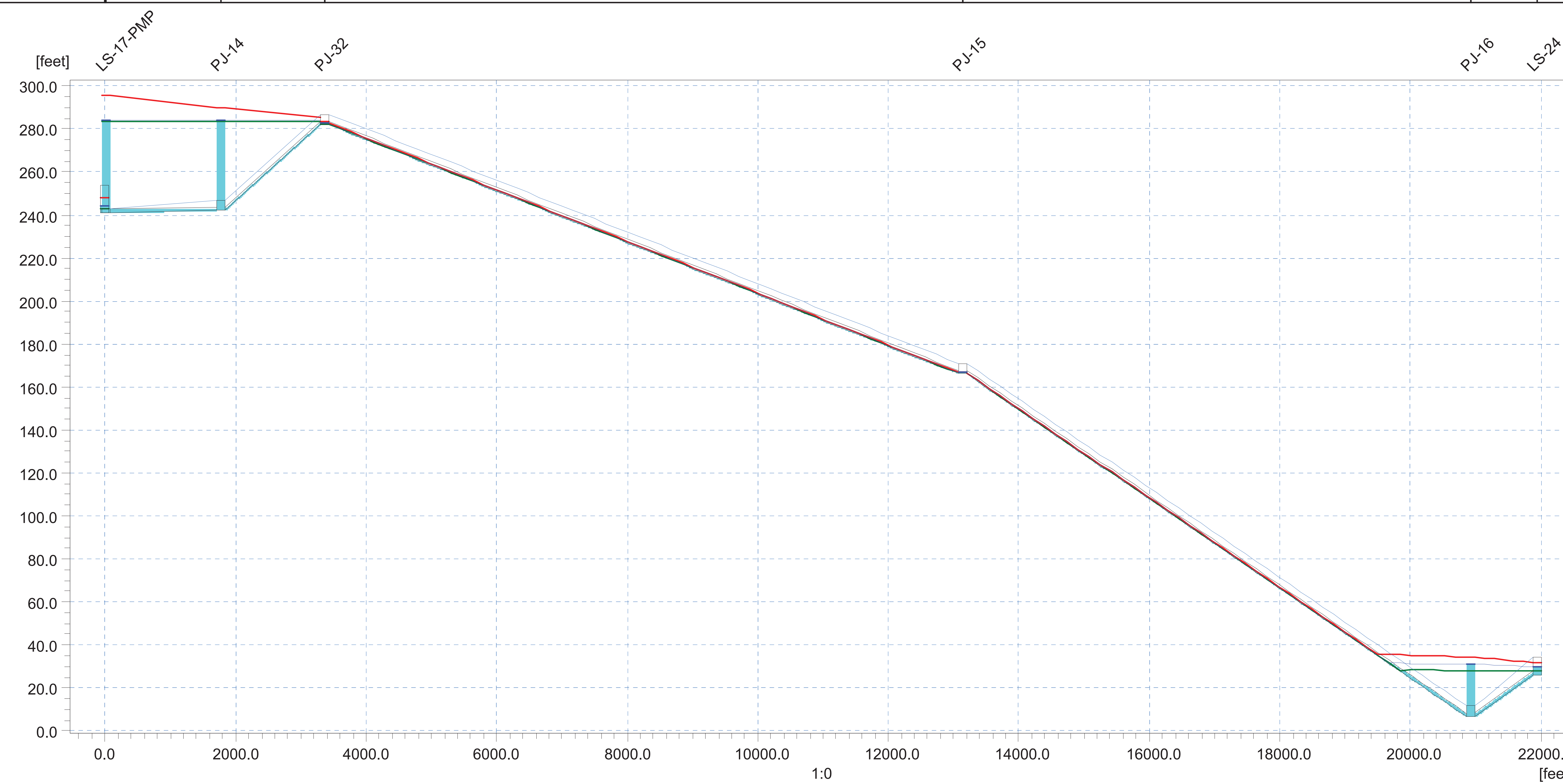
LS17 to LS 24

2017 PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 2017_Peak_FINAL2017_Peak.PRF

Discharge	-0.000	-0.000	1.398	3.026	7.129	cfs



	LS-17-PMP	PJ-14	PJ-32	PJ-15	PJ-16	
Ground Lev.	253.70	247.00	287.00	171.00	11.50	[m]
Invert lev.	241.20	242.00	282.00	166.00	6.50	[m]

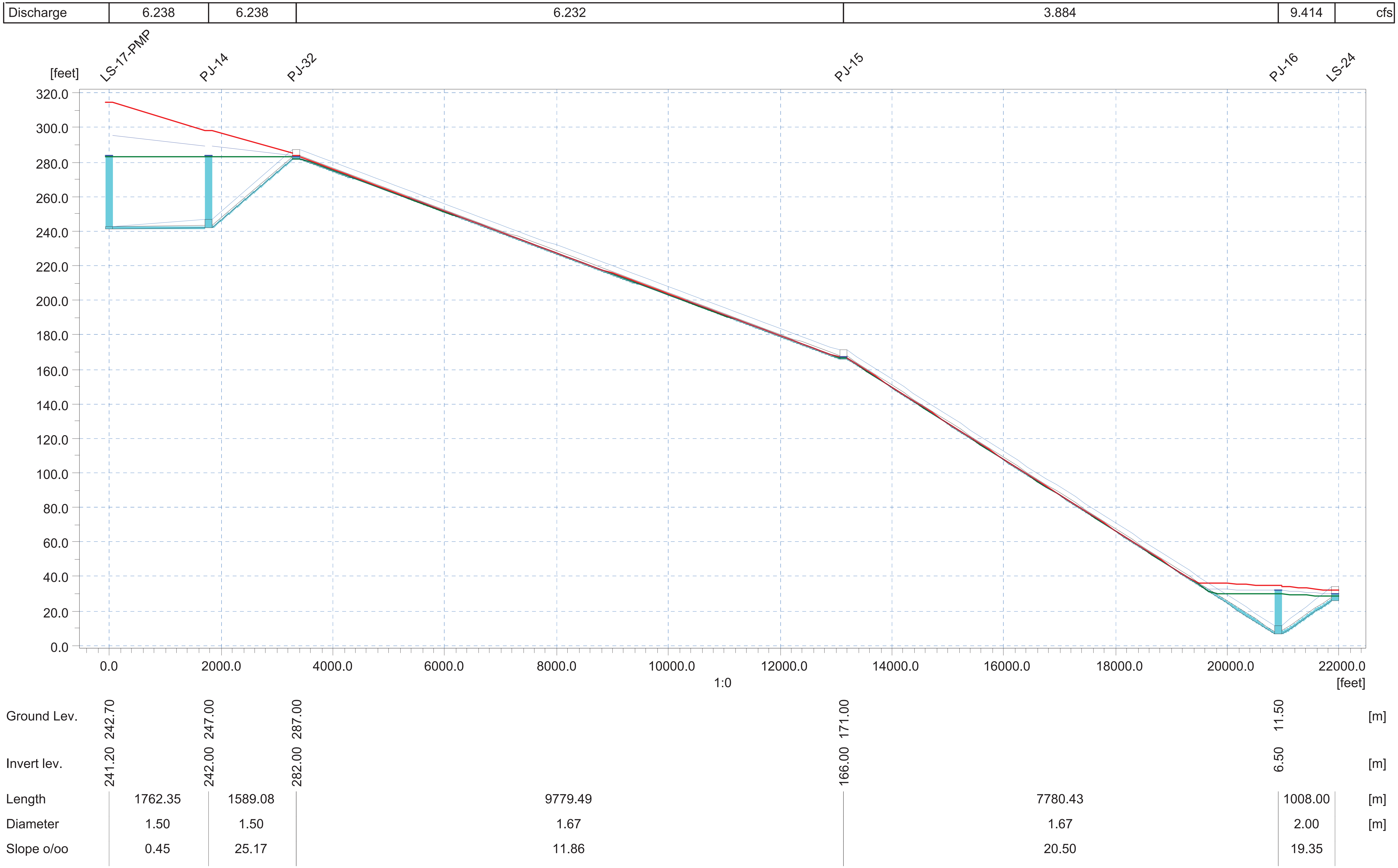
Length	1762.35	1589.08	9779.49	7780.43	1008.00	[m]
Diameter	1.50	1.50	1.67	1.67	2.00	[m]
Slope o/oo	0.45	25.17	11.86	20.50	19.35	

LS67 to LS 24
2017 PEAK FLOW CONDITIONS
PRE CIP
Link Water Level - 1-1-2007 00:00:00 2017_Peak_FINAL2017_Peak.PRF
Discharge
4.023
7.129
cfs
LS-67-PMP
PJ-17
PJ-16
LS-24-PMP
[feet]
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
1800.0
2000.0
2200.0
2400.0
2600.0
2800.0
3000.0
3200.0
3400.0
3600.0
1:0
[feet]
Ground Lev.
4.90
11.50
34.10
[m]
Invert lev.
3.90
6.50
26.00
[m]
Length
2481.16
1008.00
[m]
Diameter
1.33
2.00
[m]
Slope o/oo
7.46
19.35

LS17 to LS 24

2038 PEAK FLOW CONDITIONS
PRE CIP

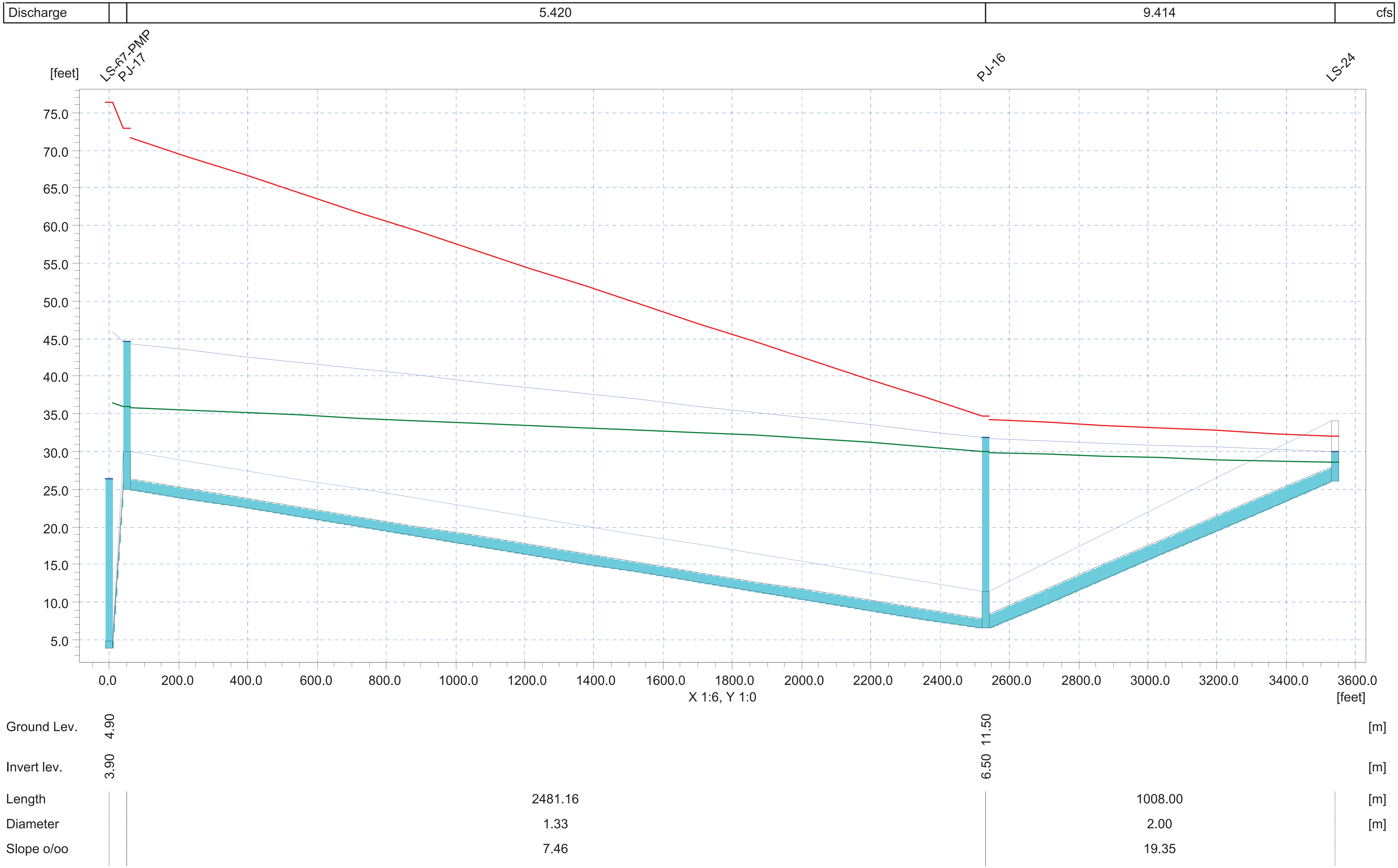
Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF



LS67 to LS 24

2038 PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK2038_Peak.PRF

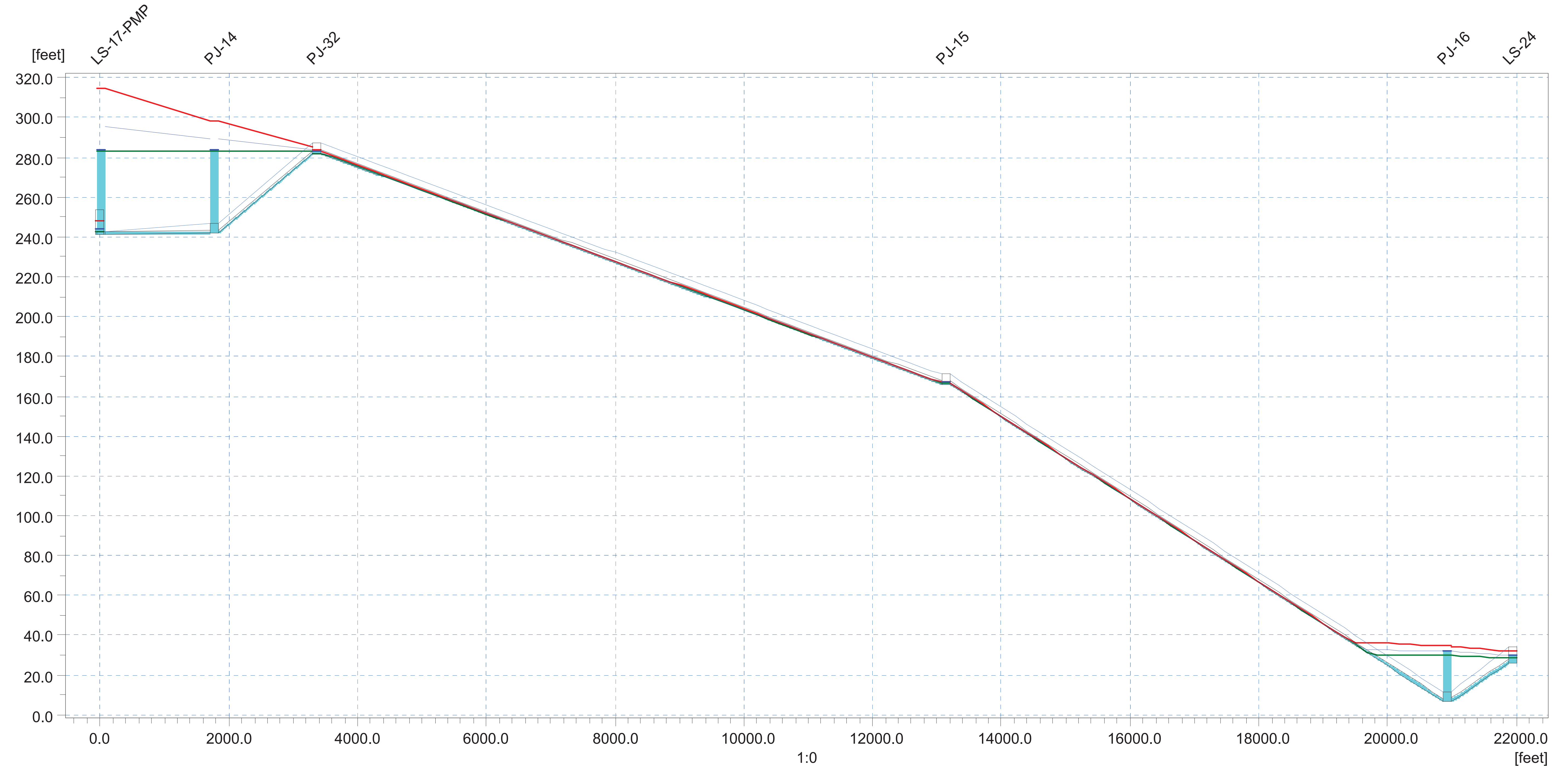


LS17 to LS 24

BUILDOUT PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

Discharge	6.238	6.238	6.232	3.884	9.414	cfs



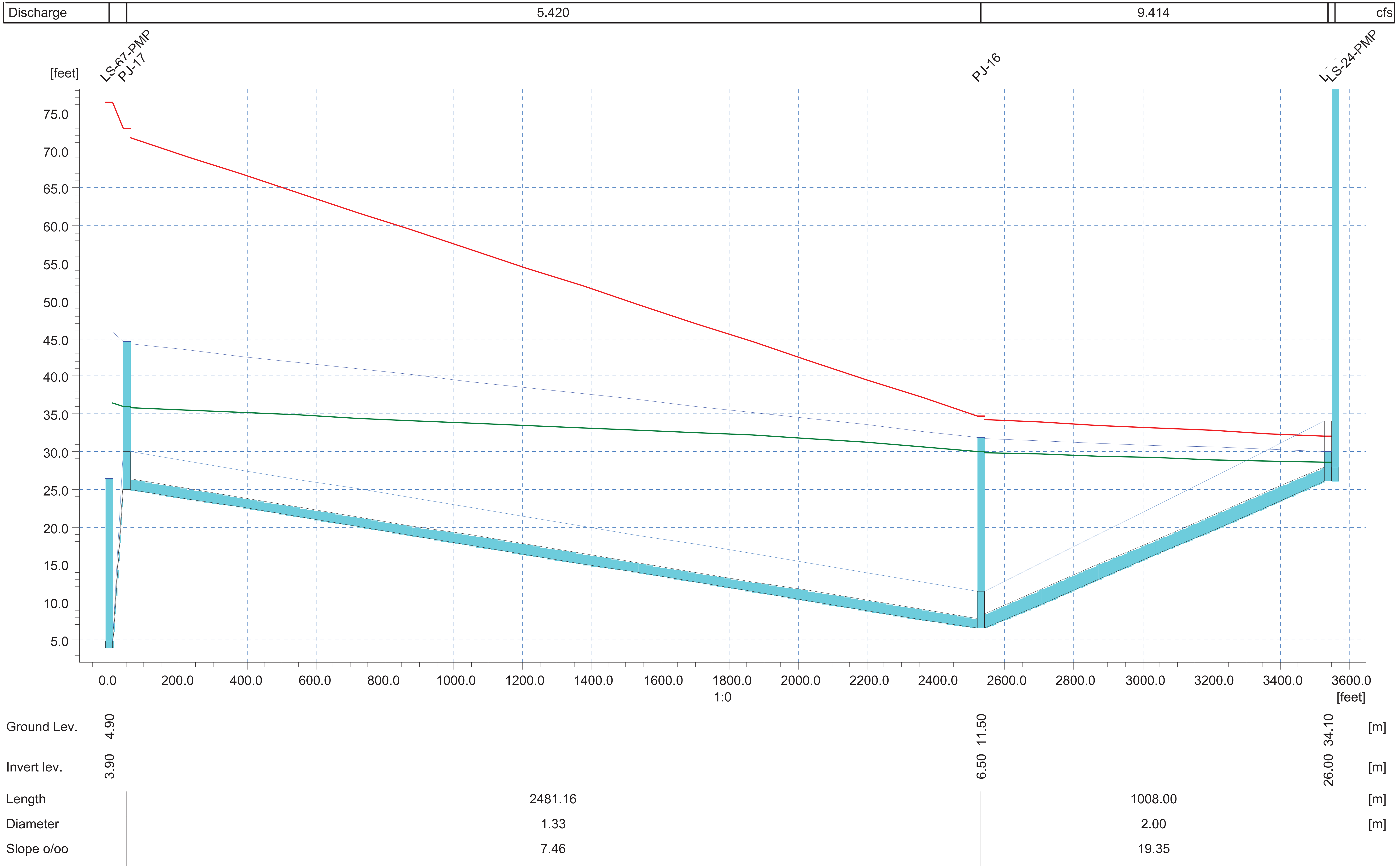
	LS-17-PMP	PJ-14	PJ-32	PJ-15	PJ-16	LS-24	
Ground Lev.	253.70	247.00	287.00	171.00	11.50		[m]
Invert lev.	241.20	242.00	282.00	166.00	6.50		[m]

Length	1762.35	1589.08	9779.49	7780.43	1008.00	[m]
Diameter	1.50	1.50	1.67	1.67	2.00	[m]
Slope o/oo	0.45	25.17	11.86	20.50	19.35	

LS67 to LS 24

BUILDOUT PEAK FLOW CONDITIONS
PRE CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_PEAKBuildout_Peak.PRF

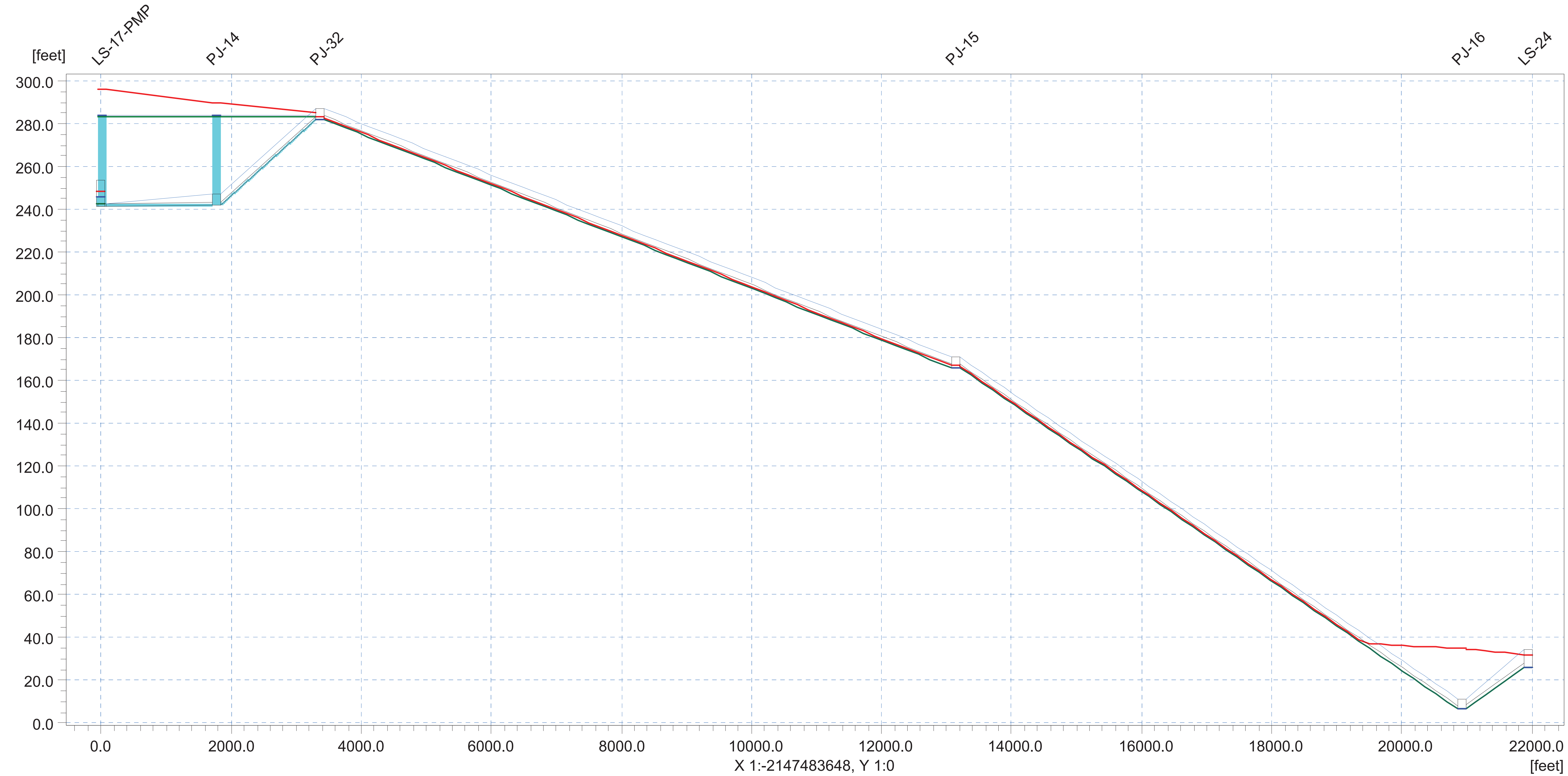


LS17 to LS 24

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK_CIPEdits.PRF

Discharge	0.000	0.000	0.001	0.001	-0.001	cfs



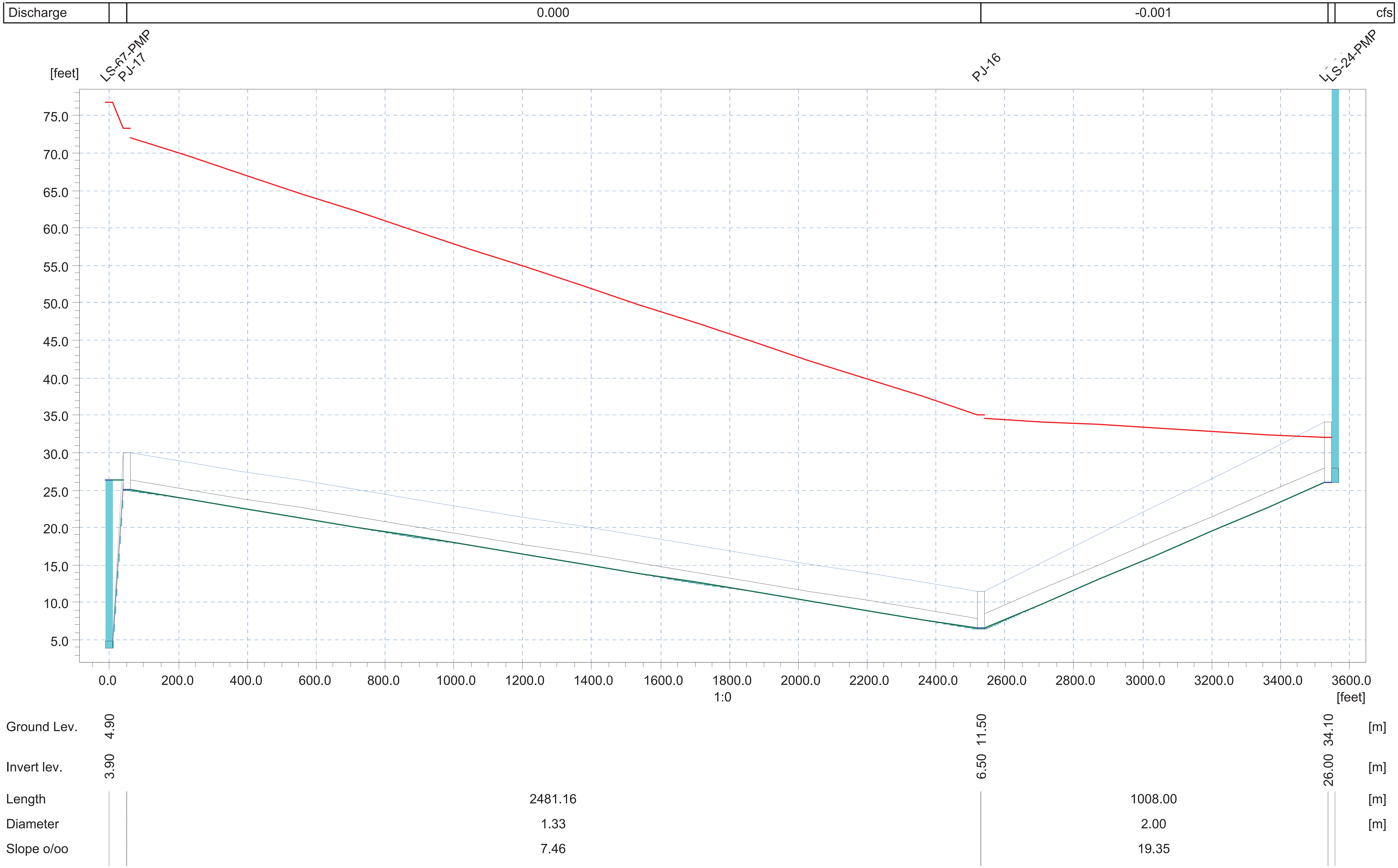
	LS-17-PMP	PJ-14	PJ-32	PJ-15	PJ-16	LS-24	
Ground Lev.	253.70	247.00	287.00	171.00	11.50		[m]
Invert lev.	241.20	242.00	282.00	166.00	6.50		[m]

Length	1762.35	1589.08	9779.49	7780.43	1008.00	[m]
Diameter	1.50	1.50	1.67	1.67	2.00	[m]
Slope o/oo	0.45	25.17	11.86	20.50	19.35	

LS67 to LS 24

2038 PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 2038_PEAK_CIPEdits.PRF

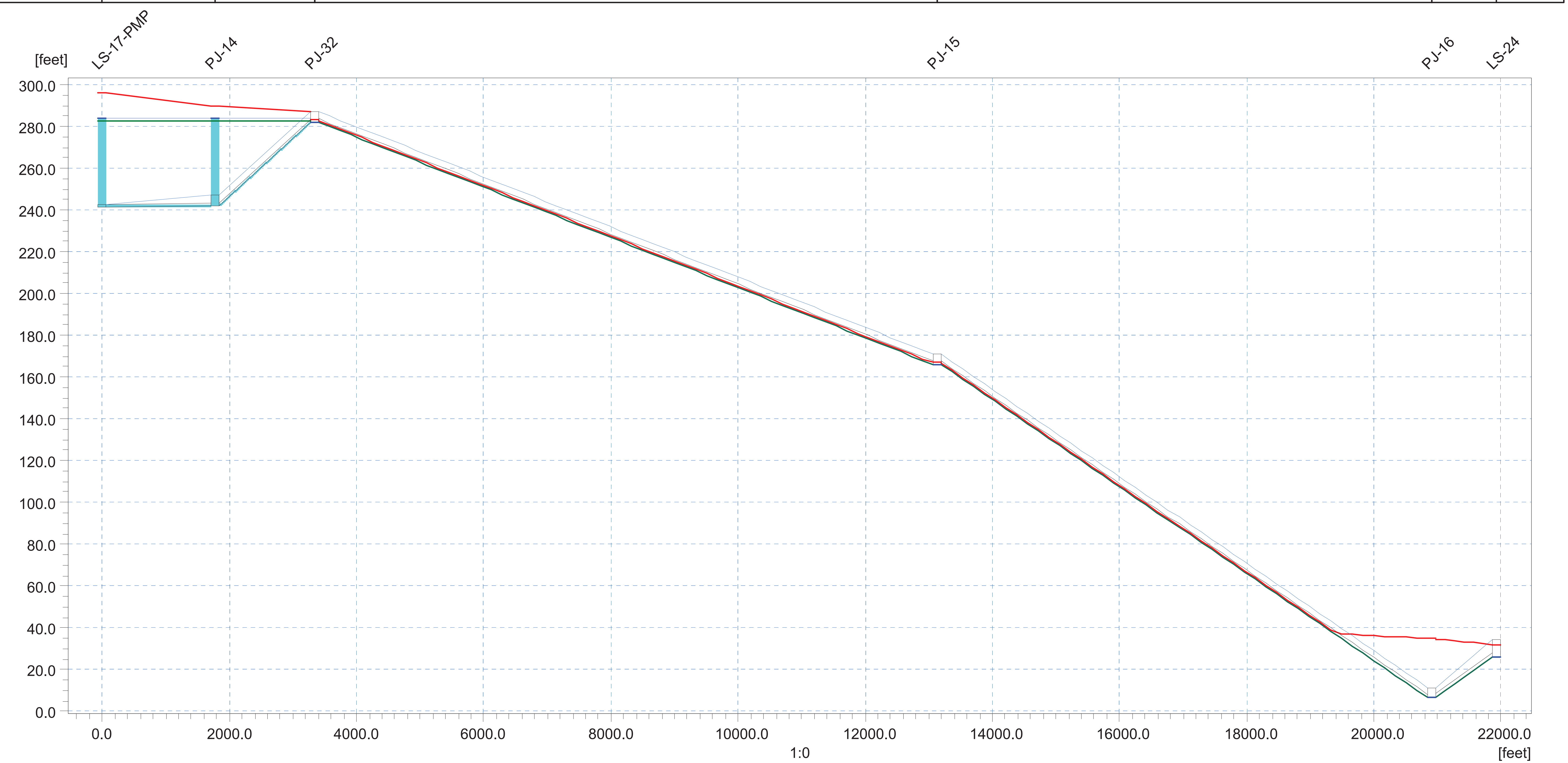


LS17 to LS 24

BUILDOUT PEAK FLOW CONDITIONS
POST CIP

Link Water Level - 1-1-2007 00:00:00 Buildout_Peak_CIPEdits.PRF

Discharge	0.000	0.000	0.001	0.001	-0.001	cfs



	LS-17-PMP		PJ-14		PJ-32		PJ-15		PJ-16		LS-24	
Ground Lev.	242.70		247.00		287.00		171.00		11.50			[m]
Invert lev.	241.20		242.00		282.00		166.00		6.50			[m]
Length		1762.35		1589.08		9779.49		7780.43		1008.00		[m]
Diameter		1.50		1.50		1.67		1.67		2.00		[m]
Slope o/oo		0.45		25.17		11.86		20.50		19.35		

LS67 to LS 24
BUILDOUT PEAK FLOW CONDITIONS
POST CIP
Link Water Level - 1-1-2007 00:00:00 Buildout_Peak_CIPEdits.PRF
Discharge
0.000
-0.001
cfs
LS-67-PMP
PJ-17
PJ-16
LS-24-PMP
[feet]
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
1800.0
2000.0
2200.0
2400.0
2600.0
2800.0
3000.0
3200.0
3400.0
3600.0
1:0
[feet]
Ground Lev.
4.90
11.50
34.10
[m]
Invert lev.
3.90
6.50
26.00
[m]
Length
2481.16
1008.00
[m]
Diameter
1.33
2.00
[m]
Slope o/oo
7.46
19.35

consor

APPENDIX B

WWTP NPDES PERMIT

Issuance Date:	June 29, 2017
Effective Date:	August 1, 2017
Expiration Date:	July 31, 2022

National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0030520

State of Washington
DEPARTMENT OF ECOLOGY
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1342 et seq.

KITSAP COUNTY PUBLIC WORKS
614 Division Street, MS-17
Port Orchard, Washington 98366

is authorized to discharge in accordance with the Special and General Conditions that follow.

Plant Location:
Central Kitsap Wastewater Treatment Plant
12351 Brownsville Highway NE
Poulsbo, WA 98370

Receiving Water:
Port Orchard Bay, Puget Sound

Treatment Type:
Biological Nutrient Removal and Tertiary Filtration

Mark Henley, P.E.
Water Quality Section Manager
Northwest Regional Office
Washington State Department of Ecology

Table of Contents

Summary of Permit Report Submittals

Refer to the Special and General Conditions of this permit for additional submittal requirements.

Permit Section	Submittal	Frequency	First Submittal Date
S3.A	Discharge Monitoring Report (DMR)	Monthly	September 15, 2017
S3.A	Discharge Monitoring Report (DMR)	Quarterly	January 15, 2018
S3.A	Discharge Monitoring Report (DMR)	Annual	January 15, 2019
S3.F	Reporting Permit Violations	As necessary	
S4.B	Plans for Maintaining Adequate Capacity	As necessary	
S4.D	Notification of New or Altered Sources	As necessary	
S4.E	Infiltration and Inflow Evaluation	1/permit cycle	December 1, 2021
S5.F	Bypass Notification	As necessary	
S5.G	Operations and Maintenance Manual Update or Review Confirmation Letter	1/permit cycle	January 31, 2022
S6.E	Industrial User Survey Update	1/permit cycle	January 31, 2022
S8	Acute Toxicity: Compliance Test and Monitoring Reports Submittal	2/year	April 30, 2018
S9	Chronic Toxicity: Compliance Test and Monitoring Reports Submittal	2/permit cycle	April 15, 2021 October 15, 2021
S10	Application for Permit Renewal	1/permit cycle	January 31, 2022
G1	Notice of Change in Authorization	As necessary	
G4	Reporting Planned Changes	As necessary	
G5	Engineering Report for Construction or Modification Activities	As necessary	
G7	Notice of Permit Transfer	As necessary	
G10	Duty to Provide Information	As necessary	
G20	Compliance Schedules	As necessary	
G21	Contract Submittal	As necessary	

Special Conditions

S1. Discharge limits

S1.A. Effluent limits

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. The discharge of any of the following pollutants more frequently than, or at a level in excess of, that identified and authorized by this permit violates the terms and conditions of this permit.

Beginning on the effective date of this permit, the Permittee may discharge treated domestic wastewater to Port Orchard Bay at the permitted location subject to compliance with the following limits:

Effluent Limits: Outfall 001 Latitude: 47.6464º Longitude: -122.6014º		
Parameter	**Average Monthly** [a]	**Average Weekly** [b]
Biochemical Oxygen Demand (5-day) (BOD_5)	30 milligrams/liter (mg/L) 1,501 pounds/day (lbs/day) 85% removal of influent BOD_5	45 mg/L 2,252 lbs/day
Total Suspended Solids (TSS)	30 mg/L 1,501 lbs/day 85% removal of influent TSS	45 mg/L 2,252 lbs/day
Parameter	**Average Monthly**	**Maximum Daily** [c]
Total Ammonia (as NH_3-N)	37 mg/L	51 mg/L
Parameter	**Daily Minimum**	**Daily Maximum**
pH [d]	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria [e]	200/100 milliliter (mL)	400/100 mL
Acute Toxicity	No acute toxicity detected in a test concentration representing the acute critical effluent concentration (ACEC). The ACEC means the maximum concentration of effluent during critical conditions at the boundary of the acute mixing zone, defined in Section S1.B of this permit. The ACEC equals 2.1% effluent. See Permit Condition S8 for more information.	
a	Average monthly effluent limit means the highest allowable average of daily discharges over a calendar month. To calculate the discharge value to compare to the limit, you add the value of each daily discharge measured during a calendar month and divide this sum by the total number of daily discharges measured. See footnote c for fecal coliform calculations.	
b	Average weekly discharge limit means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges' measured during that week. See footnote d for fecal coliform calculations.	
c	Maximum daily effluent limit is the highest allowable daily discharge. The daily discharge is the average discharge of a pollutant measured during a calendar day. For pollutants with limits expressed in units of mass, calculate the daily discharge as the total mass of the pollutant discharged over the day. This does not apply to pH or temperature.	
d	Indicate the range of permitted values. Do not average pH values.	
e	Ecology provides directions to calculate the monthly and the weekly geometric mean in publication No. 04-10-020, Information Manual for Treatment Plant Operators available at: http://www.ecy.wa.gov/pubs/0410020.pdf	

S1.B. Mixing zone authorization

Mixing zone for Outfall 001

The following paragraphs define the maximum boundaries of the mixing zones. Figure 1 illustrates the approximate relationship and sizes of the chronic and acute mixing zones around the diffuser:

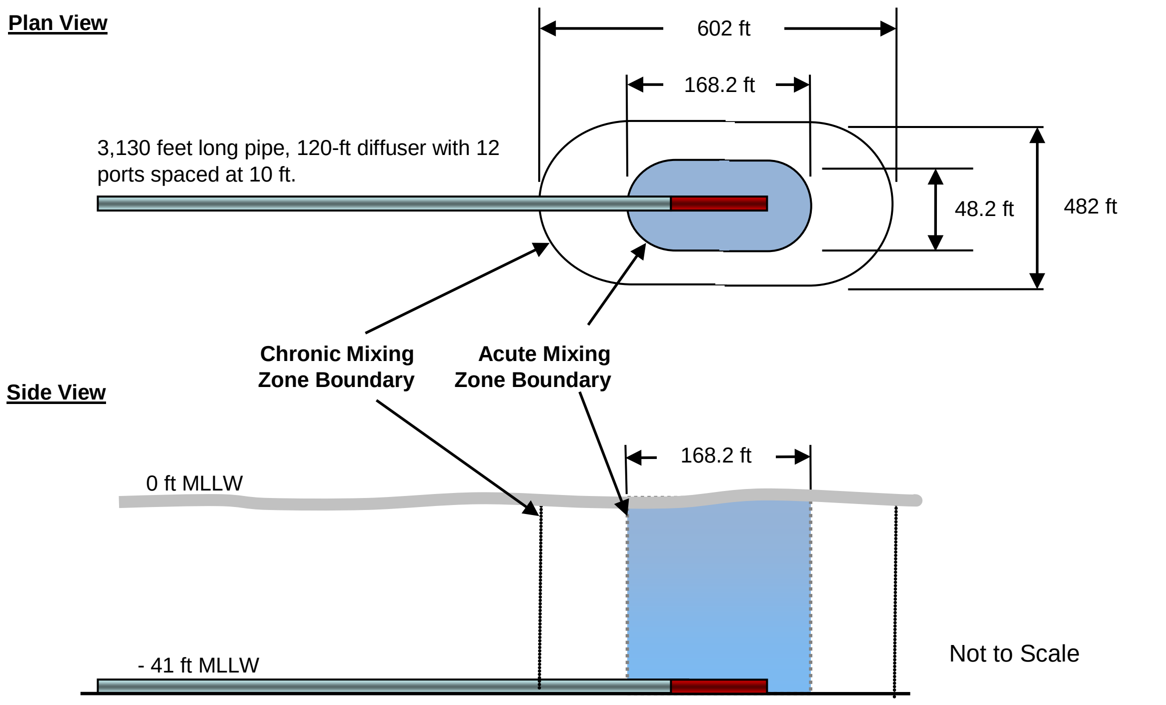


Figure 1. Outfall Mixing Zones.

Chronic mixing zone

The allowable chronic mixing zone is 602 feet (184 meters) by 482 feet (147 meters). The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the chronic zone must meet chronic aquatic life criteria and human health criteria.

Acute mixing zone

The allowable acute mixing zone is 168.2 feet (51.3 meters) by 48.2 ft (14.7 meters). The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the acute zone must meet acute aquatic life criteria.

Available Dilution (dilution factor)	
Acute Aquatic Life Criteria	47
Chronic Aquatic Life Criteria	84
Human Health Criteria - Carcinogen	91
Human Health Criteria - Non-carcinogen	84

S2. Monitoring requirements

S2.A. Monitoring schedule

The Permittee must monitor in accordance with the following schedule and the requirements specified in Appendix A.

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
(1) Wastewater influent			
Wastewater Influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant.			
Flow	MGD	Continuous [a]	Metered/recorded
BOD_5	mg/L	5/week	24-hr composite [b]
BOD_5	lbs/day	5/week	Calculated [c]
TSS	mg/L	5/week	24-hr composite
TSS	lbs/day	5/week	Calculated
(2) Final wastewater effluent			
Final Wastewater Effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The Permittee may take effluent samples for the BOD_5 analysis before or after the disinfection process. If taken after, the Permittee must dechlorinate and reseed the sample.			
Flow	MGD	Continuous	Metered/recorded
BOD_5	mg/L	5/week	24-hr composite
BOD_5	lbs/day	5/week	Calculated
BOD_5	% removal [d]	1/month	Calculated
TSS	mg/L	5/week	24-hr composite
TSS	lbs/day	5/week	Calculated
TSS	% removal	1/month	Calculated
Fecal Coliform [e]	# /100 ml	5/week	Grab [f]
pH [g]	Standard Units	Daily	Grab
Temperature [h]	Degrees Celsius (°C)	5/week	Grab or measured
(3) Whole effluent toxicity testing – final wastewater effluent			
Acute Toxicity Testing	See condition S8 for testing requirements	2/year from January 2018 through July 2021	24-hr composite
Chronic Toxicity Testing	See condition S9 for testing requirements	2/year (2021 only)	24-hr composite
Additional requirements specified in Special Condition S8 and S9.			
(4) Effluent characterization – final wastewater effluent			
Total Ammonia (NH_3-N)	mg/L as N	3/week (from May through September)	24-hr composite
Total Ammonia (NH_3-N)	lbs/day	3/week (from May through September)	Calculated
Nitrate + Nitrite Nitrogen	mg/L as N	Quarterly [i]	24-hr composite
Total Kjeldahl Nitrogen (TKN)	mg/L as N	Quarterly	24-hr composite
Total Phosphorus	mg/L as P	Quarterly	24-hr composite
Soluble Reactive Phosphorus	mg/L as P	Quarterly	24-hr composite

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
Soluble Reactive Phosphorus	lbs/day	Quarterly	Calculated
(5) Permit renewal application requirements – final wastewater effluent			
The Permittee must record and report the wastewater treatment plant flow discharged on the day it collects the sample for priority pollutant testing with the discharge monitoring report.			
Dissolved Oxygen	mg/L	Once per year	Grab
Oil and Grease	mg/L	Once per year	Grab
Total Dissolved Solids	mg/L	Once per year	Grab
Total Hardness	mg/L	Once per year	Grab
Cyanide	micrograms/liter (µg/L)	Once per year	Grab
Total Phenolic Compounds	µg/L	Once per year	Grab
Priority Pollutants (PP) – Total Metals	µg/L; nanograms(ng/L) for mercury	Once per year	24-hr composite Grab for mercury
PP – Volatile Organic Compounds	µg/L	Once per year	Grab
PP – Acid-extractable Compounds	µg/L	Once per year	24-hr composite
PP – Base-neutral Compounds	µg/L	Once per year	24-hr composite
Bis (2-ethylhexyl) phthalate (117-81-7) [j]	µg/L	Once per year	Grab (glass containers only)

a	Continuous means uninterrupted except for brief lengths of time for calibration, power failure, or unanticipated equipment repair or maintenance. The time interval for the associated data logger must be no greater than 30 minutes.
b	24-hour composite means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.
c	Calculated means figured concurrently with the respective sample, using the following formula: Concentration (in mg/L) X Flow (in MGD) X Conversion Factor (8.34) = lbs/day
d	$\% \text{ removal} = \frac{\text{Influent concentration (mg/L)} - \text{Effluent concentration (mg/L)}}{\text{Influent concentration (mg/L)}} \times 100$ Calculate the percent (%) removal of BOD_5 and TSS using the above equation.
e	Report a numerical value for fecal coliforms following the procedures in Ecology's *Information Manual for Wastewater Treatment Plant Operators*, Publication Number 04-10-020 available at: http://www.ecy.wa.gov/programs/wq/permits/guidance.html . Do not report a result as too numerous to count (TNTC).
f	Grab means an individual sample collected over a fifteen (15)-minute, or less, period.
g	Report the daily pH and the minimum and maximum for the monitoring period.
h	Temperature grab sampling must occur when the effluent is at or near its daily maximum temperature, which usually occurs in the late afternoon.
i	Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must begin quarterly monitoring for the quarter beginning on 10/1/2017 and submit results by 1/15/2018.
j	Use clean sampling techniques to assure that the detection is not a result of either sampling or laboratory contamination. Samples must be collected in clean glass bottles with polytetrafluoroethylene (PFTE or Teflon™) lids.

S2.B. *Sampling and analytical procedures*

Samples and measurements taken to meet the requirements of this permit must represent the volume and nature of the monitored parameters. The Permittee must conduct representative sampling of any unusual discharge or discharge condition, including bypasses, upsets, and maintenance-related conditions that may affect effluent quality.

Sampling and analytical methods used to meet the monitoring requirements specified in this permit must conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 (or as applicable in 40 CFR subchapters N [Parts 400–471] or O [Parts 501-503]) unless otherwise specified in this permit . Ecology may only specify alternative methods for parameters without permit limits and for those parameters without an EPA approved test method in 40 CFR Part 136.

S2.C. *Flow measurement, field measurement, and continuous monitoring devices*

The Permittee must:

1. Select and use appropriate flow measurement, field measurement, and continuous monitoring devices and methods consistent with accepted scientific practices.
2. Install, calibrate, and maintain these devices to ensure the accuracy of the measurements is consistent with the accepted industry standard, the manufacturer's recommendation, and approved O&M manual procedures for the device and the wastestream.
3. Calibrate continuous monitoring instruments weekly unless it can demonstrate a longer period is sufficient based on monitoring records. The Permittee:
   a. May calibrate apparatus for continuous monitoring of dissolved oxygen by air calibration.
   b. Must calibrate continuous pH measurement instruments using a grab sample analyzed in the lab with a pH meter calibrated with standard buffers and analyzed within 15 minutes of sampling.
4. Use field measurement devices as directed by the manufacturer and do not use reagents beyond their expiration dates.
5. Calibrate flow-monitoring devices at a minimum frequency of at least one calibration per year.
6. Maintain calibration records for at least three years.

S2.D. *Laboratory accreditation*

The Permittee must ensure that all monitoring data required by Ecology for permit specified parameters is prepared by a laboratory registered or accredited under the provisions of chapter 173-50 WAC, *Accreditation of Environmental Laboratories*. Flow, temperature, settleable solids, conductivity, pH, and internal process control parameters are exempt from this requirement. The Permittee must obtain accreditation for conductivity and pH if it must receive accreditation or registration for other parameters.

S2.E. Request for reduction in monitoring

The Permittee may request a reduction of the sampling frequency after twelve (12) months of monitoring. Ecology will review each request and at its discretion grant the request when it reissues the permit or by a permit modification.

The Permittee must:

1. Provide a written request.
2. Clearly state the parameters for which it is requesting reduced monitoring.
3. Clearly state the justification for the reduction.

S3. Reporting and recording requirements

The Permittee must monitor and report in accordance with the following conditions. Falsification of information submitted to Ecology is a violation of the terms and conditions of this permit.

S3.A. Discharge monitoring reports

The first monitoring period begins on the effective date of the permit (unless otherwise specified). The Permittee must:

1. Summarize, report, and submit monitoring data obtained during each monitoring period on the electronic discharge monitoring report (DMR) form provided by Ecology within the Water Quality Permitting Portal. Include data for each of the parameters tabulated in Special Condition S2 and as required by the form. Report a value for each day sampling occurred (unless specifically exempted in the permit) and for the summary values (when applicable) included on the electronic form.
2. Ensure that DMRs are electronically submitted no later than the dates specified below, unless otherwise specified in this permit.
3. Submit DMRs for parameters with the monitoring frequencies specified in S2 (monthly, quarterly, annual, etc.) at the reporting schedule identified below. The Permittee must:
    a. Submit **monthly** DMRs by the 15^{th} day of the following month. The first submittal is September 15, 2017.
    b. Submit **quarterly DMRs,** unless otherwise specified in the permit, by the 15^{th} day of the month following the monitoring period. Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must submit the first quarterly DMR on January 15, 2018 for the quarter beginning on October 1, 2017.
    c. Submit **annual DMRs**, unless otherwise specified in the permit, by January 15 for the previous calendar year. The annual sampling period is the calendar year. The Permittee must submit the first annual DMR on January 15, 2019, for the 2018 calendar year.

4. Enter the "No Discharge" reporting code for an entire DMR, for a specific monitoring point, or for a specific parameter as appropriate, if the Permittee did not discharge wastewater or a specific pollutant during a given monitoring period.
5. Report single analytical values below detection as "less than the detection level (DL)" by entering < followed by the numeric value of the detection level (e.g. < 2.0) on the DMR. If the method used did not meet the minimum DL and quantitation level (QL) identified in the permit, report the actual QL and DL in the comments or in the location provided.
6. Report single analytical values between the detection level (DL) and the quantitation level (QL) by entering the estimated value, the code for estimated value/below quantitation limit (j) and any additional information in the comments. Submit a copy of the laboratory report as an attachment using WQWebDMR. The contract laboratory reports must include information on the chain of custody, QA/QC results, and documentation of accreditation for the parameter.
7. **Not** report zero for bacteria monitoring. Report as required by the laboratory method.
8. Calculate and report an arithmetic average value for each day for bacteria if multiple samples were taken in one day.
9. Calculate the geometric mean values for bacteria (unless otherwise specified in the permit) using:
    a. The reported numeric value for all bacteria samples measured above the detection value except when it took multiple samples in one day. If the Permittee takes multiple samples in one day it must use the arithmetic average for the day in the geometric mean calculation.
    b. The detection value for those samples measured below detection.
10. Report the test method used for analysis in the comments if the laboratory used an alternative method not specified in the permit and as allowed in Appendix A.
11. Calculate average values and calculated total values (unless otherwise specified in the permit) using:
    a. The reported numeric value for all parameters measured between the detection value and the quantitation value for the sample analysis.
    b. One-half the detection value (for values reported below detection) if the lab detected the parameter in another sample from the same monitoring point for the reporting period.
    c. Zero (for values reported below detection) if the lab did not detect the parameter in another sample for the reporting period.

12. Report single-sample grouped parameters (for example: priority pollutants, PAHs, pulp and paper chlorophenolics, TTOs) on the WQWebDMR form and include the following: sample date, concentration detected, detection limit (DL) (as necessary), and laboratory quantitation level (QL) (as necessary).

S3.B. Permit submittals and schedules

The Permittee must use the Water Quality Permitting Portal – Permit Submittals application (unless otherwise specified in the permit) to submit all other written permit-required reports by the date specified in the permit.

When another permit condition requires submittal of a paper (hard-copy) report, the Permittee must ensure that it is postmarked or received by Ecology no later than the dates specified by this permit. Send these paper reports to Ecology at:

Water Quality Permit Coordinator
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

S3.C. Records retention

The Permittee must retain records of all monitoring information for a minimum of three (3) years. Such information must include all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit. The Permittee must extend this period of retention during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by Ecology.

S3.D. Recording of results

For each measurement or sample taken, the Permittee must record the following information:

1. The date, exact place, method, and time of sampling or measurement.
2. The individual who performed the sampling or measurement.
3. The dates the analyses were performed.
4. The individual who performed the analyses.
5. The analytical techniques or methods used.
6. The results of all analyses.

S3.E. Additional monitoring by the Permittee

If the Permittee monitors any pollutant more frequently than required by Special Condition S2 of this permit, then the Permittee must include the results of such monitoring in the calculation and reporting of the data submitted in the Permittee's DMR unless otherwise specified by Special Condition S2.

S3.F. Reporting permit violations

The Permittee must take the following actions when it violates or is unable to comply with any permit condition:

1. Immediately take action to stop, contain, and cleanup unauthorized discharges or otherwise stop the noncompliance and correct the problem.
2. If applicable, immediately repeat sampling and analysis. Submit the results of any repeat sampling to Ecology within thirty (30) days of sampling.

   a. Immediate reporting

   The Permittee must **immediately** report to Ecology and the Department of Health, Shellfish Program, and the Kitsap Public Health District (at the numbers listed below), all:

   - Failures of the disinfection system.
   - Collection system overflows.
   - Plant bypasses discharging to marine surface waters.
   - Any other failures of the sewage system (pipe breaks, etc.)

Northwest Regional Office	425-649-7000
Department of Health, Shellfish Program	360-236-3330 (business hours) 360-789-8962 (after business hours)
Kitsap Public Health District	360-728-2235 (call 24/7, after business hours press 9)

   b. Twenty-four-hour reporting

   The Permittee must report the following occurrences of noncompliance by telephone, to Ecology at the telephone numbers listed above, within 24 hours from the time the Permittee becomes aware of any of the following circumstances:

   1. Any noncompliance that may endanger health or the environment, unless previously reported under immediate reporting requirements.
   2. Any unanticipated bypass that causes an exceedance of an effluent limit in the permit (See Part S5.F, “Bypass Procedures”).
   3. Any upset that causes an exceedance of an effluent limit in the permit (See G.15, “Upset”).
   4. Any violation of a maximum daily or instantaneous maximum discharge limit for any of the pollutants in Section S1.A of this permit.
   5. Any overflow prior to the treatment works, whether or not such overflow endangers health or the environment or exceeds any effluent limit in the permit.

c. Report within five days

The Permittee must also submit a written report within five days of the time that the Permittee becomes aware of any reportable event under subparts a or b, above. The report must contain:

1. A description of the noncompliance and its cause.
2. The period of noncompliance, including exact dates and times.
3. The estimated time the Permittee expects the noncompliance to continue if not yet corrected.
4. Steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.
5. If the noncompliance involves an overflow prior to the treatment works, an estimate of the quantity (in gallons) of untreated overflow.

d. Waiver of written reports

Ecology may waive the written report required in subpart c, above, on a case-by-case basis upon request if the Permittee has submitted a timely oral report.

e. All other permit violation reporting

The Permittee must report all permit violations, which do not require immediate or within 24 hours reporting, when it submits monitoring reports for S3.A ("Reporting"). The reports must contain the information listed in subpart c, above. Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or the resulting liability for failure to comply.

S3.G. Other reporting

a. Spills of oil or hazardous materials

The Permittee must report a spill of oil or hazardous materials in accordance with the requirements of RCW 90.56.280 and chapter 173-303-145. You can obtain further instructions at the following website: http://www.ecy.wa.gov/programs/spills/other/reportaspill.htm .

b. Failure to submit relevant or correct facts

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to Ecology, it must submit such facts or information promptly.

S3.H. Maintaining a copy of this permit

The Permittee must keep a copy of this permit at the facility and make it available upon request to Ecology inspectors.

S4. Facility loading

S4.A. Design criteria

The flows or waste loads for the permitted facility must not exceed the following design criteria:

Maximum Month Design Flow (MMDF)	6.0 MGD
BOD_5 Influent Loading for Maximum Month	14,100 lb/day
TSS Influent Loading for Maximum Month	11,400 lb/day

S4.B. Plans for maintaining adequate capacity

a. Conditions triggering plan submittal

The Permittee must submit a plan and a schedule for continuing to maintain capacity to Ecology when:

1. The actual flow or waste load reaches 85 percent of any one of the design criteria in S4.A for three consecutive months.
2. The projected plant flow or loading would reach design capacity within five years.

b. Plan and schedule content

The plan and schedule must identify the actions necessary to maintain adequate capacity for the expected population growth and to meet the limits and requirements of the permit. The Permittee must consider the following topics and actions in its plan.

1. Analysis of the present design and proposed process modifications
2. Reduction or elimination of excessive infiltration and inflow of uncontaminated ground and surface water into the sewer system
3. Limits on future sewer extensions or connections or additional waste loads
4. Modification or expansion of facilities
5. Reduction of industrial or commercial flows or waste loads

Engineering documents associated with the plan must meet the requirements of WAC 173-240-060, "Engineering Report," and be approved by Ecology prior to any construction.

S4.C. Duty to mitigate

The Permittee must take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

S4.D. Notification of new or altered sources

1. The Permittee must submit written notice to Ecology whenever any new discharge or a substantial change in volume or character of an existing discharge into the wastewater treatment plant is proposed which:
   a. Would interfere with the operation of, or exceed the design capacity of, any portion of the wastewater treatment plant.
   b. Is not part of an approved general sewer plan or approved plans and specifications.
   c. Is subject to pretreatment standards under 40 CFR Part 403 and Section 307(b) of the Clean Water Act.
2. This notice must include an evaluation of the wastewater treatment plant's ability to adequately transport and treat the added flow and/or waste load, the quality and volume of effluent to be discharged to the treatment plant, and the anticipated impact on the Permittee's effluent [40 CFR 122.42(b)].

S4.E. Infiltration and inflow evaluation

1. The Permittee must conduct an infiltration and inflow evaluation. Refer to the U.S. EPA publication, I/I Analysis and Project Certification, available as Publication No. 97-03 at: http://www.ecy.wa.gov/programs/wq/permits/guidance.html .
2. The Permittee may use monitoring records to assess measurable infiltration and inflow.
3. The Permittee must prepare a report summarizing any measurable infiltration and inflow along with the following:
   a. Summary of the I/I analyses and routine inspections conducted in the last five years.
   b. A list of collection system repairs completed in the last five years.
   c. Identification of collection system areas where leaks are known or suspected.
   d. A schedule for conducting collection system inspections to locate leaks not already identified.
   e. A tentative schedule for future collection system repairs
4. The Permittee must submit a report summarizing the results of the evaluation and any recommendations for corrective actions by December 1, 2021.

S5. Operation and maintenance

The Permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances), which are installed to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance also includes keeping a daily operation logbook (paper or electronic), adequate laboratory controls, and appropriate quality assurance procedures. This provision of the permit requires the Permittee to operate backup or auxiliary facilities or similar systems only when the operation is necessary to achieve compliance with the conditions of this permit.

S5.A. Certified operator

This permitted facility must be operated by an operator certified by the state of Washington for at least a Class IV plant. This operator must be in responsible charge of the day-to-day operation of the wastewater treatment plant. An operator certified for at least a Class III plant must be in charge during all regularly scheduled shifts. The Permittee must notify Ecology when the operator in charge at the facility changes. It must provide the new operator’s name and certification level and provide the name of the operator leaving the facility.

S5.B. Operation and maintenance program

The Permittee must:

1. Institute an adequate operation and maintenance program for the entire sewage system.
2. Keep maintenance records on all major electrical and mechanical components of the treatment plant, as well as the sewage system and pumping stations. Such records must clearly specify the frequency and type of maintenance recommended by the manufacturer and must show the frequency and type of maintenance performed.
3. Make maintenance records available for inspection at all times.

S5.C. Short-term reduction

The Permittee must schedule any facility maintenance, which might require interruption of wastewater treatment and degrade effluent quality, during non-critical water quality periods and carry this maintenance out according to the approved O&M manual or as otherwise approved by Ecology.

If a Permittee contemplates a reduction in the level of treatment that would cause a violation of permit discharge limits on a short-term basis for any reason, and such reduction cannot be avoided, the Permittee must:

1. Give written notification to Ecology, if possible, thirty (30) days prior to such activities.
2. Detail the reasons for, length of time of, and the potential effects of the reduced level of treatment.

This notification does not relieve the Permittee of its obligations under this permit.

S5.D. Electrical power failure

The Permittee must ensure that adequate safeguards prevent the discharge of untreated wastes or wastes not treated in accordance with the requirements of this permit during electrical power failure at the treatment plant and/or sewage lift stations. Adequate safeguards include, but are not limited to, alternate power sources, standby generator(s), or retention of inadequately treated wastes.

The Permittee must maintain Reliability Class II (EPA 430-99-74-001) at the wastewater treatment plant. Reliability Class II requires a backup power source sufficient to operate all vital components and critical lighting and ventilation during peak wastewater flow conditions. Vital components used to support the secondary processes (i.e., mechanical aerators or aeration basin air compressors) need not be operable to full levels of treatment, but must be sufficient to maintain the biota.

S5.E. Prevent connection of inflow

The Permittee must strictly enforce its sewer ordinances and not allow the connection of inflow (roof drains, foundation drains, etc.) to the sanitary sewer system.

S5.F. Bypass procedures

A bypass is the intentional diversion of waste streams from any portion of a treatment facility. This permit prohibits all bypasses except when the bypass is for essential maintenance, as authorized in special condition S5.F.1, or is approved by Ecology as an anticipated bypass following the procedures in S5.F.2.

1. Bypass for essential maintenance without the potential to cause violation of permit limits or conditions.

   This permit allows bypasses for essential maintenance of the treatment system when necessary to ensure efficient operation of the system. The Permittee may bypass the treatment system for essential maintenance only if doing so does not cause violations of effluent limits. The Permittee is not required to notify Ecology when bypassing for essential maintenance. However the Permittee must comply with the monitoring requirements specified in special condition S2.B.

2. Anticipated bypasses for non-essential maintenance

   Ecology may approve an anticipated bypass under the conditions listed below. This permit prohibits any anticipated bypass that is not approved through the following process.

   a. If a bypass is for non-essential maintenance, the Permittee must notify Ecology, if possible, at least ten (10) days before the planned date of bypass. The notice must contain:
      - A description of the bypass and the reason the bypass is necessary.
      - An analysis of all known alternatives which would eliminate, reduce, or mitigate the potential impacts from the proposed bypass.
      - A cost-effectiveness analysis of alternatives.
      - The minimum and maximum duration of bypass under each alternative.
      - A recommendation as to the preferred alternative for conducting the bypass.
      - The projected date of bypass initiation.
      - A statement of compliance with SEPA.
      - A request for modification of water quality standards as provided for in WAC 173-201A-410, if an exceedance of any water quality standard is anticipated.
      - Details of the steps taken or planned to reduce, eliminate, and prevent recurrence of the bypass.

b. For probable construction bypasses, the Permittee must notify Ecology of the need to bypass as early in the planning process as possible. The Permittee must consider the analysis required above during the project planning and design process. The project-specific engineering report as well as the plans and specifications must include details of probable construction bypasses to the extent practical. In cases where the Permittee determines the probable need to bypass early, the Permittee must continue to analyze conditions up to and including the construction period in an effort to minimize or eliminate the bypass.

c. Ecology will determine if the Permittee has met the conditions of special condition S5.F.2 a and b and consider the following prior to issuing a determination letter, an administrative order, or a permit modification as appropriate for an anticipated bypass:

- If the Permittee planned and scheduled the bypass to minimize adverse effects on the public and the environment.
- If the bypass is unavoidable to prevent loss of life, personal injury, or severe property damage. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass.
- If feasible alternatives to the bypass exist, such as:
    - The use of auxiliary treatment facilities.
    - Retention of untreated wastes.
    - Stopping production.
    - Maintenance during normal periods of equipment downtime, but not if the Permittee should have installed adequate backup equipment in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance.
    - Transport of untreated wastes to another treatment facility.

S5.G. Operations and maintenance (O&M) manual

a. O&M manual submittal and requirements

The Permittee must:

1. Update the operations and maintenance (O&M) manual to meet the requirements of 173-240-080 WAC and submit it to Ecology for approval by January 31, 2022.
2. Submit revised sections of the O&M manual to Ecology for review and approval whenever the permittee significantly changes or upgrades treatment processes or equipment. The Permittee must submit a paper copy or an electronic copy via VPN access.

3. Keep the approved O&M manual at the permitted facility.
4. Follow the instructions and procedures of this manual.

b. O&M manual components

In addition to the requirements of WAC 173-240-080(1) through (5), the O&M Manual must be consistent with the guidance in Table G1-3 in the *Criteria for Sewage Works Design* (Orange Book), 2008. The O&M Manual must include:

1. Emergency procedures for cleanup in the event of wastewater system upset or failure.
2. A review of system components which if failed could pollute surface water or could impact human health. Provide a procedure for a routine schedule of checking the function of these components.
3. Wastewater system maintenance procedures that contribute to the generation of process wastewater.
4. Reporting protocols for submitting reports to Ecology to comply with the reporting requirements in the discharge permit.
5. Any directions to maintenance staff when cleaning or maintaining other equipment or performing other tasks which are necessary to protect the operation of the wastewater system (for example, defining maximum allowable discharge rate for draining a tank, blocking all floor drains before beginning the overhaul of a stationary engine).
6. The treatment plant process control monitoring schedule.
7. Minimum staffing adequate to operate and maintain the treatment processes and carry out compliance monitoring required by the permit.

S6. Pretreatment

S6.A. General requirements

The Permittee must work with Ecology to ensure that all commercial and industrial users of the publicly owned treatment works (POTW) comply with the pretreatment regulations in 40 CFR Part 403 and any additional regulations that the Environmental Protection Agency (U.S. EPA) may promulgate under Section 307(b) (pretreatment) and 308 (reporting) of the Federal Clean Water Act.

S6.B. Duty to enforce discharge prohibitions

1. Under federal regulations (40 CFR 403.5(a) and (b)), the Permittee must not authorize or knowingly allow the discharge of any pollutants into its POTW which may be reasonably expected to cause pass through or interference, or which otherwise violate general or specific discharge prohibitions contained in 40 CFR Part 403.5 or WAC 173-216-060.
2. The Permittee must not authorize or knowingly allow the introduction of any of the following into their treatment works:

a. Pollutants which create a fire or explosion hazard in the POTW (including, but not limited to waste streams with a closed cup flashpoint of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21).

b. Pollutants which will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0, or greater than 11.0 standard units, unless the works are specifically designed to accommodate such discharges.

c. Solid or viscous pollutants in amounts that could cause obstruction to the flow in sewers or otherwise interfere with the operation of the POTW.

d. Any pollutant, including oxygen-demanding pollutants, (BOD_5, etc.) released in a discharge at a flow rate and/or pollutant concentration which will cause interference with the POTW.

e. Petroleum oil, non-biodegradable cutting oil, or products of mineral origin in amounts that will cause interference or pass through.

f. Pollutants which result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity which may cause acute worker health and safety problems.

g. Heat in amounts that will inhibit biological activity in the POTW resulting in interference but in no case heat in such quantities such that the temperature at the POTW headworks exceeds 40 degrees Centigrade (104 degrees Fahrenheit) unless Ecology, upon request of the Permittee, approves, in writing, alternate temperature limits.

h. Any trucked or hauled pollutants, except at discharge points designated by the Permittee.

i. Wastewaters prohibited to be discharged to the POTW by the Dangerous Waste Regulations (chapter 173-303 WAC), unless authorized under the Domestic Sewage Exclusion (WAC 173-303-071).

3. The Permittee must also not allow the following discharges to the POTW unless approved in writing by Ecology:

   a. Noncontact cooling water in significant volumes.

   b. Stormwater and other direct inflow sources.

   c. Wastewaters significantly affecting system hydraulic loading, which do not require treatment, or would not be afforded a significant degree of treatment by the system.

4. The Permittee must notify Ecology if any industrial user violates the prohibitions listed in this section (S6.B), and initiate enforcement action to promptly curtail any such discharge.

S6.C. Wastewater discharge permit required

The Permittee must:

1. Establish a process for authorizing non-domestic wastewater discharges that ensures all SIUs in all tributary areas meet the applicable state waste discharge permit (SWDP) requirements in accordance with chapter 90.48 RCW and chapter 173-216 WAC.
2. Immediately notify Ecology of any proposed discharge of wastewater from a source, which may be a significant industrial user (SIU) [see fact sheet definitions or refer to 40 CFR 403.3(v)(i)(ii)].
3. Require all SIUs to obtain a SWDP from Ecology prior to accepting their non-domestic wastewater, or require proof that Ecology has determined they do not require a permit.
4. Require the documentation as described in S6.C.3 at the earliest practicable date as a condition of continuing to accept non-domestic wastewater discharges from a previously undiscovered, currently discharging and unpermitted SIU.
5. Require sources of non-domestic wastewater, which do not qualify as SIUs but merit a degree of oversight, to apply for a SWDP and provide it a copy of the application and any Ecology responses.
6. Keep all records documenting that its users have met the requirements of S6.C.

S6.D. Identification and reporting of existing, new, and proposed industrial users

1. The Permittee must take continuous, routine measures to identify all existing, new, and proposed SIUs and potential significant industrial users (PSIUs) discharging or proposing to discharge to the Permittee's sewer system (see *Appendix C* of the fact sheet for definitions).
2. Within 30 days of becoming aware of an unpermitted existing, new, or proposed industrial user who may be a significant industrial user (SIU), the Permittee must notify such user by registered mail that, if classified as an SIU, they must apply to Ecology and obtain a State Waste Discharge Permit. The Permittee must send a copy of this notification letter to Ecology within this same 30-day period.
3. The Permittee must also notify all Potential SIUs (PSIUs), as they are identified, that if their classification should change to an SIU, they must apply to Ecology for a State Waste Discharge Permit within 30 days of such change.

S6.E. Industrial user survey

The Permittee must complete an industrial user survey listing all SIUs and potential significant industrial users (PSIUs) discharging to the POTW. The Permittee must submit the survey to Ecology by January 31, 2022. At a minimum, the Permittee must develop the list of SIUs and PSIUs by means of a telephone book search, a water utility billing records search, and a physical reconnaissance of the service area.

Information on PSIUs must include, at a minimum, the business name, telephone number, address, description of the industrial process(s), and the known wastewater volumes and characteristics. The list must include SIUs and PSIUs located in all areas that contribute flow to the facility covered under this permit, including users connected to collection systems owned and operated by sewer districts or municipalities that have treatment service agreements with the Permittee.

S7. Solid wastes

S7.A. Solid waste handling

The Permittee must handle and dispose of all solid waste material in such a manner as to prevent its entry into state ground or surface water.

S7.B. Leachate

The Permittee must not allow leachate from its solid waste material to enter state waters without providing all known, available, and reasonable methods of treatment, nor allow such leachate to cause violations of the State Surface Water Quality Standards, Chapter 173-201A WAC, or the State Ground Water Quality Standards, Chapter 173-200 WAC. The Permittee must apply for a permit or permit modification as may be required for such discharges to state ground or surface waters.

S8. Acute toxicity

S8.A. Effluent limit for acute toxicity

The effluent limit for acute toxicity is:

No acute toxicity detected at the whole effluent toxicity (WET) test concentration representing the acute critical effluent concentration (ACEC). The ACEC equals 2.1% effluent.

The ACEC is the maximum concentration of effluent allowed during critical conditions at the boundary of the acute mixing zone, which is defined in Section S1.B of this permit.

S8.B. Compliance with the effluent limit for acute toxicity

Compliance with the effluent limit for acute toxicity means the results of the testing specified in Section S9.C show no statistically significant difference in survival between the control and the ACEC.

If the test results show a statistically significant difference in survival between the control and the ACEC, the effluent does not comply with the effluent limit for acute toxicity. In this case, the Permittee must then immediately conduct the additional testing described in Section S9.C. The Permittee must comply with the requirements of this section by also meeting the requirements of Section S9.C.

The Permittee must determine the statistical significance of the results of its WET testing by conducting a hypothesis test at the 0.05 level of significance (Appendix H, EPA/600/4-89/001).

If the difference in survival between the control and the ACEC is less than 10%, the Permittee must conduct the hypothesis test at the 0.01 level of significance.

S8.C. Compliance testing for acute toxicity

The Permittee must:

1. Conduct compliance testing during the months shown in the following table.
2. Perform acute WET tests with 100% effluent, the ACEC, and a control, or with a full dilution series. The ACEC equals 2.1% effluent.
3. Submit written reports of the test results to Ecology by the dates shown in the following table.
4. Perform compliance tests using each of the species and protocols listed in the following table:

Acute Toxicity Test	Species	Method	Test Date	Written Report Submittal Date
Fathead minnow, 96-hour static-renewal test	*Pimephales promelas*	EPA-821-R-02-012 October 2002	January 2018 July 2019 January 2020 July 2021	April 30, 2018 October 31, 2019 April 30, 2020 October 31, 2021
Daphnid, 48-hour static test	*Ceriodaphnia dubia*, *Daphnia pulex*, or *Daphnia magma*	EPA-821-R-02-012 October 2002	July 2018 January 2019 July 2020 January 2021	October 31, 2018 April 30, 2019 October 31, 2020 April 30, 2021

S8.D. Response to noncompliance with the effluent limit for acute toxicity

If a toxicity test conducted under Section S9.C determines a statistically significant difference in response between the ACEC and the control, using the statistical test described in Section S9.B, the Permittee must begin additional testing within one week from the time of receiving the test results. The Permittee must:

1. Conduct one additional WET test each week for four consecutive weeks, using the same test method and species as the failed compliance test.
2. Test at least five effluent concentrations and a control to determine appropriate point estimates. One of these effluent concentrations must equal the ACEC. The results of the test at the ACEC will determine compliance with the effluent limit for acute toxicity as described in Section S9.B.
3. Return to the original monitoring frequency in Section S9.C after completion of the additional compliance monitoring.

Anomalous test results: If a WET test conducted under Section S9.C indicates noncompliance with the acute toxicity limit and the Permittee believes that the test result is anomalous, the Permittee may notify Ecology that the compliance test result may be anomalous. The Permittee may take one additional sample for toxicity testing and wait for notification from Ecology before completing the additional WET testing. The Permittee must submit the notification with the report of the compliance test result and identify the reason for considering the compliance test result to be anomalous.

If Ecology determines that the test result was not anomalous, the Permittee must complete all of the additional monitoring required in this section. Or,

If the one additional sample fails to comply with the effluent limit for acute toxicity, then the Permittee must complete all of the additional monitoring required in this section. Or,

If Ecology determines that the test result was anomalous, the one additional test result will replace the anomalous test result.

If all of the additional testing in this section complies with the permit limit, the Permittee must submit a report to Ecology to identify possible causes and preventive measures for the transient toxicity event that triggered the additional compliance monitoring. This report must include a search of all pertinent and recent facility records, including:

- Operating records
- Monitoring results
- Inspection records
- Spill reports
- Weather records
- Production records
- Raw material purchases
- Pretreatment records, etc.

If the additional testing required in this section shows another violation of the acute toxicity limit, the Permittee must submit a Toxicity Identification/Reduction Evaluation (TI/RE) plan to Ecology within 60 days after the sample date (WAC 173-205-100(2)).

S8.E. Sampling and reporting requirements

1. The Permittee must submit all reports for toxicity testing in accordance with the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. Reports must contain bench sheets and results for reference toxicants. If the laboratory provides toxicity test data in an electronic format suitable for entry into Ecology's database, then the Permittee must send that electronic data to Ecology along with the test report, bench sheets, and reference toxicant results.

2. The Permittee must collect 24-hour composite effluent samples for toxicity testing. The Permittee must cool the samples to 0 - 6 degrees Celsius during collection and send them to the laboratory immediately upon completion. The laboratory must begin the toxicity testing as soon as possible but no later than 36 hours after sampling was completed.

3. The laboratory must conduct water quality measurements on all samples and test solutions for toxicity testing, as specified in the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*.
4. All toxicity tests must meet quality assurance criteria and test conditions specified in the most recent versions of the EPA methods listed in Subsection C and the Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. If Ecology determines any test results to be invalid or anomalous, the Permittee must repeat the testing with freshly collected effluent.
5. The laboratory must use control water and dilution water meeting the requirements of the EPA methods listed in Section S9.C or pristine natural water of sufficient quality for good control performance.
6. The Permittee must conduct WET tests on an unmodified sample of final effluent.
7. The Permittee may choose to conduct a full dilution series test during compliance testing in order to determine dose response. In this case, the series must have a minimum of five effluent concentrations and a control. The series of concentrations must include the ACEC. The ACEC equals 2.1% effluent.
8. All WET tests, effluent screening tests, and rapid screening tests that involve hypothesis testing must comply with the acute statistical power standard of 29% as defined in WAC 173-205-020. If the test does not meet the power standard, the Permittee must repeat the test on a fresh sample with an increased number of replicates to increase the power.

S9. Chronic toxicity

S9.A. Testing when there is no permit limit for chronic toxicity

The Permittee must:

1. Conduct chronic toxicity testing on final effluent during February 2021 and August 2021.
2. Submit the results to Ecology with the permit renewal application.
3. Conduct chronic toxicity testing on a series of at least five concentrations of effluent and a control. This series of dilutions must include the ACEC. The ACEC equals 2.1% effluent. The series of dilutions should also contain the chronic critical effluent concentration (CCEC) of 1.2% effluent.
4. Compare the ACEC to the control using hypothesis testing at the 0.05 level of significance as described in Appendix H, EPA/600/4-89/001.
5. Submit the results to Ecology by April 15, 2021 and October 15, 2021.
6. Perform chronic toxicity tests with all of the following species and the most recent version of the following protocols:

Saltwater Chronic Toxicity Tests	Species	Method
Topsmelt, survival and growth	*Atherinops affinis*	EPA/600/R-95/136
Mysid shrimp, survival and growth	*Americamysis bahia,* (formerly *Mysidopsis bahia*)	EPA-821-R-02-014

S9.B. Sampling and reporting requirements

1. The Permittee must submit all reports for toxicity testing in accordance with the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. Reports must contain bench sheets and results for reference toxicants. If the laboratory provides the toxicity test data in an electronic format suitable for entry into Ecology's database, then the Permittee must send the data to Ecology along with the test report, bench sheets, and reference toxicant results.
2. The Permittee must collect 24-hour composite effluent samples for toxicity testing. The Permittee must cool the samples to 0 - 6 degrees Celsius during collection and send them to the laboratory immediately upon completion. The laboratory must begin the toxicity testing as soon as possible but no later than 36 hours after sampling was completed.
3. The laboratory must conduct water quality measurements on all samples and test solutions for toxicity testing, as specified in the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*.
4. All toxicity tests must meet quality assurance criteria and test conditions specified in the most recent versions of the EPA methods listed in Section C and the Ecology Publication no. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. If Ecology determines any test results to be invalid or anomalous, the Permittee must repeat the testing with freshly collected effluent.
5. The laboratory must use control water and dilution water meeting the requirements of the EPA methods listed in Subsection S10.A or pristine natural water of sufficient quality for good control performance.
6. The Permittee must conduct whole effluent toxicity tests on an unmodified sample of final effluent.
7. The Permittee may choose to conduct a full dilution series test during compliance testing in order to determine dose response. In this case, the series must have a minimum of five effluent concentrations and a control. The series of concentrations must include the CCEC and the ACEC. The CCEC and the ACEC may either substitute for the effluent concentrations that are closest to them in the dilution series or be extra effluent concentrations. The CCEC equals 1.2% effluent. The ACEC equals 2.1% effluent.

8. All WET tests that involve hypothesis testing must comply with the chronic statistical power standard of 39% as defined in WAC 173-205-020. If the test does not meet the power standard, the Permittee must repeat the test on a fresh sample with an increased number of replicates to increase the power.

S10. Application for permit renewal or modification for facility changes

The Permittee must submit an application for renewal of this permit by January 31, 2022.

The Permittee must also submit a new application or addendum at least one hundred eighty (180) days prior to commencement of discharges, resulting from the activities listed below, which may result in permit violations. These activities include any facility expansions, production increases, or other planned changes, such as process modifications, in the permitted facility.

General Conditions

G1. Signatory requirements

1. All applications submitted to Ecology must be signed and certified.

   a. In the case of corporations, by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:

      - A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation, or

      - The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

   b. In the case of a partnership, by a general partner.

   c. In the case of sole proprietorship, by the proprietor.

   d. In the case of a municipal, state, or other public facility, by either a principal executive officer or ranking elected official.

   Applications for permits for domestic wastewater facilities that are either owned or operated by, or under contract to, a public entity shall be submitted by the public entity.

2. All reports required by this permit and other information requested by Ecology must be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to Ecology.

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under paragraph G1.2, above, is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph G1.2, above, must be submitted to Ecology prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section must make the following certification:

   "I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

G2. Right of inspection and entry

The Permittee must allow an authorized representative of Ecology, upon the presentation of credentials and such other documents as may be required by law:

1. To enter upon the premises where a discharge is located or where any records must be kept under the terms and conditions of this permit.
2. To have access to and copy, at reasonable times and at reasonable cost, any records required to be kept under the terms and conditions of this permit.
3. To inspect, at reasonable times, any facilities, equipment (including monitoring and control equipment), practices, methods, or operations regulated or required under this permit.
4. To sample or monitor, at reasonable times, any substances or parameters at any location for purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act.

G3. Permit actions

This permit may be modified, revoked and reissued, or terminated either at the request of any interested person (including the Permittee) or upon Ecology's initiative. However, the permit may only be modified, revoked and reissued, or terminated for the reasons specified in 40 CFR 122.62, 40 CFR 122.64 or WAC 173-220-150 according to the procedures of 40 CFR 124.5.

1. The following are causes for terminating this permit during its term, or for denying a permit renewal application:
   a. Violation of any permit term or condition.
   b. Obtaining a permit by misrepresentation or failure to disclose all relevant facts.
   c. A material change in quantity or type of waste disposal.
   d. A determination that the permitted activity endangers human health or the environment, or contributes to water quality standards violations and can only be regulated to acceptable levels by permit modification or termination.

e. A change in any condition that requires either a temporary or permanent reduction, or elimination of any discharge or sludge use or disposal practice controlled by the permit.

f. Nonpayment of fees assessed pursuant to RCW 90.48.465.

g. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090.

2. The following are causes for modification but not revocation and reissuance except when the Permittee requests or agrees:

   a. A material change in the condition of the waters of the state.

   b. New information not available at the time of permit issuance that would have justified the application of different permit conditions.

   c. Material and substantial alterations or additions to the permitted facility or activities which occurred after this permit issuance.

   d. Promulgation of new or amended standards or regulations having a direct bearing upon permit conditions, or requiring permit revision.

   e. The Permittee has requested a modification based on other rationale meeting the criteria of 40 CFR Part 122.62.

   f. Ecology has determined that good cause exists for modification of a compliance schedule, and the modification will not violate statutory deadlines.

   g. Incorporation of an approved local pretreatment program into a municipality's permit.

3. The following are causes for modification or alternatively revocation and reissuance:

   a. When cause exists for termination for reasons listed in 1.a through 1,g of this section, and Ecology determines that modification or revocation and reissuance is appropriate.

   b. When Ecology has received notification of a proposed transfer of the permit. A permit may also be modified to reflect a transfer after the effective date of an automatic transfer (General Condition G7) but will not be revoked and reissued after the effective date of the transfer except upon the request of the new Permittee.

G4. Reporting planned changes

The Permittee must, as soon as possible, but no later than one hundred eighty (180) days prior to the proposed changes, give notice to Ecology of planned physical alterations or additions to the permitted facility, production increases, or process modification which will result in:

1. The permitted facility being determined to be a new source pursuant to 40 CFR 122.29(b).

2. A significant change in the nature or an increase in quantity of pollutants discharged.

3. A significant change in the Permittee's sludge use or disposal practices. Following such notice, and the submittal of a new application or supplement to the existing application, along with required engineering plans and reports, this permit may be modified, or revoked and reissued pursuant to 40 CFR 122.62(a) to specify and limit any pollutants not previously limited. Until such modification is effective, any new or increased discharge in excess of permit limits or not specifically authorized by this permit constitutes a violation.

G5. Plan review required

Prior to constructing or modifying any wastewater control facilities, an engineering report and detailed plans and specifications must be submitted to Ecology for approval in accordance with chapter 173-240 WAC. Engineering reports, plans, and specifications must be submitted at least one hundred eighty (180) days prior to the planned start of construction unless a shorter time is approved by Ecology. Facilities must be constructed and operated in accordance with the approved plans.

G6. Compliance with other laws and statutes

Nothing in this permit excuses the Permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

G7. Transfer of this permit

In the event of any change in control or ownership of facilities from which the authorized discharge emanate, the Permittee must notify the succeeding owner or controller of the existence of this permit by letter, a copy of which must be forwarded to Ecology.

1. Transfers by Modification

   Except as provided in paragraph (2) below, this permit may be transferred by the Permittee to a new owner or operator only if this permit has been modified or revoked and reissued under 40 CFR 122.62(b)(2), or a minor modification made under 40 CFR 122.63(d), to identify the new Permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

2. Automatic Transfers

   This permit may be automatically transferred to a new Permittee if:

   a. The Permittee notifies Ecology at least thirty (30) days in advance of the proposed transfer date.

   b. The notice includes a written agreement between the existing and new Permittees containing a specific date transfer of permit responsibility, coverage, and liability between them.

   c. Ecology does not notify the existing Permittee and the proposed new Permittee of its intent to modify or revoke and reissue this permit. A modification under this subparagraph may also be minor modification under 40 CFR 122.63. If this notice is not received, the transfer is effective on the date specified in the written agreement.

G8. Reduced production for compliance

The Permittee, in order to maintain compliance with its permit, must control production and/or all discharges upon reduction, loss, failure, or bypass of the treatment facility until the facility is restored or an alternative method of treatment is provided. This requirement applies in the situation where, among other things, the primary source of power of the treatment facility is reduced, lost, or fails.

G9. Removed substances

Collected screenings, grit, solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters must not be resuspended or reintroduced to the final effluent stream for discharge to state waters.

G10. Duty to provide information

The Permittee must submit to Ecology, within a reasonable time, all information which Ecology may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee must also submit to Ecology upon request, copies of records required to be kept by this permit.

G11. Other requirements of 40 CFR

All other requirements of 40 CFR 122.41 and 122.42 are incorporated in this permit by reference.

G12. Additional monitoring

Ecology may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G13. Payment of fees

The Permittee must submit payment of fees associated with this permit as assessed by Ecology.

G14. Penalties for violating permit conditions

Any person who is found guilty of willfully violating the terms and conditions of this permit is deemed guilty of a crime, and upon conviction thereof shall be punished by a fine of up to ten thousand dollars ($10,000) and costs of prosecution, or by imprisonment in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of a waste discharge permit may incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to ten thousand dollars ($10,000) for every such violation. Each and every such violation is a separate and distinct offense, and in case of a continuing violation, every day's continuance is deemed to be a separate and distinct violation.

G15. Upset

Definition – "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limits because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limits if the requirements of the following paragraph are met.

A Permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

1. An upset occurred and that the Permittee can identify the cause(s) of the upset.
2. The permitted facility was being properly operated at the time of the upset.
3. The Permittee submitted notice of the upset as required in Special Condition S3.F.
4. The Permittee complied with any remedial measures required under S3.F of this permit.

In any enforcement action the Permittee seeking to establish the occurrence of an upset has the burden of proof.

G16. Property rights

This permit does not convey any property rights of any sort, or any exclusive privilege.

G17. Duty to comply

The Permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

G18. Toxic pollutants

The Permittee must comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G19. Penalties for tampering

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two (2) years per violation, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this condition, punishment shall be a fine of not more than $20,000 per day of violation, or by imprisonment of not more than four (4) years, or by both.

G20. Compliance schedules

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit must be submitted no later than fourteen (14) days following each schedule date.

G21. Service agreement review

The Permittee must submit to Ecology any proposed service agreements and proposed revisions or updates to existing agreements for the operation of any wastewater treatment facility covered by this permit. The review is to ensure consistency with chapters 90.46 and 90.48 RCW as required by RCW 70.150.040(9). In the event that Ecology does not comment within a thirty-day (30) period, the Permittee may assume consistency and proceed with the service agreement or the revised/updated service agreement.

Appendix A

LIST OF POLLUTANTS WITH ANALYTICAL METHODS, DETECTION LIMITS AND QUANTITATION LEVELS

The Permittee must use the specified analytical methods, detection limits (DLs) and quantitation levels (QLs) in the following table for permit and application required monitoring unless:

- Another permit condition specifies other methods, detection levels, or quantitation levels.
- The method used produces measurable results in the sample and EPA has listed it as an EPA-approved method in 40 CFR Part 136.

If the Permittee uses an alternative method, not specified in the permit and as allowed above, it must report the test method, DL, and QL on the discharge monitoring report or in the required report.

If the Permittee is unable to obtain the required DL and QL in its effluent due to matrix effects, the Permittee must submit a matrix-specific detection limit (MDL) and a quantitation limit (QL) to Ecology with appropriate laboratory documentation.

When the permit requires the Permittee to measure the base neutral compounds in the list of priority pollutants, it must measure all of the base neutral pollutants listed in the table below. The list includes EPA required base neutral priority pollutants and several additional polynuclear aromatic hydrocarbons (PAHs). The Water Quality Program added several PAHs to the list of base neutrals below from Ecology's Persistent Bioaccumulative Toxics (PBT) List. It only added those PBT parameters of interest to Appendix A that did not increase the overall cost of analysis unreasonably.

Ecology added this appendix to the permit in order to reduce the number of analytical "non-detects" in permit-required monitoring and to measure effluent concentrations near or below criteria values where possible at a reasonable cost.

The lists below include conventional pollutants (as defined in CWA section 502(6) and 40 CFR Part 122.), toxic or priority pollutants as defined in CWA section 307(a)(1) and listed in 40 CFR Part 122 Appendix D, 40 CFR Part 401.15 and 40 CFR Part 423 Appendix A), and nonconventionals. 40 CFR Part 122 Appendix D (Table V) also identifies toxic pollutants and hazardous substances which are required to be reported by dischargers if expected to be present. This permit appendix A list does not include those parameters. The list also includes pulp and paper pollutants identified in 40 CFR Part 430 and the dioxin and furan congeners identified using EPA Method 1613.

CONVENTIONAL POLLUTANTS

Pollutant	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] *µg/L unless specified*	Quantitation Level (QL) [2] *µg/L unless specified*
Biochemical Oxygen Demand		SM5210-B		2 mg/L
Biochemical Oxygen Demand, Soluble		SM5210-B [3]		2 mg/L
Fecal Coliform		SM 9221E,9222	N/A	Specified in method - sample aliquot dependent
Oil and Grease (HEM) (Hexane Extractable Material)		1664 A or B	1,400	5,000
pH		SM4500-H^+ B	N/A	N/A
Total Suspended Solids		SM2540-D		5 mg/L

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Alkalinity, Total		SM2320-B		5 mg/L as CaCO3
Aluminum, Total	7429-90-5	200.8	2.0	10
Ammonia, Total (as N)		SM4500-NH3-B and C/D/E/G/H		20
Barium Total	7440-39-3	200.8	0.5	2.0
BTEX (benzene +toluene + ethylbenzene + m,o,p xylenes)		EPA SW 846 8021/8260	1	2
Boron, Total	7440-42-8	200.8	2.0	10.0
Chemical Oxygen Demand		SM5220-D		10 mg/L
Chloride		SM4500-Cl B/C/D/E and SM4110 B		Sample and limit dependent
Chlorine, Total Residual		SM4500 Cl G		50.0
Cobalt, Total	7440-48-4	200.8	0.05	0.25
Color		SM2120 B/C/E		10 color units
Dissolved oxygen		SM4500-OC/OG		0.2 mg/L
Flow		Calibrated device		
Fluoride	16984-48-8	SM4500-F E	25	100
Hardness, Total		SM2340B		200 as CaCO3
Iron, Total	7439-89-6	200.7	12.5	50
Magnesium, Total	7439-95-4	200.7	10	50
Manganese, Total	7439-96-5	200.8	0.1	0.5
Molybdenum, Total	7439-98-7	200.8	0.1	0.5
Nitrate + Nitrite Nitrogen (as N)		SM4500-NO3-E/F/H		100
Nitrogen, Total Kjeldahl (as N)		SM4500-N_{org}B/C and SM4500NH_3-B/C/D/EF/G/H		300
NWTPH Dx [4]		Ecology NWTPH Dx	250	250
NWTPH Gx [5]		Ecology NWTPH Gx	250	250
Phosphorus, Total (as P)		SM 4500 PB followed by SM4500-PE/PF	3	10

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Salinity		SM2520-B		3 practical salinity units or scale (PSU or PSS)
Settleable Solids		SM2540 -F		Sample and limit dependent
Soluble Reactive Phosphorus (as P)		SM4500-P E/F/G	3	10
Sulfate (as mg/L SO_4)		SM4110-B		0.2 mg/L
Sulfide (as mg/L S)		SM4500-S^2F/D/E/G		0.2 mg/L
Sulfite (as mg/L SO_3)		SM4500-SO3B		2 mg/L
Temperature (max. 7-day avg.)		Analog recorder or use micro-recording devices known as thermistors		0.2º C
Tin, Total	7440-31-5	200.8	0.3	1.5
Titanium, Total	7440-32-6	200.8	0.5	2.5
Total Coliform		SM 9221B, 9222B, 9223B	N/A	Specified in method - sample aliquot dependent
Total Organic Carbon		SM5310-B/C/D		1 mg/L
Total dissolved solids		SM2540 C		20 mg/L

PRIORITY POLLUTANTS	PP #	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] ***µg/L unless specified***	Quantitation Level (QL)[2] ***µg/L unless specified***
METALS, CYANIDE & TOTAL PHENOLS					
Antimony, Total	114	7440-36-0	200.8	0.3	1.0
Arsenic, Total	115	7440-38-2	200.8	0.1	0.5
Beryllium, Total	117	7440-41-7	200.8	0.1	0.5
Cadmium, Total	118	7440-43-9	200.8	0.05	0.25
Chromium (hex) dissolved	119	18540-29-9	SM3500-Cr C	0.3	1.2
Chromium, Total	119	7440-47-3	200.8	0.2	1.0
Copper, Total	120	7440-50-8	200.8	0.4	2.0
Lead, Total	122	7439-92-1	200.8	0.1	0.5
Mercury, Total	123	7439-97-6	1631E	0.0002	0.0005
Nickel, Total	124	7440-02-0	200.8	0.1	0.5
Selenium, Total	125	7782-49-2	200.8	1.0	1.0
Silver, Total	126	7440-22-4	200.8	0.04	0.2
Thallium, Total	127	7440-28-0	200.8	0.09	0.36
Zinc, Total	128	7440-66-6	200.8	0.5	2.5
Cyanide, Total	121	57-12-5	335.4	5	10
Cyanide, Weak Acid Dissociable	121		SM4500-CN I	5	10
Cyanide, Free Amenable to Chlorination (Available Cyanide)	121		SM4500-CN G	5	10
Phenols, Total	65		EPA 420.1		50

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
ACID COMPOUNDS					
2-Chlorophenol	24	95-57-8	625	1.0	2.0
2,4-Dichlorophenol	31	120-83-2	625	0.5	1.0
2,4-Dimethylphenol	34	105-67-9	625	0.5	1.0
4,6-dinitro-o-cresol (2-methyl-4,6,-dinitrophenol)	60	534-52-1	625/1625B	2.0	4.0
2,4 dinitrophenol	59	51-28-5	625	1.5	3.0
2-Nitrophenol	57	88-75-5	625	0.5	1.0
4-Nitrophenol	58	100-02-7	625	1.0	2.0
Parachlorometa cresol (4-chloro-3-methylphenol)	22	59-50-7	625	1.0	2.0
Pentachlorophenol	64	87-86-5	625	0.5	1.0
Phenol	65	108-95-2	625	2.0	4.0
2,4,6-Trichlorophenol	21	88-06-2	625	2.0	4.0

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
VOLATILE COMPOUNDS					
Acrolein	2	107-02-8	624	5	10
Acrylonitrile	3	107-13-1	624	1.0	2.0
Benzene	4	71-43-2	624	1.0	2.0
Bromoform	47	75-25-2	624	1.0	2.0
Carbon tetrachloride	6	56-23-5	624/601 or SM6230B	1.0	2.0
Chlorobenzene	7	108-90-7	624	1.0	2.0
Chloroethane	16	75-00-3	624/601	1.0	2.0
2-Chloroethylvinyl Ether	19	110-75-8	624	1.0	2.0
Chloroform	23	67-66-3	624 or SM6210B	1.0	2.0
Dibromochloromethane (chlordibromomethane)	51	124-48-1	624	1.0	2.0
1,2-Dichlorobenzene	25	95-50-1	624	1.9	7.6
1,3-Dichlorobenzene	26	541-73-1	624	1.9	7.6
1,4-Dichlorobenzene	27	106-46-7	624	4.4	17.6
Dichlorobromomethane	48	75-27-4	624	1.0	2.0
1,1-Dichloroethane	13	75-34-3	624	1.0	2.0
1,2-Dichloroethane	10	107-06-2	624	1.0	2.0
1,1-Dichloroethylene	29	75-35-4	624	1.0	2.0
1,2-Dichloropropane	32	78-87-5	624	1.0	2.0
1,3-dichloropropene (mixed isomers) (1,2-dichloropropylene) [6]	33	542-75-6	624	1.0	2.0
Ethylbenzene	38	100-41-4	624	1.0	2.0
Methyl bromide (Bromomethane)	46	74-83-9	624/601	5.0	10.0
Methyl chloride (Chloromethane)	45	74-87-3	624	1.0	2.0

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
VOLATILE COMPOUNDS					
Methylene chloride	44	75-09-2	624	5.0	10.0
1,1,2,2-Tetrachloroethane	15	79-34-5	624	1.9	2.0
Tetrachloroethylene	85	127-18-4	624	1.0	2.0
Toluene	86	108-88-3	624	1.0	2.0
1,2-Trans-Dichloroethylene (Ethylene dichloride)	30	156-60-5	624	1.0	2.0
1,1,1-Trichloroethane	11	71-55-6	624	1.0	2.0
1,1,2-Trichloroethane	14	79-00-5	624	1.0	2.0
Trichloroethylene	87	79-01-6	624	1.0	2.0
Vinyl chloride	88	75-01-4	624/SM6200B	1.0	2.0

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
BASE/NEUTRAL COMPOUNDS (compounds in bold are Ecology PBTs)					
Acenaphthene	1	83-32-9	625	0.2	0.4
Acenaphthylene	77	208-96-8	625	0.3	0.6
Anthracene	78	120-12-7	625	0.3	0.6
Benzidine	5	92-87-5	625	20	40
Benzyl butyl phthalate	67	85-68-7	625	0.3	0.6
Benzo(*a*)anthracene	72	56-55-3	625	0.3	0.6
Benzo(b)fluoranthene (3,4-benzofluoranthene) [7]	74	205-99-2	610/625	0.8	1.6
Benzo(j)fluoranthene [7]		**205-82-3**	625	0.5	1.0
Benzo(k)fluoranthene (11,12-benzofluoranthene) [7]	75	207-08-9	610/625	0.8	1.6
Benzo(r,s,t)pentaphene		**189-55-9**	625	1.3	5.0
Benzo(*a*)pyrene	73	50-32-8	610/625	0.5	1.0
Benzo(*ghi*)Perylene	79	191-24-2	610/625	0.5	1.0
Bis(*2-chloroethoxy)*methane	43	111-91-1	625	5.3	21.2
Bis(*2-chloroethyl*)ether	18	111-44-4	611/625	0.3	1.0
Bis(*2-chloroisopropyl*)ether	42	39638-32-9	625	0.5	1.0
Bis(*2-ethylhexyl*)phthalate	66	117-81-7	625	0.3	1.0
4-Bromophenyl phenyl ether	41	101-55-3	625	0.3	0.5
2-Chloronaphthalene	20	91-58-7	625	0.3	0.6
4-Chlorophenyl phenyl ether	40	7005-72-3	625	0.3	0.5
Chrysene	76	218-01-9	610/625	0.3	0.6
Dibenzo (a,h)acridine		**226-36-8**	610M/625M	2.5	10.0
Dibenzo (a,j)acridine		**224-42-0**	610M/625M	2.5	10.0
Dibenzo(a-*h*)anthracene (1,2,5,6-dibenzanthracene)	82	53-70-3	625	0.8	1.6
Dibenzo(a,e)pyrene		192-65-4	610M/625M	2.5	10.0
Dibenzo(a,h)pyrene		189-64-0	625M	2.5	10.0
3,3-Dichlorobenzidine	28	91-94-1	605/625	2.0	14.0
Diethyl phthalate	70	84-66-2	625	1.9	7.6

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
BASE/NEUTRAL COMPOUNDS (compounds in bold are Ecology PBTs)					
Dimethyl phthalate	71	131-11-3	625	1.6	6.4
Di-n-butyl phthalate	68	84-74-2	625	0.5	1.0
2,4-dinitrotoluene	35	121-14-2	609/625	1.0	2.0
2,6-dinitrotoluene	36	606-20-2	609/625	1.0	2.0
Di-n-octyl phthalate	69	117-84-0	625	0.3	0.6
1,2-Diphenylhydrazine (*as Azobenzene*)	37	122-66-7	1625B	5.0	20
Fluoranthene	39	206-44-0	625	0.3	0.6
Fluorene	80	86-73-7	625	0.3	0.6
Hexachlorobenzene	9	118-74-1	612/625	0.3	0.6
Hexachlorobutadiene	52	87-68-3	625	0.5	1.0
Hexachlorocyclopentadiene	53	77-47-4	1625B/625	2.0	4.0
Hexachloroethane	12	67-72-1	625	0.5	1.0
Indeno(*1,2,3-cd*)Pyrene	83	193-39-5	610/625	0.5	1.0
Isophorone	54	78-59-1	625	0.5	1.0
3-Methyl cholanthrene		**56-49-5**	625	2.0	8.0
Naphthalene	55	91-20-3	625	0.4	0.75
Nitrobenzene	56	98-95-3	625	0.5	1.0
N-Nitrosodimethylamine	61	62-75-9	607/625	2.0	4.0
N-Nitrosodi-n-propylamine	63	621-64-7	607/625	0.5	1.0
N-Nitrosodiphenylamine	62	86-30-6	625	1.0	2.0
Perylene		**198-55-0**	625	1.9	7.6
Phenanthrene	81	85-01-8	625	0.3	0.6
Pyrene	84	129-00-0	625	0.3	0.6
1,2,4-Trichlorobenzene	8	120-82-1	625	0.3	0.6

PRIORITY POLLUTANT	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
DIOXIN					
2,3,7,8-Tetra-Chlorodibenzo-P-Dioxin (2,3,7,8 TCDD)	129	1746-01-6	1613B	1.3 pg/L	5 pg/L

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
PESTICIDES/PCBs					
Aldrin	89	309-00-2	608	0.025	0.05
alpha-BHC	102	319-84-6	608	0.025	0.05
beta-BHC	103	319-85-7	608	0.025	0.05
gamma-BHC (Lindane)	104	58-89-9	608	0.025	0.05
delta-BHC	105	319-86-8	608	0.025	0.05
Chlordane [8]	91	57-74-9	608	0.025	0.05
4,4’-DDT	92	50-29-3	608	0.025	0.05
4,4’-DDE	93	72-55-9	608	0.025	0.05
4,4’ DDD	94	72-54-8	608	0.025	0.05
Dieldrin	90	60-57-1	608	0.025	0.05

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
PESTICIDES/PCBs					
alpha-Endosulfan	95	959-98-8	608	0.025	0.05
beta-Endosulfan	96	33213-65-9	608	0.025	0.05
Endosulfan Sulfate	97	1031-07-8	608	0.025	0.05
Endrin	98	72-20-8	608	0.025	0.05
Endrin Aldehyde	99	7421-93-4	608	0.025	0.05
Heptachlor	100	76-44-8	608	0.025	0.05
Heptachlor Epoxide	101	1024-57-3	608	0.025	0.05
PCB-1242 [9]	106	53469-21-9	608 - Modified	0.05	0.2
PCB-1254	107	11097-69-1	608 - Modified	0.05	0.2
PCB-1221	108	11104-28-2	608 - Modified	0.05	0.2
PCB-1232	109	11141-16-5	608 - Modified	0.05	0.2
PCB-1248	110	12672-29-6	608 - Modified	0.05	0.2
PCB-1260	111	11096-82-5	608 - Modified	0.05	0.2
PCB-1016 [9]	112	12674-11-2	608 - Modified	0.05	0.2
Toxaphene	113	8001-35-2	608	0.24	0.5

PULP & PAPER POLLUTANTS (40CFR Part 430)

Pollutant	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] µg/L unless specified**	**Quantitation Level (QL)[2] µg/L unless specified**
Adsorbable Organic Halides (AOX)		EPA 1650		20
2,3,7,8- Tetrachlorodibenzo-*p*-dioxin (TCDD) (this is also priority pollutant and is listed above)	1746-01-6	EPA 1613	1.3 pg/L	5 pg/L
2,3,7,8- Tetrachlorodibenzofuran (TCDF)	51207-31-9	EPA 1613	1.3 pg/L	5 pg/L
Trichlorosyringol		EPA 1653		2.5
3,4,5-Trichlorocatechol		EPA 1653		5.0
3,4,6-Trichlorocatechol		EPA 1653		5.0
3,4,5-Trichloroguaiacol		EPA 1653		2.5
3,4,6-Trichloroguaiacol		EPA 1653		2.5
4,5,6-Trichloroguaiacol		EPA 1653		2.5
2,4,5-Trichlorophenol		EPA 1653		2.5
2,4,6-Trichlorophenol		EPA 1653		2.5
Tetrachlorocatechol		EPA 1653		5.0
Tetrachloroguaiacol		EPA 1653		5.0
2,3,4,6-Tetrachlorophenol		EPA 1653		2.5
Pentachlorphenol (this is also priority pollutant and is listed above)		EPA 1653		5.0

NONCONVENTIONALS – DIOXIN & FURAN CONGENERS

Pollutant	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
2,3,7,8- Tetrachlorodibenzo-*p*-dioxin (TCDD) (this is a priority pollutant and is also listed above)	1746-01-6	EPA 1613	1.3 pg/L	5 pg/L
Total TCDD	41903-57-5			
2,3,7,8- Tetrachlorodibenzofuran (TCDF)	51207-31-9		1.3 pg/L	5 pg/L
Total-TCDF	55722-27-5			
1,2,3,7,8- Pentachlorodibenzo-*p*-dioxin (PeCDD)	40321-76-4			
Total-PeCDD	36088-22-9			
1,2,3,7,8- Pentachlorodibenzofuran (PeCDF)	57117-41-6			
2,3,4,7,8-PeCDF	57117-31-4			
Total-PeCDF	30402-15-4			
1,2,3,4,7,8- Hexachlorodibenzo-*p*-dioxin (HxCDD)	39227-28-6			
1,2,3,6,7,8-HxCDD	57653-85-7			
1,2,3,7,8,9-HxCDD	19408-74-3			
Total-HxCDD	34465-46-8			
1,2,3,4,7,8- Hexachlorodibenzofuran (HxCDF)	70648-26-9			
1,2,3,6,7,8-HxCDF	57117-44-9			
1,2,3,7,8,9-HxCDF	72918-21-9			
2,3,4,6,7,8-HxCDF	60851-34-5			
Total-HxCDF	55684-94-1			
1,2,3,4,6,7,8- Heptachlorodibenzo-*p*-dioxin (HpCDD)	35822-46-9			
Total-HpCDD	37871-00-4			
1,2,3,4,6,7,8- Heptachlorodibenzofuran (HpCDF)	67562-39-4			
1,2,3,4,7,8,9-HpCDF	55673-89-7			
Total-HpCDF	38998-75-3			
Octachlorodibenzo-*p*-dioxin (OCDD)	3268-87-9			
Octachlorodibenzofuran (OCDF)	39001-02-0			

1. Detection level (DL) or detection limit means the minimum concentration of an analyte (substance) that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure given in 40 CFR part 136, Appendix B.

2. Quantitation Level (QL) also known as Minimum Level of Quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the lab has used all method-specified sample weights, volumes, and cleanup procedures. The QL is calculated by multiplying the MDL by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer. (64 FR 30417).
ALSO GIVEN AS:
The smallest detectable concentration of analyte greater than the Detection Limit (DL) where the accuracy (precision & bias) achieves the objectives of the intended purpose. (Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs Submitted to the US Environmental Protection Agency, December 2007).

3. Soluble Biochemical Oxygen Demand method note: First, filter the sample through a Millipore Nylon filter (or equivalent) - pore size of 0.45-0.50 um (prep all filters by filtering 250 ml of laboratory grade deionized water through the filter and discard). Then, analyze sample as per method 5210-B.
4. NWTPH Dx - Northwest Total Petroleum Hydrocarbons Diesel Extended Range – see http://www.ecy.wa.gov/biblio/97602.html
5. NWTPH Gx - Northwest Total Petroleum Hydrocarbons Gasoline Extended Range – see http://www.ecy.wa.gov/biblio/97602.html
6. 1, 3-dichloroproylene (mixed isomers) You may report this parameter as two separate parameters: cis-1, 3-dichlorpropropene (10061-01-5) and trans-1, 3-dichloropropene (10061-02-6).
7. Total Benzofluoranthenes - Because Benzo(b)fluoranthene, Benzo(j)fluoranthene and Benzo(k)fluoranthene co-elute you may report these three isomers as total benzofluoranthenes.
8. Chlordane – You may report alpha-chlordane (5103-71-9) and gamma-chlordane (5103-74-2) in place of chlordane (57-74-9). If you report alpha and gamma-chlordane, the DL/PQLs that apply are 0.025/0.050.
9. PCB 1016 & PCB 1242 – You may report these two PCB compounds as one parameter called PCB 1016/1242.

Fact Sheet for NPDES Permit WA0030520

Central Kitsap Wastewater Treatment Plant

Effective Date: August 1, 2017

Purpose of this fact sheet

This fact sheet explains and documents the decisions the Department of Ecology (Ecology) made in drafting the proposed National Pollutant Discharge Elimination System (NPDES) permit for Central Kitsap Wastewater Treatment Plant (WWTP).

This fact sheet complies with Section 173-220-060 of the Washington Administrative Code (WAC), which requires Ecology to prepare a draft permit and accompanying fact sheet for public evaluation before issuing an NPDES permit.

Ecology makes the draft permit and fact sheet available for public review and comment at least thirty (30) days before issuing the final permit. Copies of the fact sheet and draft permit for Kitsap County WWTP, NPDES permit WA0030520 , were available for public review and comment from May 13, 2017, until June 12, 2017. For more details on preparing and filing comments about these documents, please see *Appendix A - Public Involvement Information.*

Kitsap County reviewed the draft permit and fact sheet for factual accuracy. Ecology corrected any errors or omissions regarding the facility's location, history, wastewater discharges, or receiving water prior to publishing this draft fact sheet for public notice.

After the public comment period closed, Ecology summarized substantive comments and provided responses to them. Ecology included the summary and responses to comments in this fact sheet as *Appendix H - Response to Comments*, and published it when issuing the final NPDES permit. Ecology generally will not revise the rest of the fact sheet. The full document will become part of the legal history contained in the facility's permit file.

Summary

Kitsap County owns, operates, and maintains the Central Kitsap WWTP which provides sewer service for the cities of Silverdale, Keyport, and Poulsbo; Central Kitsap area; the Naval Base Kitsap Bangor (NBK); and the Naval Undersea Warfare Center (NUWC) - Division Keyport. Central Kitsap WWTP provides secondary treatment of wastewater with a four-stage Bardenpho™ treatment system followed by tertiary sand filtration. The treated effluent is disinfected with UV light and then discharged to Port Orchard Bay, Puget Sound.

The proposed permit changed the 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) effluent limit parameter to a 5-day biochemical oxygen demand (BOD_5) limit. The effluent limits for total suspended solids (TSS), fecal coliform bacteria, and pH are the same as the limits included in the previous permit. It does not include any other significant changes. The proposed permit includes a new limit for ammonia based on the effluent data collected during the previous permit cycle.

Table of Contents

I. Introduction

The Federal Clean Water Act (FCWA, 1972, and later amendments in 1977, 1981, and 1987) established water quality goals for the navigable (surface) waters of the United States. One mechanism for achieving the goals of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES), administered by the federal Environmental Protection Agency (EPA). The EPA authorized the state of Washington to manage the NPDES permit program in our state. Our state legislature accepted the delegation and assigned the power and duty for conducting NPDES permitting and enforcement to Ecology. The Legislature defined Ecology's authority and obligations for the wastewater discharge permit program in 90.48 RCW (Revised Code of Washington).

The following regulations apply to domestic wastewater NPDES permits:

- Procedures Ecology follows for issuing NPDES permits (chapter 173-220 WAC).
- Technical criteria for discharges from municipal wastewater treatment facilities (chapter 173-221 WAC).
- Water quality criteria for surface waters (chapter 173-201A WAC).
- Water quality criteria for groundwaters (chapter 173-200 WAC).
- Whole effluent toxicity testing and limits (chapter 173-205 WAC).
- Sediment management standards (chapter 173-204 WAC).
- Submission of plans and reports for construction of wastewater facilities (chapter 173-240 WAC).

These rules require any treatment facility owner/operator to obtain an NPDES permit before discharging wastewater to state waters. They also help define the basis for limits on each discharge and for requirements imposed by the permit.

Under the NPDES permit program and in response to a complete and accepted permit application, Ecology must prepare a draft permit and accompanying fact sheet, and make them available for public review before final issuance. Ecology must also publish an announcement (public notice) telling people where they can read the draft permit, and where to send their comments, during a period of thirty days (WAC 173-220-050). (*See Appendix A-Public Involvement Information* for more detail about the public notice and comment procedures). After the public comment period ends, Ecology may make changes to the draft NPDES permit in response to comment(s). Ecology will summarize the responses to comments and any changes to the permit in *Appendix G*.

II. Background Information

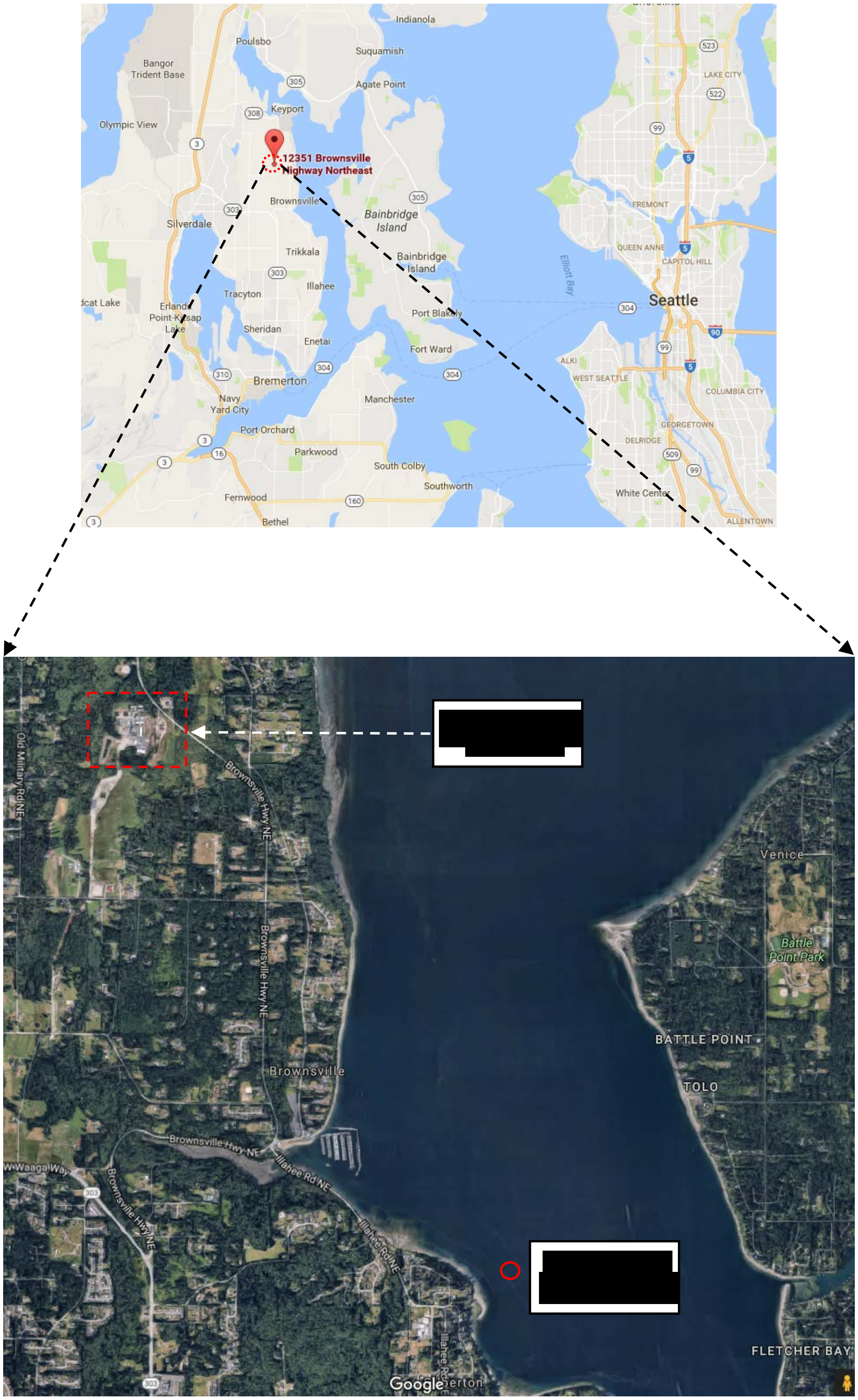
Table 1. General Facility Information

Facility Information	
Applicant	Kitsap County Public Works
Facility Name and Address	Central Kitsap Wastewater Treatment Plant 12351 Brownsville Highway NE Poulsbo, WA 98370
Contact at Facility	Name: Patrick Kongslie Title: Utility Operations Supervisor Telephone #: 360-337-5768
Responsible Official	Name: Stella Vakarcs Title: Senior Program Manager – Sewer Utility Address: 614 Division Street MS-27 Port Orchard, WA 98366 Telephone #: 360-337-5777
Type of Treatment	Biological Nutrient Removal and Tertiary Filtration
Facility Location (NAD83/WGS84 reference datum)	Latitude: 47.6739 Longitude: -122.6265
Discharge Waterbody Name and Location (NAD83/WGS84 reference datum)	Port Orchard Bay, Puget Sound Latitude: 47.6464 Longitude: -122.6014

Permit Status	
Issuance Date of Previous Permit	7/16/2012
Application for Permit Renewal Submittal Date	1/27/2017
Date of Ecology Acceptance of Application	2/6/2017

Inspection Status	
Date of Last Non-sampling Inspection Date	1/20/2016

Figure 1. Facility Location Map



A. Facility description

History

Central Kitsap WWTP is a regional treatment plant designed to serve the central portion of Kitsap County (County). The plant began operating in 1979 as a conventional activated sludge - secondary treatment facility. From 2012 to 2015, the County expanded and upgraded Central Kitsap WWTP to a water reclamation facility, which became fully operational in 2015. The expansion and upgrades constitute major parts of the County's Resource Recovery Project. The facility improvements are summarized as follows:

Biological treatment process

The existing activated sludge system was expanded and modified to provide biological nitrogen removal. Two new aeration basins were added doubling the capacity of the activated sludge system. The existing and new basins are equipped with surface overflow baffles and downward-opening gates to provide a more plug-flow flow pattern, and to prevent scum and foam accumulation. All basins are also equipped with coarse bubble diffusers to satisfy the oxygen and mixing requirements. Two existing multistage centrifugal blowers were replaced with high efficiency turbo blowers.

In addition to the two new aeration basins and ancillary equipment (i.e. mixers, RAS and WAS pumps, aeration system, etc.), the County installed new dissolved oxygen sensors and airflow valves in each existing and new basins, which are more energy efficient.

A chemical feed facility is used to provide supplemental carbon substrate (methanol) to support denitrification. The chemical facility consists of a storage tank and metering pumps. Methanol is fed to the second anoxic basin to supply readily biodegradable carbon when the carbon levels are insufficient to support desired nitrogen removals.

Reclaimed water process

The Class A reclaimed water process, a tertiary effluent filtration system, consists of three DynaSand deep bed filters with a total design capacity of 4.1 MGD, chemical coagulant equipment, chlorination equipment, air scouring system, and distribution pumps. New pumps were installed to pump secondary effluent from the UV system to the reclaimed water system.

Gas cogeneration system

In the past, the biogas generated at the facility's anaerobic digesters was burned and wasted through an existing flare. The new gas cogeneration system consists of a new engine generator and new digester gas treatment system. The new engine generator is a skid-mounted unit equipped with jacket water and exhaust heat recovery. The new digester gas treatment system treats gas before being combusted in the engine generator. The gas cogeneration system can generate electricity and heat to the facility or supply electricity to the local power grid. Further details of the new gas cogeneration system can be found in the *"2011 Reclamation and Reuse Project Report"* prepared by Brown and Caldwell.

The County expects that the new Cogeneration System will reduce annual fuel-oil consumption by as much as 90 percent, and offset carbon dioxide emissions by over 750 tons a year and improve air quality. Biogas cogeneration system is a green energy technology that does not contribute to greenhouse gas (GHG) emissions to the atmosphere.

New thickening system

A new rotary drum thickener (RDT) was added to thicken waste activated sludge (WAS) separately. This will increase the sludge thickening performance and, consequently, reduce solids load to the anaerobic digesters and postpone digester expansion by at least 15 years. Specific ancillary equipment of the new WAS thickening system include new WAS pumps, new solids building, one sludge blending tank and pump, digester feed pumps, and a foul air treatment system.

Collection system status

The Kitsap Central WWTP provides sewage service for the cities of Silverdale, Keyport, and Poulsbo; Central Kitsap area; the Naval Base Kitsap Bangor (NBK); and the Naval Undersea Warfare Center (NUWC) - Division Keyport. Primary sources of wastewater to the treatment plant are domestic wastewater from residential and commercial activities, and pretreated process wastewater from NBK and NUWC. The collection system serves approximately 20,000 residential equivalents.

The existing sewer collection and conveyance systems include gravity sewer mains, 44 lift stations, force mains, and individual grinder pump stations. According to the County, the lift stations are aging and no longer operate reliably at design and peak flow conditions. The County will upgrade and/or replace four lift stations along with portions of the collection and conveyance system to handle projected flows. Upgrades are expected to be completed in 2018.

Treatment processes

Raw sewage flows through two 0.24-inch mechanical screens to remove large debris. Raw sewage can be directed to a manual (bypass) screen that functions as a backup in emergency conditions. After screening, wastewater enters two aerated grit chambers to protect downstream equipment from excessive wear and tear. The bottom of the grit chambers is steeply sloped to accumulate grit into the collection hopper. Air is supplied at the bottom of each chamber to avoid grit from becoming compacted. Two Parshall flumes are located between the mechanical screens and the grit chamber for influent flow measurement.

Degritted raw sewage flows by gravity to two identical circular primary clarifiers through an underground channel, and is distributed via a flow splitter box. Primary treatment is used to remove easily settleable solids from the degritted sewage. Removal rates average approximately 60 percent for solids, and 20 percent for BOD_5. Each clarifier has a 65-feet diameter, a 10.5-feet side water depth and center feed distribution of influent.

Primary effluent flows through two 16-inch pipes to the RAS Mixing Box located upstream of the biological treatment process. The RAS Mixing Box is equipped with control gates for flow distribution purposes. The biological process consists of four equally sized aeration basins equipped with fine bubble diffusers, high efficiency turbo blowers and internal baffle walls to create a plug flow system with six passes in series in each basin. Each aeration basin has the capability to shut down air completely and create either an anoxic or anaerobic environment to achieve five different operating modes described as follows:

1. Sludge Re-aeration Mode for BOD_5 removal. This mode is similar to a conventional activated sludge system.

2. Biological nutrient removal (BNR) mode for BOD_5 and nitrogen removal.
3. Step Feed Mode for better hydraulics within the basins and better filamentous control due to enhanced flow and loadings distribution. In this mode primary effluent (PE) and RAS are not mixed. RAS flow is sent to the first aeration basin and PE flow is distributed between aeration basins # 2 and # 3.
4. Summer Nitrification + Denitrification Mode: Aeration in aeration basin # 1 is completely off and nitrified mixed liquor is recycled to it to create an anoxic environment and allow denitrification. Nitrification occurs in aeration basins # 2, 3, and 4.
5. Winter Anaerobic Selector Mode: Aeration of the first basin is off to create an anaerobic environment and inhibit filamentous growth.

Between the secondary clarifiers and the RAS Mixing Box, a classifying selector equipped with surface skimming system is used for foam and scum control.

A chemical feed system is used to supplement carbon substrate (methanol) to the biological treatment process to support biological denitrification during nitrogen removal mode. The chemical feed system consists of a 10,000-gallon methanol storage tank and four metering pumps.

A mixed liquor channel followed by a flow splitter box conveys the wastewater from the aeration basins to two secondary clarifiers for solids removal. Each clarifier has 104 feet diameter, 10-feet sidewater depth, center feed and peripheral overflow units. Clarifiers are equipped with inboard launders, weirs, four RAS and two WAS pump. In conventional activated sludge mode, two pumps withdraw RAS from each clarifier and recycle it to the head of the biological treatment system. In BNR mode, RAS and nitrified mixed liquor are recycled to the first anoxic basin, which is the first aerobic basin with aeration completely off. Secondary denitrification occurs in the fifth aeration basin with aeration off.

Secondary effluent flows by gravity to a Trojan 4000 UV disinfection system. The UV disinfection system consists of two parallel UV banks designed to disinfect approximately 6.0 MGD. Each bank has 60 lamps.

Secondary disinfected effluent can be either pumped to three identical Dynasand® EcoWash® filters via a 16-inch low-pressure force main for reclaimed water production, or discharged to Port Orchard Bay. The filtration system has a total capacity of 4.1 MGD. Coagulants (alum) can be injected prior to discharge at the filters. A two stage static mixer in the force main downstream of the chemical injection point provides mixing upstream of the filters. Coagulated plant effluent passes upwards through the single granular sand bed and exits the top of the filters. The plant has also the capability to chlorinate the filter effluent for storage and distribution purposes.

Disinfected and filtered final effluent is discharged to Port Orchard Bay, Puget Sound. The County is planning on submitting its Reclaimed Water Permit application in 2018. Once the permit is issued, the County will have 75 percent of the Central Kitsap WWP discharge available for beneficial uses.

Discharge outfall

Kitsap County discharges treated and disinfected effluent into Port Orchard Bay, Puget Sound, approximately 3,130 feet offshore at a depth of approximately 41 feet below mean lower low water (MLLW), via a 36-inch outfall line with a diffuser. The diffuser consists of a 30-inch diameter, 120-foot long ductile iron pipeline with twelve 5-inch diameter diffuser ports. The port spacing is 10 feet, with consecutive ports facing opposite direction.

Solids wastes / residual solids

The facility removes solids at the headworks (grid and screening), and at the primary and secondary clarifiers. Rags, scum, and other debris are removed as part of the equipment's routine maintenance. Rags and screenings are drained using a screenings compactor, and grit is drained in two classifiers prior to placing them in a dumpster for disposal as solid waste at a local landfill.

The degritted primary sludge and the waste activated sludge (WAS) from secondary clarifiers are thickened separately. Primary solids are thickened in two concrete gravity thickeners and WAS is thickened in the new rotary drum thickener. The thickened sludge and scum from the primary and secondary clarifiers are pumped to a thickened sludge blending tank and then pumped directly to the anaerobic digesters for biological stabilization. The digested sludge (Class B biosolids) is dewatered in a centrifuge to approximately 22 to 24 percent total solids concentration and hauled by trucks to Natural Selection Farms, Eastern Washington, for composting or land application. Wastewater and centrate from the solids handling processes are returned to the headworks for treatment.

Operator certification

Washington State law requires operators of municipal wastewater treatment plants to be certified at a level appropriate for the type and size of the facility. Criteria published in Ecology's *Permit Writer's Manual* and WAC 173-230 classify the treatment system at Central Kitsap WWTP as a Group IV facility. After the Resource Recovery Project's upgrades, the conventional activated sludge was converted to a biological nutrient removal system, and tertiary filtration was added to the plant's treatment process. Per Ecology's *Permit Writer's Manual*, a tertiary treatment system with a design flow of > 5 MGD is classified as a Group IV facility. As such, the operator in responsible charge at the facility must, at a minimum, be rated as a Group IV operator. An operator certified for at least a Group III facility must be in charge of each scheduled shift at the facility.

Currently, the Central Kitsap WWTP is staffed seven days a week as follows:

- Monday through Friday from 7:00 a.m. – 3:30 p.m. with one Class IV Lead Operator, two Class I operators and two Class II operators.
- Monday through Friday from 3:00 p.m. – 11:30 p.m. with one Class II operator.
- Weekends from 7:00 a.m. – 3:30 p.m. with one Class II operator.

The County has started the process to assist its Class II operators to obtain their Class III certification and Ecology will follow-up with the County in the next months to check the status of the operator's certification.

B. Description of the receiving water

Kitsap County discharges effluent from this plant into Port Orchard Bay, Puget Sound. There are no other nearby point source outfalls. Significant nearby non-point sources of pollutants include storm water runoff from developed areas, roadways, and industrial and construction sites. Section IIIE of this fact sheet describes any receiving waterbody impairments.

The ambient background data used for this permit includes the following from two of Ecology's long-term Monitoring Stations POD006 (Port Orchard – Liberty Bay/Virginia Point) and PMA001 (Port Madison – S of Buoy 65):

Table 2. Ambient Background Data

Parameter	Value Used
Temperature (highest annual 1-DADMax) Temperature (90th percentile)	17 ^{o}C 13.9 ^{o}C
pH (Maximum / Minimum)	8.3 / 6.2 standard units
Dissolved Oxygen (90th percentile)	9.8 mg/L
Total Ammonia-N (90th percentile)	0.09 mg/L
Fecal Coliform (maximum)	3/100 mL
Salinity (90th percentile)	30.4 psu

C. Wastewater influent characterization

Kitsap County WWTP monitors influent flow and waste loading to verify actual loading does not exceed approved design capacity. Table 3 summarizes facility loading, as reported on discharge monitoring reports (DMRs) from August 2012 through December 2016:

Table 3. Wastewater Influent Characterization

Parameter	Units	# of Samples	Average of Average Monthly Values	Maximum of Average Monthly Values
Flow	MGD	~1,100	3.5	4.8
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	mg/L	~1,100	253	306
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	lbs/day	~1,100	7,191	9,854
Biochemical Oxygen Demand (BOD_5)	mg/L	~1,100	286	346
Biochemical Oxygen Demand (BOD_5)	lbs/day	~1,100	8,130	10,041
Total Suspended Solids (TSS)	mg/L	~1,100	279	332
Total Suspended Solids (TSS)	lbs/day	~1,100	7,956	9,854

D. Wastewater effluent characterization

Kitsap County WWTP reported the concentrations of pollutants in the discharge in the permit application and in discharge monitoring reports. Table 4 summarizes effluent quality as reported in DMRs from August 2012 through December 2016 and as reported in the application.

Table 4. Wastewater Effluent Characterization

Parameter	Units	# of Samples	Average of Average Monthly Values	Maximum of Average Monthly Values
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	mg/L	~1,100	6.8	12.5
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	lbs/day	~1,100	196	372
Total Suspended Solids (TSS)	mg/L	~1,100	11	29.4
Total Suspended Solids (TSS)	lbs/day	~1,100	315	714
Ammonia	mg/L	139	31.6	55.4
Nitrate + Nitrite (Nitrogen)	mg/L	71	4.2	11.1
Total Kjeldahl Nitrogen (TKN)	mg/L	69	33.5	60.2
Phosphorus (Total)	mg/L	52	4.2	9.8
Temperature (Winter)	ºC	715	15	19
Temperature (Summer)	ºC	794	20	24

Parameter	Units	# of Samples	Maximum Monthly Geometric Mean	Maximum Weekly Geometric Mean
Fecal Coliforms	#/mL	~1,132	50.3	148

Parameter	Units	# of Samples	Minimum Value	Maximum Value
pH	standard units	~1,100	6.7	7.9

Parameter	Units	# of Samples	Average	Maximum
Copper	µg/L	103	12	14.5
Mercury	ng/L	3	2.8	3.7
Nickel	µg/L	103	< 5	5.1
Zinc	µg/L	103	35.9	62.3
Total Phenolic Compounds	µg/L	3	10	20

E. Summary of compliance with previous permit issued July 16, 2012

The previous permit placed effluent limits on $CBOD_5$, TSS, fecal coliform, and pH.

The Central Kitsap WWTP has generally complied with the effluent limits and permit conditions throughout the duration of the permit issued on July 16, 2012. Ecology assessed compliance based on its review of the facility's information in the Ecology Permitting and Reporting Information System (PARIS), discharge monitoring reports (DMRs) and on inspections. In 2015, the facility was undergoing major construction projects and there were a few occasions in which the influent flowmeters lost calibration. All technical problems were communicated to Ecology and solved in a timely fashion.

The following table summarizes the violations that occurred during the permit term.

Table 5. Permit Violations

Date	Parameters	Reported Value	Units	Limit Value	Units
8/1/2015	TSS	62.8	mg/L	45	mg/L
12/1/2012	TSS	9,854	lbs/day	9,690	lbs/day

Date	Violation
11/7/2016	Late Reporting Submittal
01/25/2015	Improper/incorrect reporting of flow values
01/24/2015	Improper/incorrect reporting of flow values
01/23/2015	Improper/incorrect reporting of flow values
01/22/2015	Improper/incorrect reporting of flow values
12/23/2013	Influent $CBOD_5$ analyses not conducted
12/23/2013	Effluent $CBOD_5$ analyses not conducted
11/1/2012	Late Submittal of DMR

The following table summarizes compliance with report submittal requirements over the permit term.

Table 6. Permit Submittals

Submittal Name	Due Date	Received Date
Application for Permit Renewal	January 31, 2017	January 27, 2017
Chronic Toxicity Efflluent Test Reports	January 31, 2017	January 27, 2017
Industrial User Survey Update	January 31, 2017	January 27, 2017
Industrial User Survey	January 31, 2015	December 23, 2014
Acute Toxicity Effluent Test Reports	April 30, 2013	February 12, 2013
Acute Toxicity Effluent Test Reports	October 31, 2013	August 15, 2013
Acute Toxicity Effluent Test Reports	April 30, 2014	February 7, 2014
Acute Toxicity Effluent Test Reports	October 31, 2014	August 22, 2014
Acute Toxicity Effluent Test Reports	April 30, 2015	February 6, 2015
Acute Toxicity Effluent Test Reports	October 31, 2015	September 11, 2015
Acute Toxicity Effluent Test Reports	April 30, 2016	February 12, 2016
Acute Toxicity Effluent Test Reports	October 31, 2016	November 7, 2016

F. State environmental policy act (SEPA) compliance

State law exempts the issuance, reissuance or modification of any wastewater discharge permit from the SEPA process as long as the permit contains conditions that are no less stringent than federal and state rules and regulations (RCW 43.21C.0383). The exemption applies only to existing discharges, not to new discharges.

III. Proposed Permit Limits

Federal and state regulations require that effluent limits in an NPDES permit must be either technology- or water quality-based.

- Technology-based limits are based upon the treatment methods available to treat specific pollutants. Technology-based limits are set by the EPA and published as a regulation, or Ecology develops the limit on a case-by-case basis (40 CFR 125.3, and chapter 173-220 WAC).
- Water quality-based limits are calculated so that the effluent will comply with the Surface Water Quality Standards (chapter 173-201A WAC), Ground Water Standards (chapter 173-200 WAC), Sediment Quality Standards (chapter 173-204 WAC), or the National Toxics Rule (40 CFR 131.36).
- Ecology must apply the most stringent of these limits to each parameter of concern. These limits are described below.

The limits in this permit reflect information received in the application and from supporting reports (engineering, hydrogeology, etc.). Ecology evaluated the permit application and determined the limits needed to comply with the rules adopted by the state of Washington. Ecology does not develop effluent limits for all reported pollutants. Some pollutants are not treatable at the concentrations reported, are not controllable at the source, are not listed in regulation, and do not have a reasonable potential to cause a water quality violation.

Ecology does not usually develop limits for pollutants not reported in the permit application but may be present in the discharge. The permit does not authorize discharge of the non-reported pollutants. During the five-year permit term, the facility's effluent discharge conditions may change from those conditions reported in the permit application. The facility must notify Ecology if significant changes occur in any constituent [40 CFR 122.42(a)]. Until Ecology modifies the permit to reflect additional discharge of pollutants, a permitted facility could be violating its permit.

A. Design criteria

Under WAC 173-220-150 (1)(g), flows and waste loadings must not exceed approved design criteria. Ecology approved design criteria for this facility's treatment plant in the following reports prepared for Kitsap County by Brown and Caldwell: a) *"Reclamation and Reuse Project Report (Volume 1: Basis of Design Summary)"* dated August 2011 and b) *"Plant Reclassification Technical Memorandum"* dated May 2016. The table below includes design criteria from the referenced report.

Table 7. Design Criteria for Central Kitsap WWTP

Parameter	Design Quantity
Maximum Month Design Flow (MMDF)	6.0 MGD
MMDF for the BNR system	7.0 MGD
BOD_5 Loading for Maximum Month	14,100 lb/day
TSS Loading for Maximum Month	11,400 lb/day

B. Technology-based effluent limits

Federal and state regulations define technology-based effluent limits for domestic wastewater treatment plants. These effluent limits are given in 40 CFR Part 133 (federal) and in chapter 173-221 WAC (state). These regulations are performance standards that constitute all known, available, and reasonable methods of prevention, control, and treatment (AKART) for domestic wastewater.

Table 8 identifies technology-based limits for pH, fecal coliform, BOD_5, and TSS, as listed in chapter 173-221 WAC. Section III.F of this fact sheet describes the potential for water quality-based limits.

Table 8. Technology-based Limits

Parameter	Average Monthly Limit	Average Weekly Limit
BOD_5 (concentration)	30 mg/L	45 mg/L
BOD_5 (concentration)	In addition, the BOD_5 effluent concentration must not exceed fifteen percent (15%) of the average influent concentration.	
TSS (concentration)	30 mg/L	45 mg/L
TSS (concentration)	In addition, the TSS effluent concentration must not exceed fifteen percent (15%) of the average influent concentration.	

Parameter	Monthly Geometric Mean Limit	Weekly Geometric Mean Limit
Fecal Coliform Bacteria	200 organisms/100 mL	400 organisms/100 mL

Parameter	Daily Minimum	Daily Maximum
pH	6.0 standard units	9.0 standard units

Table 9 lists the proposed technology-based mass limits for the discharge. Technology-based mass limits are based on WAC 173-220-130(3)(b) and 173-221-030(11)(b). Ecology calculated the monthly and weekly average mass limits for BOD_5 and Total Suspended Solids as follows:

Mass Limit = CL x DF x CF

where:

CL = Technology-based concentration limits listed in the above table

DF = Maximum Monthly Average Design flow (MGD)

CF = Conversion factor of 8.34

Table 9. Technology-based Mass Limits

Parameter	Concentration Limit (mg/L)	Mass Limit (lbs/day)
BOD_5 Monthly Average	30	1,501
BOD_5 Weekly Average	45	2,252
TSS Monthly Average	30	1,501
TSS Weekly Average	45	2,252

C. Surface water quality-based effluent limits

The Washington State surface water quality standards (chapter 173-201A WAC) are designed to protect existing water quality and preserve the beneficial uses of Washington's surface waters. Waste discharge permits must include conditions that ensure the discharge will meet the surface water quality standards (WAC 173-201A-510). Water quality-based effluent limits may be based on an individual waste load allocation or on a waste load allocation developed during a basin wide total maximum daily load study (TMDL).

Numerical criteria for the protection of aquatic life and recreation

Numerical water quality criteria are listed in the water quality standards for surface waters (chapter 173-201A WAC). They specify the maximum levels of pollutants allowed in receiving water to protect aquatic life and recreation in and on the water. Ecology uses numerical criteria along with chemical and physical data for the wastewater and receiving water to derive the effluent limits in the discharge permit. When surface water quality-based limits are more stringent or potentially more stringent than technology-based limits, the discharge must meet the water quality-based limits.

Numerical criteria for the protection of human health

The U.S. EPA has published 91 numeric water quality criteria for the protection of human health that are applicable to dischargers in Washington State (EPA, 1992). These criteria are designed to protect humans from exposure to pollutants linked to cancer and other diseases, based on consuming fish and shellfish and drinking contaminated surface waters. The water quality standards also include radionuclide criteria to protect humans from the effects of radioactive substances.

Narrative criteria

Narrative water quality criteria (e.g., WAC 173-201A-240(1); 2006) limit the toxic, radioactive, or other deleterious material concentrations that the facility may discharge to levels below those which have the potential to:

- Adversely affect designated water uses.
- Cause acute or chronic toxicity to biota.
- Impair aesthetic values.
- Adversely affect human health.

Narrative criteria protect the specific designated uses of all fresh waters (WAC 173-201A-200, 2006) and of all marine waters (WAC 173-201A-210, 2006) in the state of Washington.

Antidegradation

Description--The purpose of Washington's Antidegradation Policy (WAC 173-201A-300-330; 2006) is to:

- Restore and maintain the highest possible quality of the surface waters of Washington.
- Describe situations under which water quality may be lowered from its current condition.
- Apply to human activities that are likely to have an impact on the water quality of surface water.

- Ensure that all human activities likely to contribute to a lowering of water quality, at a minimum, apply all known, available, and reasonable methods of prevention, control, and treatment (AKART).
- Apply three tiers of protection (described below) for surface waters of the state.

Tier I ensures existing and designated uses are maintained and protected and applies to all waters and all sources of pollutions. Tier II ensures that waters of a higher quality than the criteria assigned are not degraded unless such lowering of water quality is necessary and in the overriding public interest. Tier II applies only to a specific list of polluting activities. Tier III prevents the degradation of waters formally listed as "outstanding resource waters," and applies to all sources of pollution.

A facility must prepare a Tier II analysis when all three of the following conditions are met:

- The facility is planning a new or expanded action.
- Ecology regulates or authorizes the action.
- The action has the potential to cause measurable degradation to existing water quality at the edge of a chronic mixing zone.

Facility Specific Requirements--This facility must meet Tier I requirements.

- Dischargers must maintain and protect existing and designated uses. Ecology must not allow any degradation that will interfere with, or become injurious to, existing or designated uses, except as provided for in chapter 173-201A WAC.

Ecology's analysis described in this section of the fact sheet demonstrates that the proposed permit conditions will protect existing and designated uses of the receiving water.

Mixing zones

A mixing zone is the defined area in the receiving water surrounding the discharge port(s), where wastewater mixes with receiving water. Within mixing zones the pollutant concentrations may exceed water quality numeric standards, so long as the discharge doesn't interfere with designated uses of the receiving water body (for example, recreation, water supply, and aquatic life and wildlife habitat, etc.) The pollutant concentrations outside of the mixing zones must meet water quality numeric standards.

State and federal rules allow mixing zones because the concentrations and effects of most pollutants diminish rapidly after discharge, due to dilution. Ecology defines mixing zone sizes to limit the amount of time any exposure to the end-of-pipe discharge could harm water quality, plants, or fish.

The state's water quality standards allow Ecology to authorize mixing zones for the facility's permitted wastewater discharges only if those discharges already receive all known, available, and reasonable methods of prevention, control, and treatment (AKART). Mixing zones typically require compliance with water quality criteria within a specified distance from the point of discharge and must not use more than 25% of the available width of the water body for dilution [WAC 173-201A-400(7)(b)(ii)].

Ecology uses modeling to estimate the amount of mixing within the mixing zone. Through modeling Ecology determines the potential for violating the water quality standards at the edge of the mixing zone and derives any necessary effluent limits. Steady-state models are the most frequently used tools for conducting mixing zone analyses. Ecology chooses values for each effluent and for receiving water variables that correspond to the time period when the most critical condition is likely to occur (see Ecology's *Permit Writer's Manual*). Each critical condition parameter, by itself, has a low probability of occurrence and the resulting dilution factor is conservative. The term "reasonable worst-case" applies to these values.

The mixing zone analysis produces a numerical value called a dilution factor (DF). A dilution factor represents the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. For example, a dilution factor of 4 means the effluent is 25% and the receiving water is 75% of the total volume of water at the boundary of the mixing zone. Ecology uses dilution factors with the water quality criteria to calculate reasonable potentials and effluent limits. Water quality standards include both aquatic life-based criteria and human health-based criteria. The former are applied at both the acute and chronic mixing zone boundaries; the latter are applied only at the chronic boundary. The concentration of pollutants at the boundaries of any of these mixing zones may not exceed the numerical criteria for that zone.

Most aquatic life *acute* criteria are based on the assumption that organisms are not exposed to that concentration for more than one hour and more often than one exposure in three years. Most aquatic life *chronic* criteria are based on the assumption that organisms are not exposed to that concentration for more than four consecutive days and more often than once in three years.

The two types of human health-based water quality criteria distinguish between those pollutants linked to non-cancer effects (non-carcinogenic) and those linked to cancer effects (carcinogenic). The human health-based water quality criteria incorporate several exposure and risk assumptions. These assumptions include:

- A 70-year lifetime of daily exposures.
- An ingestion rate for fish or shellfish measured in kg/day.
- An ingestion rate of two liters/day for drinking water.
- A one-in-one-million cancer risk for carcinogenic chemicals.

This permit authorizes a small acute mixing zone, surrounded by a chronic mixing zone around the point of discharge (WAC 173-201A-400). The water quality standards impose certain conditions before allowing the discharger a mixing zone:

1. **Ecology must specify both the allowed size and location in a permit.**

   The proposed permit specifies the size and location of the allowed mixing zone (as specified below).

2. **The facility must fully apply "all known, available, and reasonable methods of prevention, control and treatment" (AKART) to its discharge.**

   Ecology has determined that the treatment provided at Central Kitsap WWTP meets the requirements of AKART (see "Technology-based Limits").

3. Ecology must consider critical discharge conditions.

Surface water quality-based limits are derived for the water body's critical condition (the receiving water and waste discharge condition with the highest potential for adverse impact on the aquatic biota, human health, and existing or designated waterbody uses). The critical discharge condition is often pollutant-specific or waterbody-specific.

Critical discharge conditions are those conditions that result in reduced dilution or increased effect of the pollutant. Factors affecting dilution include the depth of water, the density stratification in the water column, the currents, and the rate of discharge. Density stratification is determined by the salinity and temperature of the receiving water. Temperatures are warmer in the surface waters in summer. Therefore, density stratification is generally greatest during the summer months. Density stratification affects how far up in the water column a freshwater plume may rise. The rate of mixing is greatest when an effluent is rising. The effluent stops rising when the mixed effluent is the same density as the surrounding water. After the effluent stops rising, the rate of mixing is much more gradual. Water depth can affect dilution when a plume might rise to the surface when there is little or no stratification. Ecology uses the water depth at mean lower low water (MLLW) for marine waters. Ecology's *Permit Writer's Manual* describes additional guidance on criteria/design conditions for determining dilution factors. The manual can be obtained from Ecology's website at: https://fortress.wa.gov/ecy/publications/SummaryPages/92109.html.

Table 10. Critical Conditions Used to Model the Discharge

Critical Condition	Value
Water depth at MLLW	41 feet
10^{th} or 90^{th} percentile current speeds for acute mixing zone	3.7 cm/s; 11.2 cm/s
50th percentile current speeds for chronic and human health mixing zones	7.5 cm/s
Maximum average monthly effluent flow for chronic and human health non-carcinogen	6.0 MGD
Maximum daily flow for acute mixing zone	11.0 MGD
1 DAD MAX effluent temperature	24 degrees C

Ecology obtained ambient data at critical conditions in the vicinity of the outfall from the *Central Kitsap Wastewater Treatment Plant Dilution Analysis*, dated October 2006, and prepared by Brown and Caldwell.

4. Supporting information must clearly indicate the mixing zone would not:

- Have a reasonable potential to cause the loss of sensitive or important habitat.
- Substantially interfere with the existing or characteristic uses.
- Result in damage to the ecosystem.
- Adversely affect public health.

Ecology established Washington State water quality criteria for toxic chemicals using EPA criteria. EPA developed the criteria using toxicity tests with numerous organisms and set the criteria to generally protect the species tested and to fully protect all commercially and recreationally important species.

EPA sets acute criteria for toxic chemicals assuming organisms are exposed to the pollutant at the criteria concentration for one hour. They set chronic standards assuming organisms are exposed to the pollutant at the criteria concentration for four days. Dilution modeling under critical conditions generally shows that both acute and chronic criteria concentrations are reached within minutes of discharge.

The discharge plume does not impact drifting and non-strong swimming organisms because they cannot stay in the plume close to the outfall long enough to be affected. Strong swimming fish could maintain a position within the plume, but they can also avoid the discharge by swimming away. Mixing zones generally do not affect benthic organisms (bottom dwellers) because the buoyant plume rises in the water column. Ecology has additionally determined that the effluent will not exceed 33 degrees C for more than two seconds after discharge; and that the temperature of the water will not create lethal conditions or blockages to fish migration.

Ecology evaluates the cumulative toxicity of an effluent by testing the discharge with whole effluent toxicity (WET) testing.

Ecology reviewed the above information, the specific information on the characteristics of the discharge, the receiving water characteristics, and the discharge location. Based on this review, Ecology concluded that the discharge does not have a reasonable potential to cause the loss of sensitive or important habitat, substantially interfere with existing or characteristics uses, result in damage to the ecosystem, or adversely affect public health if the permit limits are met.

5. **The discharge/receiving water mixture must not exceed water quality criteria outside the boundary of a mixing zone.**

   Ecology conducted a reasonable potential analysis, using procedures established by the EPA and by Ecology, for each pollutant and concluded the discharge/receiving water mixture will not violate water quality criteria outside the boundary of the mixing zone if permit limits are met.

6. **The size of the mixing zone and the concentrations of the pollutants must be minimized.**

   At any given time, the effluent plume uses only a portion of the acute and chronic mixing zone, which minimizes the volume of water involved in mixing. Because tidal currents change direction, the plume orientation within the mixing zone changes. The plume mixes as it rises through the water column therefore much of the receiving water volume at lower depths in the mixing zone is not mixed with discharge. Similarly, because the discharge may stop rising at some depth due to density stratification, waters above that depth will not mix with the discharge. Ecology determined it is impractical to specify in the permit the actual, much more limited volume in which the dilution occurs as the plume rises and moves with the current.

Ecology minimizes the size of mixing zones by requiring dischargers to install diffusers when they are appropriate to the discharge and the specific receiving waterbody. When a diffuser is installed, the discharge is more completely mixed with the receiving water in a shorter time. Ecology also minimizes the size of the mixing zone (in the form of the dilution factor) using design criteria with a low probability of occurrence. For example, Ecology uses the expected 95th percentile pollutant concentration, the 90th percentile background concentration, the centerline dilution factor, and the lowest flow occurring once in every ten years to perform the reasonable potential analysis.

Because of the above reasons, Ecology has effectively minimized the size of the mixing zone authorized in the proposed permit.

7. Maximum size of mixing zone.

The authorized mixing zone does not exceed the maximum size restriction.

8. Acute mixing zone.

- **The discharge/receiving water mixture must comply with acute criteria as near to the point of discharge as practicably attainable.**

  Ecology determined the acute criteria will be met at 10% of the distance of the chronic mixing zone.

- **The pollutant concentration, duration, and frequency of exposure to the discharge will not create a barrier to migration or translocation of indigenous organisms to a degree that has the potential to cause damage to the ecosystem.**

  As described above, the toxicity of any pollutant depends upon the exposure, the pollutant concentration, and the time the organism is exposed to that concentration. Authorizing a limited acute mixing zone for this discharge assures that it will not create a barrier to migration. The effluent from this discharge will rise as it enters the receiving water, assuring that the rising effluent will not cause translocation of indigenous organisms near the point of discharge (below the rising effluent).

- **Comply with size restrictions.**

  The mixing zone authorized for this discharge complies with the size restrictions published in chapter 173-201A WAC.

9. Overlap of mixing zones.

This mixing zone does not overlap another mixing zone.

D. Designated uses and surface water quality criteria

Applicable designated uses and surface water quality criteria are defined in chapter 173-201A WAC. In addition, the U.S. EPA set human health criteria for toxic pollutants (EPA 1992). The tables included below summarize the criteria applicable to the receiving water's designated uses.

- Aquatic life uses are designated using the following general categories. All indigenous fish and non-fish aquatic species must be protected in waters of the state.

a. Extraordinary quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

b. Excellent quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

c. Good quality salmonid migration and rearing; other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

d. Fair quality salmonid and other fish migration.

The *Aquatic Life Uses* and the associated criteria for this receiving water are identified below.

Table 11. Marine Aquatic Life Uses and Associated Criteria

Extraordinary Quality	
Temperature Criteria – Highest 1D MAX	13°C (55.4°F)
Dissolved Oxygen Criteria – Lowest 1-Day Minimum	7.0 mg/L
Turbidity Criteria	• 5 NTU over background when the background is 50 NTU or less; or • A 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
pH Criteria	pH must be within the range of 7.0 to 8.5 with a human-caused variation within the above range of less than 0.2 units.

- To protect shellfish harvesting, fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, and not have more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL.
- The *recreational use* is primary contact recreation.

The recreational uses for this receiving water are identified below.

Table 12. Recreational Uses

Recreational Use	Criteria
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies /100 mL.

- The *miscellaneous marine water uses* are wildlife habitat, harvesting, commerce and navigation, boating, and aesthetics.

E. Water quality impairments

The previous fact sheet indicated that the water quality in the receiving water in the vicinity of the outfall was not impaired. However, the current 303 (d) list documents that the area has a Category 2 for fecal coliform. In 2009, 1 out of 6 (16.7%) samples exceeded the percent criterion (43 col/100 mL). Currently, Ecology has no schedule for conducting a Total Maximum Daily Load (TMDL) Analysis to address this impairment listing.

F. Evaluation of surface water quality-based effluent limits for narrative criteria

Ecology must consider the narrative criteria described in WAC 173-201A-160 when it determines permit limits and conditions. Narrative water quality criteria limit the toxic, radioactive, or other deleterious material concentrations that the facility may discharge which have the potential to adversely affect designated uses, cause acute or chronic toxicity to biota, impair aesthetic values, or adversely affect human health.

Ecology considers narrative criteria when it evaluates the characteristics of the wastewater and when it implements all known, available, and reasonable methods of treatment and prevention (AKART) as described above in the technology-based limits section. When Ecology determines if a facility is meeting AKART it considers the pollutants in the wastewater and the adequacy of the treatment to prevent the violation of narrative criteria.

In addition, Ecology considers the toxicity of the wastewater discharge by requiring whole effluent toxicity (WET) testing when there is a reasonable potential for the discharge to contain toxics. Ecology’s analysis of the need for WET testing for this discharge is described later in the fact sheet.

G. Evaluation of surface water quality-based effluent limits for numeric criteria

Pollutants in an effluent may affect the aquatic environment near the point of discharge (near-field) or at a considerable distance from the point of discharge (far-field). Toxic pollutants, for example, are near-field pollutants; their adverse effects diminish rapidly with mixing in the receiving water. Conversely, a pollutant such as biochemical oxygen demand (BOD_5) is a far-field pollutant whose adverse effect occurs away from the discharge even after dilution has occurred. Thus, the method of calculating surface water quality-based effluent limits varies with the point at which the pollutant has its maximum effect.

With technology-based controls (AKART), predicted pollutant concentrations in the discharge exceed water quality criteria. Ecology therefore authorizes a mixing zone in accordance with the geometric configuration, flow restriction, and other restrictions imposed on mixing zones by chapter 173-201A WAC.

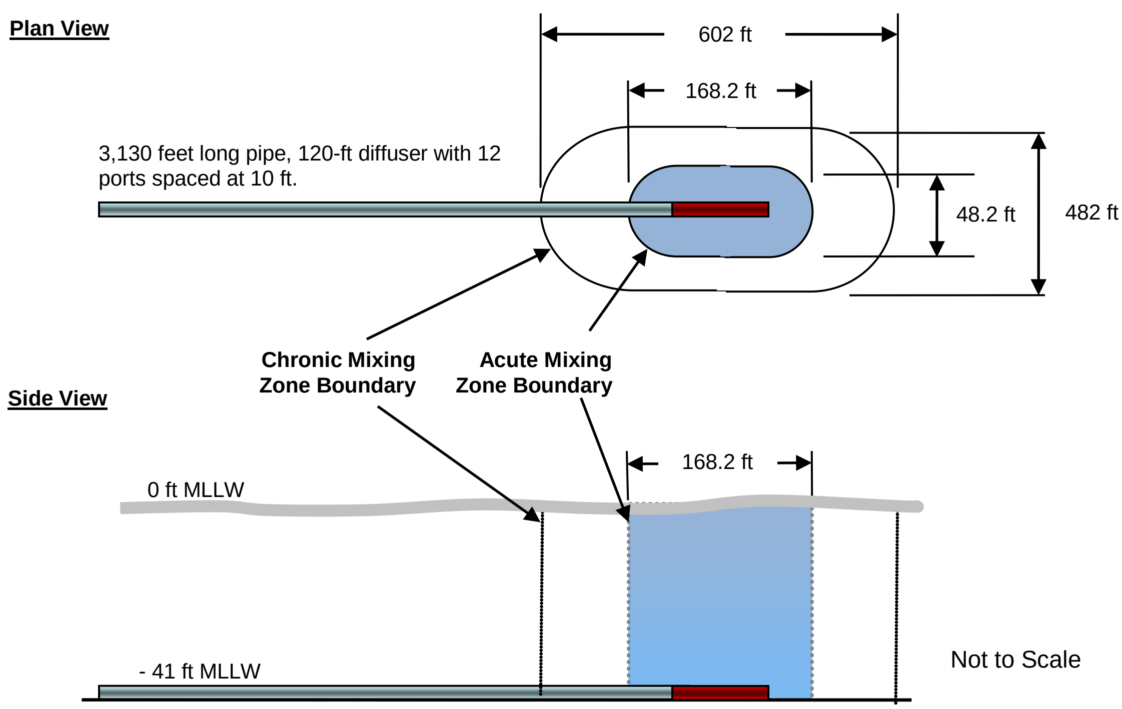
The outfall 001 from this facility discharges treated and disinfected effluent into Port Orchard Bay, Puget Sound, approximately 3,130 feet offshore at a depth of approximately 41 feet below mean lower low water, via a 36-inch outfall line with a diffuser. The diffuser consists of a 30-inch diameter, 120-foot long ductile iron pipeline with twelve 5-inch diameter diffuser ports. The port spacing is 10 feet, with consecutive ports facing opposite direction.

Chronic Mixing Zone--WAC 173-201A-400(7)(b) specifies that mixing zones must not extend in any horizontal direction from the discharge ports for a distance greater than 200 feet plus the depth of water over the discharge ports and may not occupy more than 25% of the width of the water body as measured during MLLW. The authorized mixing zone size complies with the width restriction. The horizontal distance along the semi-major axis of the chronic mixing zone is 602 feet. The horizontal distance along the semi-minor axis of the chronic mixing zone is 482 feet. The mixing zone extends from the bottom to the top of the water column

Acute Mixing Zone--WAC 173-201A-400(8)(b) specifies that in estuarine waters a zone where acute criteria may be exceeded must not extend beyond 10% of the distance established for the chronic zone. The acute mixing zone for Outfall 001 extends 24.1 feet in any direction from any discharge port.

The dimensions and boundaries of the mixing zones are as depicted below.

Figure 2. Outfall Mixing Zones



The predicted dilution factors that occur within these zones have been determined at the critical condition by the use of EPA Plumes model. The water quality model and the results are presented in the *Central Kitsap WWTP Dilution Analysis,* dated October 26, 2006, and prepared by Brown and Caldwell. The dilution factors are listed below.

Table 13. Dilution Factors (DF)

Criteria	Acute	Chronic
Aquatic Life	47	84
Human Health, Carcinogen		91
Human Health, Non-carcinogen		84

Ecology determined the impacts of dissolved oxygen deficiency, nutrients, pH, fecal coliform, ammonia, copper, mercury, nickel, zinc, total phenolic compounds and temperature as described below, using the dilution factors in the above table. The derivation of surface water quality-based limits also takes into account the variability of pollutant concentrations in both the effluent and the receiving water.

Dissolved Oxygen--BOD_5 and Ammonia Effects--Natural decomposition of organic material in wastewater effluent impacts dissolved oxygen in the receiving water at distances far outside of the regulated mixing zone. The 5-day Biochemical Oxygen Demand (BOD_5) of an effluent sample indicates the amount of biodegradable material in the wastewater and estimates the magnitude of oxygen consumption the wastewater will generate in the receiving water. The amount of ammonia-based nitrogen in the wastewater also provides an indication of oxygen demand potential in the receiving water.

With technology-based limits, this discharge results in a small amount of biochemical oxygen demand (BOD_5) relative to the large amount of dilution in the receiving water at critical conditions. Technology-based limits will ensure that dissolved oxygen criteria are met in the receiving water.

pH--Compliance with the technology-based limits of 6.0 to 9.0 will assure compliance with the water quality standards of surface waters because of the high buffering capacity of marine water.

Fecal Coliform--Ecology modeled the numbers of fecal coliform by simple mixing analysis using the technology-based limit of 400 organisms per 100 ml and a dilution factor of 84.

Under critical conditions, modeling predicts no violation of the water quality criterion for fecal coliform. Therefore, the proposed permit includes the technology-based effluent limit for fecal coliform bacteria.

Turbidity--Ecology evaluated the impact of turbidity based on the range of total suspended solids in the effluent and turbidity of the receiving water. Ecology expects no violations of the turbidity criteria outside the designated mixing zone provided the facility meets its technology-based total suspended solids permit limits.

Toxic Pollutants--Federal regulations (40 CFR 122.44) require Ecology to place limits in NPDES permits on toxic chemicals in an effluent whenever there is a reasonable potential for those chemicals to exceed the surface water quality criteria. Ecology does not exempt facilities with technology-based effluent limits from meeting the surface water quality standards.

The following toxic pollutants are present in the discharge: ammonia, copper, mercury, nickel, zinc. Ecology conducted a reasonable potential analysis (See *Appendix D*) on these parameters to determine whether it would require effluent limits in this permit.

Ammonia's toxicity depends on that portion which is available in the unionized form. The amount of unionized ammonia depends on the temperature, pH, and salinity of the receiving marine water. To evaluate ammonia toxicity, Ecology used the available receiving water information described in section II.B (Description of the receiving water) and Ecology spreadsheet tools.

No valid ambient background data were available for the other pollutants listed above. Ecology used zero for background.

Ecology determined that the toxic pollutants listed above, except ammonia, pose no reasonable potential to exceed the water quality criteria at the critical condition using procedures given in EPA, 1991 (*Appendix D*) and as described above. Ecology's determination assumes that this facility meets the other effluent limits of this permit.

Using effluent data, Ecology determined that ammonia poses a reasonable potential to exceed the water quality criteria at the critical conditions using methods from EPA, 1991 (*Appendix D)* and as described above.

The resultant effluent limits are as follows:

Average Monthly Limit = 37 mg/L (37,286 ug/L)

Maximum Daily Limit = 51 mg/L (50,718 ug/L)

Ecology's determination assumes that this facility meets the other effluent limits of this permit.

Temperature--The state temperature standards [WAC 173-201A-200-210 and 600-612] include multiple elements:

- Annual summer maximum threshold criteria (June 15 to September 15)
- Supplemental spawning and rearing season criteria (September 15 to June 15)
- Incremental warming restrictions
- Protections against acute effects

Ecology evaluates each criterion independently to determine reasonable potential and derive permit limits.

- Annual summer maximum and supplementary spawning/rearing criteria

  Each water body has an annual maximum temperature criterion [WAC 173-201A-200(1)(c), 210(1)(c), and Table 602]. These threshold criteria (e.g., 12, 16, 17.5, 20°C) protect specific categories of aquatic life by controlling the effect of human actions on summer temperatures.

  Some waters have an additional threshold criterion to protect the spawning and incubation of salmonids (9°C for char and 13°C for salmon and trout) [WAC 173-201A-602, Table 602]. These criteria apply during specific date-windows.

  The threshold criteria apply at the edge of the chronic mixing zone. Criteria for most fresh waters are expressed as the highest 7-Day average of daily maximum temperature (7-DADMax). The 7-DADMax temperature is the arithmetic average of seven consecutive measures of daily maximum temperatures. Criteria for marine waters and some fresh waters are expressed as the highest 1-Day annual maximum temperature (1-DMax).

- Incremental warming criteria

  The water quality standards limit the amount of warming human sources can cause under specific situations [WAC 173-201A-200(1)(c)(i)-(ii), 210(1)(c)(i)-(ii)]. The incremental warming criteria apply at the edge of the chronic mixing zone.

  At locations and times when background temperatures are cooler than the assigned threshold criterion, point sources are permitted to warm the water by only a defined increment. These increments are permitted only to the extent doing so does not cause temperatures to exceed either the annual maximum or supplemental spawning criteria.

  At locations and times when a threshold criterion is being exceeded due to natural conditions, all human sources, considered cumulatively, must not warm the water more than 0.3°C above the naturally warm condition.

  When Ecology has not yet completed a TMDL, our policy allows each point source to warm water at the edge of the chronic mixing zone by 0.3°C. This is true regardless of the background temperature and even if doing so would cause the temperature at the edge of a standard mixing zone to exceed the numeric threshold criteria. Allowing a 0.3°C warming for each point source is reasonable and protective where the dilution factor is based on 25% or less of the critical flow. This is because the fully mixed effect on temperature will only be a fraction of the 0.3°C cumulative allowance (0.075°C or less) for all human sources combined.

- Protections for temperature acute effects

  Instantaneous lethality to passing fish: The upper 99^{th} percentile daily maximum effluent temperature must not exceed 33°C, unless a dilution analysis indicates ambient temperatures will not exceed 33°C two seconds after discharge.

  General lethality and migration blockage: Measurable (0.3°C) increases in temperature at the edge of a chronic mixing zone are not allowed when the receiving water temperature exceeds either a 1DMax of 23°C or a 7DADMax of 22°C.

  Lethality to incubating fish: Human actions must not cause a measurable (0.3°C) warming above 17.5°C at locations where eggs are incubating.

Reasonable Potential Analysis

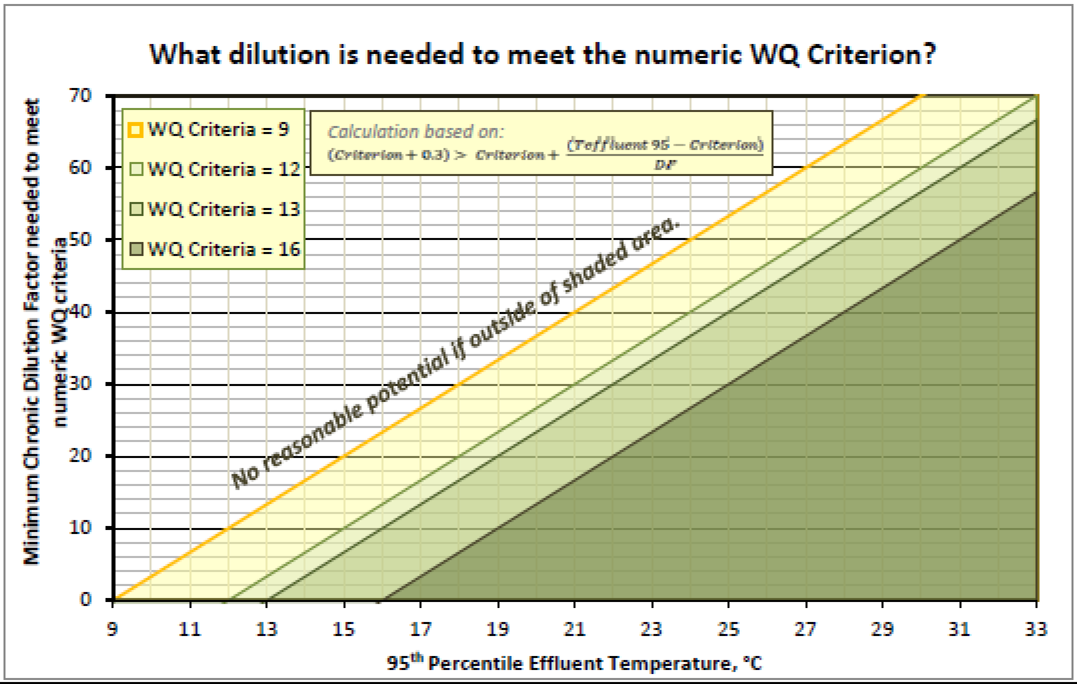
Annual summer maximum and incremental warming criteria: Ecology calculated the reasonable potential for the discharge to exceed the annual summer maximum and the incremental warming criteria at the edge of the chronic mixing zone during critical conditions. No reasonable potential exists to exceed the temperature criterion where:

(Criterion + 0.3) > [Criterion + (Teffluent95 – Criterion)/DF].

(13 + 0.3) > [13 + (24 – 13)/84] => 13.3 > 13.13

The figure below graphically portrays the above equation and shows the conditions when a permit limit will apply.

Figure 3. Dilution Necessary to Meet Criteria at Edge of Mixing Zone



Therefore, the proposed permit does not include a temperature limit. The permit requires additional monitoring of effluent temperatures. Ecology will reevaluate the reasonable potential during the next permit renewal.

H. Human health

Washington's water quality standards include numeric human health-based criteria that Ecology must consider when writing NPDES permits. In accordance with the requirements of CWA section 303(c)(2)(B), EPA has finalized 144 new and revised Washington-specific human health criteria for priority toxic pollutants, to apply to waters under Washington's jurisdiction, and has approved 45 new human health criteria submitted by Washington. For arsenic, dioxin, and thallium, the existing criteria from the National Toxics Rule (40 CFR 131.36) remain in effect.

Ecology determined the effluent may contain chemicals of concern for human health, based on data and information indicating regulated chemicals are present in the discharge. Specifically, mercury, nickel, and total phenolic compounds were among the compounds found in detectable amounts in the effluent. All have associated human health criteria that must be complied with in the receiving water.

Ecology evaluated the discharge's potential to violate the water quality standards as required by 40 CFR 122.44(d) by following the procedures published in the *Technical Support Document for Water Quality-Based Toxics Control* (EPA/505/2-90-001) and Ecology's *Permit Writer's Manual* to make a reasonable potential determination. The evaluation showed that the discharge has no reasonable potential to cause a violation of water quality standards, and effluent limits are not needed.

I. Sediment quality

The aquatic sediment standards (chapter 173-204 WAC) protect aquatic biota and human health. Under these standards Ecology may require a facility to evaluate the potential for its discharge to cause a violation of sediment standards (WAC 173-204-400). You can obtain additional information about sediments at the Aquatic Lands Cleanup Unit website. http://www.ecy.wa.gov/programs/tcp/smu/sediment.html

Through a review of the discharger characteristics and of the effluent characteristics, and facility operations, Ecology determined that this discharge has no reasonable potential to violate the sediment management standards. Therefore, the proposed permit does not require sediment monitoring in the vicinity of the discharge outfall. If substantial changes affecting the effluent occur, the Aquatic Lands Cleanup Unit (ALCU) will reassess the sediment monitoring requirements at the facility.

J. Whole effluent toxicity

The water quality standards for surface waters forbid discharge of effluent that has the potential to cause toxic effects in the receiving waters. Many toxic pollutants cannot be measured by commonly available detection methods. However, laboratory tests can measure toxicity directly by exposing living organisms to the wastewater and measuring their responses. These tests measure the aggregate toxicity of the whole effluent, so this approach is called whole effluent toxicity (WET) testing. Some WET tests measure acute toxicity and other WET tests measure chronic toxicity.

- *Acute toxicity tests measure mortality as the significant response* to the toxicity of the effluent. Dischargers who monitor their wastewater with acute toxicity tests find early indications of any potential lethal effect of the effluent on organisms in the receiving water.
- *Chronic toxicity tests measure various sublethal toxic responses*, such as reduced growth or reproduction. Chronic toxicity tests often involve either a complete life cycle test on an organism with an extremely short life cycle, or a partial life cycle test during a critical stage of a test organism's life. Some chronic toxicity tests also measure organism survival.

Laboratories accredited by Ecology for WET testing know how to use the proper WET testing protocols, fulfill the data requirements, and submit results in the correct reporting format. Accredited laboratory staff know about WET testing and how to calculate an NOEC, LC50, EC50, IC25, etc. Ecology gives all accredited labs the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* (https://fortress.wa.gov/ecy/publications/SummaryPages/9580.html), which is referenced in the permit. Ecology recommends that each regulated facility send a copy of the acute or chronic toxicity sections(s) of its NPDES permit to the laboratory.

Acute Toxicity

WET testing conducted during the previous permit term showed the facility’s effluent has a reasonable potential to cause acute toxicity in the receiving water. The proposed permit will include an acute toxicity limit. **The effluent limit for acute toxicity is: No acute toxicity detected in a test sample representing the acute critical effluent concentration (ACEC).** The acute critical effluent concentration (ACEC) is the concentration of effluent at the boundary of the acute mixing zone during critical conditions. The ACEC equals 2.1 % effluent.

Compliance with an acute toxicity limit is measured by an acute toxicity test comparing test organism survival in the ACEC (using a sample of effluent diluted to equal the ACEC) to survival in nontoxic control water. The Central Kitsap WWTP is in compliance with the acute toxicity limit if there is no statistically significant difference in test organism survival between the ACEC sample and the control sample.

Chronic Toxicity

The previous permit required the Central Kitsap WWTP to perform chronic WET tests four times during the permit term. WET testing conducted during effluent characterization showed no reasonable potential for effluent discharges to cause receiving water chronic toxicity. Therefore, the proposed permit will not include a chronic WET limit. Central Kitsap WWTP must re-test the effluent before submitting an application for permit renewal.

- If this facility makes process or material changes which, in Ecology's opinion, increase the potential for effluent toxicity, then Ecology may (in a regulatory order, by permit modification, or in the permit renewal) require the facility to conduct additional effluent characterization
- If WET testing conducted for submittal with a permit application fails to meet the performance standards in WAC 173-205-020, Ecology will assume that effluent toxicity has increased. Central Kitsap WWTP may demonstrate to Ecology that effluent toxicity has not increased by performing additional WET testing after the process or material changes have been made.

K. Groundwater quality limits

The groundwater quality standards (chapter 173-200 WAC) protect beneficial uses of groundwater. Permits issued by Ecology must not allow violations of those standards (WAC 173-200-100). The Central Kitsap WWTP does not discharge wastewater to the ground. No permit limits are required to protect groundwater.

L. Comparison of effluent limits with the previous permit issued on July 16, 2012

Table 14. Comparison of Previous and Proposed Effluent Limits

		Previous Effluent Limits: Outfall # 001		Proposed Effluent Limits: Outfall # 001	
Parameter	**Basis of Limit**	**Average Monthly**	**Average Weekly**	**Average Monthly**	**Average Weekly**
$CBOD_5$	Technology	25 mg/L, 1,251 lbs/day, 85% removal	40 mg/L, 2,002 lbs/day	-	-
BOD_5	Technology	-	-	30 mg/L, 1,501 lbs/day, 85% removal	45 mg/L, 2,252 lbs/day
TSS	Technology	30 mg/L, 1,501 lbs/day, 85% removal	45 mg/L, 2,252 lbs/day	30 mg/L, 1,501 lbs/day, 85% removal	45 mg/L, 2,252 lbs/day

Parameter	Basis of Limit	Monthly Geometric Mean Limit	Weekly Geometric Mean Limit	Monthly Geometric Mean Limit	Weekly Geometric Mean Limit
Fecal Coliform Bacteria	Technology	200/100 mL	400/100 mL	200/100 mL	400/100 mL

Parameter	Basis of Limit	Limit	Limit
pH	Technology	Daily minimum equal to or greater than 6.0; daily maximum less than or equal to 9.0	Daily minimum equal to or greater than 6.0; daily maximum less than or equal to 9.0

Parameter	Basis of Limit	Average Monthly	Maximum Daily	Average Monthly	Maximum Daily
Total Ammonia (NH_3-N)	Water Quality	-	-	37 mg/L	51 mg/L

IV. Monitoring Requirements

Ecology requires monitoring, recording, and reporting (WAC 173-220-210 and 40 CFR 122.41) to verify that the treatment process is functioning correctly and that the discharge complies with the permit’s effluent limits.

If a facility uses a contract laboratory to monitor wastewater, it must ensure that the laboratory uses the methods and meets or exceeds the method detection levels required by the permit. The permit describes when facilities may use alternative methods. It also describes what to do in certain situations when the laboratory encounters matrix effects. When a facility uses an alternative method as allowed by the permit, it must report the test method, detection level (DL), and quantitation level (QL) on the discharge monitoring report or in the required report.

A. Wastewater monitoring

The monitoring schedule is detailed in the proposed permit under Special Condition S.2. Specified monitoring frequencies take into account the quantity and variability of the discharge, the treatment method, past compliance, significance of pollutants, and cost of monitoring. The required monitoring frequency is consistent with agency guidance given in the current version of Ecology’s *Permit Writer's Manual* (Publication Number 92-109) for activated sludge facilities with design flows greater than 5.0 MGD average design flow.

Ecology has included some additional monitoring of nutrients in the proposed permit to establish a baseline for this discharger. It will use this data in the future as it develops TMDLs for dissolved oxygen and establishes WLAs for nutrients.

Monitoring of sludge quantity and quality is necessary to determine the appropriate uses of the sludge. Biosolids monitoring is required by the current state and local solid waste management program and also by EPA under 40 CFR 503.

In the previous NPDES permit, the facility was required to measure influent flow only. However, during the Class I inspection conducted on January 20, 2016 and after technical discussions with Kitsap County, Ecology learned that the Central Kitsap WWTP has the capability of monitoring effluent flows. Therefore, the proposed permit requires influent and effluent flow measurements.

In 2015, the County completed a series of improvement projects at the Central Kitsap WWTP. The existing activated sludge system was expanded and modified to provide biological nitrogen removal, which increases the capability of the facility to achieve optimal nitrification conditions. Therefore, the proposed permit requires 5-day biochemical oxygen demand (BOD_5) monitoring in lieu of carbonaceous biochemical oxygen demand ($CBOD_5$).

The monitoring data for the past two years were analyzed to determine whether Central Kitsap WWTP qualifies for reduction in monitoring frequency. An analysis of the Central Kitsap WWTP's monitoring data from December 2014 through December 2016 shows that the facility qualifies for reduction in monitoring frequency to 5/week for fecal coliform (*Appendix G*).

B. Lab accreditation

Ecology requires that facilities must use a laboratory registered or accredited under the provisions of chapter 173-50 WAC, Accreditation of Environmental Laboratories, to prepare all monitoring data (with the exception of certain parameters). Ecology accredited the laboratory at the Central Kitsap WWTP (W660-14) for the parameters and methods listed in Table 15.

Table 15. Accredited Parameters

Parameter Name	Category	Method Name	Matrix Description
Biochemical Oxygen Demand	General Chemistry	SM 5210 B-01	Non-Potable Water
Chemical Oxygen Demand	General Chemistry	SM 5220 D-97	Non-Potable Water
Total Suspended Solids	General Chemistry	SM 2540 D-97	Non-Potable Water
pH	General Chemistry	SM 4500-H+ B-00	Non-Potable Water
Fecal Coliform	Microbiology	SM 9222 D(m-FC)-97	Non-Potable Water
Ammonia	General Chemistry	EPA 350.1_2_1993	Non-Potable Water
Total Kjeldahl Nitrogen	General Chemistry	EPA 351.2_2_1993	Non-Potable Water
Nitrate + Nitrite	General Chemistry	EPA 353.2_2_1993	Non-Potable Water
Total Phosphorus	General Chemistry	EPA 365.1_2_1993	Non-Potable Water
Ortho-phosphorus	General Chemistry	SM 4500-P E-99	Non-Potable Water
Dissolved Oxygen	General Chemistry	SM 4500-O G-01	Non-Potable Water
Total Volatile Solids	General Chemistry	EPA 160.4_1971	Non-Potable Water
Total, Fixed and Volatile Solids	General Chemistry	SM 2540 G-97	Non-Potable Water
Antimony	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Arsenic	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Beryllium	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Cadmium	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Chromium	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Copper	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Lead	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Molybdenum	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Nickel	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Selenium	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Silver	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Thallium	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Zinc	Metals	EPA 200.7_4.4_1994	Non-Potable Water
Mercury	Metals	EPA 245.1_3_1994	Non-Potable Water

Table 15. Accredited Parameters

Parameter Name	Category	Method Name	Matrix Description
Arsenic	Metals	EPA 6010C_(2/07)	Non-Potable Water
Cadmium	Metals	EPA 6010C_(2/07)	Non-Potable Water
Copper	Metals	EPA 6010C_(2/07)	Non-Potable Water
Lead	Metals	EPA 6010C_(2/07)	Non-Potable Water
Molybdenum	Metals	EPA 6010C_(2/07)	Non-Potable Water
Nickel	Metals	EPA 6010C_(2/07)	Non-Potable Water
Selenium	Metals	EPA 6010C_(2/07)	Non-Potable Water
Zinc	Metals	EPA 6010C_(2/07)	Non-Potable Water
Mercury, Solid Waste	Metals	EPA 7471B_(1/98)	Non-Potable Water

V. Other Permit Conditions

A. Reporting and record keeping

Ecology based Special Condition S3 on its authority to specify any appropriate reporting and record keeping requirements to prevent and control waste discharges (WAC 173-220-210).

B. Prevention of facility overloading

Overloading of the treatment plant is a violation of the terms and conditions of the permit. To prevent this from occurring, RCW 90.48.110 and WAC 173-220-150 require Central Kitsap WWTP to:

- Take the actions detailed in proposed permit Special Condition S.4.
- Design and construct expansions or modifications before the treatment plant reaches existing capacity.
- Report and correct conditions that could result in new or increased discharges of pollutants.

Special Condition S.4 restricts the amount of flow.

If a municipality intends to apply for Ecology-administered funding for the design or construction of a facility project, the plan must meet the standard of a “Facility Plan”, as defined in WAC 173-98-030. A complete “Facility Plan” includes all elements of an “Engineering Report” along with State Environmental Review Process (SERP) documentation to demonstrate compliance with 40 CFR 35.3140 and 40 CFR 35.3145, and a cost effectiveness analysis as required by WAC 173-98-730. The municipality should contact Ecology’s regional office as early as practical before planning a project that may include Ecology-administered funding.

C. Operation and maintenance

The proposed permit contains Special Condition S.5 as authorized under RCW 90.48.110, WAC 173-220-150, chapter 173-230 WAC, and WAC 173-240-080. Ecology included it to ensure proper operation and regular maintenance of equipment, and to ensure that the Central Kitsap WWTP takes adequate safeguards so that it uses constructed facilities to their optimum potential in terms of pollutant capture and treatment.

Kitsap County conducted the last infiltration and inflow (I/I) evaluation in 2008 as part of the Central Kitsap General Sewer Plan. The conclusions and recommendations of the I/I evaluation are documented in the *Central Kitsap Wastewater Facilities Flow Projections 2005-2025* technical memorandum dated August 2008, and prepared by BHC Consultants, Inc. The I/I evaluation indicated that the average daily flow per capita during the 2006/2007 dry season was 85 gpcd, which does not exceed the United States Environmental Protection Agency (EPA) maximum of 120 gpcd for infiltration. However, the County had limited data to evaluate the influence of rain-induced inflow. Therefore, the proposed permit requires the Kitsap County to conduct an infiltration and inflow evaluation and submit a report summarizing the results of the evaluation and any recommendations for corrective actions. Specifically, the report must include the following information:

- Volume of the annual average and peak daily flow under worst conditions (inflow or infiltration) attributed to leaks.
- Location of each individual leaks.
- Size of each leak and/or volume of excess flow contributed by a run of sewer.
- Whether exfiltration occurs in the system's force mains and/or inverted siphons.

Three good references to aid in these tasks include:

- American Society of Civil Engineers and Water Environment Federation Manual of Practice FD-6, *Existing Sewer Evaluation and Rehabilitation*.
- U.S. Environmental Protection Agency, *Handbook for Sewer System Infrastructure Analysis and Rehabilitation*, EPA/625/6-91/030, 1991.
- Washington State Department of Transportation, *Standard Specifications for Road, Bridge, and Municipal Construction*, 2002.

Following characterization of the leaks, Ecology may require corrective actions by issuing an administrative order following review of the assessment.

D. Pretreatment

Duty to enforce discharge prohibitions

This provision prohibits the publicly owned treatment works (POTW) from authorizing or permitting an industrial discharger to discharge certain types of waste into the sanitary sewer.

- The first section of the pretreatment requirements prohibits the POTW from accepting pollutants which causes "pass-through" or "interference". This general prohibition is from 40 CFR §403.5(a). *Appendix C* of this fact sheet defines these terms.
- The second section reinforces a number of specific state and federal pretreatment prohibitions found in WAC 173-216-060 and 40 CFR §403.5(b). These reinforce that the POTW may not accept certain wastes, which:
  a. Are prohibited due to dangerous waste rules.
  b. Are explosive or flammable.
  c. Have too high or low of a pH (too corrosive, acidic or basic).

d. May cause a blockage such as grease, sand, rocks, or viscous materials.

e. Are hot enough to cause a problem.

f. Are of sufficient strength or volume to interfere with treatment.

g. Contain too much petroleum-based oils, mineral oil, or cutting fluid.

h. Create noxious or toxic gases at any point.

40 CFR Part 403 contains the regulatory basis for these prohibitions, with the exception of the pH provisions which are based on WAC 173-216-060.

- The third section of pretreatment conditions reflects state prohibitions on the POTW accepting certain types of discharges unless the discharge has received prior written authorization from Ecology. These discharges include:

a. Cooling water in significant volumes.

b. Stormwater and other direct inflow sources.

c. Wastewaters significantly affecting system hydraulic loading, which do not require treatment.

Federal and state pretreatment program requirements

Ecology administers the Pretreatment Program under the terms of the addendum to the "Memorandum of Understanding between Washington Department of Ecology and the United States Environmental Protection Agency, Region 10" (1986) and 40 CFR, part 403. Under this delegation of authority, Ecology issues wastewater discharge permits for significant industrial users (SIUs) discharging to POTWs which have not been delegated authority to issue wastewater discharge permits. Ecology must approve, condition, or deny new discharges or a significant increase in the discharge for existing significant industrial users (SIUs) [40 CFR 403.8 (f)(1)(i) and(iii)].

Industrial dischargers must obtain a permit from Ecology before discharging waste to the Central Kitsap WWTP [WAC 173-216-110(5)]. Industries discharging wastewater that is similar in character to domestic wastewater do not require a permit.

Routine identification and reporting of industrial users

The permit requires non-delegated POTWs to take "continuous, routine measures to identify all existing, new, and proposed significant industrial users (SIUs) and potential significant industrial users (PSIUs)" discharging to their sewer system. Examples of such routine measures include regular review of water and sewer billing records, business license and building permit applications, advertisements, and personal reconnaissance. System maintenance personnel should be trained on what to look for so they can identify and report new industrial dischargers in the course of performing their jobs. The POTW may not allow SIUs to discharge prior to receiving a permit, and must notify all industrial dischargers (significant or not) in writing of their responsibility to apply for a State Waste Discharge Permit. The POTW must send a copy of this notification to Ecology.

Requirements for performing an industrial user survey

This POTW has the potential to serve significant industrial or commercial users and must conduct an industrial user (IU) survey. The purpose of the IU Survey is to identify all facilities that may be subject to pretreatment standards or requirements so that Ecology can take appropriate measures to control these discharges. The POTW should identify each such user, and require them to apply for a permit before allowing their discharge to the POTW to commence. For SIUs, the POTW must require they actually are issued a permit prior to accepting their discharge. The steps the POTW must document in their IU Survey submittal include:

1. The POTW must develop a master list of businesses that may be subject to pretreatment standards and requirements and show their disposition. This list must be based on several sources of information including business licenses, and water and sewer billing records.
2. The POTW must canvas all the potential sources, having them either complete a survey form or ruling them out by confirming they only generate domestic wastewater.
3. The POTW must develop a list of the SIUs and potential SIUs in all areas served by the POTW. The list must contain sufficient information on each to allow Ecology to decide which discharges merit further controls such as a state waste discharge permit.

Ecology describes the information needed in IU Survey submittals to allow Ecology to make permitting decision in the manual "Performing an Industrial User Survey". Properly completing an Industrial User Survey helps Ecology control discharges that may otherwise harm the POTW including its collection system, processes, and receiving waters. Where surveys are incomplete, Ecology may take such enforcement as appropriate and/or require the POTW to develop a fully delegated pretreatment program.

The proposed permit requires Central Kitsap WWTP to conduct an industrial user survey to determine the extent of compliance of all industrial users of the sanitary sewer and wastewater treatment facility with federal pretreatment regulations [40 CFR Part 403 and Sections 307(b) and 308 of the Clean Water Act)], with state regulations (chapter 90.48 RCW and chapter 173-216 WAC), and with local ordinances.

E. Solid wastes

To prevent water quality problems the facility is required in permit Special Condition S7 to store and handle all residual solids (grit, screenings, scum, sludge, and other solid waste) in accordance with the requirements of RCW 90.48.080 and state water quality standards.

The final use and disposal of sewage sludge from this facility is regulated by U.S. EPA under 40 CFR 503, and by Ecology under chapter 70.95J RCW, chapter 173-308 WAC "Biosolids Management," and chapter 173-350 WAC "Solid Waste Handling Standards." The disposal of other solid waste is under the jurisdiction of the Kitsap County Health Department.

Requirements for monitoring sewage sludge and record keeping are included in this permit. Ecology will use this information, required under 40 CFR 503, to develop or update local limits.

F. Outfall evaluation

Kitsap County conducted visual inspection of the outfall and diffuser on September 8 and 9, 2009. The visual inspection showed the outfall pipe was in good condition with all twelve diffuser ports open and clear with good flow. The structure was observed to be intact and functioning without any problems. Therefore, the proposed permit does not require an outfall evaluation. A detailed outfall and diffuser inspection will be required in the next permit cycle because heavy marine growth and poor visibility prevented a detailed inspection of the entire outer diffuser section in 2009. Further information on the outfall and diffuser inspection can be found in the "*Underwater Inspection of Central Kitsap Wastewater Treatment Plant Outfall Diffuser*" report dated March 2010, and prepared by GeoEngineers.

G. General conditions

Ecology bases the standardized General Conditions on state and federal law and regulations. They are included in all individual domestic wastewater NPDES permits issued by Ecology.

VI. Permit Issuance Procedures

A. Permit modifications

Ecology may modify this permit to impose numerical limits, if necessary to comply with water quality standards for surface waters, with sediment quality standards, or with water quality standards for groundwaters, based on new information from sources such as inspections, effluent monitoring, outfall studies, and effluent mixing studies.

Ecology may also modify this permit to comply with new or amended state or federal regulations.

B. Proposed permit issuance

This proposed permit meets all statutory requirements for Ecology to authorize a wastewater discharge. The permit includes limits and conditions to protect human health and aquatic life, and the beneficial uses of waters of the state of Washington. Ecology proposes to issue this permit for a term of 5 years.

VII. References for Text and Appendices

Environmental Protection Agency (EPA)

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October 2010 (revised). *Water Quality Program Guidance Manual – Procedures to Implement the State's Temperature Standards through NPDES Permits*. Publication Number 06-10-100 (https://fortress.wa.gov/ecy/publications/summarypages/0610100.html)

Laws and Regulations (http://www.ecy.wa.gov/laws-rules/index.html)

Permit and Wastewater Related Information (http://www.ecy.wa.gov/programs/wq/permits/guidance.html)

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Appendix A--Public Involvement Information

Ecology proposes to reissue a permit to Kitsap County. The permit includes wastewater discharge limits and other conditions. This fact sheet describes the facility and Ecology's reasons for requiring permit conditions.

Ecology placed a Public Notice of Draft on May 13, 2017, in the *Kitsap Sun* to inform the public and to invite comment on the proposed draft National Pollutant Discharge Elimination System permit and fact sheet.

The notice:

- Told where copies of the draft permit and fact sheet were available for public evaluation (a local public library, the closest regional or field office, posted on our website).
- Offered to provide the documents in an alternate format to accommodate special needs.
- Asked people to tell us how well the proposed permit would protect the receiving water.
- Invited people to suggest fairer conditions, limits, and requirements for the permit.
- Invited comments on Ecology's determination of compliance with antidegradation rules.
- Urged people to submit their comments, in writing, before the end of the comment period.
- Told how to request a public hearing about the proposed NPDES permit.
- Explained the next step(s) in the permitting process.

Ecology has published a document entitled *Frequently Asked Questions about Effective Public Commenting*, which is available on our website at https://fortress.wa.gov/ecy/publications/SummaryPages/0307023.html.

You may obtain further information from Ecology by telephone, 425-649-7027, or by writing to the address listed below.

Water Quality Permit Coordinator
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

The primary author of this permit and fact sheet is Lazaro Eleuterio.

Appendix B--Your Right to Appeal

You have a right to appeal this permit to the Pollution Control Hearing Board (PCHB) within 30 days of the date of receipt of the final permit. The appeal process is governed by chapter 43.21B RCW and chapter 371-08 WAC. “Date of receipt” is defined in RCW 43.21B.001(2) (see glossary).

To appeal you must do the following within 30 days of the date of receipt of this permit:

- File your appeal and a copy of this permit with the PCHB (see addresses below). Filing means actual receipt by the PCHB during regular business hours.
- Serve a copy of your appeal and this permit on Ecology in paper form - by mail or in person. (See addresses below.) E-mail is not accepted.

You must also comply with other applicable requirements in chapter 43.21B RCW and chapter 371-08 WAC.

ADDRESS AND LOCATION INFORMATION

Street Addresses	Mailing Addresses
Department of Ecology Attn: Appeals Processing Desk 300 Desmond Drive SE Lacey, WA 98503	**Department of Ecology** Attn: Appeals Processing Desk PO Box 47608 Olympia, WA 98504-7608
Pollution Control Hearings Board 1111 Israel RD SW STE 301 Tumwater, WA 98501	**Pollution Control Hearings Board** PO Box 40903 Olympia, WA 98504-0903

Appendix C--Glossary

1-DMax or 1-day maximum temperature -- The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

7-DADMax or 7-day average of the daily maximum temperatures -- The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

Acute toxicity --The lethal effect of a compound on an organism that occurs in a short time period, usually 48 to 96 hours.

AKART -- The acronym for "all known, available, and reasonable methods of prevention, control and treatment." AKART is a technology-based approach to limiting pollutants from wastewater discharges, which requires an engineering judgment and an economic judgment. AKART must be applied to all wastes and contaminants prior to entry into waters of the state in accordance with RCW 90.48.010 and 520, WAC 173-200-030(2)(c)(ii), and WAC 173-216-110(1)(a).

Alternate point of compliance -- An alternative location in the groundwater from the point of compliance where compliance with the groundwater standards is measured. It may be established in the groundwater at locations some distance from the discharge source, up to, but not exceeding the property boundary and is determined on a site specific basis following an AKART analysis. An "early warning value" must be used when an alternate point is established. An alternate point of compliance must be determined and approved in accordance with WAC 173-200-060(2).

Ambient water quality -- The existing environmental condition of the water in a receiving water body.

Ammonia -- Ammonia is produced by the breakdown of nitrogenous materials in wastewater. Ammonia is toxic to aquatic organisms, exerts an oxygen demand, and contributes to eutrophication. It also increases the amount of chlorine needed to disinfect wastewater.

Annual average design flow (AADF) -- The average of the daily flow volumes anticipated to occur over a calendar year.

Average monthly (intermittent) discharge limit -- The average of the measured values obtained over a calendar month's time taking into account zero discharge days.

Average monthly discharge limit -- The average of the measured values obtained over a calendar month's time.

Background water quality -- The concentrations of chemical, physical, biological or radiological constituents or other characteristics in or of groundwater at a particular point in time upgradient of an activity that has not been affected by that activity [WAC 173-200-020(3)]. Background water quality for any parameter is statistically defined as the 95% upper tolerance interval with a 95% confidence based on at least eight hydraulically upgradient water quality samples. The eight samples are collected over a period of at least one year, with no more than one sample collected during any month in a single calendar year.

Best management practices (BMPs) -- Schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce the pollution of waters of the state. BMPs include treatment systems, operating procedures, and practices to control: plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. BMPs may be further categorized as operational, source control, erosion and sediment control, and treatment BMPs.

BOD5 -- Determining the five-day Biochemical Oxygen Demand of an effluent is an indirect way of measuring the quantity of organic material present in an effluent that is utilized by bacteria. The BOD5 is used in modeling to measure the reduction of dissolved oxygen in receiving waters after effluent is discharged. Stress caused by reduced dissolved oxygen levels makes organisms less competitive and less able to sustain their species in the aquatic environment. Although BOD_5 is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

Bypass -- The intentional diversion of waste streams from any portion of a treatment facility.

Categorical pretreatment standards -- National pretreatment standards specifying quantities or concentrations of pollutants or pollutant properties, which may be discharged to a POTW by existing or new industrial users in specific industrial subcategories.

Chlorine -- A chemical used to disinfect wastewaters of pathogens harmful to human health. It is also extremely toxic to aquatic life.

Chronic toxicity -- The effect of a compound on an organism over a relatively long time, often 1/10 of an organism's lifespan or more. Chronic toxicity can measure survival, reproduction or growth rates, or other parameters to measure the toxic effects of a compound or combination of compounds.

Clean water act (CWA) -- The federal Water Pollution Control Act enacted by Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, 97-117; USC 1251 et seq.

Compliance inspection-without sampling -- A site visit for the purpose of determining the compliance of a facility with the terms and conditions of its permit or with applicable statutes and regulations.

Compliance inspection-with sampling -- A site visit for the purpose of determining the compliance of a facility with the terms and conditions of its permit or with applicable statutes and regulations. In addition it includes as a minimum, sampling and analysis for all parameters with limits in the permit to ascertain compliance with those limits; and, for municipal facilities, sampling of influent to ascertain compliance with the 85 percent removal requirement. Ecology may conduct additional sampling.

Composite sample -- An homogenous mixture of material that reasonably characterizes the nature or quality of a monitored discharge or environmental medium that varies over time or space. Creation of the sample from a temporally varying source (e.g., a wastewater stream) may involve continuous sampling or collection of discrete samples and their combination on a "time-composited" or "flow-proportional" basis. A time-composited sample consists of identical volumes of wastewater collected from constant time intervals. A flow-proportional sample may consist of a combination of either variable sample volumes collected over constant time intervals or constant sample volumes collected over variable sampling intervals, proportional to the stream flow. Samples must be collected and stored in accordance with the procedures prescribed in Standard Methods for the Examination of Water and Wastewater.

Construction activity -- Clearing, grading, excavation, and any other activity, which disturbs the surface of the land. Such activities may include road building; construction of residential houses, office buildings, or industrial buildings; and demolition activity.

Continuous monitoring -- Uninterrupted, unless otherwise noted in the permit.

Critical condition -- The time during which the combination of receiving water and waste discharge conditions have the highest potential for causing toxicity in the receiving water environment. This situation usually occurs when the flow within a water body is low, thus, its ability to dilute effluent is reduced.

Date of receipt -- This is defined in RCW 43.21B.001(2) as five business days after the date of mailing; or the date of actual receipt, when the actual receipt date can be proven by a preponderance of the evidence. The recipient's sworn affidavit or declaration indicating the date of receipt, which is unchallenged by the agency, constitutes sufficient evidence of actual receipt. The date of actual receipt, however, may not exceed forty-five days from the date of mailing.

Detection limit -- The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the pollutant concentration is above zero and is determined from analysis of a sample in a given matrix containing the pollutant.

Dilution factor (DF) -- A measure of the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. Expressed as the inverse of the percent effluent fraction, for example, a dilution factor of 10 means the effluent comprises 10% by volume and the receiving water 90%.

Distribution uniformity -- The uniformity of infiltration (or application in the case of sprinkle or trickle irrigation) throughout the field expressed as a percent relating to the average depth infiltrated in the lowest one-quarter of the area to the average depth of water infiltrated.

Early warning value -- The concentration of a pollutant set in accordance with WAC 173-200-070 that is a percentage of an enforcement limit. It may be established in the effluent, groundwater, surface water, the vadose zone or within the treatment process. This value acts as a trigger to detect and respond to increasing contaminant concentrations prior to the degradation of a beneficial use.

Enforcement limit -- The concentration assigned to a contaminant in the groundwater at the point of compliance for the purpose of regulation, [WAC 173-200-020(11)]. This limit assures that a groundwater criterion will not be exceeded and that background water quality will be protected.

Engineering report -- A document that thoroughly examines the engineering and administrative aspects of a particular domestic or industrial wastewater facility. The report must contain the appropriate information required in WAC 173-240-060 or 173-240-130.

Fecal coliform bacteria -- Fecal coliform bacteria are used as indicators of pathogenic bacteria in the effluent that are harmful to humans. Pathogenic bacteria in wastewater discharges are controlled by disinfecting the wastewater. The presence of high numbers of fecal coliform bacteria in a water body can indicate the recent release of untreated wastewater and/or the presence of animal feces.

Grab sample -- A single sample or measurement taken at a specific time or over as short a period of time as is feasible.

Groundwater -- Water in a saturated zone or stratum beneath the surface of land or below a surface water body.

Industrial user -- A discharger of wastewater to the sanitary sewer that is not sanitary wastewater or is not equivalent to sanitary wastewater in character.

Industrial wastewater -- Water or liquid-carried waste from industrial or commercial processes, as distinct from domestic wastewater. These wastes may result from any process or activity of industry, manufacture, trade or business; from the development of any natural resource; or from animal operations such as feed lots, poultry houses, or dairies. The term includes contaminated stormwater and, also, leachate from solid waste facilities.

Interference -- A discharge which, alone or in conjunction with a discharge or discharges from other sources, both:

- Inhibits or disrupts the POTW, its treatment processes or operations, or its sludge processes, use or disposal; and
- Therefore is a cause of a violation of any requirement of the POTW's NPDES permit (including an increase in the magnitude or duration of a violation) or of the prevention of sewage sludge use or disposal in compliance with the following statutory provisions and regulations or permits issued thereunder (or more stringent State or local regulations): Section 405 of the Clean Water Act, the Solid Waste Disposal Act (SWDA) (including title II, more commonly referred to as the Resource Conservation and Recovery Act (RCRA), and including State regulations contained in any State sludge management plan prepared pursuant to subtitle D of the SWDA), sludge regulations appearing in 40 CFR Part 507, the Clean Air Act, the Toxic Substances Control Act, and the Marine Protection, Research and Sanctuaries Act.

Local limits -- Specific prohibitions or limits on pollutants or pollutant parameters developed by a POTW.

Major facility -- A facility discharging to surface water with an EPA rating score of > 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Maximum daily discharge limit -- The highest allowable daily discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge is calculated as the average measurement of the pollutant over the day.

Maximum day design flow (MDDF) -- The largest volume of flow anticipated to occur during a one-day period, expressed as a daily average.

Maximum month design flow (MMDF) -- The largest volume of flow anticipated to occur during a continuous 30-day period, expressed as a daily average.

Maximum week design flow (MWDF) -- The largest volume of flow anticipated to occur during a continuous 7-day period, expressed as a daily average.

Method detection level (MDL) -- See Detection Limit.

Minor facility -- A facility discharging to surface water with an EPA rating score of < 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Mixing zone -- An area that surrounds an effluent discharge within which water quality criteria may be exceeded. The permit specifies the area of the authorized mixing zone that Ecology defines following procedures outlined in state regulations (chapter 173-201A WAC).

National pollutant discharge elimination system (NPDES) -- The NPDES (Section 402 of the Clean Water Act) is the federal wastewater permitting system for discharges to navigable waters of the United States. Many states, including the state of Washington, have been delegated the authority to issue these permits. NPDES permits issued by Washington State permit writers are joint NPDES/State permits issued under both state and federal laws.

pH -- The pH of a liquid measures its acidity or alkalinity. It is the negative logarithm of the hydrogen ion concentration. A pH of 7 is defined as neutral and large variations above or below this value are considered harmful to most aquatic life.

Pass-through -- A discharge which exits the POTW into waters of the State in quantities or concentrations which, alone or in conjunction with a discharge or discharges from other sources, is a cause of a violation of any requirement of the POTW's NPDES permit (including an increase in the magnitude or duration of a violation), or which is a cause of a violation of State water quality standards.

Peak hour design flow (PHDF) -- The largest volume of flow anticipated to occur during a one-hour period, expressed as a daily or hourly average.

Peak instantaneous design flow (PIDF) -- The maximum anticipated instantaneous flow.

Point of compliance -- The location in the groundwater where the enforcement limit must not be exceeded and a facility must comply with the Ground Water Quality Standards. Ecology determines this limit on a site-specific basis. Ecology locates the point of compliance in the groundwater as near and directly downgradient from the pollutant source as technically, hydrogeologically, and geographically feasible, unless it approves an alternative point of compliance.

Potential significant industrial user (PSIU) -- A potential significant industrial user is defined as an Industrial User that does not meet the criteria for a Significant Industrial User, but which discharges wastewater meeting one or more of the following criteria:

a. Exceeds 0.5 % of treatment plant design capacity criteria and discharges <25,000 gallons per day; or

b. Is a member of a group of similar industrial users which, taken together, have the potential to cause pass through or interference at the POTW (e.g. facilities which develop photographic film or paper, and car washes).

Ecology may determine that a discharger initially classified as a potential significant industrial user should be managed as a significant industrial user.

Quantitation level (QL) -- Also known as Minimum Level of Quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the lab has used all method-specified sample weights, volumes, and cleanup procedures. The QL is calculated by multiplying the MDL by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer (64 FR 30417).
ALSO GIVEN AS:
The smallest detectable concentration of analyte greater than the Detection Limit (DL) where the accuracy (precision & bias) achieves the objectives of the intended purpose. (Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs Submitted to the US Environmental Protection Agency, December 2007).

Reasonable potential -- A reasonable potential to cause a water quality violation, or loss of sensitive and/or important habitat.

Responsible corporate officer -- A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or have gross annual sales or expenditures exceeding $25 million (in second quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures (40 CFR 122.22).

Sample Maximum -- No sample may exceed this value.

Significant industrial user (SIU) --

1) All industrial users subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, Subchapter N; and
2) Any other industrial user that: discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, noncontact cooling, and boiler blow-down wastewater); contributes a process wastestream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or is designated as such by the Control Authority* on the basis that the industrial user has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement [in accordance with 40 CFR 403.8(f)(6)].

Upon finding that the industrial user meeting the criteria in paragraph 2, above, has no reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement, the Control Authority* may at any time, on its own initiative or in response to a petition received from an industrial user or POTW, and in accordance with 40 CFR 403.8(f)(6), determine that such industrial user is not a significant industrial user.

*The term "Control Authority" refers to the Washington State Department of Ecology in the case of non-delegated POTWs or to the POTW in the case of delegated POTWs.

Slug discharge -- Any discharge of a non-routine, episodic nature, including but not limited to an accidental spill or a non-customary batch discharge to the POTW. This may include any pollutant released at a flow rate that may cause interference or pass through with the POTW or in any way violate the permit conditions or the POTW's regulations and local limits.

Soil scientist -- An individual who is registered as a Certified or Registered Professional Soil Scientist or as a Certified Professional Soil Specialist by the American Registry of Certified Professionals in Agronomy, Crops, and Soils or by the National Society of Consulting Scientists or who has the credentials for membership. Minimum requirements for eligibility are: possession of a baccalaureate, masters, or doctorate degree from a U.S. or Canadian institution with a minimum of 30 semester hours or 45 quarter hours professional core courses in agronomy, crops or soils, and have 5,3,or 1 years, respectively, of professional experience working in the area of agronomy, crops, or soils.

Solid waste -- All putrescible and non-putrescible solid and semisolid wastes including, but not limited to, garbage, rubbish, ashes, industrial wastes, swill, sewage sludge, demolition and construction wastes, abandoned vehicles or parts thereof, contaminated soils and contaminated dredged material, and recyclable materials.

Soluble BOD_5 -- Determining the soluble fraction of Biochemical Oxygen Demand of an effluent is an indirect way of measuring the quantity of soluble organic material present in an effluent that is utilized by bacteria. Although the soluble BOD_5 test is not specifically described in Standard Methods, filtering the raw sample through at least a 1.2 um filter prior to running the standard BOD_5 test is sufficient to remove the particulate organic fraction.

State waters -- Lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington.

Stormwater -- That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a stormwater drainage system into a defined surface water body, or a constructed infiltration facility.

Technology-based effluent limit -- A permit limit based on the ability of a treatment method to reduce the pollutant.

Total coliform bacteria -- A microbiological test, which detects and enumerates the total coliform group of bacteria in water samples.

Total dissolved solids -- That portion of total solids in water or wastewater that passes through a specific filter.

Total maximum daily load (TMDL) -- A determination of the amount of pollutant that a water body can receive and still meet water quality standards.

Total suspended solids (TSS) -- Total suspended solids is the particulate material in an effluent. Large quantities of TSS discharged to a receiving water may result in solids accumulation. Apart from any toxic effects attributable to substances leached out by water, suspended solids may kill fish, shellfish, and other aquatic organisms by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids can screen out light and can promote and maintain the development of noxious conditions through oxygen depletion.

Upset -- An exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limits because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, lack of preventative maintenance, or careless or improper operation.

Water quality-based effluent limit -- A limit imposed on the concentration of an effluent parameter to prevent the concentration of that parameter from exceeding its water quality criterion after discharge into receiving waters.

Appendix D--Technical Calculations

Several of the Excel® spreadsheet tools used to evaluate a discharger's ability to meet Washington State water quality standards can be found in the PermitCalc workbook on Ecology's webpage at: http://www.ecy.wa.gov/programs/wq/permits/guidance.html.

Simple Mixing:

Ecology uses simple mixing calculations to assess the impacts of certain conservative pollutants, such as the expected increase in fecal coliform bacteria at the edge of the chronic mixing zone boundary. Simple mixing uses a mass balance approach to proportionally distribute a pollutant load from a discharge into the authorized mixing zone. The approach assumes no decay or generation of the pollutant of concern within the mixing zone. The predicted concentration at the edge of a mixing zone (C_{mz}) is based on the following calculation:

$$C_{mz} = Ca + \frac{(Ce - Ca)}{DF}$$

where: Ce = Effluent Concentration
Ca = Ambient Concentration
DF = Dilution Factor

Reasonable Potential Analysis:

The spreadsheets Input 2 – Reasonable Potential, and LimitCalc in Ecology's PermitCalc Workbook determine reasonable potential (to violate the aquatic life and human health water quality standards) and calculate effluent limits. The process and formulas for determining reasonable potential and effluent limits in these spreadsheets are taken directly from the *Technical Support Document for Water Quality-based Toxics Control*, (EPA 505/2-90-001). The adjustment for autocorrelation is from EPA (1996a), and EPA (1996b).

Calculation of Water Quality-Based Effluent Limits:

Water quality-based effluent limits are calculated by the two-value wasteload allocation process as described on page 100 of the TSD (EPA, 1991) and shown below.

1. Calculate the acute wasteload allocation WLA_a by multiplying the acute criteria by the acute dilution factor and subtracting the background factor. Calculate the chronic wasteload allocation (WLA_c) by multiplying the chronic criteria by the chronic dilution factor and subtracting the background factor.

WLA_a = (acute criteria x DF_a) – [(background conc. x (DF_a - 1)]

WLA_c = (chronic criteria x DF_c) – [(background conc. x (DF_c -1)]

where: DF_a = Acute Dilution Factor
DF_c = Chronic Dilution Factor

2. Calculate the long term averages (LTA_a and LTA_c) which will comply with the wasteload allocations WLA_a and WLA_c.

$LTA_a = WLA_a \times e^{[0.5\sigma^2 - z\sigma]}$

where: $\sigma^2 = \ln[CV^2 + 1]$

$z = 2.326$

CV = coefficient of variation = std. dev/mean

$LTA_c = WLA_c \times e^{[0.5\sigma^2 - z\sigma]}$

where: $\sigma^2 = \ln[(CV^2 \div 4) + 1]$

$z = 2.326$

3. Use the smallest LTA of the LTA_a or LTA_c to calculate the maximum daily effluent limit and the monthly average effluent limit.

MDL = Maximum Daily Limit

$MDL = LTA x\, e^{(Z\sigma - 0.5\sigma^2)}$

where: $\sigma^2 = \ln[CV^2 + 1]$

z = 2.326 (99th percentile occurrence)

LTA = Limiting long term average

AML = Average Monthly Limit

$AML = LTA x\, e^{(Z\sigma_n - 0.5\sigma_n^2)}$

where: $\sigma^2 = \ln[(CV^2 \div n) + 1]$

n = number of samples/month

z = 1.645 (95th % occurrence probability)

LTA = Limiting long term average

Reasonable Potential Calculations

Reasonable Potential Calculation

Facility	Central Kitsap WWTP
Water Body Type	Marine

Dilution Factors:	Acute	Chronic
Aquatic Life	47.0	84.0
Human Health Carcinogenic		91.0
Human Health Non-Carcinogenic		84.0

Pollutant, CAS No. & NPDES Application Ref. No.			AMMONIA, Criteria as Total NH3	COPPER - 744058 6M Hardness dependent	MERCURY 7439976 8M	NICKEL - 7440020 9M - Dependent on hardness	PHENOL 108952 10A	ZINC- 7440666 13M hardness dependent				
Effluent Data	# of Samples (n)		139	103	3	103	3	103				
	Coeff of Variation (Cv)		0.22	0.02	0.6	0.21	0.6	0.1	0.6	0.6	0.6	0.6
	Effluent Concentration, ug/L (Max. or 95th Percentile)		50,300	14.5	0.0037	5.1	20	62.3				
	Calculated 50th percentile Effluent Conc. (when n>10)					4.3						
Receiving Water Data	90th Percentile Conc., ug/L		90	0	0	0	0	0	0			
	Geo Mean, ug/L				0	0	0	0				
Water Quality Criteria	Aquatic Life Criteria, ug/L	Acute	3,776	4.8	1.8	74	-	90				
		Chronic	567	3.1	0.025	8.2	-	81				
	WQ Criteria for Protection of Human Health, ug/L		-	-	0.15	4600	5E+06	-				
	Metal Criteria Translator, decimal	Acute	-	0.83	0.85	0.99	-	0.946				
		Chronic	-	0.83	-	0.99	-	0.946				
	Carcinogen?		N	N	N	N	N	N				

Aquatic Life Reasonable Potential

Effluent percentile value		0.950	0.950	0.950	0.950		0.950
s	$s^2=\ln(CV^2+1)$	0.217	0.020	0.555	0.208		0.090
Pn	$Pn=(1\text{-confidence level})^{1/n}$	0.979	0.971	0.368	0.971		0.971
Multiplier		1.00	1.00	3.00	1.00		1.00
Max concentration (ug/L) at edge of...	Acute	1,158	0.256	0.000	0.107		1.254
	Chronic	688	0.143	0.000	0.060		0.702
Reasonable Potential? Limit Required?		**YES**	**NO**	**NO**	**NO**		**NO**

Aquatic Life Limit Calculation

# of Compliance Samples Expected per month		4
LTA Coeff. Var. (CV), decimal		0.22
Permit Limit Coeff. Var. (CV), decimal		0.22
Waste Load Allocations, ug/L	Acute	173339
	Chronic	40177.55
Long Term Averages, ug/L	Acute	107039.4
	Chronic	31319.19
Limiting LTA, ug/L		31319.19
Metal Translator or 1?		1.00
Average Monthly Limit (AML), ug/L		**37286.2**
Maximum Daily Limit (MDL), ug/L		**50718.2**

Human Health Reasonable Potential

s	$s^2=\ln(CV^2+1)$			0.5545	0.2077	0.5545	
Pn	Pn=(1-confidence level)1/n			0.368	0.971	0.368	
Multiplier				1.2049	0.6738	1.2049	
Dilution Factor				84	84	84	
Max Conc. at edge of Chronic Zone, ug/L				5E-05	0.0512	2.9E-01	
Reasonable Potential? Limit Required?				**NO**	**NO**	**NO**	

Fecal Coliform Calculations

Calculation of Fecal Coliform at Chronic Mixing Zone

INPUT	
Chronic Dilution Factor	84.0
Receiving Water Fecal Coliform, #/100 ml	3
Effluent Fecal Coliform - worst case, #/100 ml	400
Surface Water Criteria, #/100 ml	*14*
OUTPUT	
Fecal Coliform at Mixing Zone Boundary, #/100 ml	**8**
Difference between mixed and ambient, #/100 ml	5

Conclusion: At design flow, the discharge has no reasonable potential to violate water quality standards for fecal coliform.

Dissolved Oxygen Calculations

Calculation of Dissolved Oxygen at Chronic Mixing Zone

INPUT	
Chronic Dilution Factor	84.0
Receiving Water DO Concentration, mg/L	9.8
Effluent DO Concentration, mg/L	7.4
Effluent Immediate DO Demand (IDOD), mg/L	7
Surface Water Criteria, mg/L	*7*
OUTPUT	
DO at Mixing Zone Boundary, mg/L	**9.68**
DO decrease caused by effluent at chronic boundary, mg/L	**0.12**

Conclusion: At design flow, the discharge has no reasonable potential to violate water quality standards for dissolved oxygen.

Ammonia Calculations

Marine Un-ionized Ammonia Criteria Calculation

Calculation of seawater fraction of un-ionized ammonia from Hampson (1977). Un-ionized ammonia criteria for salt water are from EPA 440/5-88-004. Revised 19-Oct-

INPUT	
1. Receiving Water Temperature, deg C (90th percentile):	17.0
2. Receiving Water pH, (90th percentile):	8.3
3. Receiving Water Salinity, g/kg (10th percentile):	30.4
4. Pressure, atm (EPA criteria assumes 1 atm):	1.0
5. Unionized ammonia criteria (mg un-ionized NH_3 per liter) from EPA 440/5-88-004:	
Acute:	0.233
Chronic:	0.035
OUTPUT	
Using mixed temp and pH at mixing zone boundaries?	No
1. Molal Ionic Strength (not valid if >0.85):	0.625
2. pKa8 at 25 deg C (Whitfield model "B"):	9.317
3. Percent of Total Ammonia Present as Unionized:	5.1%
4. Total Ammonia Criteria (mg/L as $\underline{NH_3}$):	
Acute:	4.59
Chronic:	0.69
RESULTS	
Total Ammonia Criteria (mg/L as N)	
Acute:	**3.78**
Chronic:	**0.57**

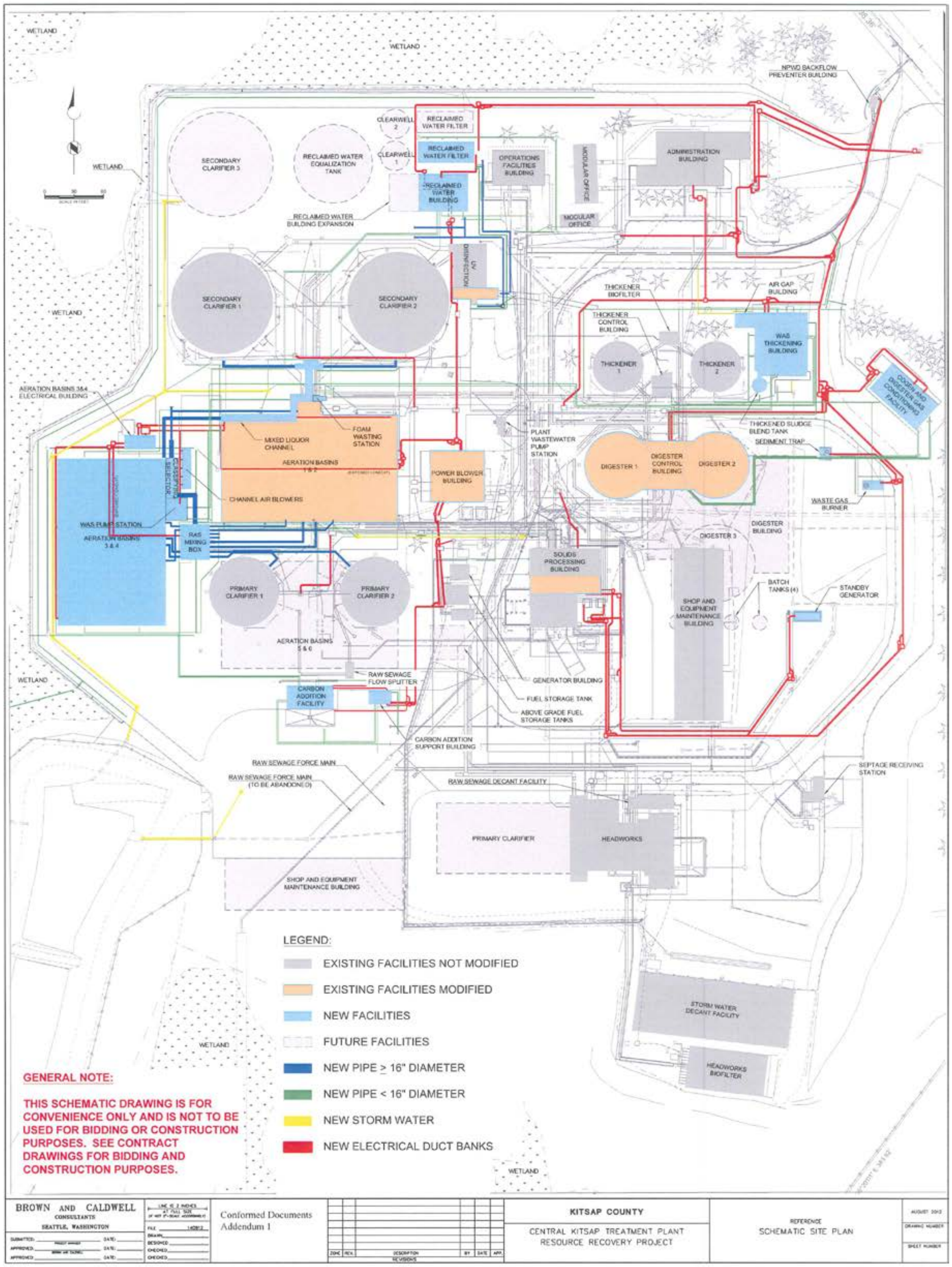
Temperature Calculations

Marine Temperature Reasonable Potential and Limit Calculation

Based on WAC 173-201A-200(1)(c)(i)--(ii) and Water Quality Program Guidance. All Data inputs must meet WQ guidelines. The Water Quality temperature guidance document may be found at: http://www.ecy.wa.gov/biblio/0610100.html

INPUT	May-Sep	Oct-Apr
1. Chronic Dilution Factor at Mixing Zone Boundary	84.0	84.0
2. Annual max 1DADMax Ambient Temperature (Background 90th percentile)	17.0 °C	11.4 °C
3. 1DADMax Effluent Temperature (95th percentile)	22.1 °C	17.6 °C
4. Aquatic Life Temperature WQ Criterion	13.0 °C	13.0 °C
OUTPUT		
5. Temperature at Chronic Mixing Zone Boundary:	17.06 °C	11.47 °C
6. Incremental Temperature Increase or decrease:	0.06 °C	0.07 °C
7. Incremental Temperature Increase 12/(T-2) if T≤ crit:	---	1.28 °C
8. Maximum Allowable Temperature at Mixing Zone Boundary:	17.30 °C	12.68 °C
A. If ambient temp is warmer than WQ criterion		
9. Does temp fall within this warmer temp range?	YES	NO
10. Temp increase allowed at mixing zone boundary, if required:	NO LIMIT	---
B. If ambient temp is cooler than WQ criterion but within 12/(T_{amb}-2) and within 0.3 °C of the criterion		
11. Does temp fall within this incremental temp. range?	---	NO
12. Temp increase allowed at mixing zone boundary, if required:	---	---
C. If ambient temp is cooler than (WQ criterion-0.3) but within 12/(T_{amb}-2) of the criterion		
13. Does temp fall within this Incremental temp. range?	---	NO
14. Temp increase allowed at mixing zone boundary, if required:	---	---
D. If ambient temp is cooler than (WQ criterion - 12/(T_{amb}-2))		
15. Does temp fall within this Incremental temp. range?	---	YES
16. Temp increase allowed at mixing zone boundary, if required:	---	NO LIMIT
RESULTS		
17. Do any of the above cells show a temp increase?	**NO**	**NO**
18. Temperature Limit if Required?	**NO LIMIT**	**NO LIMIT**

Appendix E--Central Kitsap WWTP Schematic Diagram

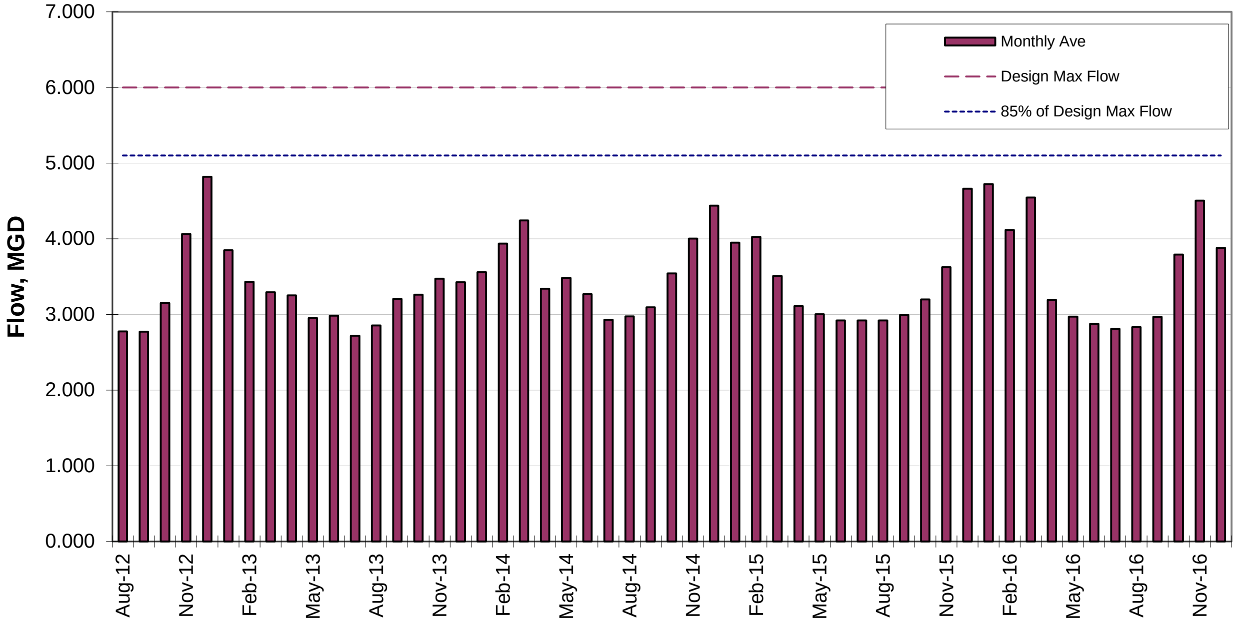


Appendix F--Central Kitsap WWTP Data (2012 – 2016)

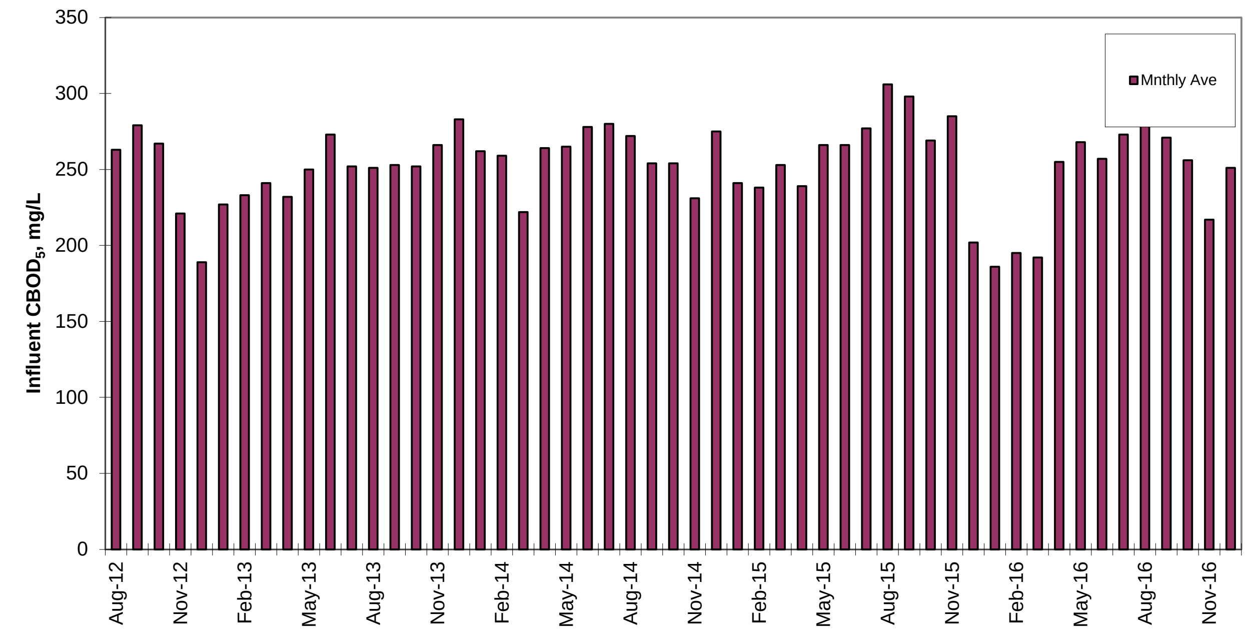
	Influent							
Date	Flow, MGD	Flow, MGD	CBOD, mg/L	BOD, mg/L	CBOD, ppd	BOD, ppd	TSS, mg/L	TSS, ppd
v	Monthly Ave	Monthly Max	Mnthly Ave	Mnthly Ave	Mnthly Ave	Mnthly Ave	Mnthly Ave	Mnthly Ave
8/1/2012	2.8	3.2	263	295	6074	6874	295	6836
9/1/2012	2.8	3.0	279	311	6550	7197	292	6851
10/1/2012	3.2	4.9	267	293	6922	7602	284	7372
11/1/2012	4.1	8.5	221	242	7605	8380	251	8878
12/1/2012	4.8	7.7	189	205	7570	8150	247	9854
1/1/2013	3.8	5.7	227	287	7237	9110	273	8651
2/1/2013	3.4	3.7	233	282	6727	8201	277	8009
3/1/2013	3.3	4.2	241	275	6675	7666	275	7618
4/1/2013	3.3	4.2	232	295	6313	7758	283	7675
5/1/2013	3.0	3.4	250	307	6237	7719	309	7758
6/1/2013	3.0	4.6	273	303	6687	7627	304	7457
7/1/2013	2.7	3.2	252	304	5669	6918	290	6554
8/1/2013	2.9	3.5	251	285	6011	6945	318	7649
9/1/2013	3.2	5.1	253	276	6960	7111	301	8274
10/1/2013	3.3	3.8	252	272	6861	7358	278	7573
11/1/2013	3.5	4.0	266	286	7884	8641	285	8457
12/1/2013	3.4	3.8	283	315	8194	9214	329	9513
1/1/2014	3.6	5.5	262	290	7704	8387	289	8484
2/1/2014	3.9	5.4	259	278	8509	9066	260	8532
3/1/2014	4.2	6.6	222	252	7832	8829	255	9057
4/1/2014	3.3	4.0	264	278	7449	7940	282	7950
5/1/2014	3.5	4.6	265	284	7720	8279	282	8181
6/1/2014	3.3	3.8	278	303	7714	8335	291	8110
7/1/2014	2.9	3.3	280	294	6908	7247	332	8169
8/1/2014	3.0	4.5	272	286	6937	7550	301	7632
9/1/2014	3.1	4.1	254	284	6516	7512	285	7334
10/1/2014	3.5	4.7	254	279	7418	8351	295	8678
11/1/2014	4.0	5.1	231	286	7758	9575	279	9406
12/1/2014	4.4	6.7	275	268	9854	9919	255	9408
1/1/2015	3.9	5.0	241	288	7948	9232	280	9271
2/1/2015	4.0	6.2	238	274	7842	8914	266	8852
3/1/2015	3.5	5.3	253	267	7489	7594	253	7508
4/1/2015	3.1	3.4	239	293	6084	7393	272	6936
5/1/2015	3.0	3.2	266	306	6712	7703	316	7992
6/1/2015	2.9	3.1	266	322	6509	7909	281	6891
7/1/2015	2.9	3.2	277	306	6790	7542	301	7368
8/1/2015	2.9	3.4	306	346	7457	8357	323	7847
9/1/2015	3.0	3.2	298	325	7493	8149	312	7865
10/1/2015	3.2	3.9	269	302	7141	7986	281	7438
11/1/2015	3.6	5.2	285	293	8728	8752	245	7511
12/1/2015	4.7	6.9	202	246	7731	9168	209	8128
1/1/2016	4.7	8.5	186	249	7196	10041	218	8800
2/1/2016	4.1	4.5	195	251	6639	8460	209	7133
3/1/2016	4.5	6.7	192	232	7156	8480	209	7940
4/1/2016	3.2	3.5	255	288	6854	7633	256	6883
5/1/2016	3.0	3.3	268	320	6691	7863	270	6721
6/1/2016	2.9	3.3	257	325	6191	7961	280	6745
7/1/2016	2.8	3.2	273	310	6409	7382	289	6785
8/1/2016	2.8	3.2	287	306	6849	7249	284	6782
9/1/2016	3.0	3.3	271	316	6730	7828	331	8247
10/1/2016	3.8	5.1	256	265	7997	8360	281	8820
11/1/2016	4.5	6.9	217	236	7842	8391	233	8442
12/1/2016	3.9	4.6	251	280	8144	9071	272	8856
AVE:	3.5	4.6	252.8	286.1	7190.9	8129.8	278.6	7956
MIN:	2.7	3.0	186	205	5669	6874	209	6554
MAX:	4.8	8.5	306	346	9854	10041	332	9854

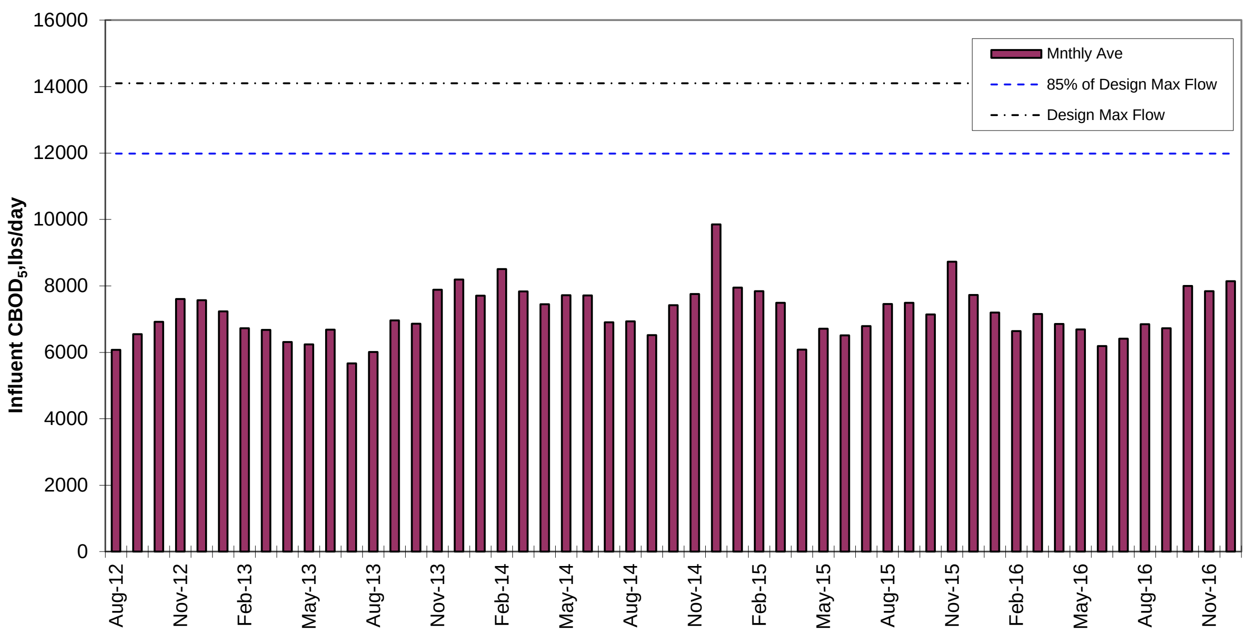
	Effluent													
Date	CBOD, mg/L	CBOD, mg/L	CBOD, ppd	CBOD, ppd	CBOD, % Removal	TSS, mg/L	TSS, mg/L	TSS, ppd	TSS, ppd	TSS, % Removal	PH	PH	Fecal Coliform,	Fecal Coliform,
v	Mnthly Ave	Wkly Ave	Mnthly Ave	Wkly Ave	Ave	Mnthly Ave	Wkly Ave	Mnthly Ave	Wkly Ave	Ave	Min	Max	GEM	GM7
8/1/2012	4.9	6.3	114	143	98.1	9.3	10.3	216	244	95.5	7.6	7.7	33.4	38
9/1/2012	11.0	20	259	471	96	9.6	11.9	224	269	96.4	7.6	7.7	34.5	101
10/1/2012	7.7	8.3	199	236	97.1	10.1	11.3	262	276	95.9	7.5	7.7	40	76
11/1/2012	8.0	10.9	300	501	96.2	11	14.8	410	683	96.7	7.3	7.6	27	55
12/1/2012	9.1	10	372	474	95.1	12.4	14.8	511	698	96.5	7.1	7.4	23	47
1/1/2013	10.0	12.3	325	445	95.5	16	20.7	517	722	96.2	7.3	7.5	22.6	62
2/1/2013	6.3	8	182	225	97.3	9.8	12.2	282	350	96.1	7.3	7.6	25.4	53
3/1/2013	7.2	8.7	198	249	97	11	12.6	304	361	95	7.4	7.8	31	45
4/1/2013	6.6	8.3	179	221	97.1	11.2	13.2	303	250	94.8	7.3	7.6	31.8	58
5/1/2013	8.9	10.1	224	240	96.4	13.3	15.3	333	377	94.4	7.4	7.6	39	72
6/1/2013	9.7	12.6	235	288	96.4	13.4	14.9	326	358	95.9	7.4	7.7	42.1	53
7/1/2013	7.5	9.3	168	204	97	10.4	12.4	233	272	96.6	7.3	7.8	25.3	44
8/1/2013	6.5	6.7	155	157	97.4	12.9	16.8	311	426	95.8	7.4	7.8	29.9	75
9/1/2013	6.3	7.7	171	203	97.5	9.9	12.5	268	331	96	7.34	7.87	50.3	66
10/1/2013	5.9	7.4	159	193	97.7	9.6	11.5	262	321	95.6	7.4	7.7	26.4	35
11/1/2013	6.4	8	188	231	97.6	10.8	12.2	317	355	97.1	7.4	7.7	34.6	42
12/1/2013	9.0	9.8	260	283	96.8	12.9	14.5	372	419	96.7	7.3	7.6	39	26
1/1/2014	9.9	12.7	290	361	96.2	14.2	17.3	418	492	96.4	7.3	7.6	29.2	15
2/1/2014	9.4	11.4	314	381	96.3	13.3	14.5	451	617	95.9	7.29	7.53	37.7	56
3/1/2014	8.9	10	320	408	95.9	14	15.6	505	647	94.2	7.2	7.6	16.4	31
4/1/2014	7.0	9.4	200	288	97.3	11.2	14.4	318	443	94.3	7.3	7.7	35.9	55
5/1/2014	6.3	7.2	185	217	97.6	9.4	10.8	275	289	95.4	7.34	7.65	31.7	27
6/1/2014	8.6	9.5	235	245	96.9	12.2	14.4	335	380	92.6	7.3	7.63	38.5	42
7/1/2014	8.1	9.8	201	252	97.1	13.1	16.6	326	417	95.5	7.1	7.7	43.7	36
8/1/2014	7.3	10.9	182	264	97.3	12.8	17.1	320	413	92.6	7.4	7.8	40.6	148
9/1/2014	5.2	7.2	133	170	97.9	8.3	8.8	212	238	93.8	7.2	7.8	33	49
10/1/2014	5.8	7.3	168	203	97.7	9.8	11.5	286	323	89.1	7.35	7.68	36.9	40
11/1/2014	5.6	6.8	191	222	97.5	10	11.4	338	368	96.3	7.17	7.63	38.6	83
12/1/2014	7.8	10.1	287	389	96.7	10.3	11.4	384	450	95.4	7.22	7.63	35.7	15
1/1/2015	8.2	10.2	272	338	96.5	15.9	20.6	525	686	94	7.15	7.52	33.5	14
2/1/2015	9.8	12.6	320	396	95.9	14.8	17.5	488	582	94.1	7.35	7.67	36.1	27
3/1/2015	7.6	9.4	228	320	97	11.6	13.6	347	430	96.7	7.14	7.54	30.2	21
4/1/2015	9.0	13.2	232	349	96.2	20.2	36.6	525	970	96.9	7.21	7.58	26.2	57
5/1/2015	8.0	9.3	200	233	96.9	13.8	15.1	348	379	97.9	7.33	7.71	40.6	36
6/1/2015	10.5	15.4	257	375	96.1	20.6	25.3	504	616	98.4	7.26	7.69	44.7	84
7/1/2015	9.0	11	220	268	96.7	18.5	23.1	452	556	98.7	7.35	7.66	40.2	52
8/1/2015	12.5	20.6	306	495	95.9	29.4	62.8	714	1513	98.7	7.26	7.57	39	121
9/1/2015	7.8	10.7	196	287	97.3	11.6	13.9	291	346	98.4	7.28	7.64	42.8	29
10/1/2015	6.6	8.16	176	225	97.5	12.8	15.1	341	418	98.6	7.21	7.53	29.9	23
11/1/2015	8.5	10.6	260	308	97	14.7	21.5	444	624	99	7.05	7.42	31.7	39
12/1/2015	4.9	9.5	197	321	97.5	12.3	16.8	497	797	98.3	6.89	7.33	25.8	25
1/1/2016	3.4	4.2	137	148	98.1	7.1	8.5	281	314	98.5	6.86	7.41	21.9	8
2/1/2016	3.9	4.41	133	149	98	6.5	8.2	222	299	98.8	6.74	7.45	16.7	20
3/1/2016	3.6	4.5	139	201	98.1	4.4	5.8	170	262	99.5	6.89	7.46	24.3	34
4/1/2016	4.0	4.34	108	117	98.4	4.17	4.8	112	121	99.5	7.06	7.58	32.8	64
5/1/2016	3.5	4.25	86.3	105	98.7	3.45	4.2	85.9	106	99.4	7.27	7.68	35.8	34
6/1/2016	3.0	3.19	71.6	73	98.8	3.68	4.0	88.4	92.2	99.2	7.27	7.6	32.5	40
7/1/2016	3.4	4.07	78.6	94.5	98.8	4.63	6.0	108	140	99.3	7.33	7.71	27.7	35
8/1/2016	2.8	3.65	67.4	83.1	99	4.05	6.2	96.5	146	97.9	7.34	7.65	37.6	48
9/1/2016	2.8	3.15	68.4	82.5	99	3.17	3.8	78.4	90	98.8	7.06	7.85	25.2	48
10/1/2016	2.6	3.1	85	109	98.9	4.5	5.9	149	218	99.0	7	7.82	30	47
11/1/2016	2.2	3.3	82.6	120	98.9	3.44	5.0	128	183	98.8	7.05	7.46	22.5	18
12/1/2016	1.8	1.89	57.8	60.4	99.3	3.1	3.2	101	103	99.1	7.14	7.41	25	9
AVE:	6.8	8.7	195.7	253	97.3	10.95	14.02	315.4	411	96.61	7.25	7.63	32.56	46.75
MIN:	1.8	1.9	57.8	60.4	95.1	3.1	3.21	78.4	90	89.1	6.74	7.33	16.4	8
MAX:	12.5	20.6	372	501	99.3	29.4	62.8	714	1513	99.5	7.6	7.87	50.3	148

Central Kitsap WWTP Influent – Flow

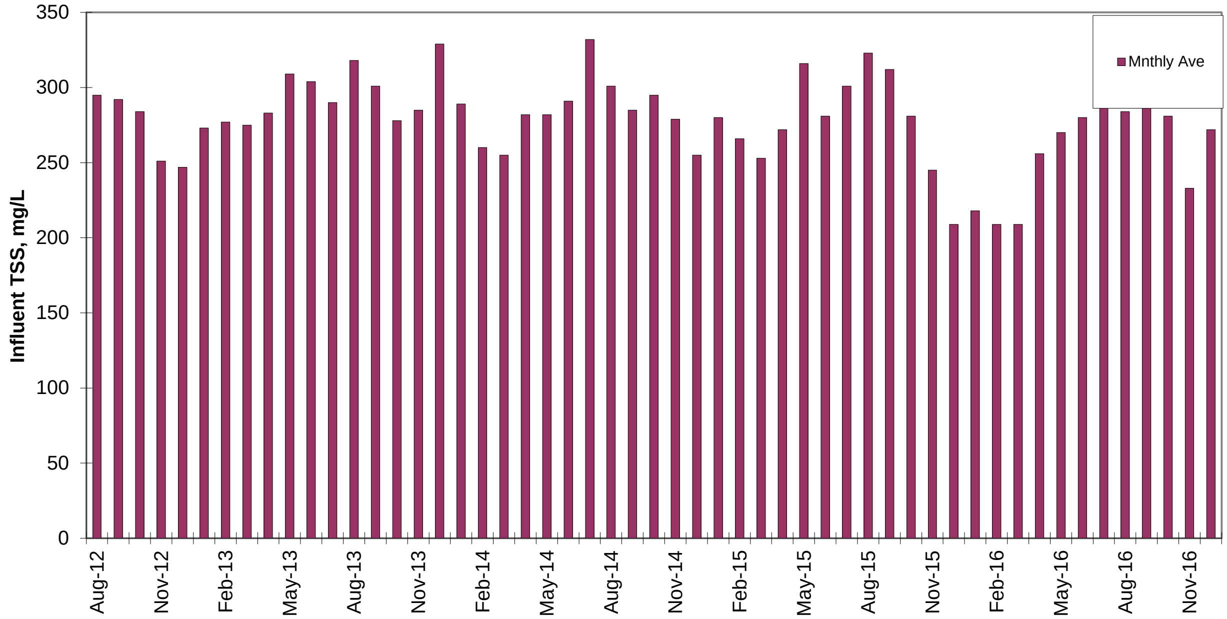


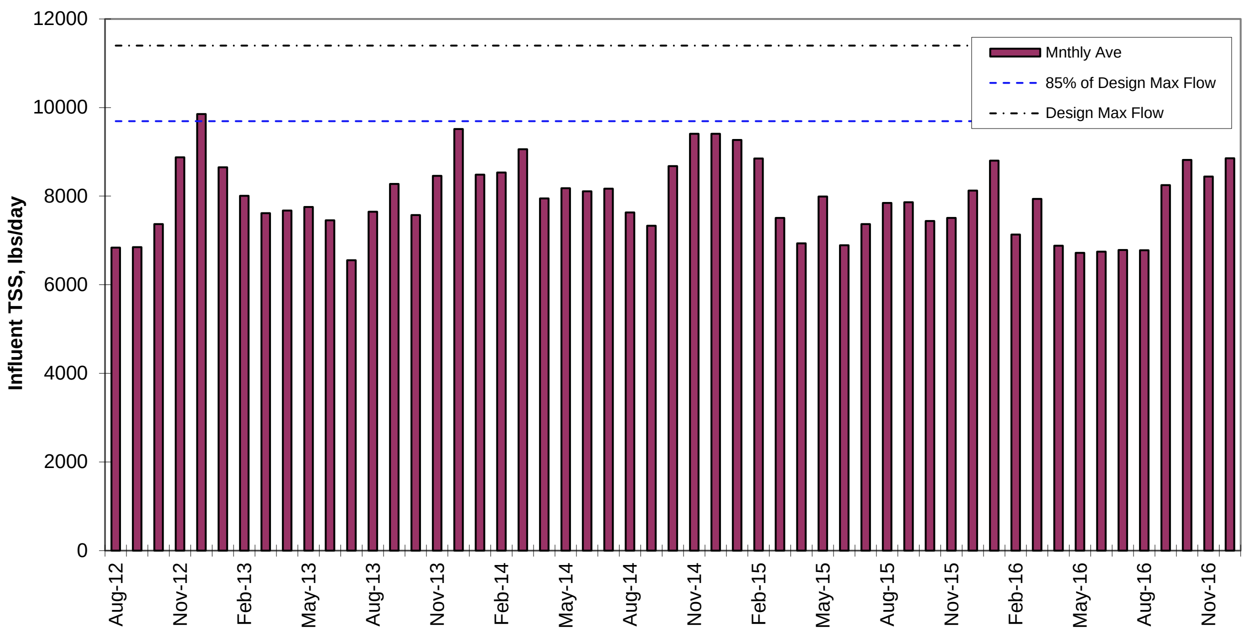
Central Kitsap WWTP Influent – $CBOD_5$



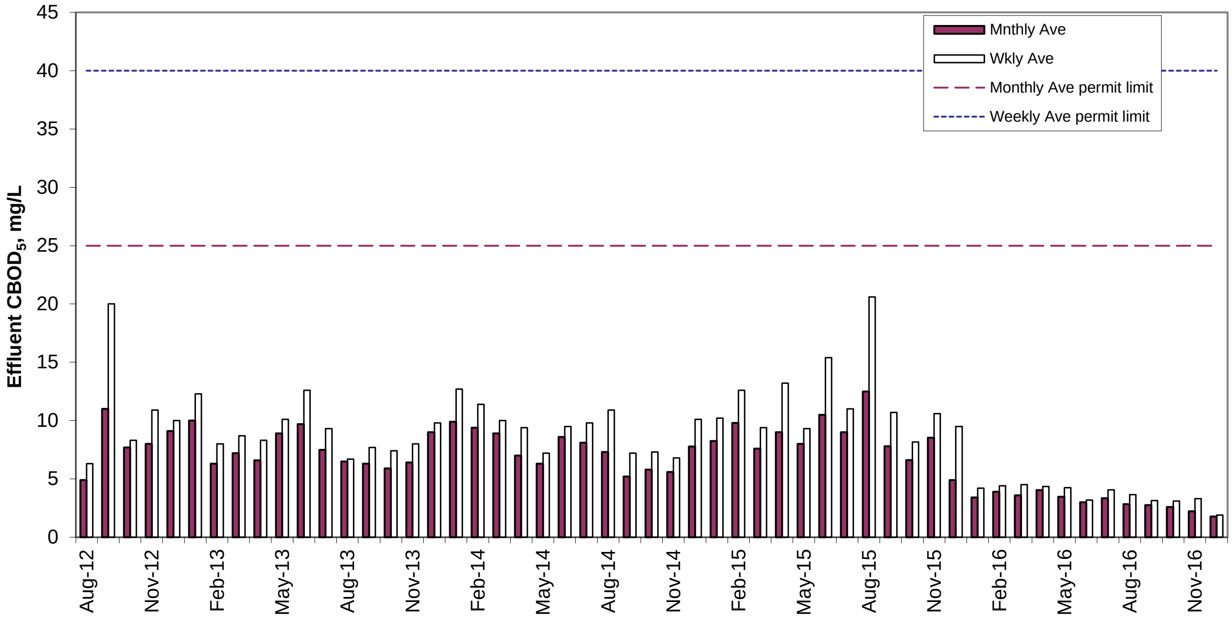


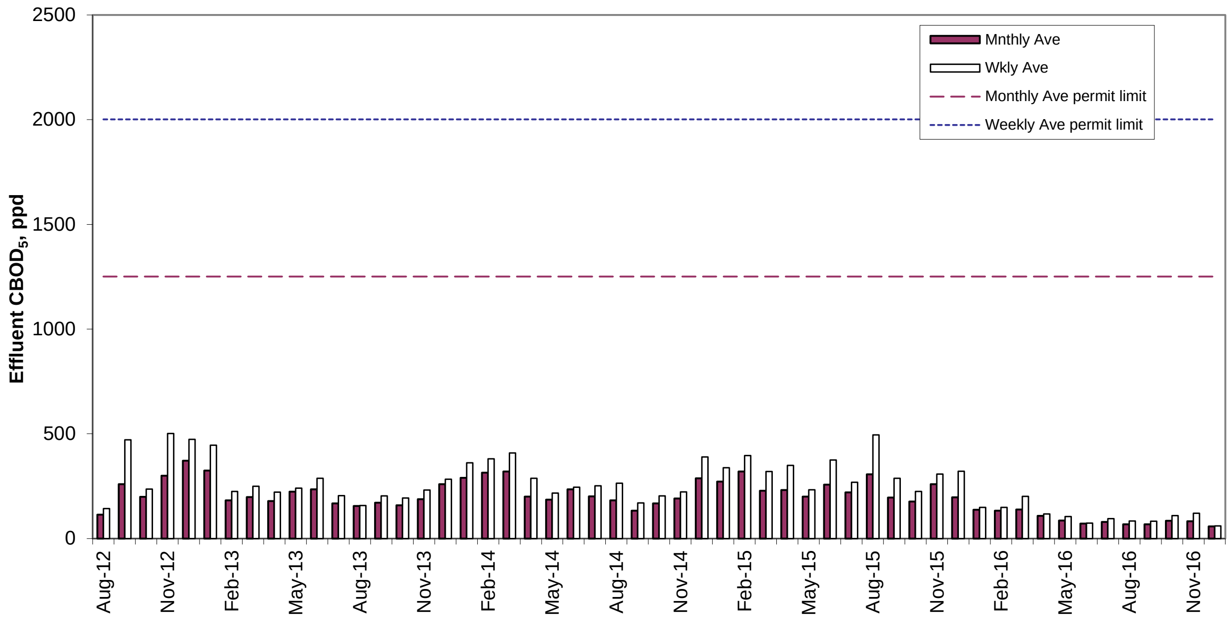
Central Kitsap WWTP Influent – TSS



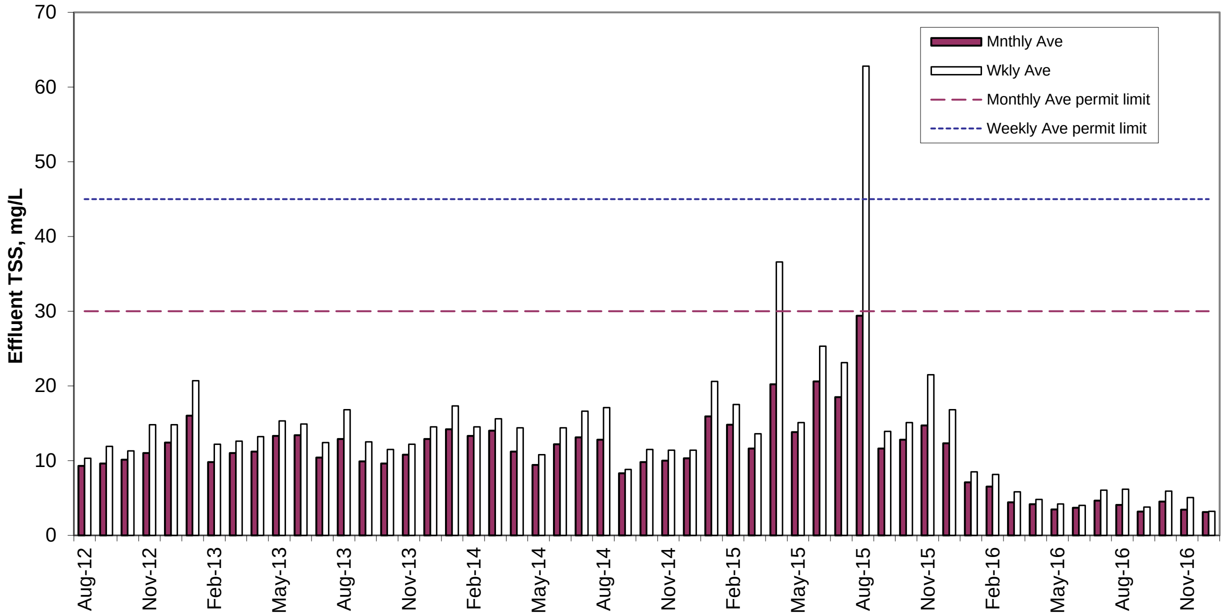


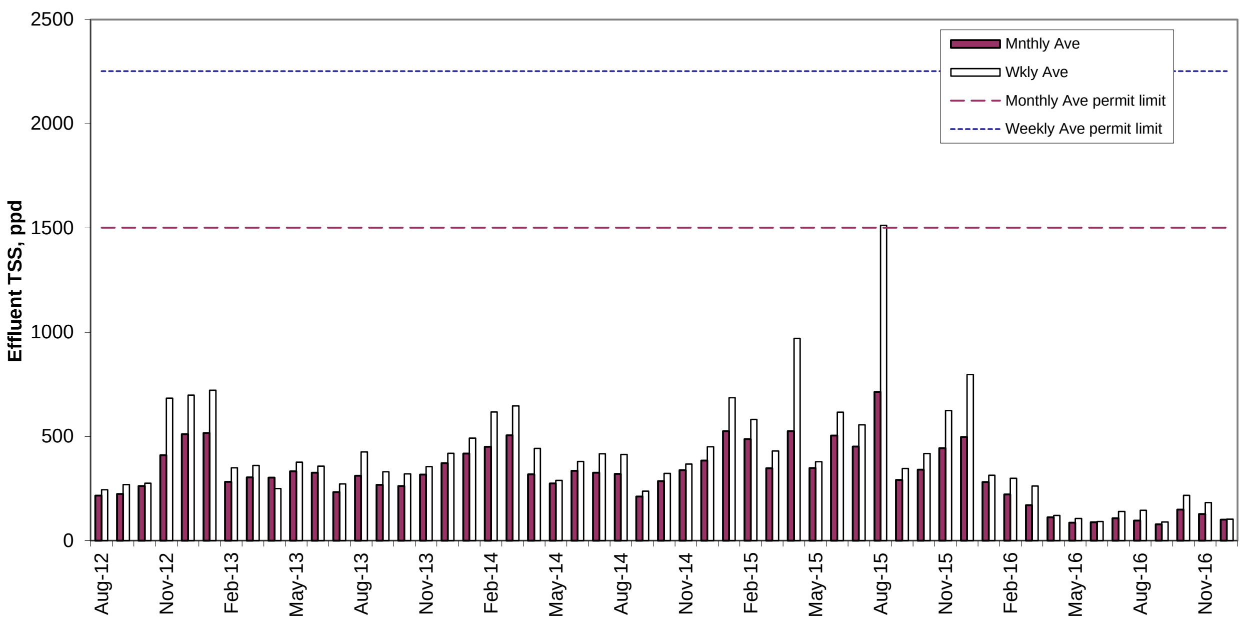
Central Kitsap WWTP Effluent – $CBOD_5$



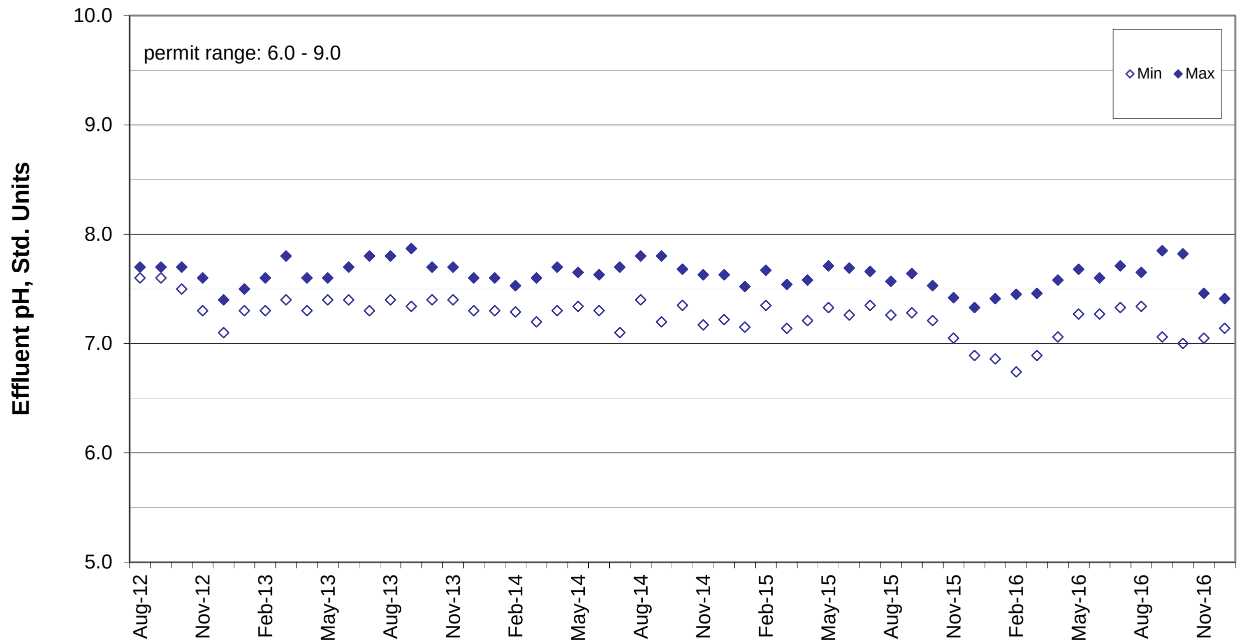


Central Kitsap WWTP Effluent – TSS

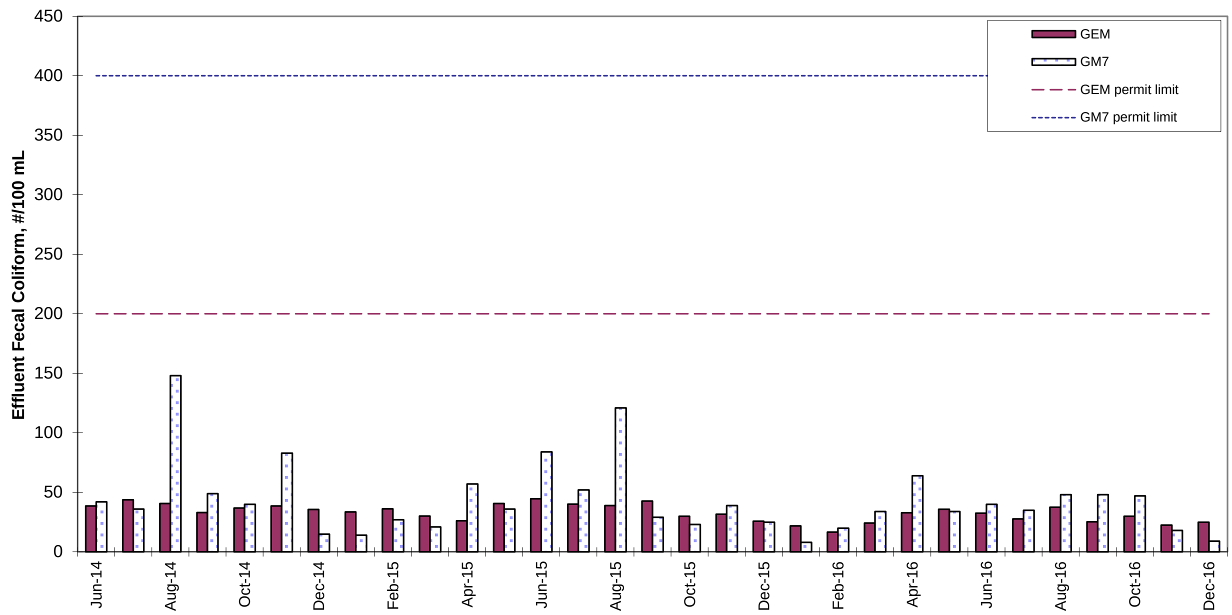




Central Kitsap WWTP Effluent – pH



Central Kitsap WWTP Effluent – Fecal Coliform



Appendix G--Monitoring Frequency Reduction Analysis

Ecology's *Permit Writer's Manual* (PWM) recommends minimum monitoring based on the size and complexity of the facility. The PWM also provides guidelines for reduction in monitoring frequency based on demonstrated good performance. Central Kitsap WWTP had no fecal coliform violations in the last 5 years and the monitoring frequency reduction analysis indicates that the facility qualifies for reduction in monitoring frequency. Facilities are not eligible for monitoring reduction for any parameter that exceeds one percent noncompliance during the past two years. Noncompliance includes monthly average, weekly average or daily maximum.

Reduction of monitoring frequency is generally granted at time of permit renewal by examination of performance in the two years preceding the permit renewal. The amount of reduction is dependent upon the ratio of performance for the last two years to the monthly average effluent limitation. The allowable monitoring frequency is shown in Table 1 below:

Table 1. Allowable Monitoring Frequency Based on Ratio of Long Term Effluent Average to the Average Monthly Limit

Baseline Monitoring Frequency	Ratio of Long Term Average (LTA) to Average Monthly Limit (AML) (LTA/AML)			
	75-66%	65-50%	49-25%	<25%
	Allowable Monitoring Frequency based on LTA/AML			
7/week	5/week	4/week	3/week	1/week

Table 2 shows a comparison of : (i) Recommended Minimum Monitoring Requirements in the PWM, (ii) Allowable Monitoring Frequency based on LTA/AML ratio, and (iii) Monitoring Frequency in the proposed permit. The DMR data analysis in Table 3 shows LTA/AML ratios for fecal coliform based on Central Kitsap WWTP monitoring data from December 2014 through December 2016.

Table 2. Comparison of PWM Recommended Monitoring Frequency, Allowable Monitoring Frequency, and Monitoring Frequency in the Proposed Permit

Parameter	Unit	LTA/AML (%)	PWM Recommended Monitoring Frequency	Allowable Monitoring Frequency based on LTA/AML	Monitoring Frequency in the Proposed Permit
Fecal Coliform	#/100 mL	20%	7/week	1/week	5/week

Table 3. DMR Data Analysis from December 2014 through December 2016

Central Kitsap DMR Data Analysis	
Date	Fecal Coliform (#/100 mL)
	Statistical Base: Geometric Mean
12/1/2014	15
1/1/2015	14
2/1/2015	27
3/1/2015	21
4/1/2015	57
5/1/2015	36
6/1/2015	84
7/1/2015	52
8/1/2015	148
9/1/2015	29
10/1/2015	23
11/1/2015	39
12/1/2015	25
1/1/2016	8
2/1/2016	20
3/1/2016	34
4/1/2016	64
5/1/2016	34
6/1/2016	40
7/1/2016	35
8/1/2016	48
9/1/2016	48
10/1/2016	47
11/1/2016	18
12/1/2016	9
LTA	39
AML*	200
LTA/AML	**20%**
*AML is equal to the monthly geometric mean	

Appendix H--Response to Comments

Kitsap County Entity Review Comments:

Kitsap County Comment # 1: Changed Carbonaceous Biochemical Oxygen Demand (5-day) to Biological Oxygen Demand (5-day). The County recognizes the change from CBOD to BOD for both influent and effluent parameters without issue.

Ecology's Response*: In 2015, the existing activated sludge system was expanded and modified to provide biological nitrogen removal, which increases the capability of the Central Kitsap WWTP to achieve optimal nitrification conditions. Therefore, the proposed permit requires 5-day biochemical oxygen demand (BOD_5) monitoring in lieu of carbonaceous biochemical oxygen demand ($CBOD_5$).*

Kitsap County Comment # 2: The County would like to request the raw data used to calculate the effluent ammonia RPA. The fact sheet for NPDES Permit WA0030520, pg. 55 shows the basic calculation, but lacks the individual data points used in the calculation. Please provide additional information including receiving water data used for the ammonia RPA calculation, worksheets that Ecology used for RPA calculation, and an example of a seasonal effluent limit for ammonia based on toxicity. The County would like this data to consider operational strategies due to the increase in operational cost with the testing as stated in the draft permit.

Ecology's Response*: Per County's request, Ecology will provide the data used in the reasonable potential analysis. Ecology used ambient background data from two of Ecology's long-term Monitoring Stations and the Central Kitsap WWTP's operating data from 2012 through 2017.*

Kitsap County Comment # 3: This section should reference footnote "E" for fecal coliform calculations.

Ecology's Response*: Footnote "e" is correct. It provides directions to calculate the monthly and the weekly geometric mean.*

Kitsap County Comment # 4: The County would like clarification for the increase in Influent BOD and TSS testing increments from 3/week to 5/week. This increase does not allow for holiday weeks or composite sampler issues without creating overtime. The County has complied with the previous permit for CBOD and TSS 3/week requirement without any violations occurring during the previous permit cycle. The violation listed in the fact sheet on December 1, 2012 was not a violation of CBOD or TSS, but a one time exceedance of the 85% capacity of the facility. The County requests this parameter remain at the current 3/week.

Ecology's Response*: Criteria published in Ecology's Permit Writer's Manual and WAC 173-230 classify the treatment system at Central Kitsap WWTP as a Group IV facility with 6 MGD design flow. Per Ecology's Permit Writer's Manual, an activated sludge treatment system with a design flow greater 5 MGD must have a minimum frequency of compliance monitoring for influent and effluent BOD and TSS of 5/week.*

Kitsap County Comment # 5: The County would like clarification for the increase in effluent BOD and TSS testing increments from 3/week to 5/week. This increase does not allow for holiday weeks or composite sampler issues without creating overtime. The County has complied with the previous permit for CBOD and TSS 3/week requirement with one exception occurring on August 1, 2015 during construction of a major plant upgrade. A TSS value was reported of 62.8 mg/L with the permit limit of 45 mg/L due to bulking in the secondary clarifiers. The County requests this parameter remain at the current 3/week based on historical plant performance.

Ecology's Response*: Criteria published in Ecology's Permit Writer's Manual and WAC 173-230 classify the treatment system at Central Kitsap WWTP as a Group IV facility with 6 MGD design flow. Per Ecology's Permit Writer's Manual, an activated sludge treatment system with a design flow greater 5 MGD must have a minimum frequency of compliance monitoring for influent and effluent BOD and TSS of 5/week.*

Kitsap County Comment # 6: This section is missing the subsection that defines the chronic mixing zone.

Ecology's Response*: Per County's request, chronic mixing zone description was added. This section was accidently deleted during drafting of the NPDES permit.*

Kitsap County Comment # 7: The County has complied with the previous permit place 5/week fecal coliform testing without any violations. The Central Kitsap Treatment Plant is staffed with laboratory analysts Monday-Friday and given the County's excellent track record , the County is asking the new permit retain the current sampling frequency of 5/week for fecal coliform.

Ecology's Response*: Per County's request, Ecology has granted a reduction in monitoring frequency to 5/week for fecal coliform. Please see Appendix G for your reference.*

Kitsap County Comment # 8: Effluent Flow – Continuous. The County will make the modifications needed to comply with this request.

Ecology's Response*: Ecology's appreciates the County's efforts to measure effluent flow in lieu of influent flow. Effluent flow measurements provide a more accurate account of the volume of wastewater discharged to Puget Sound.*

Kitsap County Comment # 9: The County does not currently have the ability for continuous monitoring of the effluent temperature. The County may need to look into an inline option in the future. The County would like to request a seasonal requirement for effluent temperature monitoring since winter temperatures should not impact the highest one day annual maximum temperature criterion for marine discharge.

Ecology's Response*: Section S2.A (Monitoring Schedule) of the proposed NPDES permit determines that the Permittee can use either measured or grab samples. Ecology recommends using grab samples for temperature monitoring until the County has a system in place that will allow continuous temperature monitoring. Temperature grab sampling must occur when the effluent is at or near its daily maximum temperature, which usually occurs in the late afternoon.*

Kitsap County Comment # 10: Effluent Priority Pollutants - Increased from 3/permit cycle to 1/year. The County can comply with this change in the testing requirements even though there is a substantial amount of cost due to these tests going to an outside laboratory for analysis. Is there a justification based on historical data for the increase in testing intervals?

***Ecology's Response**: Washington's water quality standards include numeric human health-based criteria that Ecology must consider when writing NPDES permits. In accordance with the requirements of CWA section 303(c)(2)(B), EPA has finalized 144 new and revised Washington-specific human health criteria for priority toxic pollutants, to apply to waters under Washington's jurisdiction, and has approved 45 new human health criteria submitted by Washington. Ecology has increased the effluent priority pollutant monitoring frequency from 3/permit cycle to 1/year to generate a data set that is statistically significant, more representative of the effluent discharge characteristics and, most importantly, to assure that human health criteria are met.*

Kitsap County Comment # 11: Flow measurement, field measurement, and continuous monitoring devices, Section 2 - Calibrate continuous monitoring. Suggested language - Calibrate continuous monitoring instruments as per manufacturers recommendations.

***Ecology's Response:** Ecology appreciates the County's suggestion. The NPDES permit requires that continuous monitoring instruments are calibrated following the manufacturer's recommendations.*

Kitsap County Comment # 12: Discharge Monitoring Reports, Section 6 - Submit a copy of the laboratory reports as an attachment using WQWebDMR. Please clarify this attachment requirement is for contract laboratory analysis, and not for in-house analysis.

***Ecology's Response:** This requirement is applicable to commercial laboratories that conduct priority pollutant analyses.*

Kitsap County Comment # 13: Certified Operator - An operator certified for a least a Class III Plant must be in charge during all regularly scheduled shifts. Proposed language - An operator certified as a Group III Operator must be in charge during all regularly scheduled shifts.

***Ecology's Response:** Ecology appreciates the County's suggestion and it will discuss it internally with the Permit Writer Work Group.*

Kitsap County Comment # 14: Operation and maintenance - This provision of the permit requires the Permittee to operate backup or auxiliary facilities or similar systems only when the operation is necessary to achieve compliance with the conditions of this permit. Please clarify the meaning of this statement.

***Ecology's Response:** It means that Central Kitsap WWTP is not required to use these facilities, unless it is necessary.*

Kitsap County Comment # 15: O&M Manual Submittal and Requirements, Section 2 - The Permittee must submit a paper copy and an electronic copy (preferably as PDF). The County has developed an electronic O&M manual on SharePoint for ease of access for all employees. Printing or PDF versions are not easily extracted and therefore the County would provide access to Ecology via VPN access for review. We request that this be added to approved methods of review.

Ecology's Response: *Per County's request, Ecology has added electronic O&M Manual submittal via VPN access.*

Kitsap County Comment # 16: The operator certifications are described as "Group" certifications and the plants are referred to as "Class." This should be corrected throughout the permit and fact sheet.

Ecology's Response: *WAC 173-230 determines operator certification level based on education and experience, and the plant classification based on the level of treatment and flow volume. Therefore, Ecology uses "Group" to describe operators certification and "Class" to describe plant's classification criteria.*

Public Review 30-Day Comment Period:

Comments were received during the public notice period from Northwest Environmental Advocates (NWEA). The comments are summarized below along with Ecology's responses.

NWEA Comments

Sections I. and II. of the comment letter do not include specific comments on this permit.

Comment letter section III. – This proposed permit fails to meet legal requirements.

A. **The discharge causes or contributes to violations of water quality standards and therefore a WQBEL is required for nutrients**

   Comment summary: There is no WQBEL that is intended to ensure that the discharge does not cause or contribute to violations of dissolved oxygen standards or the narrative criterion by discharges of nitrogenous oxygen-demanding materials.

   ***Ecology's Response**: Ecology has assessed the reasonable potential for the discharge to violate water quality standards and found that the discharge would not do so.*

   While treated municipal wastewater may be the dominant human source of nitrogen for Puget Sound, the largest overall source of nitrogen is the exchange of marine water with the waters of the Sound. Ecology continues to improve the modeling that allows us to assess the degree to which wastewater treatment plants may be causing or contributing to violations of water quality standards in Puget Sound. In 2014, Ecology completed the report Puget Sound and the Straits Dissolved Oxygen Assessment – Impacts of Current and Future Human Nitrogen Sources and Climate Change through 2070. Since then, Ecology incorporated into its models a more state-of-the-science methodology for accounting for sediment/water column interactions. This model improvement could affect both predictions of water quality impairments (now largely based upon model results), and estimates of nitrogen reductions needed to improve water quality.

As improved modeling results becomes available, Ecology intends to develop a coordinated permitting strategy that will reduce nitrogen discharges to Puget Sound in a cost-effective manner, to achieve the greatest environmental results with the lowest cost to the public. Ecology's ultimate decision to set permit limits for nitrogen discharges to Puget Sound may affect all the permits in the region, and must be based on accurate science. For the most recent information on Ecology's Puget Sound Nutrient Source Reduction Project, please see the website http://www.ecy.wa.gov/puget_sound/reducing-nutrients.html.

Ecology concludes that the technology-based limits included in this permit are appropriate.

B. The permit fails to assess reasonable potential for this discharge to cause or contribute to violations of WQ standards and to establish required effluent limits

Comment summary: Given that this discharger is a known source of nitrogen to Puget Sound, and therefore it is contributing to violations of water quality standards, the permit is required to also contain water quality-based effluent limits for total nitrogen.

***Ecology's Response**: see above*

C. The proposed permit fails to evaluate the discharge of nutrients to Puget Sound on an appropriate bases and the establishment of BOD5 limits is both inappropriate and inadequate

Comment summary: The BOD_5 effluent limit does not provide any limits on the ammonia nitrogen oxygen demand created by the discharge that is causing or contributing to violations of water quality standards in Puget Sound.

***Ecology's Response**: see above*

D. The proposed permit fails to comply with 40 CFR 122.44(d)(1)(ii)

Comment summary: The proposed permit does not "account for existing controls on point and nonpoint sources of pollution." Specifically, the commenter refers to nitrogen pollution from septic systems and other wastewater treatment plants.

***Ecology's Response**: see above*

E. The proposed permit may be derived on an illegal basis

Comment summary: The commenter objects to fact sheet language stating "Ecology does not develop effluent limits for all reported pollutants. Some pollutants are not treatable at the concentrations reported, are not controllable at the source, are not listed in regulation, and do not have a reasonable potential to cause a water quality violation."

***Ecology's Response**: Ecology develops effluent limits for pollutants with a reasonable potential to violate water quality standards. The language above is standardized and included in all Ecology fact sheets.*

F. The proposed permit fails to evaluate whether the discharge will cause or contribute to violations of narrative criteria

Comment summary: The fact sheet does not sufficiently explain the consideration and analysis of narrative criteria, specifically in regard to nutrient pollution in Puget Sound.

***Ecology's Response**: Compliance with narrative criteria is evaluated through the use of whole effluent toxicity testing and available information about the receiving waters. Regarding the regulation of nutrient discharges affecting Puget Sound, see response to comment III.A. above.*

G. Permit violates Tier 1 of the Antidegradation Policy contained in Washington's Water Quality Standards

Comment summary: The antidegradation policy requires this permit to include effluent limits for nitrogen to protect Puget Sound water quality.

***Ecology's Response**: Regarding the regulation of nutrient discharges affecting Puget Sound, see response to comment III.A. above.*

H. Monitoring requirements are inadequate

Comment summary: Quarterly nutrients monitoring is inadequate.

***Ecology's Response**: The nutrients monitoring frequency required by the permit is consistent with Ecology guidance for facilities of this size. Ecology considers quarterly monitoring for nutrients to be sufficient because nutrients affect water quality on a seasonal or annual cycle.*

I. Use of monitoring data

Comment summary: The commenter questions the effluent *bis(2-ethyhexyl) phthalate* monitoring.

***Ecology's Response**: The permit requires additional monitoring for bis(2-ethyhexyl) phthalate. As stated in the fact sheet, the testing results of this chemical are possibly affected by sampling or testing contamination if laboratory protocols are not properly prepared and followed. Ecology considers these monitoring requirements to be sufficient.*

J. The permit fails to ensure the implementation of AKART

Comment summary: Comment argues that the use of enhanced secondary and/or tertiary treatment for removal of nitrogen is AKART and cites the cases, City of Bellingham v. Washington Ecology, PCHB No. 84-211 and Sierra Club v. Washington, PCHB No. 11-184 in support.

***Ecology's Response**: Chapter WAC 173-221 WAC establishes and defines AKART for POTWs (domestic wastewater treatment plants) by setting discharge standards which represent "all known, available, and reasonable methods" of prevention, control, and treatment for domestic wastewater facilities which discharge to waters of the state. WAC 173-221-040 defines secondary treatment as AKART for all domestic wastewater treatment facilities and establishes effluent quality requirements. The listed parameters are BOD_5, TSS, Fecal coliform, and pH. The regulation does not include nutrient removal in the definition of AKART for domestic wastewater facilities. Nutrients are not included in the WAC for AKART. The legal cases cited by the commenter do not apply broadly to all domestic wastewater facilities. The cases involved legal questions specifically applicable to the facilities or receiving waters involved in those cases.*

K. AKART and mixing zones

Comment summary: Because AKART has not been met by the discharger, Ecology has improperly allowed a mixing zone.

***Ecology's Response**: AKART has been appropriately applied to this discharge; see response above.*

L. Mixing zones

Comment summary: This section does not include specific comments on this permit.

***Ecology's Response**: No response is needed.*

M. Public notice fails to meet Federal requirements

Comment summary: Ecology's assertion that this fact sheet complies with WAC 173-220-060 is simply not true, as demonstrated in the above comments. In addition, the fact sheet fails to meet the requirements of WAC 173-220-060(c)(iii), (e), as demonstrated above.

***Ecology's Response**: Ecology appropriately prepared this fact sheet in compliance with the above referred regulations; see response above.*

consor

APPENDIX C
INDUSTRIAL USERS SURVEY

INDUSTRIAL USER SURVEY

CENTRAL KITSAP WASTEWATER TREATMENT PLANT

FOR

WASHINGTON DEPARTMENT OF ECOLOGY

Prepared by

KITSAP COUNTY PUBLIC WORKS

SEWER UTILITY

614 DIVISION STREET

PORT ORCHARD, WA 98366-4699

360-337-7197

January 10, 2022

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SECTION 1

INDUSTRIAL USER SURVEY

POTW'S ORDINANCE

Part 1

Kitsap County
Prohibited
Discharges
Ordinance 13.12.160

Part 2

City of Poulsbo
Water and Sewer Code
Chapter 13.

PART 1 – KITSAP COUNTY

Except as provided in Section 13.12.170, no discharger shall discharge or cause to be discharged into a public sewer, place or cause to be placed where they are likely to run, leak or escape into a public sewer, any of the following:

(1) Any solid or viscous substances which may obstruct or interfere with the capacity or operation of the sewer such as but not limited to ashes, cinders, sand, earth, rubbish, mud, straw, shavings, metal, glass, rags, feathers, tar, plastic or wood;

(2) Any liquids, solids, or gases, which because of their nature or quantity are, or may be, sufficient, either alone or by interaction with other substances, to cause fire or explosion or be injurious in any other way to the wastewater collection and treatment system. At no time shall two successive readings on an explosion hazard meter, at the point of discharge into the system (or at any point in the system), be more than five percent nor any single reading over ten percent of the lower explosive limit (LEL) of the meter. Prohibited materials include but are not limited to: gasoline, kerosene, naphtha, benzene, toluene, xylene, ethers, alcohols, ketones, aldehydes, peroxides, chlorates, perchlorates, bromates, carbides, hydrides and sulfides, and any other substances that the county, the state, the EPA, or the fire department has notified the user is a fire hazard or a hazard to the system;

(3) Any matter having a temperature greater than forty degrees Celsius, or will inhibit biological activity at the wastewater treatment plant;

(4) Sewage containing suspended solids in excess of three hundred fifty milligrams per liter;

(5) Wastewater containing fats, oils or grease in excess of one hundred parts per million (mg/L);

(6) Wastewater with B.O.D. greater than three hundred milligrams per liter;

(7) Wastewater with pH lower than 6.0 or higher that 9.0, or having any corrosive property capable of causing damage to structures, equipment or personnel;

(8) Garbage that has not been properly shredded;

(9) Wastewater containing toxic substances in sufficient quantity to injure or interfere with any wastewater treatment process, constitute a hazard to humans or the environment, create any hazard in the receiving waters of a wastewater treatment plant, or exceed the limitation set forth in the pretreatment standards;

(10) Any noxious or malodorous matter capable of creating a public nuisance or hazard to life, or sufficient to prevent entry into the sewers for their maintenance and repair;

(11) Any unpolluted water including but not limited to; waters from irrigation, water main flushing, cooling processes, industrial processes creating no substantial water contamination, storm drains, surface runoff, roof runoff, subsurface drainage, swimming pools, ponds or reservoirs;

(12) Any matter which is radioactive to any degree above that which normally prevails in the county;

(13) Any substance that may cause the wastewater treatment plant's effluent or treatment residues, biosolids or scums to be unsuitable for reclamation and reuse or to interfere with the reclamation process. (In no case shall a substance discharged to the wastewater treatment plant cause the treatment plant to be in noncompliance with biosolid use or disposal criteria, guidelines, or regulations developed under Sections 405 and 503 of the Clean Water Act, any criteria, guidelines or regulations affecting biosolids use or disposal developed pursuant to the Solid Waste Disposal Act, the Clean Air Act, the Toxic Substance Control Act, or state standards applicable to the biosolids management method being used.);

(14) Any substance that will cause the wastewater treatment plant to violate its NPDES and/or other disposal system permits;

(15) Any slugload, which shall mean any pollutant, including oxygen-demanding pollutants (B.O.D., etc.), released in a single extraordinary discharge episode of such volume or strength as to cause interference to the treatment plant. In no case shall a slugload contain concentrations or qualities of pollutants that exceed for any period longer than fifteen minutes more than five times the average twenty-four-hour concentration, quantities or flow during normal operation;

(16) Wastewater containing substances not amenable to treatment or reduction by the sewage treatment process employed, or are amenable to treatment only to such a degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters;

(17) National Categorical Pretreatment Standards. National categorical pretreatment standards, as promulgated by the EPA pursuant to the Clean Water Act and as adopted, shall be enforceable by this chapter and shall be met by all dischargers of the regulated industrial categories;

(18) State Requirements. State requirements and limitations on dischargers to the wastewater system shall be met by all dischargers which are subject to standards in any instance in which they are more stringent than federal requirements and limitations or those in this or any other applicable ordinance;

(19) Any discharge that exceeds the following daily maximum pollutant limits:

Arsenic	0.15 mg/L
Cadmium	0.10 mg/L
Chromium	1.0 mg/L
Copper	0.75 mg/L
Lead	0.25 mg/L
Mercury(1)	0.010 mg/L
Molybdenum	2.0 mg/L

Nickel	0.60 mg/L
Selenium	0.80 mg/L
Silver(1)	0.50 mg/L
Zinc	2.0 mg/L
Cyanide	0.75 mg/L
Ammonia	50.0 mg/L

Notes: (1) Businesses that follow Best Management Practices (BMPs) for their industry can petition Public Works Wastewater for higher limits. This will be limited to businesses contributing less than 1% of the total flow to the Publicly Owned Treatment Works (POTW).

(Ord. 300 (2003), 2003: Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 16, 1974)

13.12.170 Disposal of prohibited wastes.

SHARE

Prohibited wastes as defined in Section 13.12.160 shall be disposed of in one of the following ways:

(1) Pretreatment. A person producing prohibited wastes may treat such wastes prior to their introduction into a public sewer so that any and all characteristics objectionable per Section 13.12.160 are removed. Prior to the utilization of any pretreatment device or process, a person producing the prohibited unlawful wastes must submit the plans and specifications for the pretreatment device or process to the director and the Washington State Department of Ecology requiring written approval of the device or process that will remove the objectionable characteristics. The entire cost of the construction, maintenance and operation of any pretreatment device or process shall be borne by the person producing the prohibited wastes.

(2) Prohibited Waste Discharge Permit.

(A) A person producing prohibited wastes may discharge such into a public sewer if a permit to do so is first obtained from the director. The application for such permit shall include the following information: name and address of applicant, location of sewage production, process which produces sewage, volume of anticipated discharge, specific type and degree of prohibited sewage characteristic, other information deemed necessary by the director. The director may approve the application if the sewage treatment plant affected has sufficient capacity to handle the increased treatment load and if the contemplated discharge will not be unnecessarily harmful to the public sewer or unreasonably detrimental to the public health, safety or welfare. A person discharging prohibited waste pursuant to a permit shall pay the county for the increased costs of the treatment thereof in addition to the regular monthly or bimonthly charge.

(B) The charge for treating such wastes pursuant to the permit shall be as follows:

$0.02 per gallon for	0 – 10,000 gallons
$0.04 per gallon for	10,001 – 20,000 gallons
$0.06 per gallon for	20,001 – 30,000 gallons

$0.08 per gallon for 30,001 – 40,000 gallons

The maximum allowable discharge shall be limited to forty thousand gallons. A fifty-dollar fee will be charged for the permit to defray administrative costs.

The director may revoke a permit upon sixty days' written notice to the person discharging the prohibited waste if it is found that the waste discharged has significantly increased in volume or degree of prohibited sewage characteristic, that the particular variety of prohibited characteristics has changed, or that the sewage treatment plant affected no longer has the capacity to handle the prohibited waste.

(3) Dilution. No discharger shall increase the use of potable or process water in any way for the purpose of diluting a discharge as a partial or complete substitute for adequate treatment to achieve compliance with applicable standards set forth in this chapter. Mass limitations may be imposed on dischargers that are using dilutions to meet applicable pretreatment standards or requirements of this chapter, or in other cases where deemed appropriate by the director.

(Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 17, 1974)

13.12.180 Inspections to ascertain character of sewage. SHARE

The director may enter premises served by a public sewer at any and all reasonable times to take sewage samples in order to determine if the sewage is an unlawful waste. Persons pretreating unlawful wastes pursuant to subsection (1) of Section 13.12.170 or permitted to discharge unlawful wastes pursuant to subsection (2) of Section 13.12.170 shall, at the direction of the director, install inspection tees or manholes in the building sewer to facilitate sampling.

(Ord. 55 (1974) § 18, 1974)

13.12.190 Discharge from mobile tanks. SHARE

(a) It is unlawful for any person to discharge or cause to be discharged from a mobile tank into a public sewer any sewage which is generated outside Kitsap County.

(b) It is unlawful for any person to discharge or cause to be discharged from a mobile tank into a public sewer any sewage which is generated inside Kitsap County from commercial or industrial sources without obtaining prior approval from the director of public works.

(c) It is unlawful for any person to discharge or cause to be discharged from a mobile tank into a public sewer any sewage except at points and in a manner designated by the director of public works.

(d) A charge of eight cents per gallon shall be made for the discharge from mobile tanks of sewage from septic tanks, cesspools, chemical toilets or similar apparatus, provided the charges shall be based upon the gallonage capacity of the mobile tank from which the sewage is discharged into the Central Kitsap Wastewater Treatment Plant. A two-cent per gallon fee shall be transferred to the public health pooling fund once each month. The rate for septage shall increase by one cent per year on October 1st of each year through the year 2001.

(e) Prior to the discharge of any sewage from mobile tanks, a written manifest shall be submitted to the Central Kitsap Wastewater Treatment Plant office at 12350 Highway No. 303 NE, Poulsbo, WA 98370, clearly identifying the source, nature and quantity of sewage to be discharged. The manifest shall be made on forms provided by Kitsap County and all information required shall be complete.

(f) The charge per gallon referenced in subsection (d) of this section shall be established from time to time by resolution of the board of county commissioners.

(Ord. 55-J (1996) § 1, 1996: Ord. 55-G (1993) § 1, 1993: Ord. 55-F (1989) § 1, 1989: Ord. 55-E (1985), 1985: Ord. 55-D (1984), 1984: Ord. 55-B (1978) § 2, 1978: Ord. 55 (1974) § 20, 1974)

13.12.200 Liability to county.

Any person who violates any provision of this chapter is liable to the county for any expense, loss, damage, cost of inspection or correction incurred by the county as a result of such violation.

(Ord. 55 (1974) § 20, 1974)

13.12.210 Charges for sewer service.

Charges for sewer service for all single-family residences shall be due and payable bimonthly. Charges for all other sewer service shall be due and payable monthly. For all new building construction, charges for sewer service shall commence upon occupancy or sixty days after issuance of a building sewer permit, whichever occurs first.

(Ord. 55-B (1977) § 1, 1977: Ord. 55 (1974) § 21, 1974)

13.12.220 Liens.

Pursuant to RCW 36.94.130 and RCW 36.94.150, the following, when not paid within thirty days of the date due, shall constitute a lien upon the premises served: Sewer service charges, repair costs, connection charges, permit fees, inspection costs, and charges in lieu of assessment. Such liens shall bear interest at eight percent per year. When a charge is not paid when due, a penalty of ten percent shall be added thereto.

(Ord. 55 (1974) § 22, 1974)

13.12.230 Industrial cost recovery.

Any industrial users of a sewer facility constructed with Environmental Protection Agency grant funds awarded after March 1, 1973, shall repay that portion of the grant amount allocable to the treatment of its wastes. The method of repayment and procedures for handling the repayment shall be in accordance with 30 Fed. Reg. 35.905-8, 35.925-12, 35.928 and 35.935-13 (1974).

(Ord. 55 (1974) § 23, 1974)

13.12.240 Violations – Penalty.

(a) Civil Penalties. Any discharger who violates an order by the county, or who fails to comply with:

(1) Any provision of this chapter; or

(2) Any regulation, rule or permit of the county, issued pursuant to this chapter, shall be liable to the county for a civil penalty. The amount of such civil penalties shall not be less than two hundred fifty dollars per violation nor more than one thousand dollars per violation. Each day upon which a violation occurs or continues shall constitute a separate violation. In addition, the county may commence an action to end the discharger's wastewater treatment service.

(b) Recovery of Cost Incurred by the County. Any discharger violating any of the provisions of this chapter who discharges or causes a discharge producing a deposit or obstruction or causes damage to or impairs the county's wastewater disposal system shall be liable to the county for any expense, loss or damage caused by such violation or discharge. The county shall, by order, bill the discharger for the cost incurred the county for any cleaning, repair, or replacement work caused by the violation or discharge and for any cost incurred by the county in investigating the violation and in enforcing the chapter against the discharger, including reasonable administrative costs, fees for testing, attorney fees, court costs, and all expenses of litigation. Refusal to pay the assessed costs shall constitute a violation of this chapter.

(c) In addition to or as an alternative to any other penalty provided in this chapter or by law, any violation of this chapter shall constitute a Class I civil infraction. Each violation shall constitute a separate infraction for each and every day or portion thereof during which the violation is committed, continued or permitted. Infractions shall be processed in accordance with the provisions of the civil enforcement ordinance (Chapter 2.116 of this code). The choice of enforcement action taken and the severity of any penalty shall be based upon the nature of the violation and the damage or risk to the public.

(Ord. 55-K (1997) § 1, 1997; Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 24, 1974)

13.12.250 Nuisance declared.

Any building sewer or side sewer hereafter constructed, moved, maintained, used or altered contrary to the provisions of this chapter shall be, and the same is, unlawful and a public nuisance. Compliance with this chapter may be enforced by mandatory injunction brought by the owner or owners of land lying in proximity to that whereon the violation exists or the prosecuting attorney may commence action or actions, proceeding or proceedings for the abatement, removal and enjoinment thereof and may take such other steps to obtain such relief as will abate or remove sewers, structures or uses and restrain and enjoin any person from constructing, maintaining or altering any such sewers contrary to the provisions of this chapter.

(Ord. 55-A (1975) § 2, 1975: Ord. 55 (1974) (part), 1974)

13.12.260 Grease interceptors.

(a) Any business involved in the process, preparation, sale or packaging of human or animal food shall install an exterior (located outside the building) grease interceptor on a separate building sewer main. This separate building sewer shall be connected directly, and only to the food handling areas of the building, with no sanitary connections permitted upstream of the grease interceptor.

(b) The grease interceptor shall be adequately designed to provide retention of a minimum of ninety percent of the contaminated oils and greases. Grease interceptors shall be sized using storage capacity factors and loading factors appropriate for the intended use of the facility and anticipated volumes. It shall include baffles that provide sufficient detention time to allow the grease to separate fully.

(c) Grease interceptors shall be properly operated and cleaned regularly to prevent escape of appreciable quantities of grease. The extracted grease shall not be reintroduced into the sanitary sewer system at another location.

(Ord. 55-I (1996) § 1 (part), 1996)

13.12.270 Administration.

SHARE

(a) Wastewater Dischargers. It is unlawful to discharge sewerage, industrial wastes, or other wastes to any sewer outlet within the jurisdiction of the county and/or to the wastewater treatment plant without first having complied with the terms of this chapter, or without having first obtained the county's approval of a compliance schedule submitted by the discharger.

(b) General Disclosure. All industrial dischargers proposing to connect to or to discharge sewage, industrial wastes, or other wastes to the wastewater treatment plant shall comply with all terms of this chapter within thirty days after the effective date of the ordinance codified in this section.

(c) Disclosure Forms. Significant industrial dischargers shall complete and file with the county a data disclosure declaration in the form prescribed by the county, and accompanied by the appropriate fee. Existing significant industrial dischargers shall file a disclosure form within sixty days after notification by the county. Proposed new source dischargers shall file a disclosure form a minimum of ninety days before connecting to the sewer system. The disclosure to be made by the discharger shall be made on written forms provided by the county and shall cover:

(1) Disclosure of name, address and location of the discharger;

(2) Disclosure of wastewater constituents and characteristics including but not limited to those mentioned in this chapter, including standards contained in Section 13.12.170 of this chapter, as appropriate, as determined by bona fide chemical and biological analysis. Sampling and analysis shall be performed according to procedures established by the EPA;

(3) Disclosure of time and duration of discharges;

(4) Disclosure of average daily and instantaneous peak wastewater flow rates, in gallons per day, monthly, and seasonal variations, if any. All flows shall be measured unless other verifiable techniques are approved by the county due to cost or nonfeasibility;

(5) Disclosure of site plans, floor plans, plumbing plans, and details to show all sewers, sewer connections, inspection manholes, sampling chambers, and appurtenances by size and location.

(d) Operating Upsets. Any discharger that experiences an upset in operations which places the discharger in a temporary state of noncompliance with this chapter shall inform the county immediately upon first awareness of the commencement of the upset. Where such information is given orally, a written follow-up report shall be filed by the discharger with the county within five days. The report shall specify:

(1) Description of the upset, the cause of it, and the upset's impact on the discharger's compliance status;

(2) Duration of noncompliance, including exact dates and times of noncompliance; and, if the noncompliance continues, the time by which compliance is reasonably expected to occur;

(3) All steps taken or to be taken to reduce, eliminate and prevent recurrence of such an upset or other conditions of noncompliance. A documented and verified bona fide operating upset shall be an affirmative defense to any enforcement action brought by the county against the discharger for any noncompliance with the chapter that arises out of violations alleged to have occurred during the period of upset.

PART 2 – CITY OF POULSBO

Chapter 13.06
WATER AND SEWER CODE

Sections:

I. GENERAL PROVISIONS, REGULATIONS AND PENALTIES

II. WATER SERVICE

III. SEWER

I. GENERAL PROVISIONS, REGULATIONS AND PENALTIES

13.06.010 Definitions. SHARE

Whenever the following terms are used in this code or attachments thereto they shall be construed to mean as follows:

A. "Fire hydrants" means a center stem three port hydrant with auxiliary gate valve and Stortz quarter-turn pumper coupling.

B. "Standard construction cost" means the cost of the pipe plus the total cost of all necessary fittings and the total cost of all installation and incidental work necessary, including engineering costs, to place the water pipe in service regardless of its size. Cost of fire hydrants will be included in the total cost.

C. "Standard residential water mains" means water mains constructed of ductile cast iron, not less than eight inches inside diameter, and if future extension is imminent toward further completion of a system grid a gate valve shall be installed to prevent disruption of water service at the time of future extension. (Ord. 2019-02 § 2 (Att. A (part)), 2019: Ord. 83-14 § 1(G.9), 1983)

13.06.020 Inspection. SHARE

Authorized employees of the city, properly identified, and with permission of the occupant, shall have free access at proper hours of the day, for purposes of inspection, to all parts of the premises or buildings to which water or sewer service is supplied by city utility facilities. In the event the owner or occupant of any premises refuses to permit the inspection, the city may, with proper justification, discontinue utility service and/or may apply to the municipal court of the city for a court order directing the owner or occupant to permit the inspection. (Ord. 83-14 § 1(G.1), 1983)

13.06.030 Delayed benefit charge. SHARE

Whenever a water or sewer line extension is constructed through an undeveloped area by the city, whether within or without the city, to provide service to an area not previously serviced by such utility, the property abutting such facility shall be subject to a delayed benefit charge when application for connection is made. Such delayed benefit charge shall be a proportionate share of the actual costs of construction plus twenty-five percent for accounting and overhead. Payment of such delayed benefit charge shall exempt the property for which payment is made from any subsequent local improvement district assessments for water or sanitary sewer facilities for the service previously provided. Delayed benefit charges shall be paid at the time of application and before actual connection is made. (Ord. 83-14 § 1(G.2), 1983)

13.06.045 Water used during construction.

Whenever city water is used in conjunction with the construction of any structure, including, but not limited to, residential, commercial or industrial structures, or the development of plats, a charge shall be made for such use pursuant to Section 13.08.110. This charge shall apply to all construction projects using city water, whether or not the construction occurs within the city limits. Except as otherwise provided, all of the provisions of this title are applicable when city water is used in conjunction with the construction of any structure or plat development. (Ord. 91-16 § 1, 1991)

13.06.050 Water and sewer usage payment.

All charges for sewer or water service shall be due and payable on the first day of each calendar month succeeding the month on which such service is furnished, and shall become delinquent on the twentieth day of the month. All charges for water and sewer service for each lot or parcel of property shall be paid at the same time. The penalty for delinquency shall be per Section 13.80.050(F). (Ord. 2019-21 § 2 (Att. A (part)), 2019: Ord. 92-15 § 1, 1992: Ord. 83-14 § 1(G.4), 1983)

13.06.060 Sewer and water connections and charges.

All sewer and water service lines from the main line to private property shall be installed by the city of Poulsbo or contractors authorized by the city of Poulsbo. All costs shall be paid by the property owner. The charges for water and sewer connections shall be established by ordinance. All excavating, pipe laying, backfilling and replacement of roadway or sidewalks will be done by the property owner to his licensed plumber or contractor pursuant to a permit issued by the city of Poulsbo. In the event any such work is accomplished by other than authorized employees of the city, periodic inspection and approval by the public works director or his designated representative must be obtained before backfilling the trench. (Ord. 2005-17 § 1 (part), 2005; Ord. 83-14 § 1(G.5), 1983)

13.06.070 Installation by owner.

The property owner or his contractor shall construct his part of the side sewer or water service pipe on this property, but inspection and approval by the public works director or his designated representative must be obtained before backfilling or use. (Ord. 2005-17 § 1 (part), 2005; Ord. 83-14 § 1(G.6), 1983)

13.06.080 Cross-connections and backflow devices.

A. All persons receiving the city of Poulsbo domestic water supply shall comply with the following provisions:

1. It is unlawful for any person to install a cross-connection between any private water supply system and a supply system of the city.

2. It is unlawful for any person to allow any contaminants to backfeed from the person's private facility and/or property into the city distribution system. Any connections now existing or hereafter installed that could allow for backfeed of any contaminants into the city distribution system shall be disconnected and/or eliminated. Connections which cannot be discontinued and/or eliminated shall require the installation of an approved backflow protection device and shall be regularly inspected and tested in accordance with the city of Poulsbo Cross-Connection and Backflow Prevention Manual.

3. It is unlawful for any person to maintain, construct or install a system to supply water for human consumption in violation of Chapter 70.54 RCW or WAC 246-290-490, as the same exist or are hereafter amended.

B. Violation of any of the aforementioned provisions listed in subsection A of this section may result in the imposition of civil and criminal penalties as set forth in Section 15.04.240 of the Poulsbo Municipal Code. In addition, violation of any of the provisions of subsection A of this section are declared to be subject to immediate abatement by the city. In addition to abatement on the impositional civil or criminal penalties, at its sole discretion the city may discontinue or refuse service of the city water supply system to any premises for violations occurring at such premises, unless corrective action is taken in accordance with the city of Poulsbo Cross-Connection and Backflow Prevention Manual.

C. The city of Poulsbo Cross-Connection and Backflow Prevention Manual attached to the ordinance codified in this section as Exhibit A is adopted by this reference as fully as if herein set forth. Copies of the manual shall be maintained in the office of the city clerk and the building official of the city of Poulsbo. The manual shall be maintained for public inspection during normal business hours and copies shall be made available at the actual cost of reproduction. (Ord. 93-04 §§ 1, 2, 1993: Ord. 83-14 § 1(G.7), 1983)

13.06.090 Improvement specifications. SHARE

All specifications for extensions, expansions, additions, betterments and replacements to the existing water utility system shall be determined by the city engineer except that no water main providing fire flow to hydrants or to complete a system grid shall be installed which is less than eight inches in diameter. (Ord. 83-14 § 1(G.8), 1983)

13.06.100 Unlawful acts. SHARE

It is unlawful for any person, unless duly authorized, to disturb, interfere with, or damage any water main, or sewer pipe, machinery, tool, meter or other appliance, building, improvement or other appurtenance belonging to, connected with, or under the control of the city water and/or sanitary sewage disposal system. (Ord. 83-14 § 1(G.10), 1983)

13.06.110 Enforcement and report—Duty. SHARE

It shall be the duty of the employees of the police and other departments of the city to aid in the enforcement of the provisions of this code and they shall report all violations thereof which come to their knowledge. (Ord. 2006-13 § 1, 2006: Ord. 83-14 § 1(G.11), 1983)

13.06.120 Interpretation—Appeals.

SHARE

The city engineer shall have authority to decide on behalf of the city any questions that may arise, through the necessity of interpretation of this code, and his decision in each case shall be final, subject to the right of the person aggrieved thereby to appeal such decision to the city council by giving written notice to the city engineer and city council of such appeal within ten days from the date such person is notified of such decision. If notice of an appeal is not given in writing in the manner and time provided in this section, such appeal shall be barred. (Ord. 83-14 § 1(G.13), 1983)

13.06.130 Violation—Penalties.

SHARE

Upon any violation of the provisions of this code, the city may discontinue service and the city may remove connection tile or pipe located within the facility right-of-way and dispose of the same without liability on the part of the city. A violation of this code shall be deemed to be a civil violation. The municipal code of the city shall have civil jurisdiction to determine the rights and obligations under this code subject to the rights of appeal as provided in the Washington Justice Court Rules applicable to the Poulsbo municipal court. (Ord. 83-14 § 1(G.12), 1983)

II. WATER SERVICE

13.06.140 Water meters required.

SHARE

A. All connections to the city water system shall henceforth include a water meter of one of the types approved by the city engineer. The number, size and locations of said meters shall be determined by the city engineer.

B. Irrigation Water Service. Separate connections to the city water system with meter may be permitted for irrigation purposes only. Cost of such water service installations shall be borne by the property owner. No sewer charge will be levied for this type of service. (Ord. 83-14 § 1(W.1), 1983)

13.06.150 Cost of meters.

SHARE

The cost of any replacement of existing water meters shall be borne by the city. The cost of water meters on services not previously metered shall be borne by the property owner, and such cost may be paid over a period of one year from time of installation. (Ord. 83-14 § 1(W.2), 1983)

13.06.160 Meter ownership—In-lieu charges.

SHARE

All meters shall be and remain the property of the city and shall not be removed unless the use of water on the premises is to be entirely stopped, the service connection discontinued or abandoned, for an accuracy test, or for replacement. In the event a meter goes out of order or fails to register properly, the customer shall be charged based on an estimate of average monthly consumption during the last three months when the meter was in good order, or from what may be considered the most reliable date or method as determined by the city. (Ord. 83-14 § 1(W.3), 1983)

13.06.170 Meter accuracy.

SHARE

In the event the accuracy of the water meter is questioned by any customer, it shall be removed at the customer's request and shall be forwarded to a meter calibration facility and be tested for accuracy. The findings of the calibration facility shall be binding and if the test discloses an error against the customer of more than three percent in the meter's registry, the excess of the consumption of the three previous readings shall be credited to customer's meter account and the city shall bear the entire cost of the test. In such an event the deposit required by this section shall be returned. If, however, an error of more than three percent against the customer is not found, the cost of the test shall be paid out of the customer's deposit and the customer shall pay the balance in those cases where the cost exceeds the deposit. A deposit in the amount of fifty dollars shall be posted by a customer before the meter will be removed and tested at the customer's request except by or in the presence of a representative of the city. (Ord. 83-14 § 1(W.4), 1983)

13.06.180 Shutoff valves.

SHARE

Each and every building, place of business, duplex, mobile home or separate dwelling when connected to one meter must be provided with separate shutoff valves in good working order, so that each unit may be shut off without disturbing service to the remaining units. Multifamily dwellings (two or more living units) including mobile home parks serviced by a master meter shall pay for water service for all living units whether occupied or not. No charge will be levied for vacant mobile home spaces, however. (Ord. 83-14 § 1(W.5), 1983)

13.06.190 Service reactivation—Fee.

SHARE

Whenever the owner or occupant of any premises already connected with the city's water supply desires to restore water service which has been shut off by the city, that person shall notify the city and request that water be turned back on to the premises; provided, that service shall not be restored until all charges for utility service provided to the premises, together with all penalties due thereon, have been paid. The shutoff/turn-on water service fee shall be as established in Section 3.12.100(G)(2) of the Poulsbo Municipal Code. (Ord. 2003-33 § 5, 2003: Ord. 83-14 § 1(W.6), 1983)

13.06.200 New service—Application—Account set up fee.

SHARE

A. Any person who desires to have premises connected with the water supply system of the city shall make application therefor upon a printed form, "Utility Connection Application," to be furnished by the city for that purpose. The application shall contain the name of the owner, legal description of the lot, block or addition, and the official house number of the premises, if any, together with the size of the meter. Such application shall be signed by the builder or the owner of the premises to be served, or his duly authorized agent, and shall be filed with the city. At the time of filing the application, the connection fees established in Section 3.12.100 shall be paid.

B. In addition to the connection fees described in subsection A of this section, there shall be an account setup fee for new owners. In the case of a change of ownership, a new account fee shall also be paid together with the submittal of a completed "Utility Change of Ownership Application" form provided by the city. The setup/new account fees shall be as established in Section 3.12.100. (Ord. 2003-33 § 6, 2003: Ord. 83-14 § 1(W.7), 1983)

13.06.210 Service—Application. SHARE

An applicant for water service shall agree to the following provisions:

A. The applicant shall pay for water service according to the rates established by ordinance along with any other fees established by ordinance.

B. The city shall be allowed to temporarily discontinue service at any time with reasonable notice or in the case of an emergency, without notice.

C. The city shall require meters to register water consumed.

D. The applicant agrees to abide by all ordinances now existing or as hereafter amended or adopted by the city.

E. The city shall not be held liable by the applicant or their successors or assigns for any damages by water or other causes resulting from defective plumbing or appliances on the premises irrespective of any inspection by the city. The same shall apply for interruptions in service due to accident or any other cause. (Ord. 83-14 § 1(W.8), 1983)

13.06.220 Service pipes—Connections. SHARE

Upon the payment of installation and system participation fees, the premises described in the application for water service, if the same abuts on a street or easement on which there is a city water main, shall be connected to the city water main by a service pipe and corporation stop extending at right angles from the main to a place within the lines of the street right-of-way or easement. The connection shall thereafter be maintained by and kept within the exclusive control of the city. A minimum of two hundred PSI one inch pipe shall be required. (Ord. 2019-02 § 2 (Att. A (part)), 2019: Ord. 83-14 § 1(W.9), 1983)

13.06.230 Separate service connections. SHARE

A. Each house or unit under separate ownership supplied by city water must have its own separate metered service connection to the city main, and the premises so supplied will not be allowed to supply water to any other premises.

1. This restriction shall not apply to services already installed except as herein provided, unless, in the judgement of the city, for the good of the service or to settle disputes, it is found necessary to enforce such provisions to connections already made.

B. Apartments may be individually metered or one meter may be used to serve each building.

1. Each separate apartment building must be metered; master meters for the site are not permitted.

2. This restriction shall not apply to services already installed except as herein provided, unless, in the judgement of the city, for the good of the service or to settle disputes, it is found necessary to enforce such provisions to connections already made.

C. Mixed use buildings shall have separate meters for each use. Commercial uses shall be metered separately from residential uses. Commercial spaces may be required to be metered separately if the city engineer determines the uses are not similar.

1. Fire lines within mixed use buildings are not required to be separate.

2. This restriction shall not apply to services already installed except as herein provided, unless, in the judgement of the city, for the good of the service or to settle disputes, it is found necessary to enforce such provisions to connections already made. (Ord. 2019-02 § 2 (Att. A (part)), 2019: Ord. 83-14 § 1(W.10), 1983)

13.06.240 Temporary and emergency shutoff. SHARE

Whenever an emergency exists affecting the water supply in the city which emergency shall be declared by the mayor, or in his or her absence, the deputy mayor, and it becomes necessary to curtail the use of water through regulation and control thereof, a proclamation shall be issued declaring the emergency and setting forth the rules under which water shall be used. The proclamation shall be published in the official newspaper of the city and copies of the proclamation shall be mailed to each water customer. Such notices and regulations established thereby shall be subject to change and shall be in full force and effect throughout the emergency and shall continue until notice is published that the emergency has passed. (Ord. 83-14 § 1(W.11), 1983)

13.06.250 Repairs—Disruption of service. SHARE

In an emergency of short duration water service may be temporarily discontinued, without notice to customers for the purpose of making repairs, extensions, fire fighting or any other necessary work, and the city shall not be held responsible for any damage resulting from interruption of service or the failure of the water supply, or failure to give water users notice thereof. Whenever possible, and in cases where it has advance notice thereof, the city shall notify all customers to be affected by any interruption of service in the official city newspaper or by a canvass of areas affected by employees of the city. (Ord. 83-14 § 1(W.12), 1983)

13.06.260 Shutoff rights—Reservation. SHARE

The city reserves the right at any time, without notice, to shut off the water supply for repairs, extensions, nonpayment of rates, or any other reason, and the city shall not be responsible for any damage such as bursting of boilers supplied by direct pressure or the breaking of any pipe or fixtures, stoppages or the interruption of water supply or any other damage resulting from the shutting off of water. (Ord. 83-14 § 1(W.13), 1983)

13.06.270 Obstruction of water meters and fire hydrants.

It is unlawful for any person to obstruct the access of any fire hydrant or water meter by placing around or thereon any stone, brick, lumber, dirt or any material or to park or stand vehicles or any obstruction within fifteen feet of any fire hydrant, or draw or attempt to draw any water therefrom or to wilfully or carelessly injure the same. The responsibility for preventing obstructions or removing of any such obstruction shall be that of the abutting property owner, except that for situations beyond the control of the owner, the responsibility shall be that of notifying the city. (Ord. 83-14 § 1(W.14), 1983)

13.06.280 Fire hydrants—Use.

No persons, other than properly authorized employees of the city or fire department, shall operate fire hydrants unless prior arrangements have been made with the public works director. (Ord. 2005-17 § 1 (part), 2005; Ord. 83-14 § 1(W.15), 1983)

13.06.290 Water use during emergency.

It is unlawful for any person knowingly to use water for lawn or garden sprinkling or other irrigation purposes on any premises receiving water from the city water system during the progress of a fire conflagration or other water emergency affecting the city's water system. (Ord. 83-14 § 1(W.16), 1983)

13.06.300 Sprinkling hours.

Sprinkling hours for lawns, gardens and shrubs are established year around from six a.m. to ten a.m. and six p.m. to ten p.m. Sprinkling shall not be done at other times. (Ord. 83-14 § 1(W.17), 1983)

III. SEWER

13.06.320 Connection required.

The owner of each lot or parcel of real property within two hundred feet of the Poulsbo sanitary sewer system as it now exists, or as it may be extended in the future, and upon which lot or parcel or real property there shall be situated any building or structure for human occupancy or for use for any other purpose which would necessitate sewage disposal, shall be required to be connected to the sanitary sewage disposal system. (Ord. 83-14 § 1(S.1), 1983)

13.06.330 Future development.

No parcel of land within the city of Poulsbo may be developed and have constructed upon it any building or structure for human occupancy or for use for any other purpose which would necessitate sewage disposal, including remodel or rezone, without having provided for the disposal of sewage generated on the property into the Poulsbo sanitary sewer system. This section shall not apply to the construction of a single-family residence located on property more than two hundred feet from an existing sewer line, or to any property granted a variance from this section by the city council of the city of Poulsbo. Failure to comply with the requirements of this section will be a basis for denying or revoking a certificate of occupancy issued by the city pursuant to the International Building Code. Any person feeling that the provisions of this section create a hardship as to that particular person's property may request a variance from this code. The city council may, after determining that it is in the best interest of the health, welfare and public safety of the city to do so, grant a variance from this section on such terms and conditions as the city council may impose. No short plat shall be approved which would result, when the property is developed, in operating to avoid the provisions of this section. (Ord. 2016-10 § 1 (part), 2016: Ord. 83-14 § 1(S.2), 1983)

13.06.335 Replacement units—Vesting of sewer capacity.

SHARE

A. In application of the policies adopted pursuant to Section 13.06.330 and the Uniform Plumbing Code, permittees may protect or vest existing sewage capacity by continuing to pay the city's monthly residential service charge from and after the demolition or removal of any housing unit from service or, for the units removed from service prior to the passage of the ordinance codified in this section by paying such charge from and after the effective date of the ordinance codified in this section until such time as the replacement units are reconnected. A replacement unit is defined to be a housing unit lawfully constructed in the city of Poulsbo in accordance with all provisions of city ordinance and the State Building Code, which has been removed from service and for which an approved development plan or building permit application has been submitted. Payment of the monthly service charge shall vest the applicant to sewer capacity as of the date of payment, in the chronological order in which the payment is first made. Failure to pay any monthly charge shall terminate this vesting provision.

B. Nothing herein shall be interpreted to obligate the city to issue a building permit or to provide a sewer hook-up if adequate sewer capacity does not exist downstream at the date of application for a building permit. For example, and by way of illustration and not limitation, the city may be obligated to deny permits in accordance with the Uniform Plumbing Code or in the event an act of God or failure of equipment and facilities reduces the capacity of the city's sewage transmission facilities, the enactment of a moratorium pursuant to the provisions of RCW 70.05.160 which prohibits further sewage connections, the order of a court or state or federal agency of competent jurisdiction, or a finding by the city council on the recommendation of the mayor and city engineer that all or part of the sewer facilities exceed current transmission capacity. In such cases, the city will endeavor to provide additional capacity in accordance with its permitting obligations by the repair, reconstruction or construction of sewage facilities in accordance with state or federal law. Upon construction of adequate sewage facilities, permits shall be issued to vested applicants in the chronological order in which they vested. In the event of conflict between the vesting rights of any owner or applicant for a building permit for a new housing unit with the vesting rights created pursuant to this section for a replacement unit, the replacement unit shall be given priority. (Ord. 2016-10 § 1 (part), 2016; Ord. 99-22 § 1, 1999)

13.06.340 Unlawful discharge. SHARE

It shall be unlawful to discharge or cause to be discharged into the Poulsbo sanitary sewer system or cause to be placed where they are likely to run, leak or escape into a public sewer, any of the following:

A. Ashes, cinders, sand, earth, rubbish, mud, straw, shavings, metal, glass, rags, feathers, tar, plastic, wood or any matter which is capable of or likely to obstruct or interfere with the capacity or operation of a public sewer;

B. Gasoline, benzine, naphtha, fuel oil, lubricating oil or any other matter which is inflammable or explosive upon introduction to a public sewer;

C. Any matter having a temperature greater than one hundred fifty degrees Fahrenheit;

D. Sewage containing suspended solids in excess of three hundred fifty milligrams per liter;

E. Sewage containing grease or oil in excess of one hundred parts per million by weight;

F. Matter with B.O.D. greater than three hundred milligrams per liter;

G. Sewage with pH lower than 5.5 or higher than 9.0;

H. Garbage that has not been properly shredded;

I. Sewage containing toxic or poisonous substances in sufficient quantity to injure or interfere with any sewage treatment process, constitute a hazard in the receiving waters of a sewage treatment plant;

J. Any noxious or malodorous matter capable of creating a public nuisance including fish parts;

K. Waters from irrigation, cooling processes, industrial processes creating no substantial water contamination, storm drains, sump pumps, surface runoff, roof runoff, subsurface drainage, swimming pools, ponds or reservoirs. Unauthorized hookups or excess infiltration to the Poulsbo sanitary sewer system described in subsection K of this section as determined by the city engineer shall result in a monthly additional sewer charge for estimated flow in excess of metered potable water. When an unauthorized hookup of a roof drain or excess infiltration is found to exist, the public works director shall notify the property owner immediately that corrective action is required and shall require that this corrective action be accomplished within sixty calendar days. If no corrective action is accomplished within sixty calendar days, the city engineer shall estimate the amount of unauthorized flow and the city shall bill the property owner an additional monthly charge for sewer as provided by separate ordinance.

L. Any matter which is radioactive to any degree above that which normally prevails in the County. (Ord. 2005-17 § 1 (part), 2005; Ord. 83-14 § 1(S.3), 1983)

13.06.350 Discharge prohibition—Effective date.

Beginning one hundred twenty days from the initial effective date of the ordinance codified in this chapter, no discharge of any sewage, except into the Poulsbo sanitary sewer system or approved individual sanitary disposal system, whether the discharge is treated or untreated, shall be permitted within the city limits or into any tidal waters over which the city has police jurisdiction. (Ord. 83-14 § 1(S.4), 1983)

13.06.360 Floating vessels or structures.

Any vessel or other floating structure used for permanent residential or commercial purposes and moored within the city limits shall have a holding tank and be periodically pumped into the Poulsbo sanitary sewer system. The owner of the moorage facility or property to which the vessel or floating structure is moored shall provide the proper pump and connection to the system. Alternatively, any vessel or other floating structure used for permanent residential or commercial purposes which has effective means aboard to treat sanitary drainage and eliminate all liquid effluent may be exempted from the requirement to discharge sanitary drains into the sanitary sewage disposal system, provided the treatment system on the vessel discharges no liquid overboard, and provided further that any discharge to the atmosphere is odorless and complies fully with all limits set by the Puget Sound Air Pollution Control Agency and the Bremerton-Kitsap County health department. (Ord. 83-14 § 1(S.5), 1983)

13.06.370 Shoreside facilities.

All property owners providing temporary or permanent boat moorage shall provide onshore toilet facilities with showers in sufficient numbers to service the facility. The toilet facilities shall be approved by the city engineer with respect to number, arrangement and conformance with the state of Washington Uniform Plumbing Code or any other applicable codes or amendments by the state of Washington, and with this code. (Ord. 2016-10 § 1 (part), 2016: Ord. 83-14 § 1(S.6), 1983)

13.06.380 Salt water discharge.

It is unlawful for any person to cause salt water to be discharged or deposited into the Poulsbo sanitary sewer system. (Ord. 83-14 § 1(S.7), 1983)

13.06.390 Controlled dumping and fees.

It is unlawful for any person, firm or corporation to discharge the contents of any septic tank, cesspool, holding tank or chemical toilet into the Poulsbo sanitary sewer except at places designated by the city for such purpose. Commercial collectors may only discharge such contents as are collected from within the Liberty Bay Drainage Basin area. Fees shall be as set forth in Section 3.12.100(G)(8). (Ord. 2003-33 § 8, 2003: Ord. 83-14 § 1(S.8), 1983)

13.06.400 Side sewer responsibility.

That portion of any side sewer pipe lying within a street right-of-way or easement shall be kept within the exclusive control of the city. That portion lying beyond the right-of-way or easement shall be the responsibility of the abutting property owner. Removal of blockages in side sewers between the premises and the city main shall be the responsibility of the property owner. (Ord. 83-14 § 1(S.9), 1983)

13.06.410 Industrial users.

All major contributing industrial users shall be required to enter into an agreement with the city of Poulsbo to provide for the payment of their proportionate share of the federal share of the capital costs of the sewage project allocable to the treatment of such industrial waste. (Ord. 83-14 § 1(S.10), 1983)

13.06.420 Industrial payments. SHARE

All industrial users of the treatment works shall be required to pay to the city of Poulsbo that portion of the federal grant attributable to the cost of transportation and treatment of industrial wastes. (Ord. 83-14 § 1(S.11), 1983)

13.06.430 Industrial proportionate share. SHARE

The recovery of the proportionate share of costs as required by the terms of this code shall be determined by agreement between the city and parties involved which share shall be based upon all factors which significantly influence the cost of the treatment works and shall be repaid, without interest in at least annual payments during the recovery period not to exceed the service life of the project or thirty years. In the event the city and users cannot agree as to the proportionate share to be repaid to the city, the proportionate share shall be determined by arbitration and the arbitrator shall be appointed by the presiding judge of the Kitsap County superior court. (Ord. 83-14 § 1(S.12), 1983)

13.06.440 Industrial compliance. SHARE

All major contributing users discharging into the treatment works shall be required to comply within three years with the pretreatment standards established by the environmental protection agency. In accordance with the pretreatment requirements, major industries are defined as those industries that:

A. Have a wastewater flow of fifty thousand gallons, or more, per average work day;

B. Have a wastewater flow greater than one percent of the flow carried by the municipal system receiving the waste; or

C. Include the discharge of a toxic material. (Ord. 83-14 § 1(S.13), 1983)

13.06.450 Meter installation on commercial property. SHARE

In those instances where sewer service is provided to a commercial property and no water meter is installed and under the terms of this code sewer charges shall be based upon water consumption, the city shall have the right to enter upon private property, if necessary, and install a water meter to the water supply furnishing water to the property for purposes of metering for sewer charges. The cost of installation shall be paid by the city and the meter shall belong to the city. In the event water service is later provided from the Poulsbo city water service, the property owner shall be required to pay a connection charge as is normally charged for water connections and may not without specific permission of the city, and after payment of a suitable charge, utilize the water meter previously installed for purposes of determining sewer service charges. (Ord. 2010-10 § 1 (part), 2010: Ord. 83-14 § 1(S.14), 1983)

SECTION 2

SOURCES USED TO COMPILE MASTER LIST

Sources of information: As recommended by the "Guidance Manual for Performing an Industrial User Survey," Kitsap County compiled a master list using billing records, specifically water use. The manual recommended surveying businesses over 25,000 gallons per day. Only 4 users exceed 25,00 gallons per day. As also decided during the 2014 Industrial User Survey, Kitsap County decided to set the standard at 2,500 gallons per day to include more users. After eliminating business which were surveyed in 2014, 8 new businesses were selected for inclusion into Kitsap County's Industrial User Survey.

Water consumption set a good representative criterion for potential Industrial dischargers. The top 4 water consumers for Kitsap County are Bangor, Clearwater Casino, City of Poulsbo, and Keyport. Bangor and Keyport are already considered Industrial dischargers and permitted through the Department of Ecology. The Clearwater Casino discharges to the Suquamish Treatment Facility, which is monitored through the EPA and is not part of this survey. The City of Poulsbo was included into this survey and reported 19 potential industrial dischargers.

After using water consumption as a criteria, the business accounts were evaluated for potential Industrial dischargers based on production. There were 9 businesses added to Kitsap County's survey based on the production criteria. It was determined 4 of these businesses operate under the St Michael Medical Center name so only one survey was returned to represent the combined discharge of one location.

The City of Poulsbo used the same criterion as Kitsap County to compile their list, which classified 19 businesses into this criterion. Between Kitsap County and the City of Poulsbo the total number of businesses surveyed in the Central Kitsap Treatment Facility's Collection System was 24 businesses.

If you have any questions or concerns, please contact 360-337-7197.

SECTION 3

INDUSTRIAL USER SURVEY

COPY OF POTW'S ORDINANCE

PART 1

Strategy for Obtaining Survey Information

As recommended by the "Guidance Manual for Performing an Industrial User Survey," Kitsap County determined their legal authority to obtain survey information, compiled a master list of potential IU's, collected and tabulated survey data, followed up with unresponsive businesses, and summarized survey data to report to the Department of Ecology.

After Kitsap County had compiled their Master List, survey questionnaire, and cover letter of authority, the surveys were mailed to businesses. A Sewer Utility employee was able to provide answers to common questions and notified the businesses the surveys needed to be returned by July 30, 2021.

All but two businesses returned the survey by the requested deadline. A follow up email was sent to the remaining businesses. Although there was a delay in receiving their response, the last survey for Kitsap County was collected on October 28, 2021, which completed Kitsap County's survey efforts.

The City of Poulsbo was informed by Kitsap County of the requirements for the Industrial User Survey in June 9, 2021. Kitsap County gave the City of Poulsbo the blank survey form and strategies used to perform and collect the surveys. The City of Poulsbo completed their survey and confirmed no new industrial users as stated in an email provided in this packet.

PART 2

Copy of Blank Questionnaire

WASTEWATER DIVISION

INDUSTRIAL USER SURVEY FOR NON-RESIDENTIAL ESTABLISHMENTS

INSTRUCTIONS: Please type or print information clearly with a pen. Attach additional sheets as needed. Please complete a survey for each facility that discharges to the Kitsap County Sanitary Sewer. Additional information and copies of this form are available from Matt Pickering, Utility Analyst – Lead.

1. Company Name:____
2. Mailing Address:____
   ____
3. Facility Address: ____
   ____
4. Telephone Number:____
5. Name and Title of Contact Person:____
6. Please provide a brief narrative of manufacturing, production, or services provided at your facility:____
   ____
   ____
7. You use approximately _____________gallons of water per day.
8. How much of your daily water use goes into the wastewater sewer system?_____________
9. Do you discharge any wastewater other than domestic waste (restrooms, showers, etc)
   ( ) Yes ( ) No
10. If Yes, what kind of non-domestic waste do you discharge?
    ____
    ____
    ____
11. Will water be used for product manufacturing, washdown, or floor cleaning in production areas? ( ) Yes ( ) No
12. Do you have floor drains in your process / production area? ( ) Yes ( ) No

13. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes ( ) No

14. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? ( ) Yes ( ) No

15. If Yes, which do you have?
( ) Grease Trap ( ) Oil / Water Separator ( ) Both

16. How often do you have it cleaned?____

17. Do you store toxic, hazardous, or dangerous materials at your facility? ( ) Yes ( ) No

18. If Yes, what materials? ____

19. Do you qualify as a Hazardous Waste Small Quantity Generator? ( ) Yes ( ) No

20. Are you aware of Kitsap County's Small Generator (SQG) Program? ( ) Yes ( ) No

21. Do you have a plan do prevent accidental spills? ( ) Yes ( ) No

For more information on the SQG Program, please call the Solid Waste Division at 360-337-5777. For technical assistance with hazardous waste, contact the Kitsap County Health District at 360-692-3611.

The information collected during this survey is used to fulfill the requirements of Kitsap County Central Kitsap Wastewater Treatment Plant's National Pollutant Discharge Elimination System (NPDES) Permit through the WA State Department of Ecology. The Permit number is WA-000030520.

Please return this survey to:

12351 Brownsville Hwy NE
Poulsbo, WA 98370

Print Name and Title

____

Signature____Date___________________

I understand by signing this, I hereby certify the above statement is true to the best of my knowledge and ability. I understand this is a legal document and will be used to determine our Industrial User Status with the Department of Ecology.

PART 3

Cover Letter Sent to Industrial Users

Completion of Industrial User Survey Forms

Dear Customer:

Kitsap County Public Works - Sewer Utility is currently collecting information on the wastewater discharged by our customers. This study is called an "Industrial User Survey" and is required by Washington State Department of Ecology. We need to collect information from non-residential customers that meet our water use criteria of over 2,500 gallons per/day and have potential to discharge non-residential waste. We use the information provided to determine if businesses can be eliminated from any future surveys.

After we successfully survey the businesses on our list, we send the results to the Department of Ecology, who uses this information to determine if a business requires a Wastewater Discharge Permit or a pre-treatment program. The primary goal is to identify any discharge that may be a problem to our collection/treatment systems. We must ensure that proper controls are in place to reduce significant or potential sources of pollution as disclosed in the Kitsap County Code 13.12.160 that may ultimately end up in the Puget Sound.

The Department of Ecology is the permit administrator for the Central Kitsap Wastewater Treatment Plant, Permit # WA-0030520. This permit is a National Pollutant Discharge Elimination System (NPDES) Permit. To comply with our requirement we need to successfully receive a completed survey from every business on our list. This survey should be completed by the authority onsite that can vouch for the discharge of the business. Please complete and return this form by July 30, 2021.

Thank you for your cooperation as Kitsap County continues to provide safe and clean water resources for its residents. If you have any questions feel free to call (360) 337-7197 or e-mail me at csheridan@co.kitsap.wa.us.

Thank You,

Chris Sheridan
Sewer Utility Operations Manager
Kitsap County Public Works-Sewer Utility Division

SECTION 4

INDUSTRIAL USER SURVEY

Part 1

Kitsap County
Master List of
Surveyed Users

Part 2

City of Poulsbo
Master List of Surveyed
Users

PART 2 – CITY OF POULSBO MASTER LIST

Potential new City of Poulsbo Industrial Users with discharges above 2,500 gallons since 2014 User Survey

	Commercial Accounts		
Account Number	Customer Name	Service Address	Comments
00570-3	SAFEWAY INC SITE #3148	19245 10TH AVE NE	Grocery
02422-1	CAR WASH ENTERPRISES INC	18764 STATE HIGHWAY 305 NE	Car Wash
00575-1	TOWN & COUNTRY MARKETS INC	20148 10TH AVE NE	Grocery
04009-0	BURKS ASHLEY	21205 OLHAVA WAY NW	Car Wash
00893-1	LAURELHURST APARTMENTS CO	19425 & 19505 7TH AVE NE	Laundromat, Dry Cleaners, Retail
00301-1	WAL MART TRS LLC STORE 5272	21200 OLHAVA WAY NW	Grocery, Oil change, Retail
03808-1	MORA ICED CREAMERY	22195 VIKING AVE NW	Food Manufacturing
00721-1	CURRENT DEVELOPMENT LLC	19472 NE POWDER HILL PL	Kidney Dialysis, Office space
00909-1	HOONS CORPORATION	19801 7TH AVE NE	Hotel
00908-2	CAR WASH ENTERPRISES INC	19774 7TH AVE NE	Car Wash
01284-1	XENOS JOHN E	18779 ANDERSON PKWY NE	Restaurants
	Multi-Family		
00850-1	VIKINGS CRESTS OWNERS ASSOCIATION	20026 NE VIKING CREST RD #OS	Apartments-Domestic discharge
00480-1	POULSBO MOBILE HOME PARK	1800 NE LINCOLN RD	Moble Home Park-Domestic discharge
02256-2	HOSTMARK VILLAGE COVE	703 NE HOSTMARK ST	Apartments-Domestic discharge
00428-1	LIBERTY SHORES RETIREMENT CENTER	19360 VIKING AVE NW	Retirement Center-Domestic discharge
01319-1	MARTHA & MARY HEALTH SERVICES	19160 FRONT ST NE	Retirement Center-Domestic discharge
00489-2	EMERITUS SENIOR LIVING SITE 0642	1250 NE LINCOLN RD	Retirement Center-Domestic discharge
00978-1	HILLSIDER 50 APTS	19630 ASH CREST LP NE #OS	Apartments-Domestic discharge
00945-1	RC LIBERTY VIEW LLC	19781 FRONT ST NE #OS	Apartments-Domestic discharge

No discharges were determined to be significant based on City of Poulsbo data. See email below for confirmation of no new industrial users since 2014. Email provided by Keith Svarthumle, City of Poulsbo – Public Works, Assistant Superintendent

I apologize. Just got back from vacation. I will get back on this. No new industrial users for sure. Here are the additional accounts exceeding 2500 gpd.

Keith Svarthumle

City of Poulsbo-Public Works

Assistant Superintendent

From: *Carter Braunz <CBraunz@co.kitsap.wa.us>*
Sent: *Wednesday, July 21, 2021 2:49 PM*
To: *Keith Svarthumle <ksvarthumle@cityofpoulsbo.com>*
Cc: *Matt Pickering <MPickering@co.kitsap.wa.us>; Kevin Smiley <KSmiley@co.kitsap.wa.us>*
Subject: *CKTP IU Survey 2021*

CAUTION: This email originated from outside your organization. Exercise caution when opening attachments or clicking links, especially from unknown senders.

Good afternoon Keith,

I just wanted to check in again on how you are doing with the list of potential significant users from Poulsbo that are discharging waste to the Central Kitsap Treatment Plant. Last time we talked, you had said that you didn't expect any changes from the survey that was done in 2014. We have also found that many businesses were able to be crossed off our list, leaving us with just an handful of businesses that we mailed the survey to last week.

Respectfully,

Carter Braunz

Kitsap County Public Works

Sewer Utility Division

(360) 620-4203

SECTION 5

INDUSTRIAL USER SURVEY

SIGNED SURVEY FORMS

APPENDIX D
KITSAP COUNTY SEWER UTILITY
SCADA MASTER PLAN
TECHNICAL MEMORANDUM,
MURRAYSMITH/HDR, 2022

consor

TM-1: Existing System Overview

FINAL

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

November 2, 2020

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-1: Existing System Overview

November 2, 2020

Prepared by:

John M. Thomas, P.E.
HDR Engineering, Inc.
(425) 450-6240

I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

Tables

Figures

Appendices

Abbreviations

µm	micron(s)
AAA	authentication, authorization, and accounting
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
AOI	Add-on Instruction
BNR	biological nutrient removal
Branom	Branom Instrument Co.
CIA	Confidentiality, Integrity, and Availability
CIP	capital improvement program
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
County	Kitsap County
CTU	central telemetry unit
DHS	U.S. Department of Homeland Security
DO	dissolved oxygen
EMS	energy management system
eO&M	electronic operation and maintenance
FCC	Federal Communications Commission
ft^3	cubic foot/feet
FVNR	full-voltage non-reversing
GbE	gigabit(s) Ethernet
GBT	gravity belt thickener
GE	General Electric
GHz	gigahertz
gpm	gallon(s) per minute
H_2S	hydrogen sulfide
HDR	HDR Engineering, Inc.
HIP	Host Identity Protocol
HMI	human-machine interface
HOA	Hand-Off-Auto
hp	horsepower
HVAC	heating, ventilation, and air conditioning
Hz	hertz
I&C	instrumentation and controls
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
in	inch(es)
I/O	input/output
IP	Internet Protocol
IR	infrared
ISA	International Society of Automation
IT	Information Technology
kB	kilobyte(s)
kbps	kilobit(s) per second
kHz	kilohertz
KPI	key performance indicator
KPUD	Kitsap Public Utility District
kW	kilowatt(s)
KWWTP	Kingston Wastewater Treatment Plant
LAN	local area network
LEL	lower explosive limit

LIMS	laboratory information management system
LTE	Long-Term Evolution
M2M	machine-to-machine
mA	milliampere(s)
MB	megabyte(s)
Mbps	megabit(s) per second
MCC	motor control center
MFA	multi-factor authentication
mgd	million gallons per day
MHz	megahertz
MTU	master telemetry unit
MWWTP	Manchester Wastewater Treatment Plant
N/A	not applicable
NAT	Network Address Translation
NEC	National Electrical Code
NIC	network interface card
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
OIT	operator interface terminal
O&M	operation and maintenance
OM1	Optical Multi-mode 1
OM3	Optical Multi-mode 3
OOP	object-oriented programming
OS2	Optical Single-mode 2
OSI	Open Systems Interconnection
OT	Operational Technology
PC	personal computer
P&ID	piping and instrumentation diagram
PID	proportional-integral-derivative
PLC	programmable logic controller
PNL	panel
PS	pump station
PSTN	public switched telephone network
QCC	Quality Controls Corporation
QoS	Quality of Service
RACS	Raptor Acceptance Control System
RAS	return activated sludge
RDT	rotary-drum thickener
RFB	Remote Frame Buffer
RIO	remote input/output
RS	Recommended Standard
RTU	remote telemetry unit
RVSS	reduced-voltage soft starter
SBR	sequencing batch reactor
SCADA	supervisory control and data acquisition
Sewer Utility	Public Works Sewer Utility Division
SMS	Short Message Service
SNMP	Simple Network Management Protocol
SOP	standard operating procedure
SP1	Service Pack 1
SPB	solids processing building
SSID	Service Set Identifier
ST	straight-tip
SWGR	switchgear

SWWTP	Suquamish Wastewater Treatment Plant
TCC	total calculated capacity
TCP	Transmission Control Protocol
THD	total harmonic distortion
TM	technical memorandum
UDT	User-defined Data Type
UPS	uninterruptible power supply
USB	Universal Serial Bus
UTP	unshielded twisted pair
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VFD	variable-frequency drive
VHF	very high frequency
VLAN	virtual local area network
VM	virtual machine
VNC	Virtual Network Computing
VPN	virtual private network
W3	service water
WAN	wide-area network
WAS	waste activated sludge
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This Existing System Overview Technical Memorandum (TM)-1 describes the current condition, arrangement, life-cycle state, and identified areas of risk for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system components and associated wastewater treatment plant (WWTP) and pump station (PS) systems. The content of TM-1 is based on information that HDR Engineering, Inc. (HDR) obtained from the Sewer Utility and field data collected by HDR during various site assessment visits conducted in August 2020.

1.1 Technical Memorandum Organization

TM-1 is organized into nine sections and four appendices, as described below. In any subsection where a risk or deficiency is identified, a summary risk or deficiency description is presented at the end of that subsection, as shown below, so that these risks and deficiencies are easily visible and can be quickly located. Risks and deficiencies are compiled in Section 8 in Table 8-2.

> ✸ Identified risks and deficiencies are shown in condensed highlighted form like this throughout the report.

Section 1: Introduction summarizes TM organization, briefly describes each Sewer Utility wastewater facility included in the TM, and details the site assessment work performed in preparation of TM-1.

Section 2: Network Architecture describes the existing Operational Technology (OT) network architecture at the Sewer Utility WWTPs and pump stations. It includes an overview of the current network topologies and segmentation practices, major hardware and software elements, network management and system backup procedures, and cybersecurity measures currently implemented at the facilities.

Section 3: Industrial Control System Hardware describes the current industrial control system (ICS) hardware at Sewer Utility WWTPs and wastewater pump stations. It includes a description of the major hardware elements and a summary of the WWTP control room equipment.

Section 4: Industrial Control System Software describes the Sewer Utility's current ICS software, including an overview of the programmable logic controller (PLC) programming, human-machine interface (HMI), historian, and alarm notification software packages in use at the WWTPs and wastewater pump stations. It also describes the SCADA system functionality that has been implemented with this software.

Section 5: Industrial Control System Documentation summarizes documentation associated with the Sewer Utility's wastewater ICS. It describes the type of documents that the Sewer Utility has available along with a general description of how they are organized and maintained.

Section 6: Other Software Packages provides an overview of the non-ICS software packages at the Sewer Utility's WWTPs that bear a relationship to the Sewer Utility

SCADA system and the assets with which it interacts. It includes a description of the software tools and provides a general summary of their current uses at Sewer Utility facilities.

Section 7: Organizational Improvement Categories presents five organizational improvement categories that apply to utility control systems and how they will be applied within the Sewer Utility SCADA Master Plan to relate risks, deficiencies, and proposed improvements to facets of the Sewer Utility's organizational health.

Section 8: Risk and Deficiency Summary compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in previous sections of TM-1, correlating each of them to one or more of the organizational improvement categories.

Section 9: References lists the supporting source materials cited in TM-1.

Appendix A: Site Maps includes an overall site map showing the general locations of the Sewer Utility's WWTPs and pump stations. The appendix also includes a site map for each of the WWTPs, labeled with major buildings and process areas.

Appendix B: Network Architecture Diagrams includes various network architecture diagrams that are referenced throughout TM-1.

Appendix C: QCC Network Design Diagrams includes various network diagrams that Quality Controls Corporation (QCC) has developed to document implementation of telemetry and wide-area network (WAN) upgrades it is contracted to perform for the Sewer Utility. At the time of this writing, QCC's work is ongoing and the network documentation included in Appendix C may not reflect as-built conditions once QCC's work is complete.

Appendix D: WWTP PLC I/O Summary and PLC and Remote I/O Module Summary includes a summary of input/output (I/O) quantities and types by PLC and a summary of the installed modules at the various PLC and remote input/output (RIO) racks throughout each WWTP.

1.2 Site Descriptions

The following site descriptions provide a general summary of the Sewer Utility's 4 WWTPs and 12 pump stations included in HDR's site assessments. The Sewer Utility has a total of 62 pump stations that are currently in service with remote alarm monitoring. An overall site map showing the general locations of the Sewer Utility's WWTP and pump station facilities can be found in Appendix A.

1.2.1 Central Kitsap Treatment Plant

The Central Kitsap Treatment Plant (CKTP), located at 12351 Brownsville Highway NE in Poulsbo, Washington, is a regional facility serving the central area of Kitsap County. The facility, which was put into service in 1979, uses a conventional activated sludge secondary treatment process, ultraviolet (UV) disinfection, and sand filtration for tertiary treatment and reclaimed water. CKTP has a design flow of 6.0 million gallons per day (mgd) of average dry weather flow and has attended operations 17 hours per day, 7 days per week, with significantly reduced staff during evening operations. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.2 Kingston Wastewater Treatment Plant

The Kingston Wastewater Treatment Plant (KWWTP), located at the end of a gravel road near 23055 S Kingston Road NE in Kingston, Washington, is an oxidation ditch type activated sludge facility with a mechanical fine screen and aerated grit chamber for preliminary treatment. Following the oxidation ditches, the liquid stream flows through secondary clarifiers for solids settling and then to UV disinfection before reaching the KWWTP outfall. Sludge removed from the secondary clarifiers is thickened by a gravity belt thickener (GBT) and stored for transport to CKTP for further treatment and disposal. KWWTP has a design flow of 0.292 mgd for the average day within the maximum month flow. The facility, which was first put into service in 2005, is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.3 Manchester Wastewater Treatment Plant

The Manchester Wastewater Treatment Plant (MWWTP), located at 8020 E Caraway Road in Port Orchard, Washington, is an activated sludge facility with a rotary screen and aerated grit chamber for preliminary treatment and aeration basins for biological treatment. Following the aeration basins, the liquid stream flows through secondary clarifiers for solids settling and then to UV disinfection before reaching the plant outfall. Sludge removed from the secondary clarifiers is thickened by a GBT and stored for transport to CKTP for further treatment and disposal. MWWTP has a design flow of 0.460 mgd for the average day within the maximum month flow. The original facility, which consisted of primary treatment only, was first put into service in 1969. The final phase of secondary treatment improvements was completed in 1998. MWWTP is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.4 Suquamish Wastewater Treatment Plant

The Suquamish Wastewater Treatment Plant (SWWTP), located on land belonging to the Suquamish Tribe at 18019 Division Avenue NE in Suquamish, Washington, is a sequencing batch reactor (SBR)-type activated sludge facility with a rotary bar screen and aerated grit chamber for preliminary treatment. Supernatant from the SBRs is decanted to an equalization tank and then flows to UV disinfection before reaching the plant outfall. Sludge removed from the SBRs is thickened by a rotary-drum thickener (RDT) and stored for transport to CKTP for further treatment and disposal. SWWTP has an average design flow of 0.4 mgd. The facility, which was first put into service in the 1970s, was upgraded in 1998 to accommodate increased flows and to convert SWWTP to an SBR-type activated sludge facility. SWWTP is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.5 Pump Stations

The Sewer Utility selected the wastewater pump stations listed in Table 1-1 for inclusion based on criticality; they serve as a representative sample for all of the Sewer Utility's wastewater conveyance system pump stations. The table presents the pump station numbers and descriptions along with their site address, number and type of pump, pump horsepower (hp), and type of pump motor controller (e.g., variable-frequency drive [VFD], reduced-voltage soft starter [RVSS], or full-voltage non-reversing [FVNR] starter). The pump station wet well total calculated capacities (TCCs) listed in Table 1-1 were obtained from Sewer Utility–provided documentation and were not verified by HDR. The County's Utilities group handles day-to-day operation and maintenance (O&M) of the pump stations. The Utilities staff visit the pump stations on a weekly basis to test pump station alarms and perform maintenance as needed.

Table 1-1. Sewer Utility pump station summary

Station	Pump station description	Site address	Pump qty.	Pump type	hp	Motor controller	TCC (ft^3)
PS-01	Levin Road	10015 Levin Rd. NW Silverdale, Washington	3	Submersible	160	VFD	3,334
PS-04	Pump station 4	9606 Frederickson Rd. NW Bremerton, Washington	3	Vertical non-clog centrifugal	75	VFD	5,636
PS-06	Parkwood East	457 NE Conifer Dr. Bremerton, Washington	3	Submersible	60	VFD	2,837
PS-07	Fairgrounds	1300 NE Fairgrounds Rd. Bremerton, Washington	3	Submersible	150	VFD	1,948
PS-12	Newberry Hill	8160 Chico Way NW Silverdale, Washington	2	Vertical non-clog centrifugal	10	FVNR	673
PS-17	Bangor	14690 Clear Creek Rd. NW Silverdale, Washington	3	Vertical non-clog centrifugal	40	VFD	1,920
PS-24	Brownsville Highway	14501 Brownsville Hwy. NE Poulsbo, Washington	3	Vertical non-clog centrifugal	250	VFD	4,111
PS-32	Riddell Road	1552 NE Riddell Rd. Bremerton, Washington	2	Vertical non-clog centrifugal	10	FVNR	874
PS-34	Central Valley	6240 Central Valley Rd. NE Bremerton, Washington	2	Submersible	60	FVNR	1,884
PS-41	Kingston waterfront	10809 NE West Kingston Rd. Kingston, Washington	2	Vertical non-clog centrifugal	15	FVNR	558
PS-67	Keyport	15378 Washington Ave. NE Keyport, Washington	3	Submersible	70	VFD	6,030
PS-71	Kingston (old plant)	26198 Dulay Rd. NE Kingston, Washington	2	Vertical non-clog centrifugal	75	RVSS w/ FVNR bypass	942

1.3 Site Assessment Protocol

The current Sewer Utility SCADA Master Plan effort (for which TM-1 is a deliverable) is part of a larger effort the Sewer Utility is currently undertaking to update its sewer and wastewater treatment facility plans. The site assessment work conducted under this first phase of the Sewer Utility SCADA Master Plan was focused on identifying the current condition, arrangement, life-cycle state, and areas of risk for the major SCADA infrastructure components and associated systems.

1.3.1 Existing Documentation

To the extent possible, existing documentation provided by the Sewer Utility was used in conjunction with fieldwork assessments to identify SCADA and associated system components and determine their arrangement, configuration, and potential risks and deficiencies. This documentation includes the following:

- Contract and record drawings
- Internet Protocol (IP) address lists
- O&M manuals
- Monthly lab reports
- Pump station holding time data

1.3.2 Field Surveys

Fieldwork for the site assessments consisted of site visits to all WWTP facilities and 12 pump stations, occurring over two rounds of site visits totaling 7 days in August 2020. HDR instrumentation and controls (I&C) engineer John Thomas and HDR I&C engineer-in-training Maddi Hutson performed the fieldwork. As part of the fieldwork, HDR obtained the following additional documentation to include in its assessment:

- Photo documentation of existing Sewer Utility infrastructure
- Screenshots of various software packages
- Wonderware Historian and General Electric (GE) EnerVista Viewpoint database exports
- PLC program files

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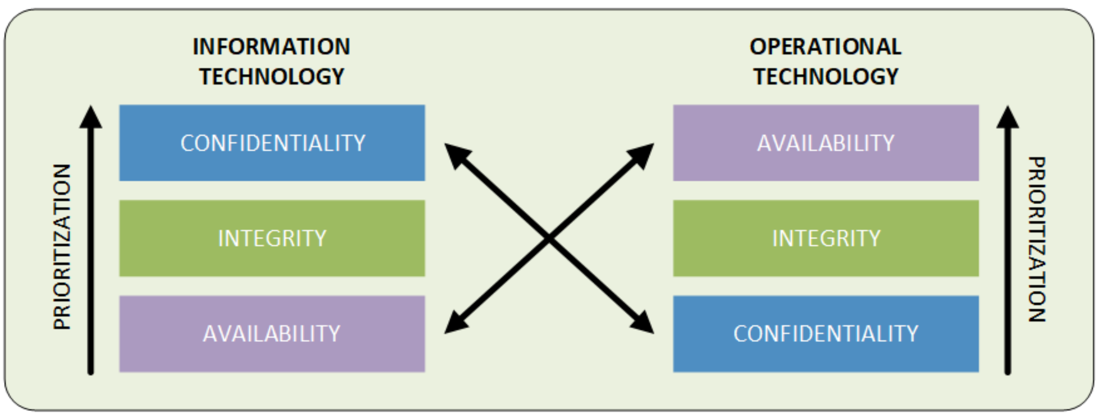
2 Network Architecture

This section describes the existing OT network architecture at the Sewer Utility WWTPs and pump stations. It includes an overview of the current network topologies and segmentation practices, major hardware and software elements, network management and system backup procedures, and cybersecurity measures currently implemented at the facilities.

2.1 Operational Technology versus Information Technology

Before discussing the Sewer Utility's OT networks, it is important that some of the differences between Information Technology (IT) and OT networks are understood. To facilitate the comparison, Figure 2-1 introduces an information security industry model known as the Confidentiality, Integrity, and Availability (CIA) Triad. The CIA Triad consists of three core components for the security of any communication network, and the figure depicts how these security components are prioritized in IT and OT networks.

Figure 2-1. CIA Triad for IT and OT networks



Many readers may be more familiar with IT networks because these are the standard home and office network environments. In IT networks, confidentiality, or the securing of sensitive and/or private information, is typically the highest priority. Preventing unauthorized access to trade secrets, employee/customer personally identifiable information, or credit card information is mission critical. Data integrity is also very important, and typically involves taking steps to back up critical files and databases to avoid loss of information and preventing unauthorized access that could lead to data corruption and/or manipulation. While availability is also important in IT networks, it is the lowest priority of the three security components. Outages to services, file systems, and databases typically result only in lost revenue or efficiency and planned outages for updates and maintenance can often be scheduled around business hours.

In OT networks, availability is the highest priority. OT networks involve equipment and processes that interact with the physical world. Disruption of OT network communication can jeopardize the safety of an organization's personnel and infrastructure, as well as the natural environment. Data integrity is equally important to both IT and OT networks, as they both rely on these data for day-to-day operation. Confidentiality, on the other hand, is much less of a priority in OT networks. Though organizations may prefer to keep SCADA and other OT network data private, their chief concerns are with maintaining the availability of the OT network resources and ensuring that the data being generated are of sufficient quality to provide insight and inform decisions.

Because IT and OT networks have different priorities, they require different approaches to security and architecture. The discussions and observations provided in Section 2 are based on the OT network priorities described above and tailored to the specific requirements of wastewater facilities as critical infrastructure.

2.2 WWTP Network Architecture Overview

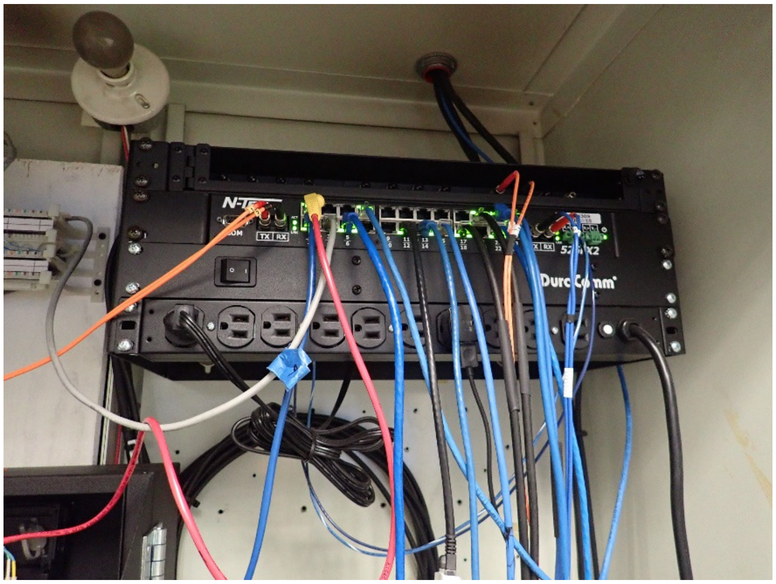
This subsection provides an overview of the network at each of the Sewer Utility WWTPs.

2.2.1 Central Kitsap Treatment Plant

The CKTP OT network is configured in an extended-star topology, as shown in the Central Kitsap Treatment Plant Physical Network Diagram in Appendix B, Figure B1. The network has no core or distribution switches and consists only of managed and unmanaged industrial access switches installed within control panels in the various buildings and process areas. These switches provide access to the CKTP OT network for the various IP-connected devices (IP nodes) near their respective locations.

The most critical switch within the OT network is an unmanaged access switch located within a network cabinet in the solids process building (SPB) control room (see Figure 2-2). This switch handles traffic between the CKTP SCADA nodes, historian server, and all CKTP PLCs. All data exchange that will eventually occur between CKTP and the other Sewer Utility WWTPs would also traverse this switch, given the current network topology. This switch is a single point of failure for the CKTP OT network.

Figure 2-2. Unmanaged switch (N-Tron 526FX2) in SPB control room network cabinet



Being unmanaged, this switch introduces additional risks to the OT network. Among other shortcomings, unmanaged switches provide no means of filtering broadcast and multicast packets and will propagate these packets to all connected nodes, creating the potential for flooding events that can take down the network. The Microsoft Windows operating system, which is running on all personal computers (PCs) connected to this switch, is notorious for generating a high volume of needless broadcast and multicast packets because of the large number of processes that are set to run by default within the operating system. Having managed switches handle network traffic to and from PCs and servers would, among other benefits, allow the Sewer Utility to filter undesirable packets and preserve OT network bandwidth for its intended use.

Though much of the CKTP OT network topology is typical of industrial networks that evolve organically throughout multiple capital improvement program (CIP) projects, the network arrangement in panel (PNL) 8580A within the SPB control room deserves attention. Several of the CKTP building access switches for the OT network are connected to one of two modular access switches located in PNL 8580A (see Figure 2-3). These modular switches are networked via a fiber-optic patch cable, but only one of these switches has a connection to a network switch that provides connectivity to the CKTP SCADA nodes, which are the endpoints for most of the traffic traversing these switches from the various PLCs throughout CKTP. This arrangement effectively forces traffic from one of the modular switches to traverse the other modular switch. All traffic from both modular switches is then consolidated onto one fiber-optic pair between one of the modular switches and the unmanaged switch (discussed above) that serves as the access switch for the SCADA PCs, historian server, and other ICS IP nodes within the SPB. This arrangement creates multiple single points of failure (e.g., the fiber patch cord, the switch ports at either end, the modular switch processor, etc.) for communications between the plant SCADA PCs and most of the PLCs at CKTP.

Figure 2-3. Modular access switches in PNL 8580A

2.2.2 Kingston Wastewater Treatment Plant

The KWWTP OT network is configured in an extended-star topology, as shown in the Kingston WWTP Physical Network Diagram in Appendix B, Figure B2. This relatively small network consists of industrial access switches installed within control panels in the operations building, process building, and headworks area. These switches provide access to the KWWTP OT network for the various IP nodes within these buildings and process areas.

2.2.3 Manchester Wastewater Treatment Plant

The MWWTP OT network is configured in an extended-star topology, as shown in the Manchester WWTP Physical Network Diagram in Appendix B, Figure B3. This relatively small network consists of industrial access switches installed within control panels in the operations building, blower building, and headworks building. These switches provide access to the MWWTP OT network for the few IP nodes within these buildings.

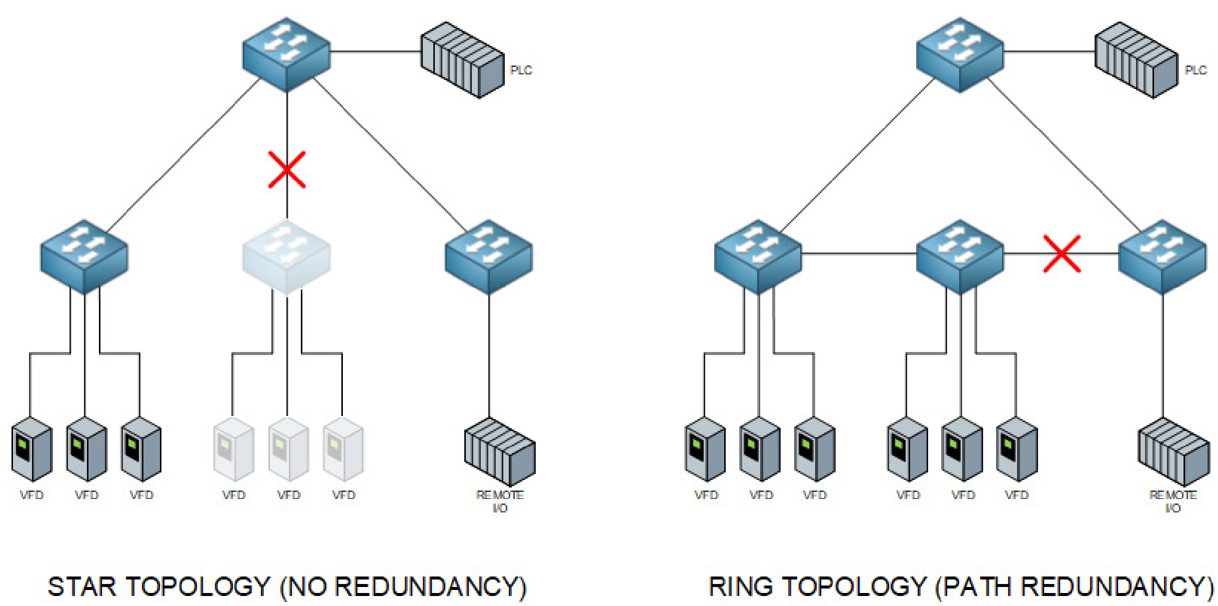
2.2.4 Suquamish Wastewater Treatment Plant

The SWWTP OT network is configured in an extended-star topology, as shown in the Suquamish WWTP Physical Network Diagram in Appendix B, Figure B4. This relatively small network consists of industrial access switches installed within control panels in the process building. These switches provide access to the SWWTP OT network for the few IP nodes within the building.

2.2.5 Resilience Considerations

As shown in the WWTP physical network diagrams in Appendix B, the Sewer Utility's WWTP OT networks have no N+1 redundancy. Without switch-level and/or cable path redundancy for connected devices, failure of an access switch would result in loss of communications for all connected IP nodes. Similarly, with all connections between access switches consisting of single copper and/or fiber-optic cable segments, the WWTP OT networks have no resilience against damage or disconnection of one of these cables or failure of one of the switch ports to which the cable connects on either side. Figure 2-4 illustrates how a single cable or switch port failure would impact devices on a non-redundant network topology versus a network topology with path redundancy. The screened back devices shown in the star topology portion of the figure are the devices that would lose communication under the depicted failure scenario. The ring topology, on the other hand, is tolerant of single path failures and preserves communications for all devices shown in the figure.

Figure 2-4. Consequences of cable path or switch port failure in star versus ring topology



Though non-resilient network topologies like the ones deployed at the Sewer Utility's WWTPs are common within the water/wastewater industry, a general best practice is for the OT network segments and components to adopt the same level of redundancy inherent in the plant processes that they serve, at a minimum. This practice prevents the OT network from inadvertently reducing or eliminating the actual redundancy of plant processes in the event of a single network component and/or cable failure.

Central Kitsap Treatment Plant

At CKTP, many of the plant processes consist of parallel trains and equipment systems designed to provide some degree of redundancy. The plant electrical distribution system has also been designed with redundancy in mind. Electrical loads for parallel and/or redundant processes have been split between "A" bus and "B" bus throughout the CKTP electrical distribution system so that loss of either the “A” or “B” bus may reduce process capacity but will not result in a total loss of the process. By configuring main-tie-main breakers, the Sewer Utility can also quickly re-establish utility power to CKTP loads in the event of a feeder fault or circuit breaker failure.

Given the inherent redundancy of the process design and the electrical distribution system serving the process electrical loads, there are instances where the resilience of the CKTP OT network could be improved so that the redundancy of the process is not undermined by a singular network component or cable failure. Even where the approach taken at CKTP to distribute process control among PLCs local to the processes themselves has significantly reduced the number of potential network failures that could impact a PLC’s ability to govern the process(es) it controls, improved OT network resilience could preserve Sewer Utility staff’s ability to monitor and control the various plant processes from SCADA and prevent gaps in historical data in the event of singular network component or cable failures.

Kingston, Manchester, and Suquamish Wastewater Treatment Plants

In the case of KWWTP, MWWTP, and SWWTP, many of the process trains have no redundancy. These WWTPs are also much smaller than CKTP and are more manageable for Sewer Utility operations staff to run manually in the event of an OT network outage. However, if OT network redundancy were to reflect process redundancy, the liquid stream at KWWTP branches into two parallel trains for the oxidation ditches and secondary clarifiers. The network components and cable segments that establish communications between the KWWTP PLC and RIO racks in the process building, where I/O associated with these processes are received, could be candidates for redundancy considerations. The liquid stream at MWWTP also splits into two parallel trains, but the plant has only one RIO rack dedicated to the liquid stream processes. An investment in OT network resilience at MWWTP without a more redundant control system design would not fully complement the redundancy of the process.

- Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.
- The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.
- CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between plant SCADA nodes and all of the plant PLCs.
- CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.

- Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.
- KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.

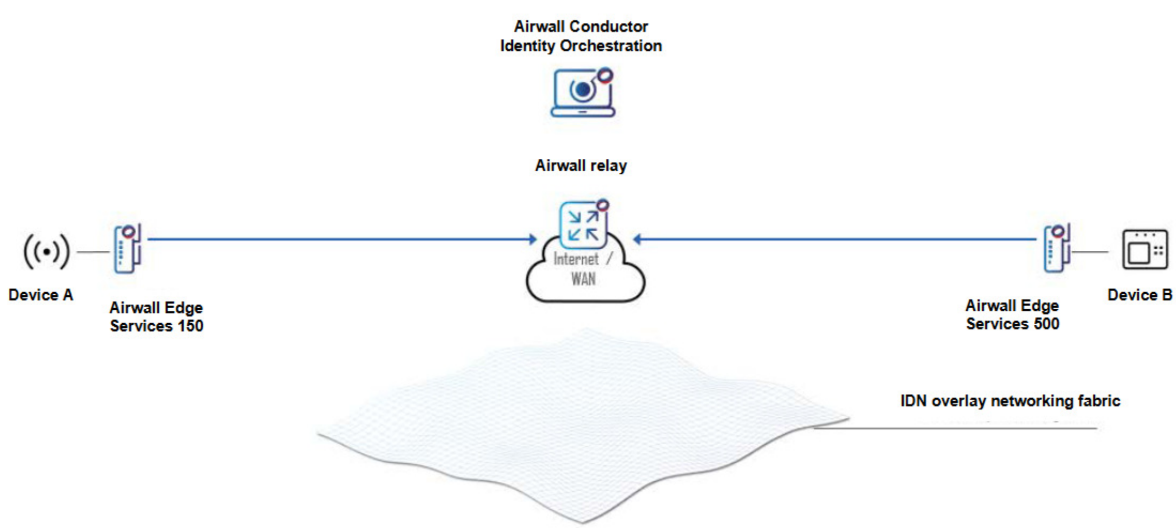
2.3 Wide-area Network Architecture Overview

This subsection provides an overview of the WANs that maintain communications between the WWTPs and pump stations.

2.3.1 WWTP WAN

In 2019 the Sewer Utility hired QCC to establish network connectivity between the OT networks at the remote WWTPs and the CKTP OT network. QCC implemented a solution from Tempered Networks that is founded on Host Identity Protocol (HIP) and proprietary software. The Tempered Networks Airwall system implemented for the Sewer Utility consists of hardware security appliances called HIPswitches that are installed at each WWTP, software agents installed on County laptops and tablets, a virtual security appliance called a HIPrelay that is hosted in a Microsoft Azure cloud instance, and the Tempered Networks Conductor software, which is also cloud-hosted. Figure 2-5 depicts a general overview of the core Tempered Networks Airwall system components. A high-level network diagram of the Tempered Networks Airwall system implemented for the Sewer Utility is depicted on QCC drawing N-00 in Appendix C.

Figure 2-5. Tempered Networks Airwall system general overview diagram



Source: Tempered Networks.

The Tempered Networks Airwall system is configured to deny all communications by default. Through the use of HIP and proprietary software, the technology is designed to "cloak" network devices behind Airwall edge services (e.g., HIPswitches, software agents, and server agents) so that they are not discoverable by untrusted external devices using network scans, ping requests, and other traditional enumeration methods. The technology also functions as an overlay to existing network switch and router hardware infrastructure and can effectively bypass active configurations at these hardware instances that might otherwise prevent communication between remote devices. This feature can simplify management of the WAN, greatly reduce commissioning efforts when implementing within existing networks, and allow for micro-segmentation (i.e., the practice of logically dividing the network into several small segments based on workload or intended communication groups) that would otherwise require a significant network configuration and management effort to establish and maintain.

The Tempered Networks Conductor provides a web-based user interface for network managers to add trusted devices to user-defined groups, each of which can have specific security policies and permissions defined. Once security policies and permissions are in place, devices belonging to a group may communicate over an encrypted data plane that spans between Airwall edge services. Because the data plane spans the public Internet and typically involves two devices belonging to separate private networks, the HIPrelay is required to overcome this double Network Address Translation (NAT) scenario and to provide secure routing between the Airwall edge services. The HIPrelay does not decrypt the packets sent over the data plane, so the encryption remains intact between endpoints. The Airwall edge services are responsible for enforcing the security policies defined in the Conductor using an authenticated key exchange. They also manage encryption and decryption of outgoing and incoming packets, respectively.

At the time of this writing, the WWTP WAN is used by QCC only to provide remote programming and configuration services and by County staff to provide periodic remote monitoring of CKTP SCADA alarm screens. Data exchange between the SCADA systems at remote WWTPs and CKTP has yet to be implemented. Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled. Sewer Utility staff must call the on-duty operator at the remote WWTPs to obtain plant process operation status and near real-time process values.

2.3.2 Pump Station VHF Licensed Radio WAN

This subsection describes the existing configuration, historical performance, and planned modifications of the Sewer Utility's very high frequency (VHF) licensed radio WAN for the wastewater pump stations.

Existing Configuration

Most of the Sewer Utility's pump stations within the wastewater conveyance system communicate with a master telemetry unit (MTU) at CKTP via VHF licensed radio. The MTU polls the pump station in a set round-robin sequence where each station is polled one at a time until the last station in the sequence is polled, then the sequence starts over from the beginning of the sequence. High-level network diagrams depicting the VHF licensed radio WAN and the repeaters involved in some of the radio paths are shown in QCC drawings N-02, N-03, N-04, and N-05 in Appendix C. These QCC drawings also depict some of the planned work between the Sewer Utility and QCC to move additional pump stations onto the cellular network and to modify the radio paths of the Manchester area pump stations to communicate with MWWTP instead of CKTP.

The Sewer Utility has standardized on CalAmp Viper SC 100 (depicted in Figure 2-6) and SC+ 100 radios for the pump station VHF licensed radio WAN. The radios have been configured to communicate using a frequency of 173.3125 megahertz (MHz) and a 6.25-kilohertz (kHz) channel bandwidth. The County has an active license with the Federal Communications Commission (FCC) for this frequency, which is set to expire in July 2024.

Figure 2-6. CalAmp Viper SC 100 VHF radio

Source: CalAmp.

Some of the benefits of VHF include longer range and better penetration of trees and other foliage when compared to higher frequency ranges. Given that FCC restrictions on antenna mounting heights likely rule out line-of-sight radio paths for most, if not all, of the pump stations, VHF is likely to be more tolerant of the non-ideal radio paths within the Sewer Utility's licensed radio WAN than higher-frequency range alternatives. In theory, the licensed frequency should also eliminate noise resulting from competing signals produced by other entities operating within the same frequency range.

One of the significant limitations of VHF and lower frequency ranges, in general, is lower bandwidth. This means that the VHF radio paths within the Sewer Utility's licensed radio WAN take considerably longer than higher frequency alternatives to communicate the same amount of data. While the current volume of data exchange occurring over the Sewer Utility's licensed radio WAN is limited, the lower bandwidth contributes to longer polling cycle times (i.e., the time it takes for the MTU to complete one round of transmitting and receiving data to and from each pump station). Sewer Utility staff have indicated that it can take the MTU roughly 8 minutes to complete a polling cycle, which means that the CKTP SCADA system is receiving updates for pump station statuses and alarms only every 8 minutes or so, assuming that all communication attempts are successful. If communication attempts are unsuccessful, then updates for a given pump station may occur at intervals greater than 16 minutes. These delays in communication of pump station statuses and alarms have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.

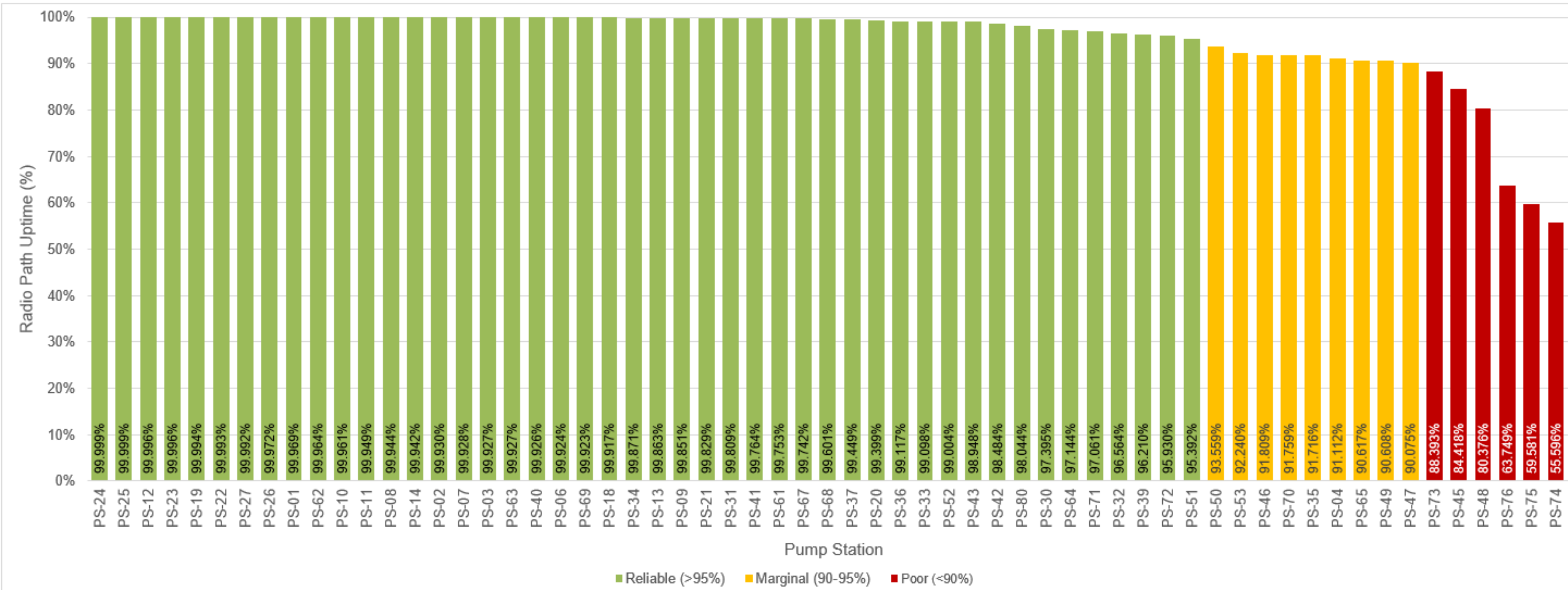
The Sewer Utility has expressed a desire to move toward more real-time monitoring and alarming for the pump stations. Furthermore, the recommendations that are anticipated to come from the ongoing Sewer Utility SCADA Master Plan will likely include increasing the amount of data exchanged between the pump stations and the CKTP SCADA system. Decreasing polling cycle times while supporting increased data exchange over the Sewer Utility's pump station WAN will likely not be achievable using VHF-based telemetry.

The Sewer Utility has also indicated that some pump stations experience poor communications on the VHF licensed radio WAN. The County considers improving the communications for these sites a high priority so that status and alarms are communicated more frequently and communication loss alarms have significance and are not a nuisance for staff.

Historical Performance

To better quantify the performance of the pump station VHF licensed radio WAN, HDR obtained 2 years' worth of communication data from the CKTP historian for the period between August 24, 2018, and August 24, 2020. During this period, the median polling cycle time was 8 minutes and 41 seconds, which aligns with information obtained from Sewer Utility staff. Uptime percentages were calculated for each pump station radio path based on the ratio of successful versus attempted data exchanges between the MTU and pump station PLCs. The radio path uptime percentages for each station are presented in Figure 2-7.

Figure 2-7. Pump station VHF licensed radio WAN radio path uptime percentages



Notes:

a. Radio path uptime calculations are based on historical data obtained between 8/24/2018 and 8/24/2020.

b. PS-17 has been on the cellular WAN for more than half of this period and is excluded from the figure.

As depicted in Figure 2-7, six of the pump stations were found to have poor communications. Two of these pump stations (PS-75 and PS-76) have already been added to the pump station cellular WAN described in the following subsection. PS-04 has also been added to the pump station cellular WAN. Based on discussions with Sewer Utility staff, the upgrade to cellular communications has greatly improved the reliability of communications with these pump stations.

The PLC that serves as the MTU for the VHF licensed radio WAN is programmed to generate a new value for a “watchdog” parameter for each pump station on every polling cycle. These “watchdog” parameter values, which are logged in the CKTP historian, were used to determine the timing of the polling cycles for Figure 2-7. The MTU PLC is also programmed to update a communication efficiency parameter for each pump station based on the outcome of the data exchange between the MTU PLC and the PLC at the pump station during each polling cycle. If the data exchange is successful, 0.1 is added to the communication efficiency parameter value (with the value restricted to an upper bound of 100.0), while 0.1 is subtracted from the communication efficiency parameter value when the data exchange fails. The pump station communication efficiency parameter values are displayed at the CKTP SCADA HMI and logged in the CKTP historian.

While these values are helpful for locating failed communication attempts when reviewing historical data, the values themselves do not accurately represent “communication efficiency” and may be misrepresenting the performance of the various radio paths to Sewer Utility staff. Consider a scenario where there are 20 successful and 20 unsuccessful data exchange attempts within a given period. At the end of this period, the communication efficiency parameter value may have returned to the same value it had at the beginning of the period. If that value was 75.0, for example, staff may be led to believe that 75.0 percent of data exchange attempts have been successful.

Planned Modifications

Historically, communications for Manchester area pump stations have been poor because of the surrounding terrain and dependence on multiple repeaters along the communication paths. Currently, these stations communicate with the CKTP MTU radio. QCC has installed an industrial VHF radio within the MWWTP operations building electrical room and an omnidirectional antenna near the southwest corner of the building. The radio was not connected to the MWWTP OT network during HDR’s site visit. The new radio and antenna are in preparation for modifying the VHF radio paths of the Manchester area pump stations to communicate with this new radio at MWWTP. QCC and the Sewer Utility are planning to have the MWWTP PLC handle data exchange for the Manchester area pump stations and to relay that data exchange to CKTP over the Tempered Networks WWTP WAN.

2.3.3 Pump Station Cellular WAN

The Sewer Utility has subscribed to Verizon Wireless’s Private Network service and contracted with QCC to implement a 4G Long-Term Evolution (LTE) cellular WAN for the Sewer Utility’s wastewater pump stations. A high-level network diagram depicting the cellular WAN is presented in QCC drawing N-01 in Appendix C. As shown in QCC’s network diagram, QCC has cut over four of the Sewer Utility's pump stations to use the new cellular WAN as a primary communications path and there are plans to cut over seven additional pump stations in the near future. The Sewer Utility is leaving the VHF licensed radio equipment in place at the pump stations that are added to the cellular WAN so that the pump stations can fail over to the VHF licensed radio WAN in the event of a prolonged cellular communications outage.

The Sewer Utility has standardized on Cradlepoint IBR600C Series cellular routers for the pump station cellular WAN (see Figure 2-8). These routers are equipped with a 1-gigabit Ethernet (GbE) local area network (LAN) port, support virtual private network (VPN) tunnels, and have 75-megabit per second (Mbps) throughput capability. The routers also have a rugged enclosure and an extended operating temperature range, making them suitable for installation within the industrial control panel environments found at the Sewer Utility's pump stations.

Figure 2-8. Cradlepoint IBR600C Series cellular router

Source: Cradlepoint.

The Sewer Utility's cellular WAN has a dedicated MTU PLC that manages data exchange between the pump stations and the CKTP SCADA system. A cursory review of the PLC's programming suggests that QCC and the Sewer Utility are implementing a report-by-exception telemetry scheme for the pump stations on the cellular WAN. Under this scheme, the pump stations initiate data exchange based on a change in status or process values with the MTU PLC programmed to poll any pump station that has not initiated data exchange within a set period. The report-by-exception scheme can significantly reduce the volume of data traversing the WAN, which also reduces the data usage charges on the Sewer Utility's monthly bill(s) from Verizon Wireless. The scheme can also reduce CKTP historian workload by filtering out static status and process values at the WAN periphery.

Unlike the VHF licensed radio WAN, the CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN. Historical SCADA data reviewed by HDR showed static values for communication efficiency and "watchdog" parameters at the four pump stations communicating via the cellular WAN. Tracking parameters related to the quality of communications for pump stations on the cellular WAN is recommended so that the County has historical reference for communications at all sites.

Given the data throughput capabilities of the Sewer Utility's cellular routers, and 4G LTE cellular technology in general, the Sewer Utility's pump station cellular WAN provides a means of tightening the data gaps and eliminating the long polling cycle times that hinder the Sewer Utility's VHF licensed radio WAN. The cellular WAN should also be capable of supporting the increased data exchange anticipated from recommendations to come in subsequent phases of the Sewer Utility SCADA Master Plan. It should be noted that cellular reception may not be sufficient at every pump station to make the pump station's inclusion in the cellular WAN viable. In general, cellular signal strength surveys should be performed at pump stations to gauge the feasibility of cellular communications prior to implementation.

- Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.
- Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.
- The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near real-time monitoring and alarming for wastewater pump stations.
- Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.
- The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.
- The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.

2.4 Network Cabling

This subsection describes the network cabling installed at the Sewer Utility's WWTPs and wastewater pump stations.

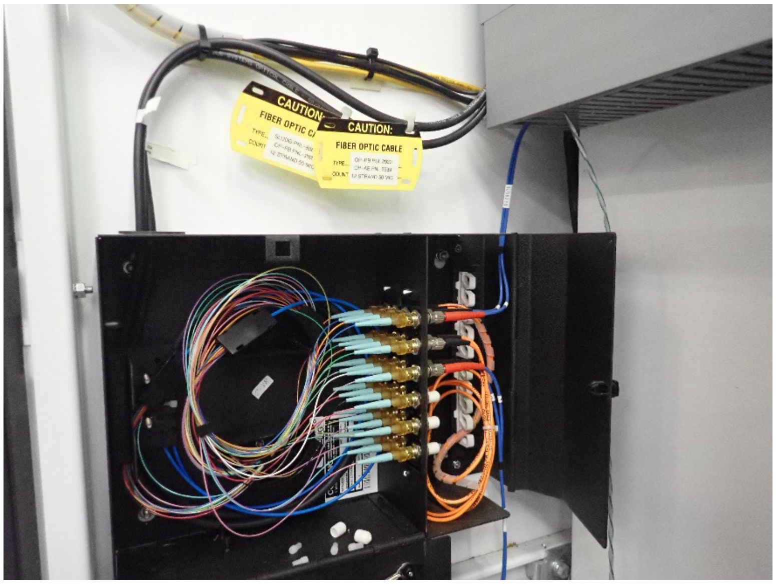
2.4.1 Central Kitsap Treatment Plant

Ethernet cabling within the CKTP OT network consists of multi-mode fiber-optic cables and a variety of copper Category cables. Among the fiber-optic cables, a mix of 62.5/125-micron (µm) (Optical Multi-mode 1 [OM1]) multi-mode fiber and laser-optimized, 50/125 µm (Optical Multi-mode 3 [OM3]) multi-mode fiber is installed at CKTP and the Sewer Utility has standardized on straight-tip (ST) connectors for fiber-optic cable terminations at fiber-optic patch panels. OM1 and OM3 fiber have a distance limitation of 275 meters and 550 meters, respectively, for 1 GbE throughput. GbE has replaced fast Ethernet (with a theoretical throughput of 100 Mbps) as the default base speed provided for modern PC and server network interface cards (NICs). Industrial automation manufacturers are following suit, and GbE network interfaces are becoming more common throughout the automation industry. As data volumes increase because of the proliferation of IP-based communications in industrial networks, it will become critical that fiber-optic networks can support GbE throughput, at a minimum, in the coming years.

Fortunately, the distances of the multi-mode fiber-optic cables observed at CKTP appear to be well below the GbE distance limitation thresholds. Assuming that the fiber-optic strands within these cables have not been damaged, the existing cables should support near-term modifications and upgrades to the OT network that affect their respective endpoints. However, it should be noted that OM1 fiber-optic cable has a distance limitation of 33 meters for 10 GbE throughput (the next higher Institute of Electrical and Electronics Engineers [IEEE] standard for Ethernet speed), so the existing OM1 cables will not support future 10 GbE network connections, if and when the CKTP OT network requires them.

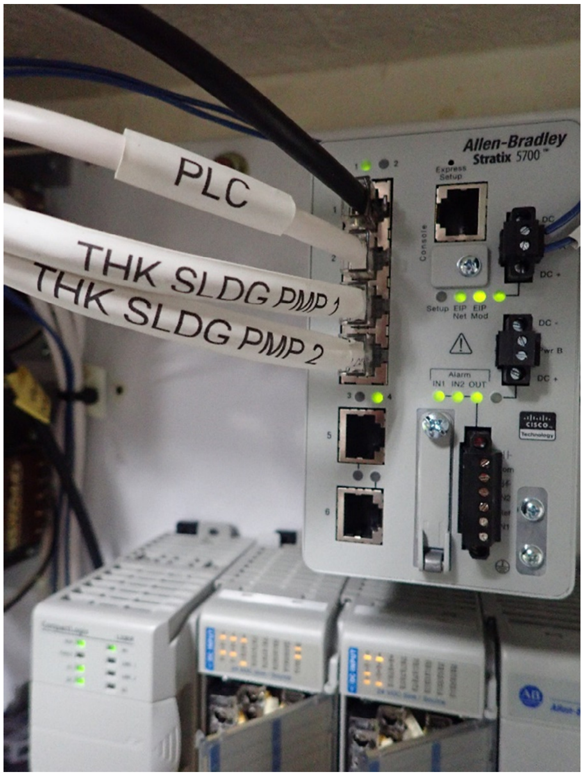
During its site visits, HDR noticed that an OM1 patch cord (the orange patch cord shown in Figure 2-9) was used to connect two OM3 cables at the fiber-optic patch panel within PNL 2920 in the power/blower building. Mixing OM1 and OM3 fiber-optic cables can result in severe losses at the connection points because of mismatches in the core sizes of the two fiber strands (50 µm versus 62.5 µm). This OM1 patch cable should be replaced with a suitable OM3 patch cable.

Figure 2-9. OM1 patch cord used to patch OM3 cables in PNL 2920



Most of the copper Ethernet cabling at CKTP is unshielded twisted pair (UTP) Category cable. There are instances where shielded, 600-volt (V)-rated Category 6 cable is used to connect IP nodes installed within motor control centers (MCCs) or other 480-volt alternating current (VAC)-rated equipment enclosures, but this best practice has not been adhered to in all cases. Figure 2-10 presents an example from PNL 6000 in the digester control building, where the control panel's network switch receives two UTP Category cables from VFDs located within an adjacent electrical enclosure. These cables are most likely rated for 300 V and installing them within an enclosure that houses electrical equipment powered from a higher voltage than the cables' insulation rating without proper separation is a National Electrical Code (NEC) violation. Shielding of copper Ethernet cables is important, when run in parallel with power cables or within power equipment enclosures, to mitigate outside interference (particularly from VFDs) that may impact data integrity and to prevent induced voltage on the cable's conductors that could damage sensitive electronics and create personnel and fire safety issues.

Figure 2-10. UTP cable received from 480 VAC VFD enclosure



2.4.2 Kingston Wastewater Treatment Plant

Ethernet cabling within KWWTP is exclusively copper cable. Shielded Category 6 cable is used for network connections between buildings and to connect IP nodes installed within MCCs. The remainder of the Ethernet cabling is UTP Category cable. Aside from the incoming fiber-optic Internet service from Kitsap Public Utility District (KPUD), described in Section 2.8 below, no fiber-optic cable is installed at KWWTP.

2.4.3 Manchester Wastewater Treatment Plant

Ethernet cabling within MWWTP is exclusively copper, UTP Category cable. Aside from the incoming fiber-optic Internet service from KPUD, described in Section 2.8 below, no fiber-optic cable is installed at MWWTP.

2.4.4 Suquamish Wastewater Treatment Plant

Ethernet cabling within SWWTP is exclusively copper cable. Shielded Category 5e cable is used for network connections between the three sludge pump VFDs and the network switch in CP-01. HDR did not confirm the insulation rating of these cables. Aside from the incoming fiber-optic Internet service from KPUD, described in Section 2.8 below, no fiber-optic cable is installed at SWWTP.

2.4.5 Pump Stations

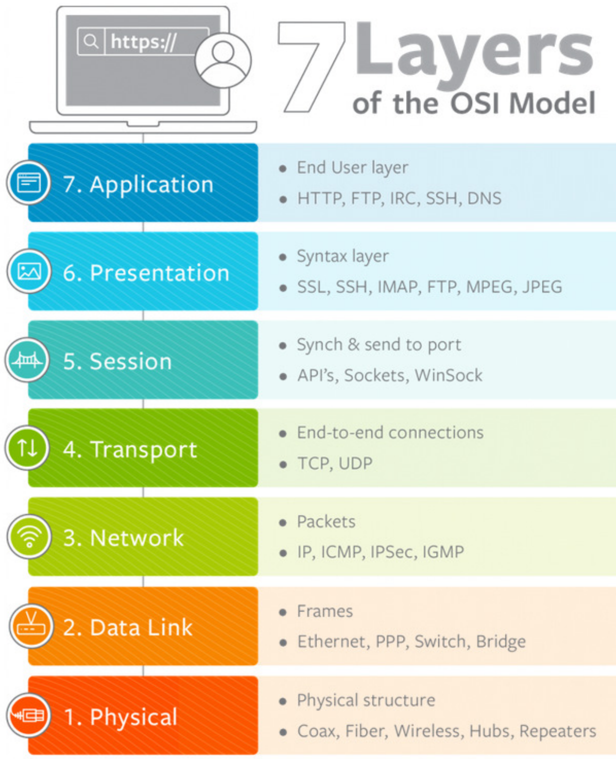
Ethernet cabling at the pump stations is limited and, where found, appears to be exclusively copper, UTP Category cable. HDR observed UTP Category cable connecting the VFDs for PS-67 pumps to the network switch in the station's control panel. HDR did not confirm the insulation rating of these cables. As previously mentioned, copper Ethernet cables routed near power cables and/or connecting IP nodes within 480 VAC equipment enclosures should be shielded and have a 600 V insulation rating. No fiber-optic cable appears to be installed at the pump stations visited by HDR.

- An OM1 fiber-optic patch cable has been used to patch two OM3 fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.
- There are instances of UTP Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.

2.5 Network Switches

A variety of managed (Layer 2) and unmanaged network switches exist throughout the Sewer Utility OT networks. For reference, Layer 2 refers to a specific layer within the Open Systems Interconnection (OSI) Model (see Figure 2-11), which was developed to help establish order through the use of standard protocols in a wildly diverse technological marketplace. Unlike Layer 3 or multilayer switches, Layer 2 switches deal only with the Data Link and Physical layers and do not recognize IP addressing or other packet headers within the frames they traffic. In basic terms, this means that they are incapable of routing. However, their Layer 2 management functionality provides several benefits when compared to unmanaged switches, as discussed in the following paragraphs.

Figure 2-11. OSI Model summary



Source: BMC Software, Inc.

Most of the unmanaged switches are installed in vendor control panels, which is a fairly common practice because vendors often default to unmanaged switches to reduce costs and simplify integration of their systems with existing industrial networks. However, there are a few instances where unmanaged switches have been installed at more critical locations within the OT networks—an example of this being the unmanaged switch serving the CKTP SCADA PCs discussed in Section 2.2 above.

In addition to the filtering of broadcast and multicast packets mentioned previously, managed switches provide several other benefits, including the following:

- Means of segmenting the network to avoid exposing devices to traffic from other devices they were never intended to communicate with
- Monitoring of network traffic to help troubleshoot network upsets
- Implementation of more resilient network architectures like ring and redundant star topologies
- Prioritization of specific traffic over other network traffic when bandwidth capacity is reached
- The ability to disable unused ports
- Mitigation of several common network security risks

A list of unmanaged switches that are recommended for replacement with managed switches is included in Table 2-1.

Table 2-1. Unmanaged switches recommended for replacement

Facility	Location	Panel	Manufacturer	Model
CKTP	Administration and lab building network closet	N/A	N-Tron	112FX4
CKTP	SPB control room	Master station CTU	N-Tron	108TX
CKTP	SPB control room	Network cabinet	N-Tron	526FX2
CKTP	Trailer 103 I&C technician office	N/A	Netgear	ProSAFE GS105E
CKTP	Headworks electrical room	PNL 1050	N-Tron	526FX2

For most network switches within its OT networks, the Sewer Utility appears to have standardized on N-Tron (acquired by Red Lion in 2010) industrial DIN-rail-mountable switches. N-Tron 700 Series switches appear to be the most prevalent product line of the manufacturer's offerings found at Sewer Utility facilities, though there does not appear to be standardization on a specific model within that product line. An example of one of the switches within the 700 Series product line found at Sewer Utility facilities is depicted in Figure 2-12.

Figure 2-12. N-Tron 716TX industrial managed Ethernet switch

Source: Red Lion.

The N-Tron 700 Series switches are managed (Layer 2) switches that have rugged enclosures and support a broader operating temperature range than more conventional network switches designed for office, server room, or communications closet environments. Among the management features available with these switches are Quality of Service (QoS), Internet Group Management Protocol (IGMP) snooping (a critical feature for filtering undesirable multicast traffic, as discussed previously), per-port virtual local area network (VLAN) configuration, and support for Simple Network Management Protocol (SNMP) management and monitoring. All ports on these switches are 10/100BaseTX or 100BaseFX ports, so the existing IP nodes at Sewer Utility facilities with GbE NICs have their potential throughput effectively capped at the theoretical 100 Mbps limit inherent in the 700 Series switch ports. As data volumes increase with the anticipated proliferation of IP nodes within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.

Another notable network switch product within the CKTP OT network is the N-Tron 7900 Series switches installed within PNL 8580A in the SPB control room (see Figure 2-13). Like the 700 Series switches, these network switches are managed (Layer 2), DIN-rail-mountable, have rugged enclosures, and support a relatively broad operating temperature range. The switches also benefit from the same management features included with 700 Series switches. Where the 7900 Series switches differ is in their modular design, which allows for customizable fiber-optic or copper switch port arrangements. The 7900 Series switches also feature two 1 GbE fiber-optic ports on the processor module.

Figure 2-13. N-Tron 7900 Series modular, industrial, managed Ethernet switch

Source: Red Lion.

As part of its condition assessment site work, HDR was able to obtain access to the web-browser-based management interface for several of these Ethernet switches using the manufacturer's default username and password. Because default usernames and passwords are easily discoverable on the Internet, information security industry standard practice for hardening network devices includes changing device login credentials to disable access via default username and password combinations. HDR recommends establishing new login credentials for theses switches and disabling access via the manufacturer's default username and password.

- Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.
- The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.
- All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.

✸ Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.

2.6 On-Premises Wireless Access to OT Networks

At CKTP, the Sewer Utility has implemented a wireless extension of the OT network using a 5-gigahertz (GHz) Wi-Fi base station and access points from Ubiquiti. The base station installed within the SPB control room (see Figure 2-14) has been configured for point to multi-point communications with two access points installed at trailer 103 and the operations facilities building at the north end of CKTP. This wireless application appears to be solely for the purpose of providing OT network connectivity for three SCADA PCs located in trailer 103 and the operations facilities building. HDR does not believe that the Sewer Utility is currently using the installed access points to provide Wi-Fi access to Sewer Utility staff mobile devices. The Ubiquiti base station and access points also do not appear to be broadcasting Service Set Identifiers (SSIDs), which increases the network's security by not advertising its existence to nearby Wi-Fi cable devices.

Figure 2-14. Ubiquiti Rocket Prism 5AC Gen 2 5 GHz access point

Source: Ubiquiti Networks.

Without OT network access via mobile devices while on-site, operators can access CKTP OT network IP nodes only via SCADA PCs and available ports at OT network access switches. Operators can also access SCADA HMI screens via HMI thick client panel PCs installed in the enclosure doors of control panels in the headworks building, power/blower building, aeration basin electrical building, reclaimed-water building, and waste activated sludge (WAS) thickening building. Though not implementing wireless access to the OT networks for mobile devices eliminates some common potential attack vectors that can be exploited by malicious actors, it also eliminates one method of implementing tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.

Wireless access to the OT networks via Wi-Fi technology has not been implemented at KWWTP, MWWTP, or SWWTP. At these WWTPs, Sewer Utility staff must use the SCADA PC in the plant control room or physically connect to an available port at one of the OT network access switches to interact with IP nodes on the plant OT network.

> ✸ The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.

2.7 Network Segmentation and Segregation

This subsection describes the network segmentation and segregation practices within the Sewer Utility OT networks.

2.7.1 Segmentation

This subsection describes the network segmentation practices within the Sewer Utility OT networks.

Central Kitsap Treatment Plant

The CKTP OT network is configured as a single /24 subnet allocated from the County's public IP address range. No further segmentation of the network was observed. Though the IP nodes within the CKTP OT network should not be directly reachable from the public Internet, having IP addresses that are routable from the public Internet is a significant security risk. Misconfiguration of a switch or security appliance or inadvertent connection of the OT network to an Internet-facing network like the CKTP business LAN could potentially expose devices on the OT network to the public Internet, making them reachable by anyone in the world with an Internet connection. Standard practice for securing ICS networks includes assigning ICS IP nodes private IP addresses, which are not routable from the public Internet.

The size of the CKTP OT subnet presents another concern in terms of future growth and development of the network. As a /24 subnet, the CKTP OT network is restricted to 254 usable IP addresses, which limits the number of IP-capable devices communicating on the network to 254. Though the Sewer Utility has yet to reach this number of connected devices, the number of devices on the CKTP OT network is expected to grow considerably in the coming years. The industrial automation industry has embraced IP-based communications, and demand for more robust data exchange between ICS devices and software platforms is driving a proliferation of IP devices in ICS networks. The Sewer Utility will require a larger pool of IP addresses to support this industry trend and benefit from the data that newer IP-based technologies can provide.

Suquamish Wastewater Treatment Plant

The SWWTP OT network is also configured as a single /24 subnet allocated from the County's public IP address range. No further segmentation of the network was observed. Though the IP nodes within the SWWTP OT network should not be directly reachable from the public Internet, the same security risk introduced by assigning public IP addresses to ICS devices that was discussed for the CKTP OT network also applies to the SWWTP OT network.

Because of the small size of SWWTP, the connected device limitation of a /24 subnet is not likely to constrain near-term potential growth of the plant's OT network. Because the current network is small in scale and all IP nodes on the network are part of the ICS, further segmentation of the OT network is not recommended at this time. Segmenting an already small network of closely related devices would introduce complexity and maintenance requirements that would likely outweigh any security or performance enhancements that could be achieved from separating the IP nodes into different broadcast domains.

Kingston and Manchester Wastewater Treatment Plants

The KWWTP and MWWTP OT networks are configured as single Class C networks using a private IP address range. No further segmentation of the networks was observed. The assignment of private IP addresses to devices within these OT networks adds a layer of security and is consistent with standard practice for securing ICS networks.

Because of the small size of KWWTP and MWWTP, the connected device limitation of a /24 subnet is not likely to constrain near-term potential growth of the plants' OT networks. Because the current networks are small in scale and all IP nodes on the networks are part of the ICS, further segmentation of the OT networks is not recommended at this time. Segmenting an already small network of closely related devices would introduce complexity and maintenance requirements that would likely outweigh any security or performance enhancements that could be achieved from separating the IP nodes into different broadcast domains.

Pump Station VHF Licensed Radio Network

Each pump station has been allocated a single /24 subnet using a private IP address range. At CKTP, a separate /24 subnet also using private IP addresses has been assigned for the devices involved in the pump station telemetry. This CKTP subnet is distinct from the subnet used for the remainder of the CKTP OT network. Finally, a separate /24 subnet has been assigned to the VHF licensed radio network, also using a private IP address range. All of these subnets share the same first two octets in their IP addresses, which was most likely done to simplify the subnet scheme and its documentation.

Under this subnet scheme, IP devices within the pump stations are assigned IP addresses from the station's subnet, while the external-facing interface on the VHF radios is assigned an IP address from the radio network subnet. Similarly, at CKTP, the MTU PLCs and dedicated interfaces at the SCADA PCs have been assigned IP addresses from CKTP's pump station telemetry subnet, while the external-facing interface on the CKTP VHF radio is assigned an IP address from the radio network subnet. The VHF radios have been configured to handle routing between the various subnets via entries made within the radio routing tables. In this way, the Sewer Utility can restrict communication between devices in different subnets to the devices that need to communicate only. Based on the few VHF radio configurations reviewed during HDR's site visits, HDR believes that the VHF radio routing tables have been configured to limit communication over the VHF licensed radio network to communication between the VHF radio MTU PLC at CKTP and each pump station remote telemetry unit (RTU). Communication between devices at different pump stations, for example, does not appear to be permitted given current routing table configurations.

Pump Station Cellular Network

The LAN interfaces of the cellular routers installed at Sewer Utility pump stations and CKTP are assigned IP addresses belonging to the same subnets used for the pump station VHF licensed radio network. The MTU PLC responsible for the cellular telemetry at CKTP has also been assigned an IP address within the CKTP pump station telemetry subnet. The actual cellular communications between the cellular routers occur over the Sewer Utility's cellular provider's network. The cellular carrier's management of this communication is discussed in more detail under Section 2.7.3 below.

Tempered Networks WWTP WAN

The LAN interfaces of the Tempered Networks HIPswitches installed at Sewer Utility WWTPs are assigned IP addresses belonging to the same subnets used for the WWTP OT networks. The external-facing interfaces on the HIPswitches are assigned public IP addresses. All trusted devices situated behind the HIPswitches at the Sewer Utility WWTPs are part of the OT network for that WWTP and have been assigned IP addresses from the WWTP OT network subnets. As discussed in Section 2.3 above, the Sewer Utility's HIPrelay handles routing between devices within the various subnets.

2.7.2 Unused Access Ports

During its site visits, HDR performed a cursory review of the configurations for a selection of the managed network switches found within the Sewer Utility's WWTPs. All managed Ethernet switch ports reviewed are currently enabled and assigned to default VLAN 1. As an example, the port configuration screen for the managed switch in the MWWTP influent pump station control panel is shown in Figure 2-15. Under the Admin Status column (boxed in red), all ports are shown as enabled though only ports 1 and 8 are in use, as indicated by the adjacent Link Status column. Information security industry standard practice and National Institute of Standards and Technology (NIST) recommendations for ICSs include disabling unused ports as part of recommended network device hardening measures (NIST 2015). Though disabling unused ports is the primary means of securing unused switch ports, assigning unused switch ports to an unused VLAN (i.e., black hole VLAN) can provide an additional layer of security from inadvertent connection errors and unauthorized network access.

Figure 2-15. Example managed switch port configuration screen

Port Configuration View

Port No	Port Name	Admin Status	Link Status	Auto Nego	Port Speed	Duplex Mode	Cross Over	Flow Control	Port State	PVID	Usage Alarm Low [%]	Usage Alarm High [%]
01	TX1	Enabled	Up	Enabled	100	Full	Auto	Disabled	Forwarding	1	0	100
02	TX2	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
03	TX3	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
04	TX4	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
05	TX5	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
06	TX6	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
07	TX7	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
08	TX8	Enabled	Up	Enabled	100	Full	Auto	Disabled	Forwarding	1	0	100

Refresh

2.7.3 Segregation

This subsection describes the network segregation practices within the Sewer Utility OT networks.

Central Kitsap Treatment Plant

During its site visits, HDR observed that the unmanaged access switch serving the SPB SCADA PCs, CKTP historian, and other OT network devices is connected to a managed switch used by the CKTP business LAN. Both switches are located in the SPB control room network cabinet. Depending on how the business LAN switch is configured, the CKTP OT network may be exposed to PCs and other devices on the business LAN that have Internet access and can present a security risk to the OT network if given direct access. HDR did not review the configuration of this managed switch, but considers a direct connection between the business LAN and OT network a significant security risk for the OT network that should be remedied.

HDR also observed a cellular router connected to the same OT network unmanaged access switch in the SPB control room network cabinet (see Figure 2-16). Based on discussions with Sewer Utility I&C technicians, the purpose of this cellular router is unknown and the router is believed to have been left behind by an equipment vendor or past systems integrator. Sewer Utility staff do not recall having granted permission for the router to be installed on the OT network. The cellular router presents a significant risk to the CKTP OT network as it can serve as a backdoor into the network, bypassing security measures implemented by the CKTP HIPswitch and other security appliances that may be in place within KPUD's Carrier Ethernet network. The Sewer Utility also has no control over the security of the device or devices that may be connecting to the CKTP OT network via this cellular router, so any vulnerabilities inherent with those devices or any malware present on the devices could easily be shared with the Sewer Utility's network. After a discussion of the potential security risks presented by the cellular router, Sewer Utility staff powered down the device and disconnected it from the network.

Figure 2-16. TP-Link MR3040 cellular router connected to OT network unmanaged switch

Suquamish Wastewater Treatment Plant

During its site visits, HDR observed that the secure gateway used to provide Internet connectivity to a wireless access point on the SWWTP business LAN is also connected to a managed switch on the SWWTP OT network. This managed switch, located in CP-01, is “behind” the Tempered Networks HIPswitch in the SWWTP OT network architecture. HDR did not review the configuration of the secure gateway to determine the level of segregation between the two networks provided by the gateway’s firewall functionality. However, allowing connection from the public Internet to the OT network through the secure gateway would effectively bypass any security controls implemented via the Tempered Networks WAN. Eliminating an unnecessary external access method to the SWWTP OT network would reduce the network’s attack surface by eliminating a potential entry point, allowing the Sewer Utility and its contractors to focus on maintaining the security of a single data conduit between the SWWTP OT network and external permissioned devices.

Kingston and Manchester Wastewater Treatment Plants

HDR did not observe instances of the OT networks and business LANs sharing physical network devices at KWWTP or MWWTP, nor were multi-homed PCs observed. The KWWTP and MWWTP OT networks appear to be physically and logically separated from the plant business LANs, which is consistent with information security industry recommended practices for ICSs.

Pump Station Cellular Network

The Sewer Utility's cellular provider is Verizon Wireless and the Sewer Utility has subscribed to the Verizon Wireless Private Network service, which has been deployed as a zero-tunnel configuration for machine-to-machine (M2M) applications. This service provides the Sewer Utility with a private cellular WAN for devices within the Sewer Utility's IP pool. The cellular WAN is segregated from the public Internet and the rest of the cellular carrier's network. Though this approach effectively outsources much of the WAN security to Verizon Wireless and requires trust in the cellular carrier's ability to maintain the segregation it advertises, it does provide a low-maintenance, economical means of establishing communication between CKTP and the remote pump stations with significantly higher data throughput than the VHF licensed radio network can offer.

- Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.
- The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.
- Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.
- There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.
- A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.
- There appear to be parallel entry points to the SWWTP OT network from external networks: one via the plant's Tempered Networks HIPswitch and one via a secure gateway used for the plant business LAN wireless access point.

2.8 Internet Service

This subsection describes the Internet service for the Sewer Utility's wastewater facilities.

2.8.1 Central Kitsap Treatment Plant

CKTP receives Internet service from KPUD via a fiber-optic connection to KPUD's Carrier Ethernet network. This connection consists of a single strand of single-mode (Optical Single-mode 2 [OS2]) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the administration and lab building communications room. The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between the KPUD and Sewer Utility networks. The KPUD Internet service connection serves ingress and egress traffic from both the CKTP business LAN and OT network.

2.8.2 Kingston Wastewater Treatment Plant

To establish network connectivity between the KWWTP OT network and the CKTP OT network, the Sewer Utility contracted with KPUD for the installation of fiber-optic cable to KWWTP. KWWTP now receives Internet service from KPUD over this fiber-optic connection, which consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the operations building electrical room (see Figure 2-17). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks.

Figure 2-17. KWWTP operations building electrical room communications backboard

The Sewer Utility has implemented a separate Internet service for the KWWTP business LAN, which consists primarily of a PC located in the operations building control room. Internet access for the business LAN is achieved via a Peplink PEPWAVE MAX BR1 mini-cellular router. HDR did not review configuration or security settings for this device.

2.8.3 Manchester Wastewater Treatment Plant

To establish network connectivity between the MWWTP OT network and the CKTP OT network, the Sewer Utility contracted with KPUD for the installation of fiber-optic cable to MWWTP. MWWTP now receives Internet service from KPUD over this fiber-optic connection, which consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the operations building electrical room (see Figure 2-18). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks.

Figure 2-18. MWWTP operations building electrical room communications backboard

The Sewer Utility has implemented a separate Internet service for the MWWTP business LAN, which consists primarily of a wireless access point and a laptop located in the operations building control room. Internet access for the business LAN is achieved via a Motorola SB5120 cable modem. HDR did not review configuration or security settings for this device.

2.8.4 Suquamish Wastewater Treatment Plant

SWWTP receives Internet service from KPUD via a fiber-optic connection to KPUD's Carrier Ethernet network. This connection consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the process building electrical room (see Figure 2-19). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's ADVA FSP 150CC-GE114 Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks. The KPUD Internet service connection serves ingress and egress traffic from both the SWWTP business LAN and OT network.

Figure 2-19. SWWTP process building electrical room communications backboard

2.9 Remote Access

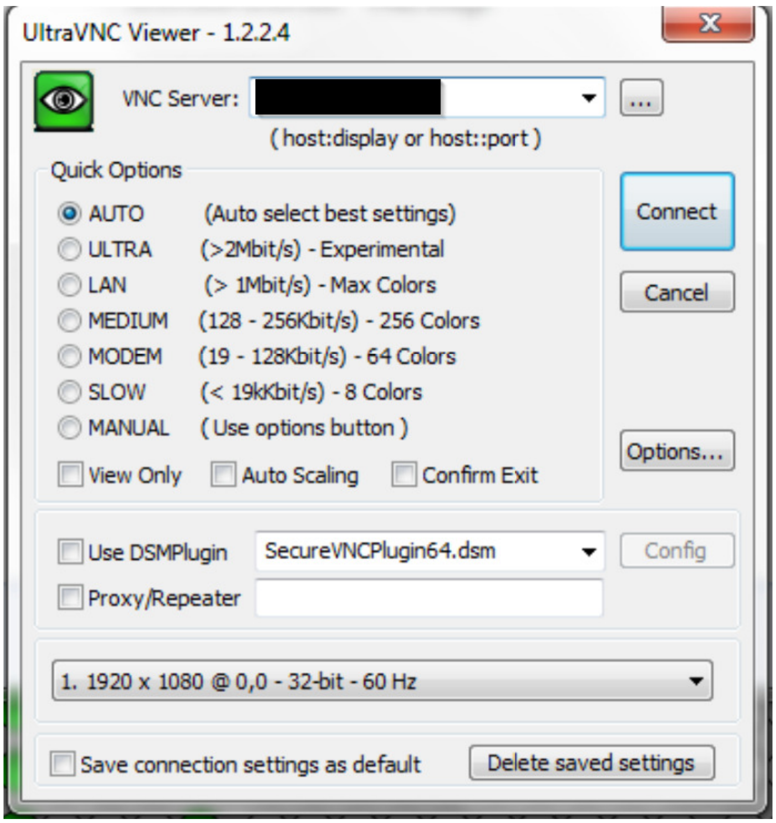
This subsection describes the remote access methods in place for the Sewer Utility's OT networks.

2.9.1 Central Kitsap Treatment Plant

The Sewer Utility has implemented remote access to the CKTP OT network for QCC, County Utilities group personnel, Sewer Utility I&C technicians, on-call operators, and the on-call supervisor. Currently, County Utilities group personnel and Sewer Utility on-call staff use County-issued tablets to access CKTP SCADA system alarm screens for review and acknowledgment of active alarms, the Utilities group personnel focusing on alarms pertaining to the pump stations. Sewer Utility I&C technicians use a County-issued laptop to access CKTP SCADA system screens for remote monitoring of the plant and to support troubleshooting efforts. QCC uses one of its programming laptops to access the CKTP OT network for online PLC programming modification, modifications to Wonderware screens and historian configuration, and other device configuration and maintenance services.

All remote access to the CKTP OT network occurs over the Tempered Networks WWTP WAN from trusted devices that have been added to the appropriate Airwall overlay network. Users on a trusted device initiate the remote access sessions by opening a Virtual Network Computing (VNC) application called UltraVNC Viewer on the trusted device and selecting the desired VNC Server over which to assume control (see screenshot in Figure 2-20). Typically, users select from one of the three SCADA PCs located in trailer 103 and the operations facilities building, but UltraVNC Server is installed on all SCADA PCs at CKTP so no measures are in place to prevent users from also taking control of those machines. After the user has selected a VNC Server, the user is then prompted for a common password shared by all users before remote control of the SCADA PC is granted. Once the VNC session is established, users must log onto Wonderware with their unique username and password to obtain the control and alarm acknowledgment permissions that have been established for them.

Figure 2-20. UltraVNC Viewer screenshot



VNC is founded on the Remote Frame Buffer (RFB) protocol, which is not a secure protocol. In the absence of encrypted tunnels, passwords exchanged over an unsecure network can be easily cracked by malicious actors. UltraVNC has an encryption plugin that strengthens the security of the application by providing encryption for the VNC sessions. HDR observed that this plugin has not been enabled for the UltraVNC Servers within the CKTP OT network (see the unchecked Use DSMPlugin box in Figure 2-20). Though the VNC sessions occurring over the Sewer Utility’s Tempered Networks WWTP WAN benefit from the encryption inherent in the Tempered Networks Airwall system, enabling encryption of the VNC session itself within the UltraVNC application would provide another layer of security for the CKTP OT network.

However, the security risks inherent with VNC-based applications are rarely worth the benefit of the simplified approach to remote access that they offer. HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.

The practice of having one common password for all users to establish remote access sessions presents a security risk for the CKTP OT network. Common username and password scenarios do not allow for user authentication, authorization, or accounting (AAA). This means that the Sewer Utility has no means of positively identifying who is assuming remote control of a PC on the CKTP OT network. When users are not required to identify themselves (i.e., authentication), there is no means of limiting their permissions and access to network resources (i.e., authorization) or keeping track of their activity while on the network (i.e., accounting). Though the Sewer Utility requires user authentication for the CKTP Wonderware platform, remote users have full access to several other network resources once given control over a CKTP SCADA PC.

Though requiring unique username and password entry to establish remote access to the CKTP OT network would provide a significant boost to network security, this measure, alone, still leaves the CKTP OT network vulnerable to some common security risks like the loss or theft of tablets and laptops that are designated as trusted devices. Information security industry best practice is to require multi-factor authentication (MFA) prior to establishing a remote connection to ICS networks. For remote access applications, MFA requires the user to authenticate using two or more of the following:

- Something the user knows (e.g., a password)
- Something the user has (e.g., a mobile phone)
- Something the user is (e.g., retinal scan)

A common and effective MFA approach is the one taken by County Information Services for VPN connections to the County SharePoint site, which requires users to enter a unique username and password and then successfully enter a code they receive on their mobile phone via text message (i.e., something the user knows and something the user has).

2.9.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

Sewer Utility staff do not currently access the KWWTP, MWWTP, and SWWTP OT networks remotely. However, the Tempered Networks Airwall system provides the necessary infrastructure for remote access to occur, as described previously for CKTP. Based on review of the Tempered Networks Conductor configuration, HDR believes that County and contractor tablets and laptops already have access to specific devices within the KWWTP, MWWTP, and SWWTP OT networks. The same security risks identified for remote access sessions to the CKTP OT networks also apply to the other WWTP OT networks.

2.9.3 Pump Stations

Aside from the remote ICS monitoring occurring via the VHF licensed radio and cellular WANs, Sewer Utility staff do not currently access the pump station OT networks remotely.

- UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.
- Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.
- Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.
- MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.

2.10 Network Security Hardware and Software

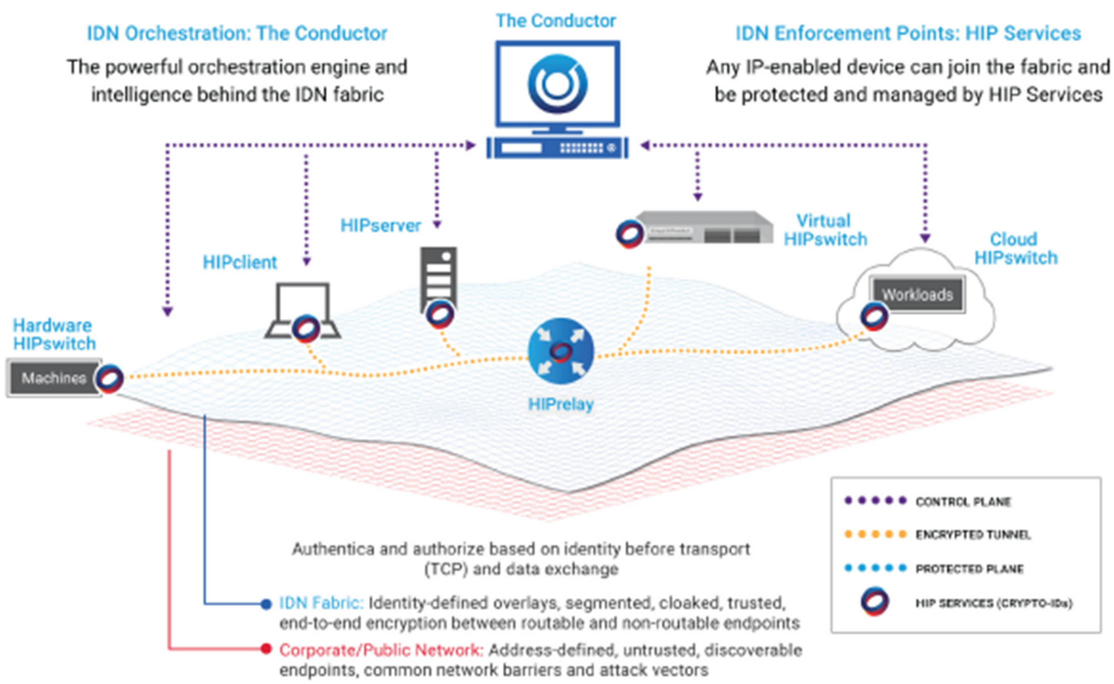
This subsection describes the network security hardware currently enforcing security controls for Sewer Utility OT network ingress and egress traffic.

2.10.1 Tempered Networks Conductor

The Tempered Networks Conductor is a cloud-hosted, web-based user interface for network managers to add trusted devices to user-defined groups, called overlay networks, within their Tempered Networks Airwall system deployment. Security policies and permissions for each overlay network can be defined so that any trusted device added to the overlay network inherits those policies and permissions. Security settings can also be configured at the device level, and permissions for specific devices can be enabled and disabled manually or via timed or scheduled sessions.

Modifications to security policies and settings are pushed out from the Conductor to the Airwall edge services over the Tempered Networks control plane, which is distinct from the encrypted data plane over which the overlay network data exchange occurs. Once modifications to security policies and settings are registered by the Airwall edge services, they will be retained by the HIPswitches, HIPrelays, and software and server agents within the Airwall system. In this way, the Airwall edge services are not reliant on the Conductor to implement security and the system can remain online, enforcing the most recently registered security policies and settings, even if the Conductor is taken offline. Figure 2-21 depicts the Conductor's role within the Airwall system and the separation of the control and data planes.

Figure 2-21. Tempered Networks Conductor diagram



Source: Tempered Networks.

Though the Tempered Networks Airwall system has many benefits, its simplicity and convenience come with some tradeoffs. The benefit of having one "pane of glass," the Conductor, to establish and manage communication between devices also presents a potential vulnerability in that the security of the communication links is consolidated into a single software platform. Inadvertent modifications to settings or inclusion of a device in the wrong overlay network could potentially expose the Sewer Utility's OT networks to considerable risk.

Because any user given access to the Sewer Utility's Conductor instance essentially holds the "keys to the kingdom," in terms of Sewer Utility OT network cybersecurity, it is essential that access to the Conductor be restricted to a minimum number of trained and trusted individuals. Authentication of these individuals should also be required to improve security and allow for meaningful accounting of which modifications are made by whom. Currently, the only two user accounts that are active for the Conductor are QCC and Local Administrator. In addition, no MFA measures are in place, so users are required to enter only one of these usernames and the corresponding password. Creating unique user accounts that are each attributable to a single individual and implementing MFA for access to the Conductor would significantly improve the security of the Sewer Utility's Conductor instance.

Currently, QCC and the Sewer Utility have established three overlay networks involving various devices on the Sewer Utility's OT networks. The Remote Support overlay network appears to be a work in progress and has no trusted devices or Airwall edge services assigned to it. The Kitsap Telemetry overlay network consists of all County-issued tablets and laptops, a QCC laptop, SCADA PCs and HIPswitches at all four of the Sewer Utility WWTPs, the PLCs at the remote WWTPs, the MTU PLC at CKTP, and various operator interface terminals (OITs) and HMIs at the four WWTPs.

A principle in the information security industry, referred to as Least Privilege, dictates that permissions for the various user groups on an ICS network should be tightly restricted to the access needs and monitoring and control functionality use cases required by the users to perform their work. While HDR did not review the security controls implemented at the Conductor for each trusted device in the Sewer Utility's overlay networks, it appears that Sewer Utility on-call staff may have access to some of the Sewer Utility WWTP PLCs, OITs, and HMIs from their tablets. There are not likely to be any desirable use cases for Sewer Utility on-call staff to access these devices from their tablets. Though on-call staff may be denied access via device settings made within the Conductor, a more secure approach would be to establish a separate overlay network for on-call staff that includes only the tablets and the limited number of SCADA PCs they are anticipated to interact with.

Similarly, a separate overlay network (e.g., the Remote Support overlay network) should be established for QCC so that third-party access to the Sewer Utility's OT network can be more tightly managed. This would allow the Sewer Utility to easily enable and disable QCC's access, add and remove Sewer Utility resources from the overlay network that QCC has access to on an as-needed basis, and maintain a clearer view of the Sewer Utility resources accessible to QCC at any given moment.

The third overlay network is called Kitsap IC. This overlay network consists of the County-issued I&C technician laptop, SCADA PCs at all four Sewer Utility WWTPs, the KWWTP PLC, the Wonderware thick-client HMI at the reclaimed-water building control panel, and the HIPswitches at all four Sewer Utility WWTPs. HDR believes that this overlay network was established to provide the Sewer Utility's I&C technicians with mobile and remote access to the Sewer Utility WWTP SCADA systems via VNC sessions. Unless there is a current need for Sewer Utility I&C technicians to access the KWWTP PLC or the Wonderware thick-client HMI at the reclaimed-water building remotely, to better adhere to the principle of Least Privilege, HDR recommends eliminating these devices from the Kitsap IC overlay network to reduce the scope of the overlay network to the I&C technician laptop and SCADA PCs only.

The current approach of allowing remote access to all SCADA PCs at CKTP may be convenient for QCC and County staff, but this approach also spreads the risks inherent in remote access to all of the SCADA PCs. As part of the Sewer Utility SCADA Master Plan effort, HDR recommends defining the specific use cases for remote access for each type of user so that appropriate security controls can be identified and implemented. For example, if Sewer Utility on-call staff require access only to Wonderware alarm screens, allowing them to assume remote control over a SCADA PC on the CKTP OT network provides them with many more permissions and a higher level of access than that use case would require. Limiting the number of OT network resources that are accessible remotely and segmenting these resources from the rest of the OT network would also improve the security of the Sewer Utility's OT networks.

While performing a cursory review of the Sewer Utility's Conductor configuration, HDR observed that all Airwall edge services have one of a variety of non-current firmware versions installed. Technology providers use firmware updates to fix bugs and patch vulnerabilities in their software and hardware offerings. Establishing routine patch management procedures to maintain current firmware versions for its Airwall edge services would help the Sewer Utility reduce the number of known vulnerabilities to which its OT networks are exposed.

2.10.2 Firewalls

At all four of the Sewer Utility's WWTPs, the Tempered Networks HIPswitch is deployed as the sole Sewer Utility–controlled security appliance at the OT network periphery. Though the HIPswitches do have internal stateful firewalls, they provide only a single layer of defense for critical Sewer Utility OT networks. And while Tempered Networks Airwall technology has yet to achieve widespread adoption in the marketplace and may benefit from a degree of "security by obscurity," as the technology gains market penetration it will likely receive more attention from threat actors.

Because no device or technology is immune to cybersecurity vulnerabilities, the U.S. Department of Homeland Security (DHS) and several other information security organizations recommend a Defense-in-Depth strategy for securing ICS networks (DHS 2016). This approach is based on implementing layers of security controls so that the security of the ICS does not depend on a single component or security control. For example, installing a Sewer Utility–managed firewall between the KPUD Internet service demarcation appliance and the Tempered Networks HIPswitch at each WWTP would add another layer of security for the Sewer Utility OT networks. This measure would reduce the Sewer Utility's exposure to zero-day and other vulnerabilities that may exist in the Tempered Networks Airwall system or the Sewer Utility's implementation of the Airwall technology.

2.10.3 Central Kitsap Treatment Plant

At CKTP, a Tempered Networks HIPswitch 100g (see Figure 2-22) is installed between the plant OT network and the point of demarcation with KPUD's network, through which CKTP receives access to the Internet as described in Section 2.8 above. The HIPswitch is an industrial edge gateway that monitors inbound and outbound network traffic and provides local enforcement of security policies and permissions that are configured via the Sewer Utility's cloud-hosted Tempered Networks Conductor software service. Tempered Networks indicates that this HIPswitch model is limited to 10 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.

Figure 2-22. Tempered Networks HIPswitch 100g

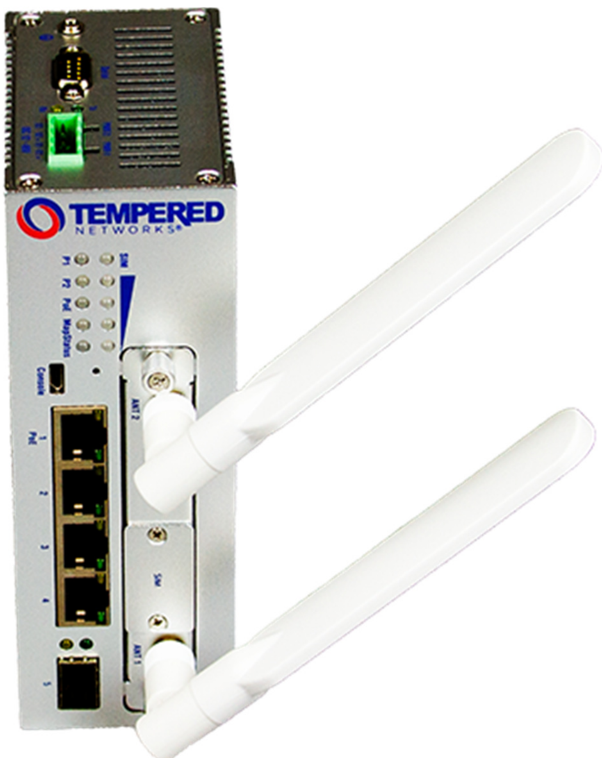
Source: Tempered Networks.

Figure 2-22 depicts a HIPswitch 100g with a cellular antennas used to provide failover to a secondary cellular network in the event of failure of the wired network. The HIPswitch at CKTP has no cellular antennas installed and the Sewer Utility has not configured the HIPswitch for failover to a secondary cellular network. While a non-redundant communication link between these WWTPs and CKTP is not a critical issue for remote monitoring purposes, if these communication links will be used for communication of plant alarms or remote control of the plants, establishing a secondary communication link would be worth considering. Provided that cellular reception is adequate at CKTP, the secondary cellular communications capability of the HIPswitch would be a suitable means of implementing this secondary communication link.

2.10.4 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

At KWWTP, MWWTP, and SWWTP, a Tempered Networks HIPswitch 150e (see Figure 2-23) is installed between the plant OT network and the point of demarcation with KPUD's network, through which the WWTPs receive access to the Internet as described in Section 2.8 above. The HIPswitch is an industrial edge gateway that monitors inbound and outbound network traffic and provides local enforcement of security policies and permissions that are configured via the Sewer Utility's cloud-hosted Tempered Networks Conductor software service. The HIPswitch is capable of 75 Mbps of data throughput. Given the intended application for SCADA-related data exchange between KWWTP and CKTP, this amount of throughput is likely adequate for the Sewer Utility's near-term needs.

Figure 2-23. Tempered Networks HIPswitch 150e



Source: Tempered Networks.

Figure 2-23 depicts a HIPswitch 150e with an optional cellular expansion module that provides failover to a secondary cellular network in the event of failure of the wired network. This feature is not included in the HIPswitches deployed at KWWTP, MWWTP, and SWWTP. While a non-redundant communication link between these WWTPs and CKTP is not a critical issue for remote monitoring purposes, if these communication links are to be used for communication of plant alarms or remote control of the plants, establishing a secondary communication link would be worth considering. Provided that cellular reception is adequate at KWWTP, MWWTP, and SWWTP, the optional cellular expansion module for the HIPswitch would be a suitable means of implementing this secondary communication link.

2.10.5 Pump Stations

Because the Sewer Utility's wastewater pump stations have no Internet service, the exposure to cyber threats at the stations is greatly reduced. With no Internet access and limited IP infrastructure, the Sewer Utility has not deployed network security appliances at the pump stations. As discussed in Section 2.7 above, the security of the pump station cellular WAN is largely dependent on Verizon Wireless. HDR did not review the configuration of the pump station cellular routers, but hardening of the cellular routers could provide an additional layer of security.

The only means of securing the VHF licensed radio communications at the pump stations is via configuration of the radios themselves. HDR's review of the configurations for a selection of the VHF radios showed that Advanced Encryption Standard (AES) encryption has not been enabled. Encryption of the data streams between the pump stations and the MTU at CKTP is highly recommended to prevent eavesdropping and to mitigate potential security risks from malicious actors intruding on the radio network to modify radio configuration or otherwise disrupt communications. Enabling the VHF radios' inherent 128-bit AES encryption feature would provide a significant layer of security for a relatively minor configuration effort.

- The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.
- No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.
- On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.
- Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.
- Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.
- The Sewer Utility's Airwall edge services do not have current firmware versions installed.
- HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.
- The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.
- Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.

✸ Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.

2.11 Servers and Personal Computers

This subsection describes the servers and PCs deployed within the WWTP OT networks.

2.11.1 Central Kitsap Treatment Plant

CKTP has a variety of PCs and one tower server in the OT network inventory. A summary of the manufacturer, model, operating system, and release date for these machines is found in Table 2-2. Microsoft discontinued support for the Windows 7 operating system in January 2020, which means that security patches are no longer provided for the operating system on three of the CKTP SCADA PCs and the PC dedicated to the GE EnerVista Viewpoint power monitoring software platform. Windows 10 is the most current version of the Windows operating system for PCs and is currently supported by Microsoft. Microsoft has announced an extension of its support for Windows Server 2012 R2 through October 10, 2023.

Given the release dates for the various PCs, some of the PCs have most likely been in service for 5 to 7 years. Depending on the warranty period for the PCs, a general best practice is to replace business-grade PCs and servers, like the Dell PCs and server in the CKTP OT network inventory, every 3 to 5 years. Because the Sewer Utility plans to upgrade the Wonderware implementation at CKTP, HDR recommends that the replacement of the older PCs and server be aligned with the Wonderware upgrade to ensure that PCs and servers are selected to meet Wonderware's recommended hardware specifications. The replacement of these PCs would also resolve the lack of manufacturer support for the operating system running on these older PCs.

Table 2-2. CKTP OT network PC and server summary

PC name	Location	Manufacturer	Model	Operating system	PC release date
CKTPHISTORIAN	SPB control room	Dell	PowerEdge T130	Windows Server 2012 R2 Standard	2015
SCADA1	SPB ground floor	Dell	Precision T1700	Windows 7 Pro SP1	2013
SCADA2	SPB control room	Dell	Precision T1700	Windows 7 Pro SP1	2013
SCADA3	Administration and lab building office	Dell	Precision T1700	Windows 7 Pro SP1	2013
VIEWPOINTKITSAP	SPB control room	Dell	Inspiron 3647	Windows 7 Pro SP1	2014
N/A	Operations facilities building	Dell	Inspiron 3670	Windows 10 Pro	2019
N/A	I&C tech office	Dell	Inspiron 3670	Windows 10 Pro	2019

Table 2-2. CKTP OT network PC and server summary

PC name	Location	Manufacturer	Model	Operating system	PC release date
N/A	M&O supervisor office	Dell	Inspiron 3670	Windows 10 Pro	2019

The CKTP OT network has been set up as a workgroup. This implementation establishes all PCs and servers on the network as peers and requires that they remain in the same subnet to maintain the ability to share resources. It also requires that any user accounts that the Sewer Utility wishes to create for the PCs and servers be established on every PC and server in the workgroup, which can quickly become a burden for those maintaining the network as the number of PCs, servers, and users increases. Implementing a domain for the OT network, on the other hand, would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.

In terms of user access, the PCs that HDR observed have been configured to maintain the operating system user login sessions and do not automatically log out the user based on inactivity. Unlike the PCs, the historian server does log the user out on inactivity. For the PCs that HDR observed, a generic Operator username is used for the maintained login sessions on the PCs. While the practice of leaving the login sessions active is much more convenient for operators needing to occasionally glance at real-time process values or review and acknowledge alarms than if they were required to continually log in throughout their shift, it does prevent the Sewer Utility from implementing accounting measures that could attribute actions and events occurring on the network to specific individuals.

When it comes to managing user login sessions, there is a tradeoff between network security and workforce efficiency. Making the process of accessing ICS software too cumbersome can reduce operator engagement with the software, while leaving the machines running the software open to anyone can expose the organization to additional risks from unauthorized users and internal malicious actors. Whether to prioritize network security or user experience and efficiency is something each organization must decide for itself.

2.11.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

The KWWTP and MWWTP SCADA PCs are Dell Optiplex 5050s running the Windows 10 Professional operating system. The SWWTP SCADA PC is a Dell XPS 8910 also running the Windows 10 Professional operating system. Windows 10 is the most current version of the Windows operating system and is currently supported by Microsoft. Given the 2017 release date for the KWWTP and MWWTP PCs, the machines have most likely been in service for less than 3 years. The SWWTP PC has a release date in 2016. Depending on the warranty period for the PCs, a general best practice is to replace business-grade PCs, like the Dell Optiplex 5050, every 3 to 5 years. Because the Sewer Utility plans to upgrade the Wonderware implementation at KWWTP, MWWTP, and

SWWTP, HDR recommends that the replacement of these PCs be aligned with the Wonderware upgrade to ensure that a PC is selected to meet Wonderware's recommended hardware specifications.

The username and password credentials used to log into the operating system on the SCADA PCs at these WWTPs are the same as those used for the CKTP SCADA PCs. The operating system login sessions are also persistent and the user is not logged out on inactivity. Because there is ordinarily only one operator at these WWTPs, attributing network activity to a specific individual becomes much easier and it is less likely for an unauthorized user to gain access to the PCs unnoticed.

No other servers, workstations, PCs, or tablets in use at KWWTP, MWWTP, and SWWTP are associated with the OT network.

- Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.
- CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.
- Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.
- KWWTP, MWWTP, and SWWTP SCADA have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the WWTPs.

2.12 Network Infrastructure Physical Security, Environmental Conditions, and Power Supply

This subsection describes the physical security, environmental conditions, and power supply where the Sewer Utility OT network infrastructure is installed.

2.12.1 Physical Security

This subsection describes the physical security where the Sewer Utility OT network infrastructure is installed.

Central Kitsap Treatment Plant

CKTP is at least partially surrounded by a chain-link fence. HDR did not walk the CKTP perimeter to confirm that the fencing is continuous. The two gated entrances for vehicle entry are secured with padlocks. CKTP buildings are secured with keyed locks on man doors but, with the exception of the administration and lab building, the doors are not monitored with intrusion switches. Based on discussions with Sewer Utility staff, HDR believes that the administration and lab building doors are monitored by a third-party alarm system. HDR did not observe motion detectors or security cameras installed at CKTP.

Kingston Wastewater Treatment Plant

KWWTP is surrounded by a chain-link fence with three-line barbed wire. The one gated entrance for vehicle entry is secured with a padlock. KWWTP buildings are secured with keyed locks on man doors and intrusion switches on the operation building and process building doors generate an alarm via the SCADA system during hours when KWWTP is not attended. The operations building also has a motion detector that generates an alarm via the SCADA system after hours. No security cameras are installed at KWWTP.

Manchester Wastewater Treatment Plant

MWWTP is surrounded by a chain-link fence with three-line barbed wire. The two gated entrances for vehicle entry are secured with padlocks. MWWTP buildings are secured with keyed locks on man doors but the doors are not monitored with intrusion switches. A motion detector installed in the operations building control room generates an alarm via the SCADA system during hours when MWWTP is not attended. No security cameras are installed at MWWTP.

Suquamish Wastewater Treatment Plant

SWWTP is surrounded by a chain-link fence with three-line barbed wire. The one gated entrance for vehicle entry is secured with a padlock. SWWTP buildings are secured with keyed locks on man doors but the doors are not monitored with intrusion switches. No motion detectors or security cameras are installed at SWWTP.

WWTP Network Equipment Panels

The only enclosed network equipment racks, panels, or cabinets dedicated to OT network components found within the Sewer Utility’s facilities are the network cabinet and network panel (PNL 8580A) in the SPB control room. Both of these panels are left unlocked and are, therefore, dependent on the security of the building itself to prevent unauthorized access. Because Sewer Utility staff are not anticipated to require frequent access to these enclosures, establishing the practice of keeping the enclosures locked at all hours would help protect the OT network components from unauthorized access and inadvertent disruptions caused by untrained staff.

2.12.2 Environmental Conditions

Network components are installed at all four WWTPs outside of enclosures on communications backboards and/or open communication racks in electrical rooms. At CKTP, exposed plumbing passes next to OT network components (see Figure 2-24) in the administration and lab building electrical room. In addition to exposed water and air piping, the small room is shared by an air compressor and other mechanical equipment. Ideally, sensitive network components are kept away from mechanical equipment and plumbing, especially when those components are not housed within a protective enclosure. Rupture of a pipe or failure of the mechanical equipment in this electrical room could easily destroy the OT network and business LAN components therein.

Figure 2-24. Exposed plumbing next to network components in CKTP administration and lab building electrical room

At KWWTP, the KPUD Carrier Ethernet switch is installed low to the ground on a communications backboard (see Figure 2-17). The ongoing construction activities at KWWTP have generated a significant amount of dust, which can be seen collected on the floor in the figure. It appears that staff have covered the building entrance terminals for the plant telephone system in a plastic bag to protect the equipment from dust. However, the KPUD Carrier Ethernet access switch that serves as KWWTP’s Internet service demarcation appliance has been left exposed to the dust. Significant and/or prolonged exposure to dust can cause unprotected network components without rugged enclosures to fail prematurely.

Most of the remaining network components at the Sewer Utility’s facilities are installed within industrial control panels. Environmental conditions for the Sewer Utility’s industrial control panels are discussed in Section 3.

2.12.3 Network Infrastructure Battery Backup Power

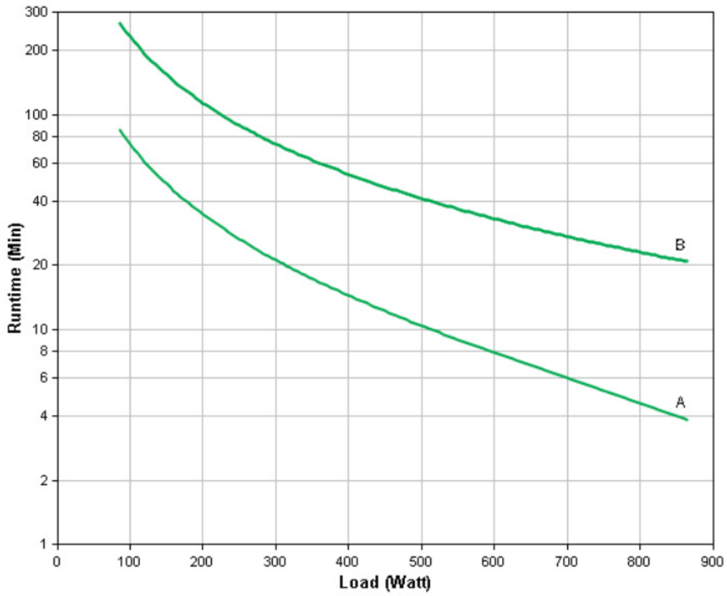
The SCADA PCs, CKTP historian server, and CKTP control room network cabinet have been provided with uninterruptible power supply (UPS) battery backup power to ride through brownouts and keep components powered until the plant or pump station transitions to standby generator power. These UPSs are line-interactive type, which provide an intermediate level of surge protection and noise filtering compared to other UPS technologies. The installed UPSs are not monitored by the facility SCADA system, so Sewer Utility staff have no indication of whether the SCADA PCs and servers and network equipment are on utility or battery power and do not receive notification of UPS low battery or fault conditions. Furthermore, the installed line-interactive UPSs have no remote monitoring capability in the form of relay contacts or Ethernet communications. Monitoring UPS health and status points at SCADA can alert Sewer Utility staff to issues that UPSs might be experiencing prior to a power outage event, which can avoid discovering these issues when the Sewer Utility is dependent on the UPSs to provide power to critical loads during emergency scenarios.

HDR observed that the KPUD-owned Carrier Ethernet access switches at KWWTP, MWWTP, and SWWTP are plugged into standard wall receptacles and are not receiving UPS power. Any brownouts experienced at these WWTPs have the potential to suspend communications occurring through these switches while the switches recover from the brownout, power up, and go through their boot cycle. Loss of power to these WWTPs also results in loss of communications until the WWTPs transition to generator power and the switches complete their boot cycle. Providing these switches with UPS power would eliminate unnecessary power-related communication losses and avoid delaying the communication of KWWTP, MWWTP, and SWWTP power-related alarms to CKTP.

A typical battery life for UPSs of the type found at Sewer Utility facilities is between 3 and 5 years, while the useful service life for the UPS itself typically ranges between 6 and 8 years. HDR did not review the Sewer Utility's battery replacement practices or obtain installation dates for the various UPSs in the Sewer Utility's inventory.

HDR also did not review or perform electrical load calculations for the Sewer Utility's UPS inventory. The UPS size along with the total electrical load that a UPS will need to power during loss of utility power determine how long the UPS batteries can support the connected electrical loads. Figure 2-25 shows the battery runtime graph for the APC Back-UPS 1500 UPS, which the Sewer Utility has provided for its SCADA PCs and CKTP historian server and installed in several of its industrial control panels. As indicated in the figure, UPSs of this size are not intended to support loads for extended periods and are typically provided as a buffer to carry the loads through brownouts or until standby generators come online for blackout scenarios.

Figure 2-25. Battery runtime graph for APC Back-UPS 1500



Source: APC (Schneider Electric 2020).

Sewer Utility staff indicated that during a recent power outage in August 2020, the standby generator feeding the low-voltage switchgear (SWGR) in the SPB failed to come online because of improper controller settings at the switchgear. This resulted in loss of the Sewer Utility's SCADA PCs and historian shortly thereafter, which could be an indicator of an improperly sized or faulty UPS. If the Sewer Utility wishes to maintain power for OT network servers, PCs, and other critical loads during emergency scenarios where the standby generator(s) fail to come online in a matter of minutes after utility power is lost, a more robust UPS strategy will be required.

2.12.4 Power Supply Redundancy

HDR observed that, in general, the network switches within the Sewer Utility's OT networks accept a single power input. Where switches accept two power supply inputs, like the unmanaged switch in the CKTP SPB control room network cabinet, only one power supply input has been wired. There are also several network switches that are powered with 24 volts direct current (VDC) in enclosures that have no 24 VDC power supply redundancy. Specific enclosures with a lack of 24 VDC power supply redundancy are discussed in Section 3.3. Providing power supply redundancy for critical network switches would help prevent OT network outages because of single power supply failures.

- Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.
- Network cabinet and network panel PNL-8580A are routinely left unlocked.

- Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.
- Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.
- Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.
- KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.
- The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.
- In general, the network switches within the Sewer Utility's OT network have no onboard power supply or external 24 VDC power supply redundancy.

2.13 Backup Procedures and Disaster Recovery

This subsection describes the Sewer Utility's current backup procedures and general disaster recovery preparedness for its OT network resources.

2.13.1 Backup Procedures

At CKTP, ICS software programming and configuration files for the Sewer Utility PLCs, HMIs, and OITs appear to be manually backed up on the CKTP historian server. The folder containing the CKTP PLC programming files that HDR observed contained several versions for many of the PLCs, making it difficult to ascertain which version was the most current in some cases. In terms of historical SCADA data, HDR does not believe that the Sewer Utility has procedures for backing up the CKTP historian data. Unless QCC or another contracted systems integrator obtains periodic backups of the historian data, failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.

At KWWTP, MWWTP, and SWWTP, the WWTP's Wonderware configuration files are stored on an external hard drive resting on top of the SCADA PC (see Figure 2-26). The LGH files containing the WWTPs' historical SCADA data are also automatically saved on this external hard drive. HDR did not find copies of these LGH files at CKTP, and if there are copies they would have had to have been obtained manually. Given that the SCADA PCs and external hard drives reside in the same physical location, a catastrophic event at the location of the SCADA PC would likely result in loss of all available historical SCADA data for that WWTP. External hard drives also have a typical useful service life of 3 to 5 years, but are often overlooked in asset management programs and left in service until someone observes that data have been corrupted. Any off-site backups of the SCADA PC, ICS software configuration and programming files, and historical SCADA data that exist are likely to be held by the systems integrator(s) that last upgraded or worked on the KWWTP, MWWTP, and SWWTP ICS.

Figure 2-26. KWWTP SCADA PC with connected external hard drive

Other than what contracted systems integrators may have stored on their networks, HDR does not believe that the Sewer Utility has placed backups of ICS programming and configuration files or historical data in off-site or cloud storage. HDR also believes that backing up the OT network PCs and servers themselves is not a current Sewer Utility practice.

2.13.2 Disaster Recovery

All SCADA PCs and servers observed within the Sewer Utility OT networks are also running ICS software installed on the host operating system. Aside from one instance of Rockwell’s Studio 5000 running on a virtual machine (VM) hosted on the SWWTP SCADA PC, HDR did not observe any ICS software running within a virtualized environment. There are several advantages to virtualization when compared with installing services directly on host operating systems. The greatest advantage, given the relatively small scale of the Sewer Utility’s OT networks, is the ability to quickly recover from loss of the physical host machine. With hypervisor software, purpose-built VMs running SCADA system services like the HMI software and historian can be easily cloned and transferred to other physical machines. As long as regularly scheduled backups occur, virtualization would allow the Sewer Utility to quickly recover from disaster or server equipment failure and avoid having to manually reinstall and configure software, which would likely require contracting a systems integrator for support. Other advantages of virtualization include the following:

- Easier backup procedures
- Ability to dedicate VMs to specific services so that an issue with one service does not result in a single point of failure for the rest of the services
- Ability to test patches and software upgrades in a controlled environment
- Potentially some cost savings in server hardware and energy consumption due to fewer physical servers

- ✷ Backups of PLC programming project files could be better organized to improve version control.
- ✷ No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.
- ✷ No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.
- ✷ Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.
- ✷ No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.
- ✷ The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.

2.14 Network Management

This subsection describes the Sewer Utility's network management practices for the WWTP OT networks.

2.14.1 Central Kitsap Treatment Plant

Aside from the Tempered Networks Conductor described previously, HDR does not believe that the Sewer Utility is currently using other software to monitor and manage the performance of the CKTP OT network. Many of the managed switches have web-based interfaces where basic switch configuration and status information may be obtained and firmware may be upgraded, but the Sewer Utility has no other means of observing the network. The Sewer Utility also does not have a syslog server or other central repository for collecting device logs and network event data. With no logging practices in place and no software tools to provide visibility into current and historical network status and performance, abnormal events within the CKTP OT network likely go undetected until they begin disrupting communications between devices. Without a baseline against which to compare current network activity, and with no software tools, it is also likely that Sewer Utility staff face significant challenges when attempting to troubleshoot network disruptions.

Aside from simplifying network maintenance and troubleshooting, monitoring and logging of network events and activity could also improve the Sewer Utility's ability to respond to a cybersecurity event. Early detection of unauthorized access to the CKTP OT network could allow the Sewer Utility to contain the threat before significant harm is done. Good logging practices can be helpful in determining how malicious actors gained access to the network so that exploited vulnerabilities can be mitigated. The information contained in network logs can also be crucial to helping federal authorities prosecute malicious actors.

Current configuration files for the Sewer Utility's VHF radios appear to be stored on the CKTP historian server. HDR was unable to locate configuration file backups for the managed switches and cellular routers within the Sewer Utility's OT networks. It is likely that QCC has current configuration files for some of these devices, but having more immediate access to the files would enable Sewer Utility staff to recover more quickly from a failure of one of these devices. Maintaining backup configuration files for the managed switches and cellular routers within the OT networks is recommended, if not already included in the Sewer Utility's network management practices.

2.14.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

Because of the small scale of the KWWTP, MWWTP, and SWWTP OT networks, the Sewer Utility does not use software tools to manage and monitor the networks. Because the OT networks are isolated from the public Internet, Windows and other potentially disruptive software updates and hotfixes are prevented from happening automatically and must be performed manually. HDR does not believe that the Sewer Utility maintains backups of managed switch configuration files. Backups of these configuration files, if they exist, are most likely held by the system integrator that last worked on these devices.

- The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.

- The Sewer Utility does not have a syslog server or other central repository for collecting CKTP OT network device logs and network event data.
- The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.

2.15 Network Documentation and Tagging

This subsection describes the network documentation and tagging practices observed at Sewer Utility WWTPs and pump stations along with their level of completeness.

2.15.1 Network Architecture Diagrams

The Sewer Utility does not have a complete and accurate set of network architecture diagrams for the WWTPs. Several partial ICS network diagrams from a variety of past construction projects along with high-level block diagrams show general physical connections between ICS components available on the County's electronic operation and maintenance (eO&M) SharePoint site. Some of the network diagrams available are no longer current or do not provide a complete representation of the current network implementation in the areas or buildings covered by the diagrams.

2.15.2 Fiber-Optic Patch Panels and Fiber-Optic Cabling

The Sewer Utility has high-level block diagrams that document the fiber-optic cable runs between various buildings, but these diagrams do not indicate fiber count or the uses of the various fiber runs (e.g., whether the fiber is used for the business LAN or the OT network). Fiber-optic patch panels at CKTP do not have printed schedules noting destination of fiber pairs and Sewer Utility staff do not maintain detailed fiber-optic patch cable schedules that identify fiber connections between buildings along with individual fiber pair connections to end devices.

A fiber-optic cable and fiber-optic patch panel tagging system does not appear to be in practice at CKTP. Many of the fiber-optic patch panels observed and several of the fiber-optic cables entering fiber-optic patch panels at the various buildings and process areas are not labeled. Those cables that are labeled indicate the equipment tags of the control panels or equipment enclosures in which terminations are made at both ends of the cable. Without additional documentation, someone unfamiliar with CKTP must follow fiber patch cables and as-build the connections to identify end devices for each fiber pair.

2.15.3 Copper Ethernet Cabling

Documentation for IP network connections occurring via copper Ethernet cables consists of what was described in Section 2.15.1. Where Category cables connect PCs or other network hardware to network switches, there are very few cases where the cables are labeled at either end. Within control panel enclosures, there are some instances where cables are labeled at either end, but there are several cases where labels have not been applied or have fallen off. This lack of cable labeling makes documenting the installed network very difficult and can present challenges for network maintenance and troubleshooting efforts.

- Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.
- Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.
- Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.

2.16 Cybersecurity Incident Response Program

Though the County Information Services department may have protocols in place for the County, in general, the Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages. These programs establish procedures to prepare for cybersecurity threats, identify when cybersecurity incidents occur, how to respond to the incidents, which individuals and agencies to contact, and how to adequately document any cybersecurity incidents and resolutions. Having a cybersecurity incident response program in place that is practiced and updated at regular intervals can greatly improve an organization’s ability to respond effectively if and when an incident occurs. Effective responses can minimize the impact and duration of attacks and allow staff to collect valuable information that can help federal agencies identify and prosecute attackers.

- The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.

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3 Industrial Control System Hardware

This section describes the current ICS hardware at Sewer Utility WWTPs and pump stations. It includes a description of the major hardware elements, along with their power supply and environmental conditions. The section also includes a summary of the WWTP control room equipment.

3.1 Programmable Logic Controllers

This subsection describes the major PLC hardware elements at Sewer Utility WWTPs and pump stations.

3.1.1 Controller Hardware

The Sewer Utility has standardized on Allen-Bradley PLCs throughout its wastewater infrastructure. Table 3-1 provides a list of PLCs installed at the WWTPs and pump stations visited by HDR during its site assessments. In addition to model and catalog number information, the table lists the manufacturer life-cycle status and installation year for each PLC.

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
CKTP	PNL 1021	Influent screen 1 main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1023	Influent screen 3 main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1026	Screwpactor main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1050	Headworks control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1111	Grit washer 1 control panel	Allen-Bradley	SLC 5/05	1747-L551	Active mature	2010
CKTP	PNL 1112	Grit washer 2 control panel	Allen-Bradley	SLC 5/05	1747-L551	Active mature	2010
CKTP	PNL 2920	Power/blower building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 2939	Aeration basins electrical building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 2990	Power/blower building I/O panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	SCC 3100	UV system control center	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2018
CKTP	PNL 4012	RDT control panel	Allen-Bradley	CompactLogix 5370	1769-L30ER/A	Active	2014
CKTP	PNL 4050	Polymer blending system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 4080	Polymer feed system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 4905	WAS thickening building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	N/A	RACS operator interface control panel	Allen-Bradley	MicroLogix 1100	1763-L16BWA	Active mature	2010
CKTP	PNL 5010	Raptor septage acceptance plant control panel	Allen-Bradley	MicroLogix 1100	1763-L16AWA	Active mature	2010
CKTP	PNL 6000	Digester building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 7105	PLC 7105 I/O rack	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 7110	Centrifuge 1 control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
CKTP	PNL 7120	Centrifuge 2 control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
CKTP	PNL 7225	Dewatering polymer panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
CKTP	PNL 8200	Filter system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 8905	Reclaimed-water control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 9201	Digester gas treatment control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	N/A	Master station CTU (radio)	Allen-Bradley	CompactLogix L3x	1769-L35E	End of life	2017
CKTP	N/A	Master station CTU (cell)	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
KWWTP	CP-200	Operations building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2020
KWWTP	FCP-201	Mechanical fine screen control panel	Allen-Bradley	MicroLogix 1400	1766-L32AWA	Active	2020
MWWTP	PCP	Plant control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2018
PS-1	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-1	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
PS-4	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24BWA	Discontinued	2004
PS-4	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-6	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-6	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
PS-7	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24AWA	Discontinued	2007
PS-7	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-12	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-17	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24BWA	Discontinued	2004

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
PS-17	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-24	N/A	Main control panel	Allen-Bradley	SLC 5/03	1747-L532	Active mature	2000
PS-24	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-32	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-34	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-41	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-67	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-67	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-71	N/A	Main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2004
PS-71	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
SWWTP	CP-01	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
SWWTP	CP-15	RDT control panel	Allen-Bradley	CompactLogix 5370	1769-L30ER/A	Active	2016

Current PLC Standard for Process Control Applications

Though a variety of PLC models are installed throughout the WWTPs and pump stations, in recent years, the Sewer Utility has standardized on Allen-Bradley 1769-L33ER CompactLogix 5370 L3 controllers and Bulletin 1769 Compact I/O modules (see Figure 3-1) for WWTP and pump station industrial control panels. These controllers have 2 megabytes (MB) of user memory and two 10/100 Mbps EtherNet/IP communication ports that support ring network topologies. They also support up to 16 connected I/O modules and are capable of integrating up to 32 EtherNet/IP nodes via installed PLC programming logic. Given that the Sewer Utility has installed these PLCs to handle controls for pump stations, small WWTPs, and dedicated processes at the larger CKTP, HDR believes that the CompactLogix PLC is well-suited and right-sized for its current applications within the Sewer Utility's wastewater infrastructure. The next processor tier above the CompactLogix series in the Allen-Bradley product line is the ControlLogix series, which is better suited for larger and/or more centralized control applications or where process criticality demands a hot-standby redundancy solution.

Figure 3-1. Allen-Bradley CompactLogix PLC with 1769-L33ER controller and Bulletin 1769 Compact I/O modules

Source: Rockwell Automation.

Rockwell has released a newer generation of the CompactLogix controller line (CompactLogix 5380), which has options for greater controller user memory and supports 1 GbE EtherNet/IP communication and an increased number of EtherNet/IP nodes. However, the CompactLogix 5370 PLCs and the Bulletin 1769 Compact I/O modules are still in the active phase of the manufacturer's life cycle, which indicates that they are considered a current product offering and are fully supported by the manufacturer.

Current PLC Standard for Telemetry Applications

For the pump station RTU control panels, the Sewer Utility has standardized on Allen-Bradley 1766-L32BXBA MicroLogix 1400 controllers (see Figure 3-2). These compact controllers have 10 kilobytes (kB) of user memory, 32 onboard hardwired I/O points, one serial port that can be configured for a variety of serial-based protocols, and one 10/100 Mbps EtherNet/IP communication port for EtherNet/IP peer-to-peer messaging. These

PLCs are well-suited and right-sized for managing the telemetry controls for the Sewer Utility's wastewater pump stations.

Figure 3-2. Allen-Bradley 1766-L32BXBA MicroLogix 1400 PLC

Source: Rockwell Automation.

Discontinued PLCs

As shown in Table 3-1, the Sewer Utility has some PLCs in its inventory that have been discontinued by the manufacturer. According to information available on the Allen-Bradley website, MicroLogix 1500 PLCs are no longer manufactured or available for sale and the manufacturer is encouraging migration to MicroLogix 1400 or CompactLogix 5370 PLC platforms (Rockwell Automation 2020a). Replacement parts for these PLCs are anticipated to become increasingly difficult to procure in the coming years. The MicroLogix 1500 PLCs in the Sewer Utility's inventory have also been in service for roughly 13 to 16 years. Depending on the environmental conditions to which PLCs are subjected throughout their service life, the typical useful service life for PLCs is roughly 15 years. These discontinued PLCs are nearing the end of their useful service life and will soon be operating in their wear-out period.

End-of-Life Announcements and Active Mature Products

Table 3-1 also indicates that the Sewer Utility has five Allen-Bradley CompactLogix L3x PLCs in its inventory. The manufacturer has made an end-of-life announcement for these PLCs, warning that the components will no longer be manufactured or available for sale as of December 2020 (Rockwell Automation 2020b). Allen-Bradley is encouraging migration of these PLCs to the CompactLogix 5380 platform. In the meantime, a small window remains for the Sewer Utility to make last-time purchases of spare components for these PLCs, if there is interest in doing so.

The Sewer Utility also has several Allen-Bradley SLC 500 Series and MicroLogix 1100 PLCs installed throughout its WWTPs and pump stations. Both of these PLC platforms are in the active mature phase of the manufacturer's life cycle, which indicates that the products are still fully supported by the manufacturer but that migration to a newer PLC platform is encouraged (Rockwell Automation 2020c). Though an end-of-life announcement has yet to be released for these PLCs, the Sewer Utility may wish to consider near-term upgrades of the PS-24 and PS-71 PLCs because they have been in service for roughly 20 years and 16 years, respectively, and are nearing the end of their useful service life.

Miscellaneous Observations

During its site visits, HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks electrical room (see Figure 3-3). This could indicate that the battery voltage has fallen below a threshold level, or the battery is missing or not connected. Because the PLC memory where the programming is stored is backed up by the PLC's internal battery, loss of power to this PLC could result in loss of the programming and a prolonged equipment outage to enable Sewer Utility staff to re-download programming to the controller.

Figure 3-3. CKTP bar screen 1023 main control panel PLC controller battery alarm light illuminated

Another observation is that the RIO control panel in the MWWTP blower building is installed above the old SBR control panel and is not readily accessible. Figure 3-4 shows this panel with its door open above the SBR control panel. Sewer Utility staff would need a ladder to perform modifications to the panel or troubleshoot its wiring.

Figure 3-4. MWWTP blower building RIO control panel installation

3.1.2 DeviceNet Networks

At CKTP, several of the MCCs have been furnished with a DeviceNet network connecting the various overload relays and VFDs within the MCC to a DeviceNet scanner module in the PLC rack within the industrial control panel that provides control for the building or process area. Figure 3-5 shows the DeviceNet scanners dedicated to MCC 2935 and MCC 2936 in the aeration basins 3 and 4 electrical building. These and most other DeviceNet MCCs at CKTP were commissioned in 2014 as part of the CKTP Resource Recovery project. The DeviceNet MCCs in the headworks building were commissioned in 2010 as part of the Headworks Upgrade project.

Figure 3-5. DeviceNet scanners in PNL 2939 PLC rack

DeviceNet technology, originally developed by Allen-Bradley, features a bus topology consisting of a common trunk line to which devices are connected via taps and dedicated drop lines. Device power and communication occur over the same physical cables used in this topology and terminating resistors are required at either end of the bus. The DeviceNet network data rate is configurable and selection of an appropriate data rate needs to take into consideration the overall trunk and drop line cable lengths and cable type used. With a maximum data rate of 500 kilobits per second (kbps), DeviceNet has become a dated technology that falls well below the bandwidths achievable with today's Ethernet-based technologies. Furthermore, with several design and implementation considerations and more components involved, the physical layer of DeviceNet networks is also relatively complex when compared to Ethernet networks. This complexity can often lead to maintenance and troubleshooting challenges for the end user. Sewer Utility staff have reported experiencing difficulties working with DeviceNet technology at CKTP. The challenges Sewer Utility staff are having with the maintenance and troubleshooting of the DeviceNet networks have the potential to increase downtime for equipment connected to the DeviceNet networks.

Like Ethernet, DeviceNet allows for an increased volume of data exchange between the ICS and networked devices that would not be possible via hardwired I/O alone. Currently, data derived from DeviceNet-connected devices represents a significant portion of the overall unique I/O points received from and sent to field devices by the CKTP ICS.

3.1.3 Hardwired Input/Output

When it comes to data exchange between the Sewer Utility's PLCs and process equipment and instrumentation, much of this control and monitoring is hardwired. For analog signals, the Sewer Utility has standardized on 4–20-milliampere (mA) current-based I/O. The Sewer Utility facilities have a mix of isolated and non-isolated analog I/O modules at the PLCs and RIO racks. Hardwired discrete I/O was observed to be a mix of 120 VAC and 24 VDC I/O, depending on the connected equipment. A summary of the

I/O modules types and quantities installed in the various PLC and RIO racks throughout the WWTPs is provided in Appendix D.

Though the Sewer Utility has succeeded in standardizing on one manufacturer for all PLCs in its inventory, there is some diversity when it comes to the I/O modules that systems integrators and/or consulting engineers have selected for Sewer Utility industrial control panels over the years. The Sewer Utility may be able to reduce its spare-parts inventory and enforce its preferences by standardizing on specific I/O modules for future projects. For example, for most analog signal applications, an industry best practice is to select isolated analog I/O modules to mitigate noise issues on analog signals and to prevent faults on one signal from impacting other inputs or outputs on the same I/O module. If the Sewer Utility wished to establish a preference for isolated analog I/O modules, this requirement could be introduced to Sewer Utility standards documentation and used to guide consulting engineers and systems integrators in the design and fabrication of future industrial control panels.

3.1.4 IP Network Input/Output

CKTP, KWWTP, and SWWTP all have a few Allen-Bradley VFDs that communicate with plant PLCs via EtherNet/IP. The overload relays for the new oxidation ditch mixers at KWWTP also communicate with the plant PLC via EtherNet/IP. At CKTP, power monitors installed within several of the MCCs and switchgear lineups communicate with GE controllers in the SWGR 2961 control stack via Modbus Transmission Control Protocol (TCP)/IP as part of the CKTP energy management system (EMS) described in Section 6 below. Aside from these cases, HDR observed relatively little IP network–based data exchange occurring between Sewer Utility PLCs and field equipment and instrumentation.

- The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.
- Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs will be discontinued by the manufacturer as of December 2020.
- The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer’s product life cycle and are nearing the end of their useful service life.
- HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.
- The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.

- Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.
- The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.

3.2 Human-Machine Interfaces

This subsection describes the HMI hardware by which Sewer Utility staff interact with the ICS at the various Sewer Utility facilities.

3.2.1 Wonderware Thick Clients

The Sewer Utility has standardized on Wonderware InTouch 2014 R2 for the SCADA HMIs at its WWTPs. The software and its configuration and implementation are discussed in Section 4. In terms of HMI hardware, the Sewer Utility has installed a Wonderware InTouch runtime license on each control room operator SCADA PC for KWWTP, MWWTP, and SWWTP. Throughout CKTP, the Sewer Utility has installed several Wonderware InTouch thick clients. These thick clients consist of several SCADA PCs and industrial panel PCs (see Figure 3-6) installed in various buildings throughout CKTP, as depicted in the Central Kitsap Treatment Plant Physical Network Diagram included in Appendix B (Figure B1).

Figure 3-6. Headworks building electrical room Wonderware InTouch thick client

The Sewer Utility has standardized on National Electrical Manufacturers Association (NEMA) 4X, touchscreen hardware for its industrial panel PCs at CKTP. Table 3-2 provides a summary of manufacturer, model, size, and year of manufacture information for the industrial panel PCs installed throughout CKTP. Depending on the environmental conditions to which industrial panel PCs are subjected throughout their service life, the typical useful service life for industrial panel PCs is roughly 5 to 7 years. Based on this information, the CKTP industrial panel PCs are expected to have most of their useful service life remaining.

Table 3-2. CKTP industrial panel PC summary

Panel tag	Panel description	Manufacturer	Model	Size (in)	Year manufactured
PNL 1050	Headworks control panel	Arista	ARP-1715AP-108	15.0	2017
PNL 2920	Power/blower building control panel	Arista	ADM-1821AP	21.5	2019
PNL 2939	Aeration basin control panel	Arista	ADM-1821AP	21.5	2020
PNL 4905	WAS thickening building control panel	Arista	ADM-1821AP	21.5	2019
PNL 8905	Reclaimed-water control panel	Arista	ADM-1821AP	21.5	2019

The SCADA PCs used for the Wonderware InTouch thick clients at the Sewer Utility WWTPs are described in Section 2.

3.2.2 Control Panel Operator Interface Terminals

In addition to the WWTP Wonderware InTouch thick clients, several OITs are installed throughout the Sewer Utility's WWTPs and pump stations. These OITs are dedicated to the PLC within their respective industrial control panels and do not provide visibility into other systems within the Sewer Utility's ICS. Table 3-3 provides a summary of manufacturer, model, size, and year of manufacture information for the OITs installed throughout the Sewer Utility WWTPs and pump stations. The table also lists the current manufacturer life-cycle status for each of the OITs, where life-cycle status information is readily available from the manufacturer.

Table 3-3. WWTP and pump station OIT summary

Facility	Panel tag	Panel description	Manufacturer	Model	Size (in)	Life-cycle status	Year manufactured
CKTP	PNL 4012	RDT control panel	Maple Systems	HMI5070TH	7.0	Legacy	2013
CKTP	PNL 4050	Polymer blending control panel	Allen-Bradley	PanelView Plus 600	5.7	End of life	2013
CKTP	PNL 4080	Polymer feed control panel	Allen-Bradley	PanelView Plus 600	5.7	End of life	2013
CKTP	PNL 7110	Centrifuge 1 control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	PNL 7120	Centrifuge 2 control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	PNL 7225	Dewatering polymer panel	Allen-Bradley	PanelView Plus 700	6.5	End of life	2018
CKTP	PNL 8200	Filter system control panel	Siemens	SIMATIC MP 277	8.0	Phase out	2013
CKTP	PNL 9201	Digester gas treatment control panel	Pro-face	GP-4601T	12.1	Unknown	2013
CKTP	SCC 3100	UV system control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	N/A	Master station CTU	Allen-Bradley	PanelView Plus 1000	10.4	End of life	2012
CKTP	N/A	RACS operator interface control panel	Maple Systems	HMI6060T	6.0	Legacy	2010
CKTP	N/A	SWGR 2961	VarTech Systems	VTPC150P	15.0	Unknown	2013
CKTP	N/A	SWGR 2961 control stack	VarTech Systems	VTPC150P	15.0	Unknown	2013
KWWTP	CP-300	Process building control panel	Allen-Bradley	PanelView 600	5.7	Discontinued	2004
KWWTP	N/A	Mechanical fine screen control panel	Allen-Bradley	PanelView 800	7.0	Active	2020
PS-01	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2016
PS-04	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	Discontinued	2004
PS-06	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2016
PS-07	N/A	Main control panel	Allen-Bradley	PanelView Plus 1000	10.4	End of life	2014
PS-17	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	Discontinued	2004
PS-24	N/A	Main control panel	Allen-Bradley	PanelView Plus 600	5.7	Discontinued	2000

Table 3-3. WWTP and pump station OIT summary

Facility	Panel tag	Panel description	Manufacturer	Model	Size (in)	Life-cycle status	Year manufactured
PS-67	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2015
PS-71	CP-100	Main control panel	Allen-Bradley	PanelView Plus 600	5.7	Discontinued	2004
SWWTP	CP-15	RDT control panel	Maple Systems	HMI5097XL	9.7	Active	2016

Unlike industrial panel PCs where SCADA software is installed on a base operating system, OITs run proprietary software developed by the OIT manufacturer that is distinct from the Sewer Utility's Wonderware InTouch software. The distinct software platforms require additional configuration and development effort to implement and maintain graphical content and functionality for these OITs.

Depending on the environmental conditions to which OITs are subjected throughout their service life, the typical useful service life for OITs is roughly 7 to 10 years. However, it is not uncommon for OITs that receive infrequent use to remain in service for significantly longer than this. As Table 3-3 suggests, a few OITs in the Sewer Utility's inventory are likely nearing the end of their useful service life, particularly at some of the Sewer Utility's pump stations and CP-300 at KWWTP.

During its site visit at KWWTP, HDR observed that a communication error was displayed at the CP-300 OIT, indicating it could not communicate with a specific IP address. This issue may be due to the ongoing construction effort at KWWTP and will likely be resolved as the ICS upgrade implementation at KWWTP is finalized. HDR also observed that the OIT at the master station central telemetry unit (CTU) control panel in the SPB control room at CKTP has been disconnected from the network switch in that panel and appeared to be powered down. This OIT may be permanently out of service. However, given its proximity to a SCADA PC with Wonderware InTouch screens dedicated to the various pump stations, replacement of this OIT may not provide much value to Sewer Utility staff.

- The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.
- The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.
- The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.

3.3 Power Supply and Environmental Conditions

This subsection describes the power supply measures provided for the industrial control panels containing ICS components, control panel National Fire Protection Association (NFPA) 70E considerations, and the environmental conditions to which these control panels are subjected.

3.3.1 ICS Battery Backup Power

Several of the industrial control panels containing OT network and ICS components within the Sewer Utility WWTPs and pump stations have a dedicated UPS installed within the panel enclosure that provides the control system, instrumentation, and network components with battery backup power to ride through brownouts and keep components powered until the WWTP or pump station transitions to standby generator power. In general, the UPSs installed at Sewer Utility facilities are line-interactive type. However, in most cases, the UPSs are not monitored by the facility SCADA system, so Sewer Utility staff have no indication of whether the control panels are on utility or battery power and do not receive notification of UPS low battery or fault conditions. Furthermore, many of the installed line-interactive UPSs have no remote monitoring capability in the form of relay contacts or Ethernet communications. Monitoring UPS health and status points at SCADA can alert Sewer Utility staff to issues that UPSs might be experiencing prior to a power outage event, which can avoid discovering these issues when the Sewer Utility is dependent on the UPSs to provide power to critical loads during emergency scenarios.

Industrial control panels containing OT network and ICS components without UPS or other form of battery backup power are listed in Table 3-4. The control system, instrumentation, and OT network components housed within or powered from these panels immediately lose power during loss of utility power and may drop offline during voltage dips and power fluctuations experienced at the plant. The components without UPS battery backup power also do not benefit from the surge protection and noise filtering that line-interactive or online, double-conversion UPSs provide. Note, PNL 1050, included in Table 3-4 below, does have a line-interactive UPS installed within its enclosure, but the UPS was found unplugged during HDR's site visit. Note, also, that Table 3-4 is limited to Sewer Utility industrial control panels containing OT network components and/or major ICS components, like PLCs, and does not apply to all industrial control panels within the Sewer Utility's infrastructure.

Table 3-4. Industrial control panels containing OT network and ICS components with no battery backup power

Facility	Location	Panel	Panel description
CKTP	Digester control building	PNL 6000	Digester control building control panel
CKTP	Headworks building	PNL 1026	Screwpactor main control panel
CKTP	Headworks building	PNL 1027	Grit washer 1 control panel
CKTP	Headworks building	PNL 1028	Grit washer 2 control panel
CKTP	Headworks building	PNL 1050	Headworks control panel
CKTP	Power/blower building	PNL 2920	Power/blower building control panel
CKTP	Power/blower building	PNL 2990	Power/blower building I/O panel
CKTP	SPB	PNL 7105	PLC 7105 I/O rack
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel
KWWTP	Headworks area	N/A	Mechanical fine screen control panel
MWWTP	Blower building	SBR-CP	Blower building control panel
MWWTP	Headworks building	LP-225	Influent pump station control panel
MWWTP	Operations building	PCP	Plant control panel
PS-07	Pump station 7	N/A	PS-07 control panel
PS-17	Pump station 17	N/A	PS-17 control panel
PS-34	Pump station 34	N/A	PS-34 control panel

3.3.2 24 VDC Power Supplies

Providing UPS battery backup power is a means of establishing a degree of power source redundancy and fault tolerance for critical ICS and OT network components. However, many of these ICS and OT network components are powered from 24 VDC power supplies that are typically downstream from utility and UPS power sources within the industrial control panel electrical distribution. If there is no redundancy in the 24 VDC power supply, as well, the power supply redundancy and fault tolerance measures introduced by the UPS do not carry all the way through to the critical components.

During its site visits, HDR observed that several Sewer Utility industrial control panels containing OT network and ICS components do not have 24 VDC power supply redundancy. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy are listed in Table 3-5. The 24 VDC control system, instrumentation, and OT network components housed within or powered from these panels immediately lose power upon failure of the control panel's 24 VDC power supply. Control panels that have 24 VDC UPS systems or 24 VDC battery power, like the telemetry control panels, are not included in the table. Failure of the single 24 VDC power supply in these control panels would still leave the OT network and ICS components with a buffer of backup battery power and would not result in an immediate loss of power for the 24 VDC–powered components.

Table 3-5. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy

Facility	Location	Panel	Panel description
CKTP	Digester control building	PNL 6000	Digester control building control panel
CKTP	Digester gas conditioning facility	PNL 9201	Digester gas treatment control panel
CKTP	Headworks building	PNL 1021	Influent screen 1 west channel
CKTP	Headworks building	PNL 1023	Influent screen 3 east channel
CKTP	Headworks building	PNL 1026	Screwpactor main control panel
CKTP	Headworks building	PNL 1027	Grit washer 1 control panel
CKTP	Headworks building	PNL 1028	Grit washer 2 control panel
CKTP	Headworks building	PNL 1050	Headworks control panel
CKTP	Power/blower building	PNL 2990	Power/blower building I/O panel
CKTP	Reclaimed-water building	PNL 8200	Filter system control panel
CKTP	Septage receiving	N/A	RACS operator interface control panel
CKTP	Septage receiving	PNL 5010	Raptor septage acceptance plant control panel
CKTP	SPB	N/A	Master station CTU
CKTP	SPB	MCC 2984	MCC 2984 control section
CKTP	WAS thickening building	PNL 4012	RDT control panel
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel

Table 3-5. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy

Facility	Location	Panel	Panel description
KWWTP	Headworks area	N/A	Mechanical fine screen control panel
MWWTP	Blower building	SBR-CP	Blower building control panel
MWWTP	Headworks building	LP-225	Influent pump station control panel
MWWTP	Operations building	PCP	Plant control panel
PS-04	Pump station 4	N/A	PS-04 control panel
PS-07	Pump station 7	N/A	PS-07 control panel
PS-17	Pump station 17	N/A	PS-17 control panel
PS-24	Pump station 24	N/A	PS-24 control panel
PS-67	Pump station 67	N/A	PS-67 control panel
PS-71	Pump station 71	N/A	PS-71 control panel
SWWTP	Process building	CP-01	Main control panel
SWWTP	Process building	CP-15	RDT control panel

3.3.3 NFPA 70E Considerations

As discussed in Section 3.1, HDR observed a mix of 120 VAC and 24 VDC controls in the various Sewer Utility industrial control panels. In many cases, the power and control voltages were not readily apparent and required closer inspection of the components to identify. According to NFPA 70E: Standard for Electrical Safety in the Workplace, all voltages 50 V and greater are considered to present a shock hazard under most circumstances (NFPA 2021). To reduce or eliminate shock hazards for personnel, a common practice is to standardize on 24 VDC controls and power distribution, to the extent possible, within industrial control panels and for field instrumentation. Where 120 VAC power or controls are required to enter control panel enclosures (e.g., incoming 120 VAC power supply from a nearby panelboard), these circuits can be consolidated within a designated region of the control panel. The use of color-coded, covered wireways can also help alert staff to the presence of different voltages within control panel enclosures.

Though converting existing 120 VAC control system wiring to 24 VDC would be infeasible, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls for industrial control panels introduced by future CIP projects.

3.3.4 Environmental Conditions

Several of the industrial control panels observed during HDR’s site visits are installed in indoor, temperature-controlled environments with enclosures that prevent dust ingress. The control panels housing network and ICS components located in process areas or outdoors generally have NEMA 4X enclosures. Given the rugged design and extended operating temperature ranges of the industrial network and ICS components installed in these control panels, HDR did not observe severe environmental conditions that would significantly jeopardize the functionality of these components.

One notable exception to this observation is the CKTP digester control building control panel (PNL 6000), which is subjected to significant levels of hydrogen sulfide (H_2S) and high ambient temperatures. Evidence of this H_2S exposure can be seen in the blackening of the control panel's copper ground bar shown in Figure 3-7. H_2S is a corrosive gas, particularly to copper and silver, which are prevalent in network components, ICS hardware, and other sensitive electronics. Prolonged exposure to H_2S and high ambient temperatures can lead to premature failure of these components. County electricians have reported that H_2S corrosion has been a significant maintenance issue with control wiring at the MCC installed near this control panel in the digester control building. During HDR's site visit, the ambient temperature in the ground floor of the digester control building was easily above 90 degrees Fahrenheit. The digester control building also has a hazardous-area classification for which the PNL 6000 enclosure and many of its internal components are not rated, which is a NEC violation.

Figure 3-7. H_2S corrosion on digester control building control panel (PNL 6000) copper ground bar

Staff have also reported that microprocessor-based HVAC control panels installed to control temperatures within some of the CKTP electrical rooms are overly complicated and ultimately fail to adequately control the electrical room temperature. The HVAC control panels within the WAS thickening building and SPB electrical rooms are two examples of failed temperature control implementations. HDR also observed that the HVAC system for the headworks building electrical room was incapable of maintaining the temperature set point entered at the thermostat, resulting in an undesirably high ambient temperature in the electrical room (see Figure 3-8).

Figure 3-8. Headworks building electrical room thermostat

HDR observed a similar electrical room climate control issue at the MWWTP operations building. On the day of HDR's site visit to MWWTP, Sewer Utility staff had propped open the operations building electrical room door and temporarily placed a fan in the doorway to try to reduce the electrical room temperature (see Figure 3-9). During summer months, it is likely that the control system and network components within the room are regularly exposed to ambient temperatures above desirable ranges.

Figure 3-9. Temporary ventilation measure for MWWTP electrical room

- OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of H_2S and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is an NEC violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.
- Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.
- Several control panels at Sewer Utility facilities do not have battery backup power.
- Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.
- A mix of 120 VAC and 24 VDC control and power circuits are installed within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.
- The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.

3.4 Control Room

The Sewer Utility has stated that one of its near-term goals for the Sewer Utility SCADA system is to establish a central location where Sewer Utility staff can monitor and control all WWTPs and pump stations managed by the Sewer Utility. At CKTP, a control room on the second floor of the SPB provides office space for the CKTP Plant Operations Supervisor and other operations staff (see Figure 3-10). With exterior windows running nearly the entire length of two sides of the room and its position on the second floor of a centrally located building within CKTP, the control room provides a good vantage point from which to monitor plant activity. In addition to operations staff PCs and printers, the control room is equipped with a SCADA PC, the CKTP historian server, and the CKTP EMS PC. The network cabinet and network panel in the control room serve as the central hub for the CKTP OT network, and the master station CTU control panel housing the master PLCs for the Sewer Utility's wastewater pump station VHF licensed radio and cellular WANs is also installed within the room.

Figure 3-10. CKTP SPB control room

Given its location at CKTP and proximity to central connection points for the CKTP OT network and pump station WANs, the existing SPB control room is an obvious choice for a space in which to implement a control center for the Sewer Utility. The room is also an architecturally finished, climate-controlled space, which would provide suitable environmental conditions for PCs, workstations, displays, and other sensitive electronics introduced as part of the Sewer Utility control center implementation. Furthermore, the room's drop ceiling would simplify installation of new data communications cabling between future control center equipment.

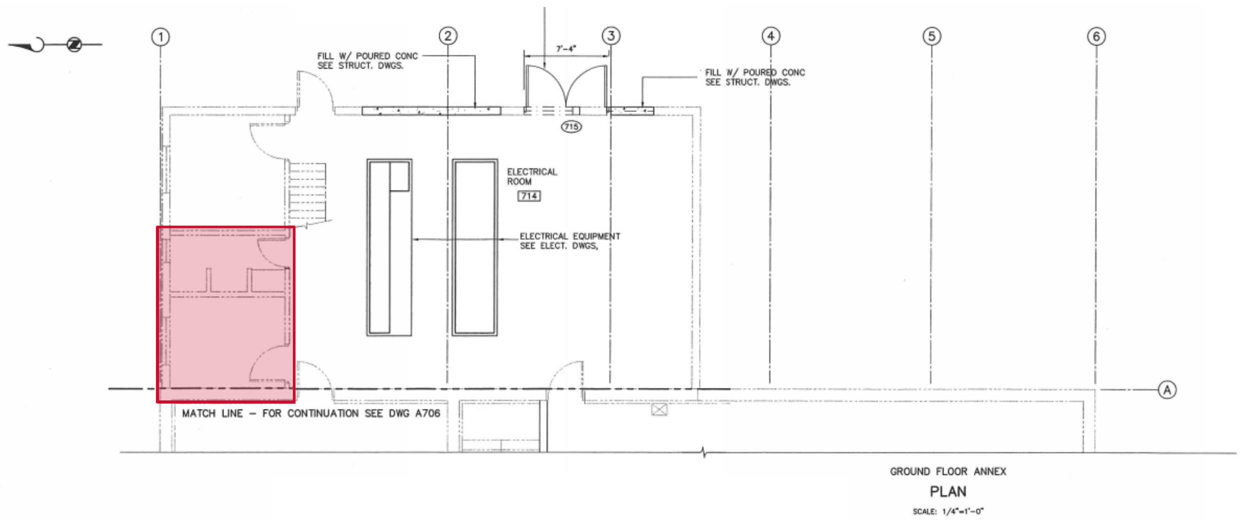
Though the control room has a SCADA PC, the PC is equipped with only two standard-size monitors (see Figure 3-11). This arrangement may be suitable for an individual, but is not an ideal solution for control center scenarios where multiple staff members need to engage with the SCADA screens and discuss current status, alarms, and/or events. The Sewer Utility would benefit from having large-format displays so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Having additional displays would also allow Sewer Utility staff to leave specific commonly used screens on display at all times to avoid having to constantly navigate back and forth between screens because only two monitors are available.

Figure 3-11. SPB control room SCADA PC monitors

Currently, Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs. The Sewer Utility is working with QCC to establish data exchange between CKTP and the remote WWTPs, and this will be a critical step toward the future control center that the Sewer Utility wishes to implement. The Sewer Utility's ability to monitor its pump stations from CKTP is also significantly limited by the data refresh rate caused by the long polling cycle times discussed in Section 2. Because the information displayed on pump station SCADA screens is nowhere near real-time, Sewer Utility staff have indicated that they typically only make use of alarm information reported through the SCADA system for the pump stations.

Depending on spatial requirements and the quantity of servers and network appliances required by future CKTP ICS upgrades, the Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment. A potential candidate for such a space in the SPB would be a combination of the filing room and adjacent storage space in the ground floor of the SPB annex (proposed space shown enclosed in a red box in Figure 3-12). Though work would be required to properly prepare the space for use as a server room, this location would keep the ICS servers and critical network equipment in close proximity to the Sewer Utility control center and current incoming fiber-optic and copper cable network connections from other buildings at CKTP. Some of the work involved with converting this space into an appropriate server room environment would include combining the filing room and storage space; filling in existing windows; installing heating, ventilation, and air conditioning (HVAC) equipment to provide adequate cooling for the space; and providing new power and data communications circuits to the space.

Figure 3-12. SPB annex, ground floor: potential location for future server room



- The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.
- Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.
- Sewer Utility staff do not have access to near real-time status and alarm information for wastewater pump stations at CKTP.
- The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.

3.5 Instrumentation

HDR site assessments did not include assessment of individual field instrumentation. However, HDR has included some general observations made during its site assessments and discussions with Sewer Utility staff that pertain to instrumentation and controls in the following paragraphs. The ideal time to perform a condition assessment survey of current instrumentation associated with a certain process or equipment is when that process or equipment is being evaluated for increased levels of automation and performance optimization. This way, the existing instruments are assessed based on identified future needs for the process or equipment to meet automation and performance optimization goals.

3.5.1 Instrumentation Calibration and Maintenance Program

Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops. Typically, I&C technicians are notified by maintenance or operations staff when instrumentation issues are encountered, at which time they investigate and troubleshoot. The Sewer Utility has hired Branom Instrument Co. (Branom) to perform field calibrations of select field instruments in the past, but does not have a service contract in place with Branom for scheduled routine calibration services.

Implementing regularly scheduled calibration and maintenance practices in accordance with manufacturer recommendations is critical to maintaining the accuracy, reliability, and repeatability of the I&C loops on which the Sewer Utility's process control and standard operating procedures (SOPs) depend. Furthermore, if the Sewer Utility wishes to pursue more data-centric operational strategies, the integrity of the historical data becomes increasingly important. Without a formal instrumentation calibration and maintenance program, instruments are often allowed to drift until inaccuracies become so great that they become noticeable to the staff who rely on the instruments to perform their work. This may result in long periods where the historian is logging inaccurate measurements. Regular calibration is especially important for instrument technologies that have a tendency to drift more significantly than others—technologies like analyzers (e.g., chlorine residual, dissolved oxygen [DO], turbidity, pH, and lower explosive limit [LEL]) and pressure instrumentation with diaphragm seals, for example.

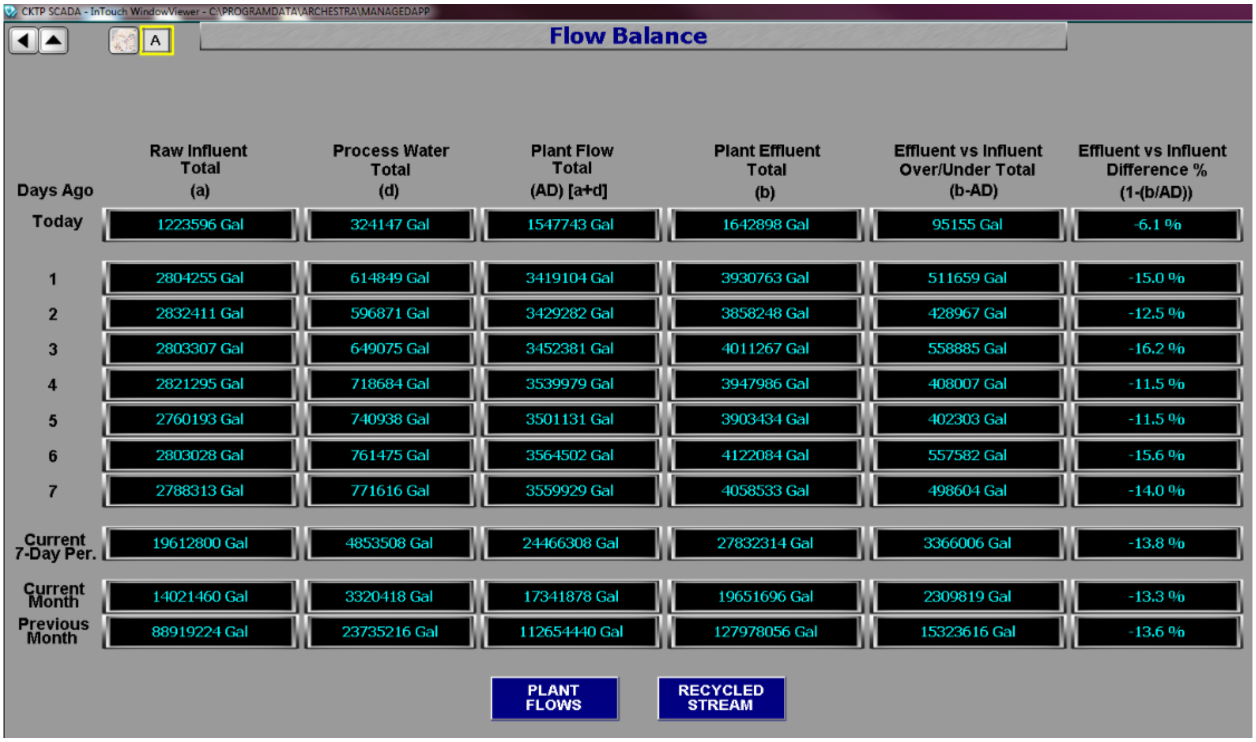
3.5.2 Central Kitsap Treatment Plant

This subsection describes HDR's general observations pertaining to field instrumentation and controls at CKTP.

Plant Effluent Flow Monitoring

The Sewer Utility has no means of direct measurement for CKTP effluent flow. Sewer Utility staff have installed various flow measurement technologies (including laser-based) at the effluent manhole where the effluent sampler draws its samples, but have been unsuccessful in establishing reliable flow readings. The effluent pipe connecting the discharge from the UV basins and tertiary treatment to the effluent manhole is buried deep and runs beneath the roadway, which has made more traditional flow measurement approaches, like installation of a magmeter, infeasible. Currently, CKTP's Trojan UV system calculates plant effluent flow by means of a level-based flow-over-weir calculation. However, these plant effluent flow calculations have typically been found to be anywhere from 6 to 16 percent higher than effluent flow values derived from an accounting of flow measurements recorded elsewhere within CKTP. This discrepancy can be seen in several historical values displayed on the CKTP Wonderware InTouch flow balance screen shown in Figure 3-13.

Figure 3-13. CKTP flow balance SCADA screen



Days Ago	Raw Influent Total (a)	Process Water Total (d)	Plant Flow Total (AD) [a+d]	Plant Effluent Total (b)	Effluent vs Influent Over/Under Total (b-AD)	Effluent vs Influent Difference % (1-(b/AD))
Today	1223596 Gal	324147 Gal	1547743 Gal	1642898 Gal	95155 Gal	-6.1 %
1	2804255 Gal	614849 Gal	3419104 Gal	3930763 Gal	511659 Gal	-15.0 %
2	2832411 Gal	596871 Gal	3429282 Gal	3858248 Gal	428967 Gal	-12.5 %
3	2803307 Gal	649075 Gal	3452381 Gal	4011267 Gal	558885 Gal	-16.2 %
4	2821295 Gal	718684 Gal	3539979 Gal	3947986 Gal	408007 Gal	-11.5 %
5	2760193 Gal	740938 Gal	3501131 Gal	3903434 Gal	402303 Gal	-11.5 %
6	2803028 Gal	761475 Gal	3564502 Gal	4122084 Gal	557582 Gal	-15.6 %
7	2788313 Gal	771616 Gal	3559929 Gal	4058533 Gal	498604 Gal	-14.0 %
Current 7-Day Per.	19612800 Gal	4853508 Gal	24466308 Gal	27832314 Gal	3366006 Gal	-13.8 %
Current Month	14021460 Gal	3320418 Gal	17341878 Gal	19651696 Gal	2309819 Gal	-13.3 %
Previous Month	88919224 Gal	23735216 Gal	112654440 Gal	127978056 Gal	15323616 Gal	-13.6 %

Biofilter Sprinkler Control

The SJE Rhombus biofilter sprinkler control panel (see Figure 3-14) for the headworks odor control biofilter is no longer in service. Sewer Utility staff currently water the headworks odor control biofilter via a hose connected to sprinklers positioned over the biofilter. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.

Figure 3-14. Out-of-service headworks odor control biofilter sprinkler control panel

Headworks Odor Control LEL Measurement

During its site visit, HDR observed that the LEL transmitter for the headworks odor control fan ductwork is registering an infrared (IR) source fault (see Figure 3-15). This is preventing the sensor and transmitter from measuring the concentration of combustible gas in the odor control system.

Figure 3-15. CKTP headworks odor control fan ductwork LEL transmitter in fault

Biological Nutrient Removal Control

Sewer Utility staff have indicated that the control of the biological nutrient removal (BNR) process at CKTP is currently the most significant operational challenge and frustration at the plant. According to Sewer Utility staff, the aeration blowers are controlled off of pressure but aeration control valves are responding too quickly to DO measurements in the basins, which has caused the blowers to go into surge. Because automated controls have proved to be unstable, the aeration control valves are currently positioned manually and operators have to frequently adjust blower header pressure set points based on process demand. Murraysmith and HDR are scoped to address BNR optimization at CKTP as part of a separate task.

Aeration Basin 1 DO Monitoring

Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. DO measurement is critical input to the feedback loop governing aeration control strategies. Without DO measurement, the Sewer Utility has had to infer DO values in aeration basin 1 from DO values measured in other basis. This is one of the deficiencies frustrating the Sewer Utility’s BNR efforts at CKTP.

Aeration Basin Ammonium and Nitrate Monitoring

Currently, aeration basin 4 is the only basin with ammonium and nitrate probes installed. Ammonium and nitrate values for aeration basins 1 through 3 are being derived from measurements read from the probes installed in aeration basin 4. Without probes to measure these values in aeration basins 1 through 3, the Sewer Utility has no means of monitoring the nitrogen removal occurring via the nitrification and denitrification process in these basins.

Reclaimed-Water Chlorine Residual and Turbidity Monitoring

During its site visits, HDR observed that the chlorine residual and turbidity analyzers associated with the reclaimed-water filtration system were both powered down (see Figure 3-16 and Figure 3-17). HDR did not confirm whether these instruments were still functional, but in their powered-down state no chlorine residual or turbidity measurement is occurring for the reclaimed-water filtration system.

Figure 3-16. CKTP reclaimed-water filtration system chlorine residual analyzer powered down

Figure 3-17. CKTP reclaimed-water filtration system turbidity analyzer powered down

Thickened Sludge Blending Tank Low-Level Interlock

Sewer Utility staff indicated that the low-level switch for the thickened sludge blending tank has failed. This switch provides low-level shutdown of the thickened sludge blending tank circulation pump and digester feed pumps via PLC software interlock. Sewer Utility staff have plans to eliminate this switch and to provide low-level shutdown of these pumps based on level measurement from the tank's pressure-based level transmitter. Until the proposed alternate controls are implemented, these pumps are likely operating with no low-level shutdown interlock.

Aerated Grit Tank 1 Stage 2 Airflow Monitoring

HDR observed that the thermal dispersion flowmeter installed on the aeration line to the aerated grit tank 1 stage 2 diffuser is measuring zero flow (see Figure 3-18), while the positions of manual valves on either side of the instrument suggest that flow should be occurring. Comparing the totalized flow on the flowmeter's display with the other three flowmeters on the grit tank aeration lines, it appears that this instrument has been measuring zero flow for a significant amount of time. HDR did not investigate the root cause of the zero flow reading, but the matter should be investigated to confirm that the grit tank is being properly aerated (e.g., a zero flow reading could be due to a plugged diffuser).

Figure 3-18. CKTP aerated grit tank 1 stage 2 flowmeter reading zero flow

Cogeneration System

According to Sewer Utility staff, the CKTP cogeneration system has been offline for roughly a year. The cogeneration system was installed only a little more than 4 years ago and the Sewer Utility has already had to pay to have local mechanics rebuild the engine. The engine has since failed again and would require substantial maintenance to repair. There have been several other maintenance issues with the cogeneration system and the digester gas conditioning system, and Sewer Utility staff have come to believe that the maintenance and material costs associated with keeping the infrastructure in operation would exceed any energy savings CKTP may receive from the cogeneration system.

Another operational challenge for the cogeneration system has been the limited digester level range that the Sewer Utility has to operate within. According to Sewer Utility staff, this level range is about 1 foot. This narrow operating level range has limited how much digester gas could be supplied to the cogeneration system, which resulted in the system running at well below its rated output when it was in operation, limiting the system's potential to deliver energy savings. Even if the digester operating level constraints were resolved, the Sewer Utility has indicated that the digesters may not produce enough gas for the cogeneration system to run continually at its rated output.

Because the cogeneration system has been effectively abandoned in place, HDR did not perform a site assessment of its ICS components.

3.5.3 Kingston Wastewater Treatment Plant

HDR did not make significant observations pertaining to instrumentation and controls at KWWTP. Because the new instrumentation and controls associated with ongoing construction activities at KWWTP have yet to be commissioned, HDR did not assess the conditions of this new infrastructure.

3.5.4 Manchester Wastewater Treatment Plant

This subsection describes HDR’s general observations pertaining to field instrumentation and controls at MWWTP.

Plant Influent Flow Monitoring

The Sewer Utility has no means of direct measurement for plant influent flow. Incoming flows are received in the influent pump station wet well and there is not a convenient on-site location for installing flow measurement equipment upstream from the wet well. Based on discussions with Sewer Utility staff, HDR believes that the Sewer Utility is deriving MWWTP influent flow from measurements of plant effluent and return activated sludge (RAS) flows. Plant influent flow is a critical parameter for laboratory measurements and plant process performance metrics. Therefore, direct measurement of plant influent flow would be preferable to derivation from other plant flows.

Headworks Odor Control and Associated Chemical System Instrumentation

HDR observed that some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. For example, the sodium hypochlorite storage tank appears to have no level measurement instrumentation. Though a level value for this tank is displayed at the plant SCADA screens, historical SCADA data reviewed by HDR show a constant zero value for this parameter. The odor control system control panel also appears to have a non-functional analyzer, an analyzer with an active warning, and another analyzer displaying a potentially inaccurate negative pH value (see Figure 3-19). Based on observations and discussions with Sewer Utility staff, HDR believes that the odor control system is no longer functioning per its original design.

Figure 3-19. MWWTP odor control system control panel instrumentation

Gravity Belt Thickener Flow Monitoring

During its site visit, HDR observed that the magmeter on the sludge line feeding the MWWTP GBT was severely corroded (see Figure 3-20). As the meter continues to deteriorate, failure of the instrument will become more likely.

Figure 3-20. Corroded magmeter on sludge line to MWWTP gravity belt thickener

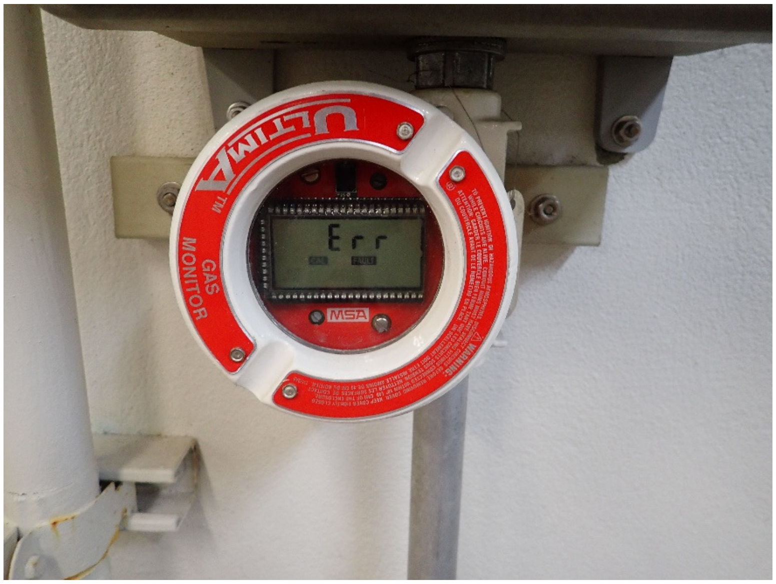
Aeration Basin Dissolved Oxygen Monitoring

The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process. Sewer Utility staff indicated that DO probes previously installed in the basins had presented maintenance challenges and were removed. Without DO measurement, control of the constant-speed aeration blowers has become more of a manual process.

LEL Monitoring

During its site visit, HDR observed that several of the MWWTP LEL gas monitors and transmitters were non-functional (see Figure 3-21 for an example). Non-functional LEL gas monitors were found in the operations building sludge pumping gallery, at the headworks odor control system, and at the WAS tank. Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in these areas.

Figure 3-21. MWWTP sludge pumping gallery faulted LEL gas monitor



W3 Flow Monitoring

During its review of MWWTP HMI screens and historical SCADA data, HDR observed that a flow signal is not being received from the flow transmitter and totalizer on the MWWTP service water (W3) pump discharge piping (see Figure 3-22). HDR observed that the MWWTP W3 pumps HMI screen displayed zero flow while one of the W3 pumps was running. Historical data obtained for the last 2 years also show a constant zero value for W3 flow.

Figure 3-22. MWWTP W3 pump flow transmitter and totalizer

UV Disinfection Controls

Sewer Utility operations staff indicated that a recent fecal-coliform issue at MWWTP is believed to have been caused by a sensor within the Trojan UV system reporting false readings, which led to under-dosing of UV. After County electricians cleaned and serviced the sensor, the Trojan UV system performance has improved. However, operations staff still suspect there are some inaccuracies in the sensor readings and have reduced confidence in the equipment.

3.5.5 Suquamish Wastewater Treatment Plant

This subsection describes HDR's general observations pertaining to field instrumentation and controls at SWWTP.

Odor Control System

Based on nameplate information, HDR believes that the SWWTP odor control system has been in operation for at least 23 years. Sewer Utility operations staff indicated that they have had to resort to manual procedures like manually dosing the system with sodium hypochlorite to keep the equipment in operation. During its site visit, HDR observed that one of the analytical probes associated with the odor control system appears to have a splice in the probe's manufacturer cable (see Figure 3-23). Field splices are not a recommended practice for analog signals and this splice may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.

Figure 3-23. SWWTP odor control system analytical probe with splice in manufacturer cable

Process Building Upper-Floor Process Room LEL Monitoring

During its site visit, HDR observed that the LEL gas monitor in the process building upper-floor process room is non-functional (see Figure 3-24). Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in this area.

Figure 3-24. Non-functional LEL gas monitor in the SWWTP process building upper-floor process room

Plant Effluent Flow Control Valve Control

Sewer Utility staff have indicated that the SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so SWWTP would need to shut down in order for the control valve to be serviced or replaced.

Rotary-Drum Thickener Control

Sewer Utility operations staff indicated that the RDT operation is a highly manual process that requires operators to watch the sludge and manually modulate the spray bar, polymer dosing, and drum drainage to control sludge thickness. Because the sludge piping between the thickened sludge pump and the sludge storage tank is reported to be too small (3 or 4 inches), the thickened sludge pump, which is a progressing-cavity pump, shuts down on high pressure if the sludge is too thick. Operators must make sure that sludge thickness is below a certain threshold to avoid high pressures in the pump discharge piping. However, this workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.

Thickened Sludge Storage Tank Level Measurement

According to Sewer Utility operations staff, the level transmitter for the thickened sludge storage tank is reporting level measurements that do not align with actual tank levels. Operations staff indicated that it provides them with a ballpark estimate of tank level, but when low levels are reached during drawdown activities they have to resort to visual confirmation of tank levels to complete the drawdown. Based on record drawings from the SWWTP Thickening project under which the tank was installed, the tank level is measured by a pressure transmitter that was specified to be installed on a dedicated tank nozzle. HDR observed that the instrument was instead installed on the suction piping for the truck loadout pump within a few feet of the pump's inlet flange (see Figure 3-25). Installing the pressure-based level instrument on the suction piping for the progressing-cavity pump may be impacting stable and accurate level measurements when the pump is in operation.

Figure 3-25. SWWTP thickened sludge tank level transmitter on truck loadout pump suction piping

Sludge Storage Tank Level Measurement

The Sewer Utility is not monitoring sludge storage tank level. Operations staff report that they have tried multiple level measurement technologies, but all transmitters have failed. Operators have resorted to relying on a float switch installed on a string (see Figure 3-26) for high-level alarm indication and shutdown of sludge supply to the tank. To control tank level, operators use a flowmeter to gauge tank fill rate. However, this approach requires operators to be vigilant about when to stop flow to the tank because the remaining sludge in the tank sludge supply piping when the valve closes will continue to gravity-drain to the tank. The current approach to controlling sludge storage tank level introduces significant risk of operator error, has no backup level instrumentation, and relies on a level switch with a non-ideal installation.

Figure 3-26. SWWTP sludge storage tank high-level switch installation

Process Building Fire Alarm System

Sewer Utility staff indicated that the process building fire alarm dialer is no longer functional, so the fire alarm system was tied into SCADA for alarm callouts. However, the fire alarm panel (see Figure 3-27) itself has since failed so SWWTP is not currently monitoring or alarming for fires. Per NFPA 820 Table 6.2.2(a), Row 12, a fire alarm system is required due to the presence of dewatering equipment (e.g., the RDT) in the upper floor process area (NFPA 2020).

Figure 3-27. Failed fire alarm system panel at SWWTP process building

SBR Dissolved Oxygen Monitoring

The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process. Sewer Utility staff indicated that DO probes previously installed in the SBRs had presented maintenance challenges and were removed. Without DO measurement, control of the constant-speed aeration blowers is based on operator-entered set points derived from institutional knowledge and not based on measured conditions within the SBRs.

Damaged RDT Spray Water Flow Switch

The thermal dispersion flow switch on the RDT spray water supply line has been damaged (see Figure 3-28). This may result in a shorter than expected useful service life for the switch.

Figure 3-28. Damaged flow switch on SWWTP RDT spray water supply line

3.5.6 Pump Stations

This subsection describes HDR's general observations pertaining to field instrumentation and controls at the wastewater pump stations.

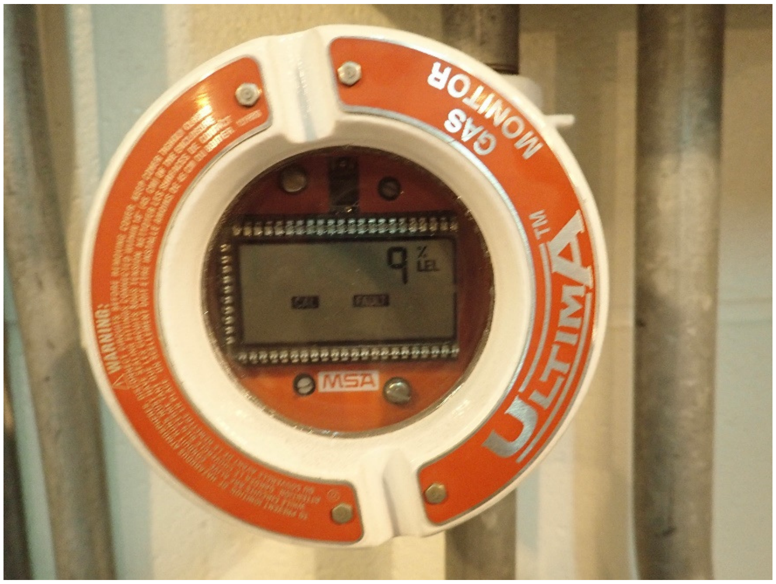
PS-24 Pumps Short Cycling

During HDR's site visit, one of PS-24's pumps turned on and off multiple times, running for about 30 seconds each time before turning off. Sewer Utility staff indicated that short cycling of the pumps is a common occurrence at this pump station. However, PS-24 can receive sudden high flows, so staff have been reluctant to tinker with the existing pump controls.

PS-24 Wet Well LEL Monitoring

During HDR's site visit, a CAL FAULT indication was observed at the wet well LEL gas monitor (see Figure 3-29). This typically indicates that the last calibration attempted was either incomplete or unsuccessful. The fault may be impairing the instrument's ability to accurately measure the concentration of combustible gas in the pump station wet well. Per NFPA 820 Table 4.2.2, Row 14, combustible gas detectors are required for wastewater pumping stations that are mechanically ventilated, which includes odor control, or that open into a building interior (NFPA 2020). Because the PS-24 wet well has an odor control system with mechanical ventilation, HDR believes that the NFPA 820 requirement for combustible gas detection at the station wet well applies to PS-24.

Figure 3-29. Faulted PS-24 wet well gas monitor



PS-24 Wet Well Level Measurement

During HDR's site visit, the ultrasonic level transducer measuring wet well level was observed to be coated with grime and dried scum (see Figure 3-30). The condition of the transducer may be degrading the accuracy of the level measurement.

Figure 3-30. PS-24 wet well ultrasonic level transducer coated with grime and dried scum

PS-34 Wet Well Level Control

PS-34 has no PLC and the pump station's wet well level appears to be controlled by a Precision Digital level indicator and controller that monitors the wet well's radar level transmitter. The remainder of PS-34's controls are hardwired. The pump station used to be controlled via a bubbler and its control panel (see Figure 3-31) includes several components associated with bubbler-based level control along with a handwritten note documenting procedures for reverting back to bubbler control in the event of radar level transmitter failure. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.

Figure 3-31. PS-34 control panel

PS-71 BIOXIDE Storage Tank Level Monitoring

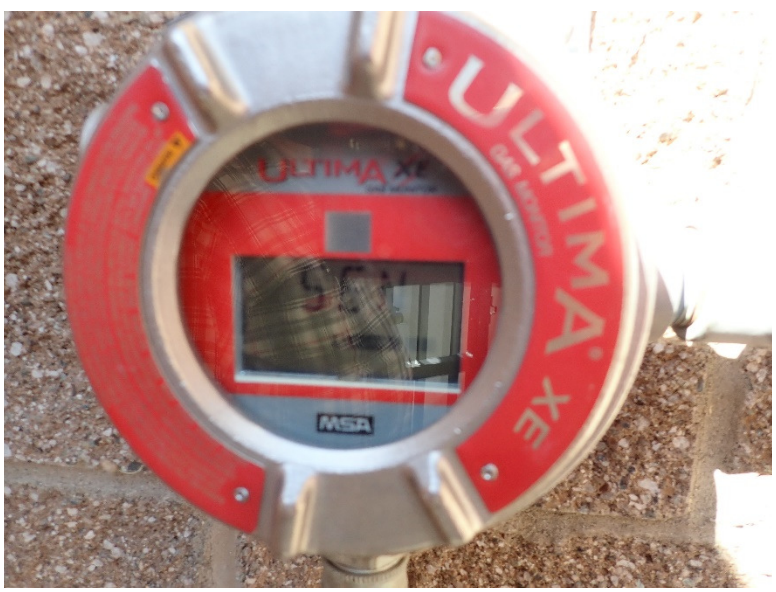
Sewer Utility staff indicated that the ultrasonic probe on the old sodium hypochlorite tank failed after 2 weeks because of exposure to the chemical. The tank has since been converted to a BIOXIDE storage tank, but the level instrument still remains hanging off of an old flange and is no longer connected to the tank (see Figure 3-32). The Sewer Utility is not currently monitoring BIOXIDE storage tank level.

Figure 3-32. Failed ultrasonic level probe disconnected from PS-71 BIOXIDE storage tank

PS-71 Wet Well LEL Monitoring

During its site visit, HDR observed that the LEL gas monitor for the PS-71 wet well is registering a fault and is not currently functioning (see Figure 3-33). Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in the pump station wet well. Because the PS-71 wet well has an odor control system with mechanical ventilation, HDR believes that the NFPA 820 requirement for combustible gas detection at the station wet well applies to PS-71.

Figure 3-33. PS-71 wet well LEL monitor in alarm



- Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.
- A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.
- The Sewer Utility has no means of direct measurement for CKTP effluent flow.
- Current CKTP effluent flow calculations provided by the Trojan UV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.
- The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.
- The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an IR source fault and is not monitoring combustible-gas concentration in the odor control system.
- Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.
- Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.
- Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.
- The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.
- The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.
- HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is

measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.

- The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.
- The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.
- Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.
- The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.
- The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.
- Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.
- The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.
- Instrumentation within the MWWTP Trojan UV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.
- One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.
- Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.
- The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.
- Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This

workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.

- Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.
- The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.
- The SWWTP process building fire alarm panel has failed so the plant is not currently monitoring or alarming for fires.
- The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.
- The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.
- Short cycling of the pumps is a common occurrence at PS-24.
- Combustible-gas monitoring equipment at the PS-24 wet well is faulted.
- The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.
- PS-34 has no PLC and the pump station’s wet well level appears to be controlled by a level indicator and controller that monitors the wet well’s radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.
- The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.
- Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.

4 Industrial Control System Software

This section describes the Sewer Utility's current ICS software, including an overview of the PLC programming, HMI, historian, and alarm notification software packages in use at the WWTPs and wastewater pump stations. It also describes the SCADA system functionality that has been implemented with this software.

4.1 PLC Programming Software

This subsection describes the PLC programming environments, firmware and software versions, and methods used in the development and maintenance of Sewer Utility PLCs.

4.1.1 Programming Environments

The various Allen-Bradley PLCs installed throughout the Sewer Utility's wastewater infrastructure are programmed via one of two separate Rockwell Automation software applications. Programming project files for the Allen-Bradley MicroLogix and SLC 500 series PLCs are developed with RSLogix 500, while programming files for the CompactLogix PLCs are developed within the Studio 5000 Logix Designer programming environment. Programming logic developed in the two programming environments is not interchangeable, which prevents standard programming templates or blocks developed in one environment from being used in the other. Because Rockwell Automation does not provide a single programming environment for all of its controllers, the consumer is left with the choice of standardizing on one controller that may be oversized for some applications or investing in additional effort to develop and maintain programming files in multiple programming environments. The Sewer Utility has opted for the latter scenario.

4.1.2 Firmware and Software Versions

Both RSLogix 500 and Studio 5000 Logix Designer are frequently updated by the manufacturer, along with firmware updates to the processors themselves, to fix bugs and mitigate security vulnerabilities. This has resulted in several versions of the firmware and software over the years. Keeping up with these firmware and software updates can be a challenge for any organization and it is not uncommon for firmware updates to yield unexpected results that require tweaks to programming files, which can result in unanticipated downtime. Another maintenance challenge is that the firmware and software versions need to be aligned, so programmers cannot simply install the most recent version of the programming environment and have the ability to work on programming files created in previous versions or make online revisions to programs downloaded to controllers running previous firmware versions.

Because of the manufacturer's approach to firmware and software versioning, many organizations adopt the practice of developing programming files with the latest software version available at the time the PLC is installed and avoiding firmware and software updates thereafter. Judging from the various software versions used to develop the Sewer Utility's PLC programming project files, it appears that the Sewer Utility has adopted this practice. For example, versions of Studio 5000 Logix Designer (and its predecessor RSLogix 5000) used for the development of Sewer Utility PLC programming project files reviewed by HDR range from versions 19.01.00 to 30.02.00. While avoiding firmware updates can provide some cost savings in terms of ICS maintenance and eliminates the chance of hiccups while controller firmware is updated, it leaves PLCs running without the advantages of current security patches and optimized controller features. Having a variety of firmware versions throughout the Sewer Utility's ICS also requires the Sewer Utility and contracted systems integrators to have several programming environment software versions installed on the machines used to work on the PLCs.

4.1.3 Programming Methods

With few exceptions, the Sewer Utility's PLCs are programmed using ladder logic. In general, the various systems integrators that have developed the Sewer Utility's programming project files have leveraged object-oriented programming (OOP) concepts to apply a degree of standardization to the programming project files and to make them more efficient and easier to maintain. For example, the Sewer Utility's programming project files that were developed in the Studio 5000 Logix Designer programming environment make extensive use of Add-on Instructions (AOIs) and User-defined Data Types (UDTs), which significantly reduces the amount of repetitive ladder logic rungs and manual tag creation.

Though OOP-based best practices appear to have been applied to several of the Sewer Utility's PLC programs, at least three systems integrators have independently applied these best practices over the years. This has resulted in an overall lack of standardization when it comes to organization, tag naming convention, annotation practices, and the AOIs and UDTs used throughout the Sewer Utility's PLC programming project files. Establishing PLC programming standards based on OOP principles would help the Sewer Utility implement a uniform approach to how its assets are managed within the ICS, which would simplify ICS programming maintenance and help guide future programming efforts by Sewer Utility staff and contracted systems integrators.

- Sewer Utility PLCs are running a variety of firmware versions.
- The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.

4.2 Human-Machine Interface Software

This subsection describes the Sewer Utility's HMI software as well as its configuration and implementation.

4.2.1 Wonderware InTouch

The Sewer Utility is currently standardized on Wonderware InTouch 2014 R2 Service Pack 1 (SP1) for CKTP and SWWTP. This software is currently in the mature support phase of the software developer's product life cycle. Mature support is the final phase in the product life cycle, during which limited support is offered and users are encouraged to upgrade licensing to current software versions. The Wonderware InTouch version at KWWTP and MWWTP has been recently upgraded to Wonderware InTouch 2017. This software is currently in the extended support phase of the software developer's product life cycle, but will soon reach the mature support phase in November 2020. Based on information provided by the Sewer Utility, HDR believes that the Wonderware InTouch licenses at CKTP are 60,000-tag licenses, while the licenses at the other WWTPSs are 3,000-tag licenses. Note, Wonderware has been rebranded as AVEVA as part of a recent reverse merger between Schneider Electric and AVEVA. However, this TM refers to the software as Wonderware, the name under which it has been marketed for several years.

The Sewer Utility's Wonderware InTouch software has been implemented in its standalone variant and not as part of a Wonderware System Platform deployment that incorporates Wonderware's ArchestrA Framework. Though this approach avoids much of the complexity introduced by the ArchestrA Framework, it provides none of the efficiencies and other benefits that come from a more centralized approach to managing ICS device data and SCADA visualizations. This lack of centralized management has resulted in non-standardized programming objects and visualizations at the various WWTPs. At CKTP, where there is more than one SCADA PC for the plant, the lack of a centralized server-client model for the HMIs has also presented some operational challenges such as alarm acknowledgments made at one HMI thick client not being registered by other HMI thick clients.

Based on discussions with the Sewer Utility and QCC, HDR believes that the Sewer Utility and QCC are planning to upgrade the Sewer Utility's Wonderware licensing at CKTP to a more current version. As part of the upgrade, QCC will implement an ArchestrA Framework–based Wonderware System Platform deployment consisting of redundant Wonderware Application Servers; an ArchestrA Galaxy Repository; two Wonderware InTouch runtime thick client PCs; and configuration of several Wonderware InTouch runtime thin clients for existing industrial panel PCs, SCADA PCs, and County-issued tablets. HDR's understanding is that the existing CKTP SCADA screens will be preserved as part of this upgrade and that modifications to the screens' graphics and functionality are not included in QCC's current scope of work.

4.2.2 Human-Machine Interface Screens

This subsection summarizes current Sewer Utility practices for HMI organization, color, overview screens, process screens, pump station screens, equipment pop-up screens, trend screens, and alarming.

Organization

The Sewer Utility WWTP HMI screens are generally arranged in a three-level hierarchy that begins with an overview screen (level 1) and provides more information and detail to operators as they progress through process-specific screens (level 2) to equipment-specific pop-up windows/screens and trend screens (level 3). The HMI screen composition differs depending on the WWTP, but all WWTPs have standardized on a top or bottom horizontal navigation banner with most of the screen dedicated to the screen-specific content. CKTP and SWWTP also include a bottom horizontal alarm summary banner on each screen, which is meant to display the most recent SCADA alarms.

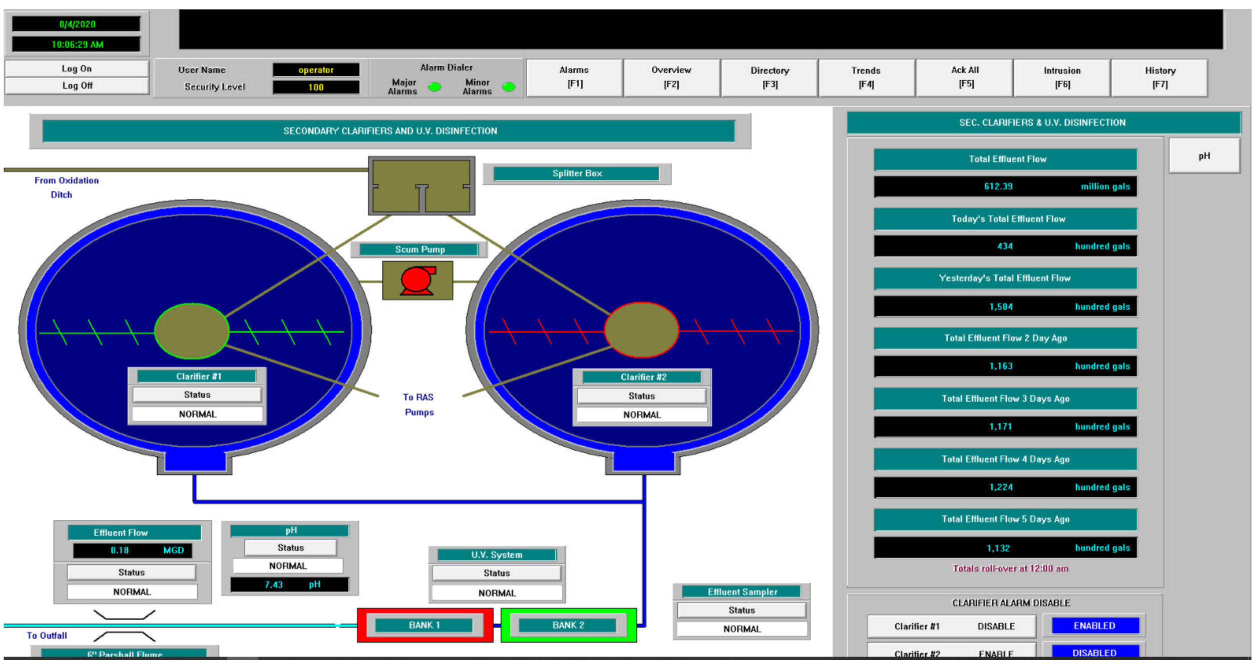
However, the alarm summary banner at SWWTP may be non-functional because it was displaying a single alarm from more than 4 months prior to HDR's site visit and did not include more current alarms found on the alarm summary screen. At CKTP, several plant flow values and select equipment operational statuses are also displayed in a vertical column at the right of each screen.

Operators can navigate through the WWTP HMI screens by means of the navigation banner, clickable screen content on the various screens, and, in some cases, by clicking on arrows that advance through the process screens. MWWTP and KWWTP also have a directory screen that allows operators to select the plant process or equipment group they would like to view.

Color

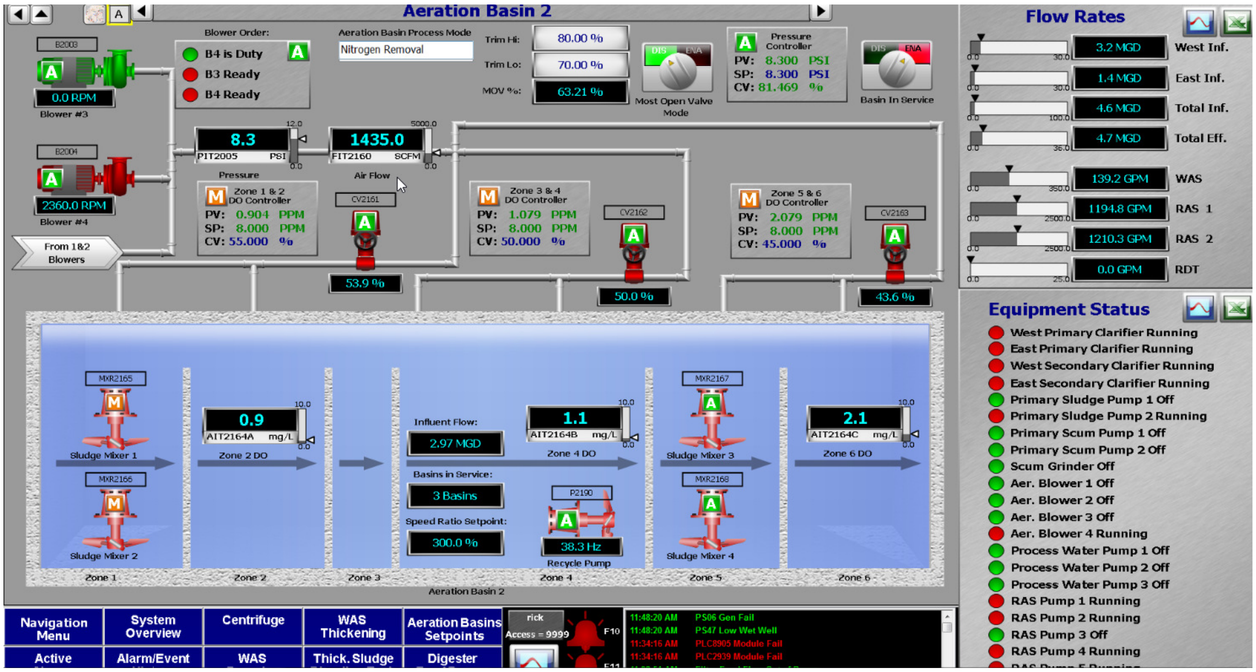
Throughout the HMI screens, color is often the sole means of differentiating important condition, status, or alarm state. For example, the secondary clarifiers and UV disinfection HMI screen at KWWTP shown in Figure 4-1 communicates clarifier, scum pump, and UV bank running status with color only. Because of the prevalence of color-detection deficiencies among the population, modern HMI graphics development best practices call for indication of condition, status, and alarm state to be accompanied by text and/or shapes.

Figure 4-1. KWWTP secondary clarifiers and UV disinfection HMI screen



Relying solely on color to communicate status, condition, and alarm state can also create confusion for operators (particularly recent hires) because institutional knowledge is required to decipher color significance. For example, an individual looking at the screen depicted in Figure 4-1 would have to know that red means "off" at KWWTP to understand that the scum pump shown on the screen is not running. The potential for confusion and operator error can increase significantly when "on/off" and "open/closed" color schemes are not consistently applied throughout an organization's infrastructure, as is the case with the Sewer Utility's HMI screens. At CKTP, for example, the on/off, open/closed color scheme appears to be reversed from the scheme adopted at KWWTP. As shown in the CKTP aeration basin 2 HMI screen depicted in Figure 4-2, running blowers, mixers, and pumps are shown in red. The color scheme inconsistency was also observed at the Sewer Utility's wastewater pump station OIT screens.

Figure 4-2. CKTP aeration basin 2 HMI screen

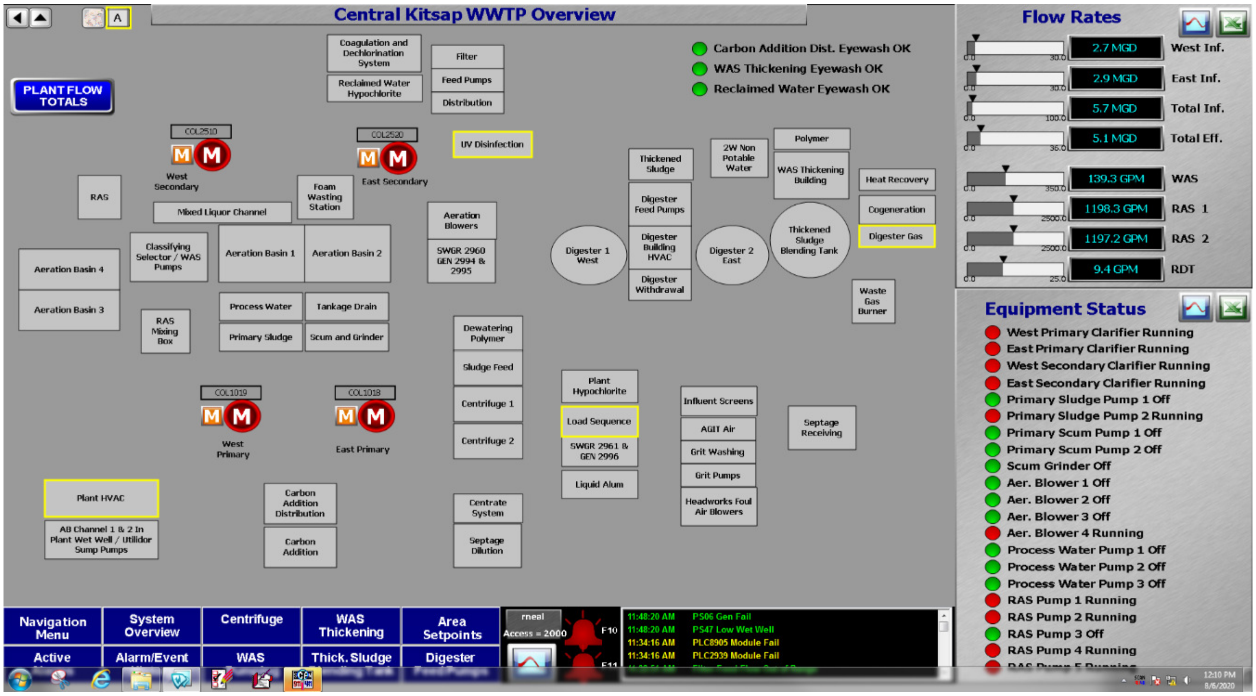


In many cases throughout the Sewer Utility's HMI screens, binary-type statuses like on and off are distinguished with equally vivid colors. Static portions of the CKTP and SWWTP HMI screens, like the piping and equipment graphics, are often displayed with colors that are brighter than the HMI screen background color. The background color for KWWTP and MWWTP HMI screens is white, which renders all other colors used to convey status, condition, or alarm state darker than the background. A general best practice is to show equipment that is running with a brighter color than the background and equipment that is off with a darker color than the background. Equipment and other elements that are not controlled via the ICS but are shown for other purposes would be shown filled with the same color as the background.

Overview Screens

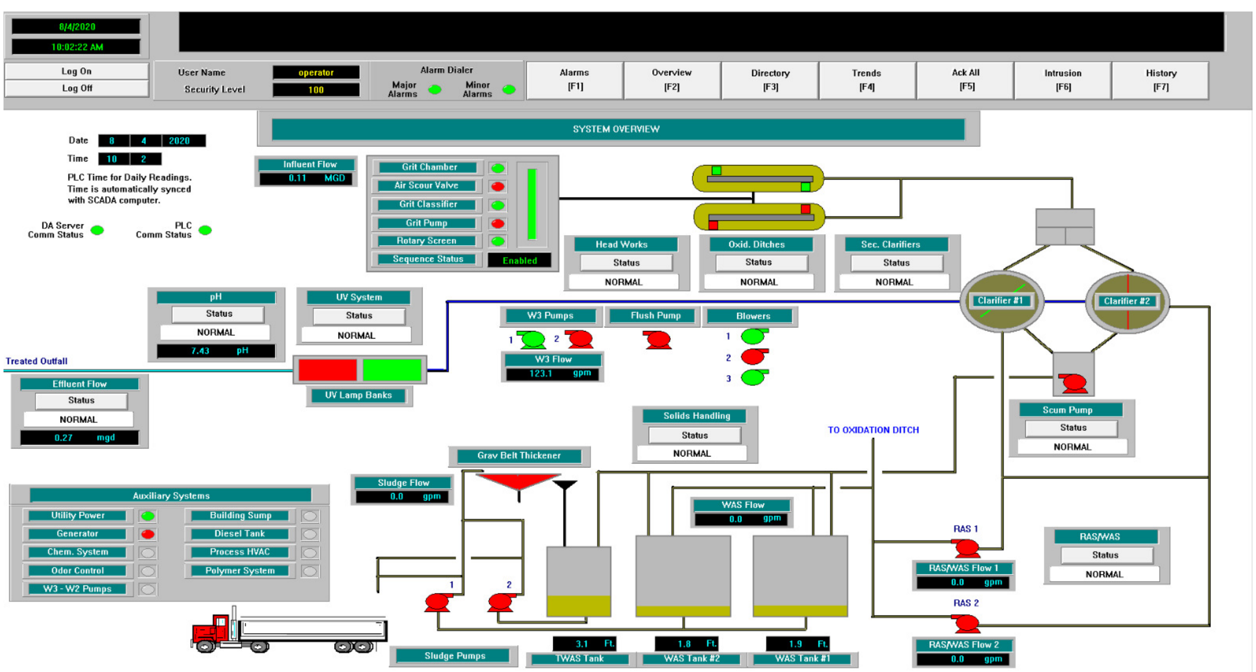
The CKTP overview HMI screen is displayed in Figure 4-3. Aside from displaying primary and secondary clarifier status and some emergency eyewash alarm status indications, the HMI screen functions more as a directory for operators to navigate to specific process screens than an overview of current CKTP operational status. It appears that process screens with active alarms and/or warnings are displayed with yellow outlines to draw operator attention. Beyond these elements and the plant flow and equipment status information displayed on all CKTP HMI screens, no additional information can be obtained from the screen.

Figure 4-3. CKTP overview HMI screen



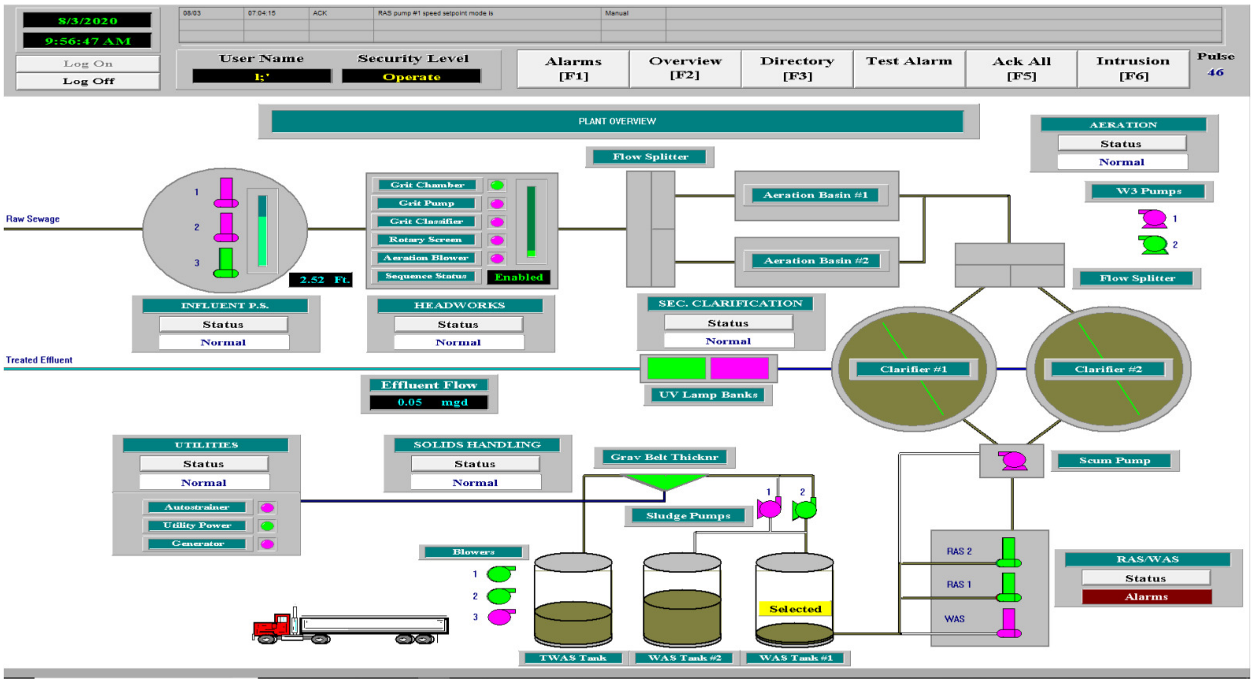
The KWWTP overview HMI screen is displayed in Figure 4-4. This screen provides a general process flow overview for KWWTP with running status for major plant equipment communicated by the plant's red and green color scheme. Several process parameters like level, flow, and pH are displayed on the overview screen along with current utility and generator power statuses.

Figure 4-4. KWWTP overview HMI screen



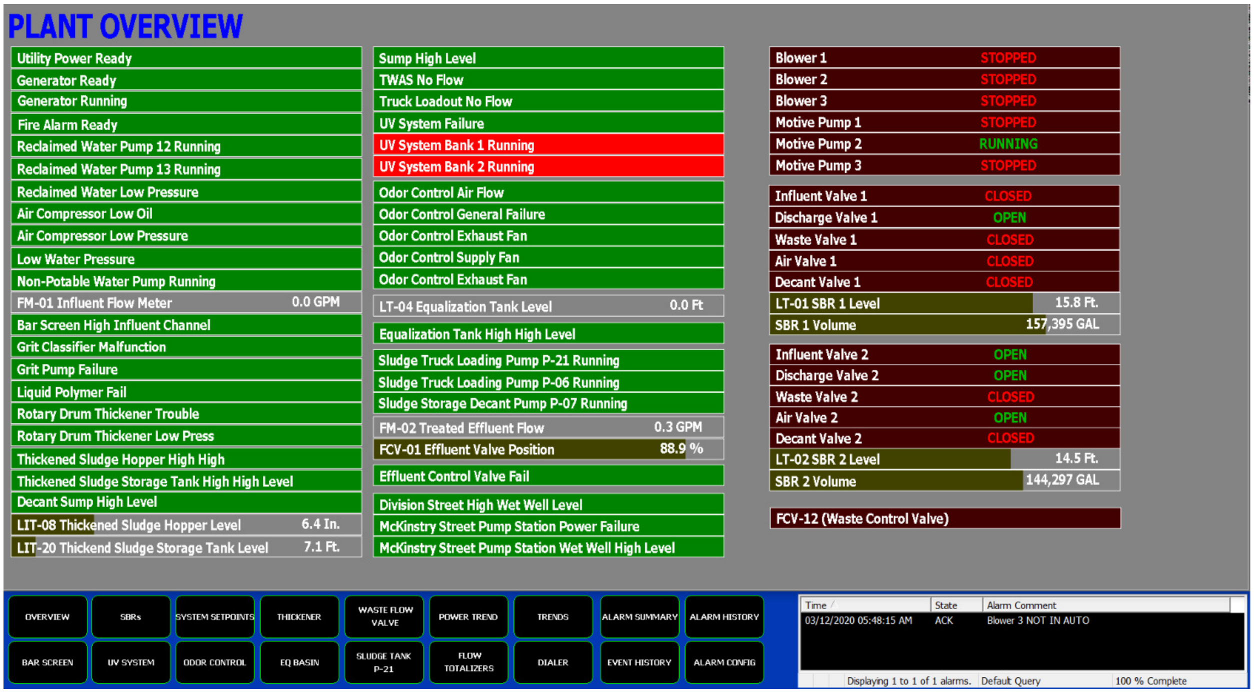
The MWWTP overview HMI screen is displayed in Figure 4-5. This screen provides a general process flow overview for MWWTP with running status for major plant equipment communicated by the plant's magenta and green color scheme. MWWTP influent pump station level and effluent flow values are displayed on the overview screen along with current utility and generator power statuses. Sludge tank levels are represented as proportional fill of their respective cylinders, but no level values are displayed.

Figure 4-5. MWWTP overview HMI screen



The SWWTP overview HMI screen is displayed in Figure 4-6. This screen provides no process flow overview and instead presents major equipment running status and SWWTP alarm information in table format using the plant's red and green color scheme. One confusing aspect of the overview screen is that the text associated with the equipment and alarm statuses does not appear to change along with the color. For example, the word "RUNNING" appears in both red and green cells. In addition to process-related on/off and alarm status information, several level and flow values for SWWTP processes are displayed on the overview screen along with current utility and generator power statuses.

Figure 4-6. SWWTP overview HMI screen



Despite the information displayed on the Sewer Utility's WWTP overview HMI screens, the screens do not provide much in the way of context that can aid situational awareness. For example, it would be difficult to relate the quantities of equipment in operation and displayed process values to percentage of plant/process operating capacity without the support of institutional knowledge. Normal operating ranges, target performance set points and ratios, and other key performance indicators (KPIs) are also absent. As currently configured, the overview screens rely on operator knowledge and experience to put the displayed process values in context and arrive at judgments related to current plant conditions.

Process Screens

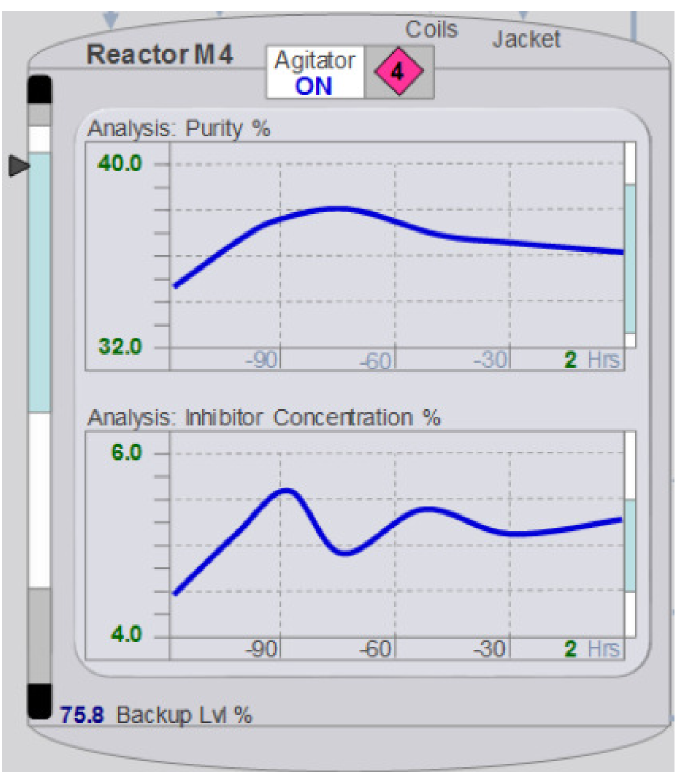
The various Sewer Utility process-specific HMI screens typically show a piping and instrumentation diagram (P&ID)-like, not-to-scale representation of the process with major equipment and vessels interconnected via pipelines with arrows showing flow direction. Process equipment and actuated valves are typically labeled with a descriptive name to help operators associate the graphics with the actual equipment, and, in some cases, the equipment tags are also included. Equipment running status and valve open/close position status are generally communicated via a green and red or green and magenta color scheme. Motor speed is also displayed, where applicable, though engineering units for speed vary between hertz (Hz) and percent speed depending on the equipment. Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for speed values (e.g., percent speed is displayed for values that represent hertz). Manual and auto status of equipment is also typically presented on the process screens.

In general, process parameters displayed on the HMI screens are shown with engineering units. Where HMI screens cover processes that include proportional-integral-derivative (PID) controllers, the screens provide some valuable context in terms of current process value versus target set point for the PID controller. However, HDR did not provide an in-depth comparison of PLC programming logic with HMI screens to determine the extent to which PID target set points are displayed alongside current process values.

As with the overview screens, the process screens lack some context that would provide greater insight into recent and present conditions. When levels are displayed, it is either just a value or a value with a bar or proportional fill that provides a visual gauge of how the current value relates to the capacity of the vessel. Though the bar and proportional fill gauges are an improvement over a simple value display, they could be further improved by including normal operating range, low- and high-level alarm set points, deadband, overflow, and/or equipment shutdown set point overlays. This type of information provides operators with obvious and immediate context when interpreting current level values. Adding sparklines to the level displays can expand on this context by showing the recent trending of the level signal, without operators having to leave the screen to open a separate trend screen.

Figure 4-7 depicts an example SCADA HMI graphics visualization that includes sparklines and vertical bars with normal operating ranges (light blue regions), low- and high-level alarm set points (borders of gray and black regions), and deadband (gray regions). The same approach could be applied to the various level, flow, pressure, temperature, and analytical measurements, which are currently displayed as values only or with limited context on the HMI screens.

Figure 4-7. Example HMI graphics content providing additional context and situational awareness

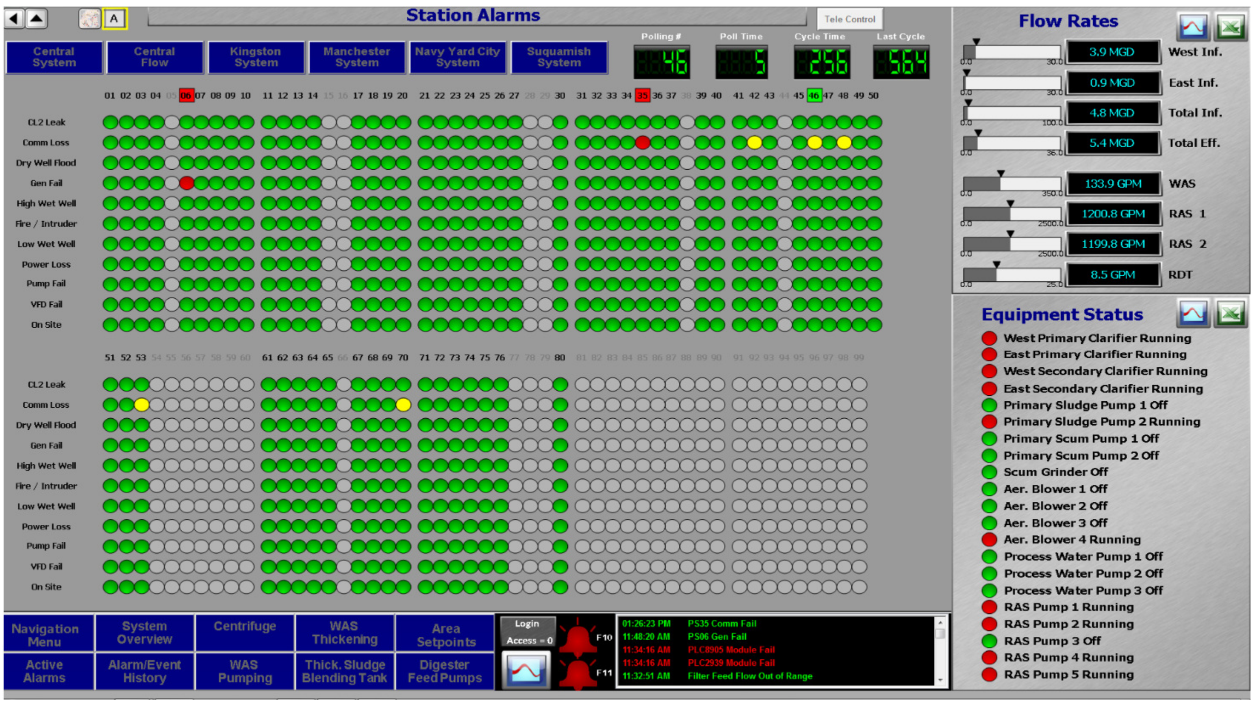


Source: PAS Global LLC.

Pump Station Screens

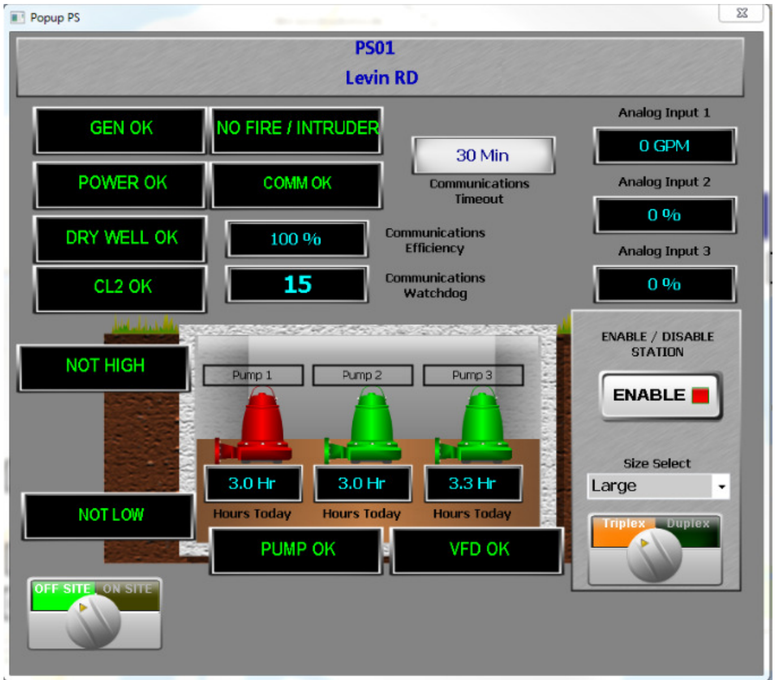
At CKTP, a pump station alarm screen displays the states of all monitored alarms for each pump station along with information pertaining to the current pump station being polled, the polling time, and current and previous polling cycle times (see Figure 4-8). As shown in the figure, the screen provides an intuitive overview of current alarm activity for the pump station that is conducive to quick assessment and location of pertinent information. Though the screen is effective at presenting alarm information, Sewer Utility staff have no means of remotely resetting pump station alarms from this or any other HMI screen at CKTP. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.

Figure 4-8. Pump station alarm HMI screen



From a separate map HMI screen, operators can select individual pump stations by number, which brings up a pop-up screen dedicated to the pump station. An example pump station pop-up screen is shown in Figure 4-9. These pump station pop-up screens are derived from a common template, which has resulted in some fields and alarms being displayed for which data may not be available at the selected pump station.

Figure 4-9. Example pump station pop-up HMI screen



HDR also observed that there are issues with communication of analog parameters for some of the pump stations. Evidence of this can be seen in several of the pump station pop-up screens. For example, from the pump colors in Figure 4-9, it would appear that one of the station's pumps is running. However, the flow value is reading 0 gallons per minute (gpm). Historical data reviewed by HDR also indicate that constant, out-of-range values are being logged for several pump station analog parameters.

Even where communication of pump station analog parameters appears to be functional, the analog parameters included in the Sewer Utility's remote monitoring capabilities that HDR observed are limited to discharge flow. The Sewer Utility does not appear to be monitoring wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.

Equipment Pop-up Windows/Screens

While the HMI process screens typically communicate only equipment running status, manual/auto status, and speed (where applicable), in many cases operators can click on individual equipment to view an equipment-specific pop-up window or separate HMI screen. An example pop-up screen is depicted in Figure 4-10. These pop-up windows and screens provide additional information about the equipment that can include local Hand-Off-Auto (HOA) selector switch position, SCADA Manual-Off-Auto setting, ready status, accumulated runtime, and total starts or cycles. For equipment with DeviceNet or EtherNet/IP networked overload relays or VFDs, electrical parameters like voltage, current, power, and power factor are also displayed. Depending on login credentials, equipment start and stop control or open and close control, in the case of valves and gates, and SCADA manual and automatic control selection can be accessed through these pop-up windows/screens.

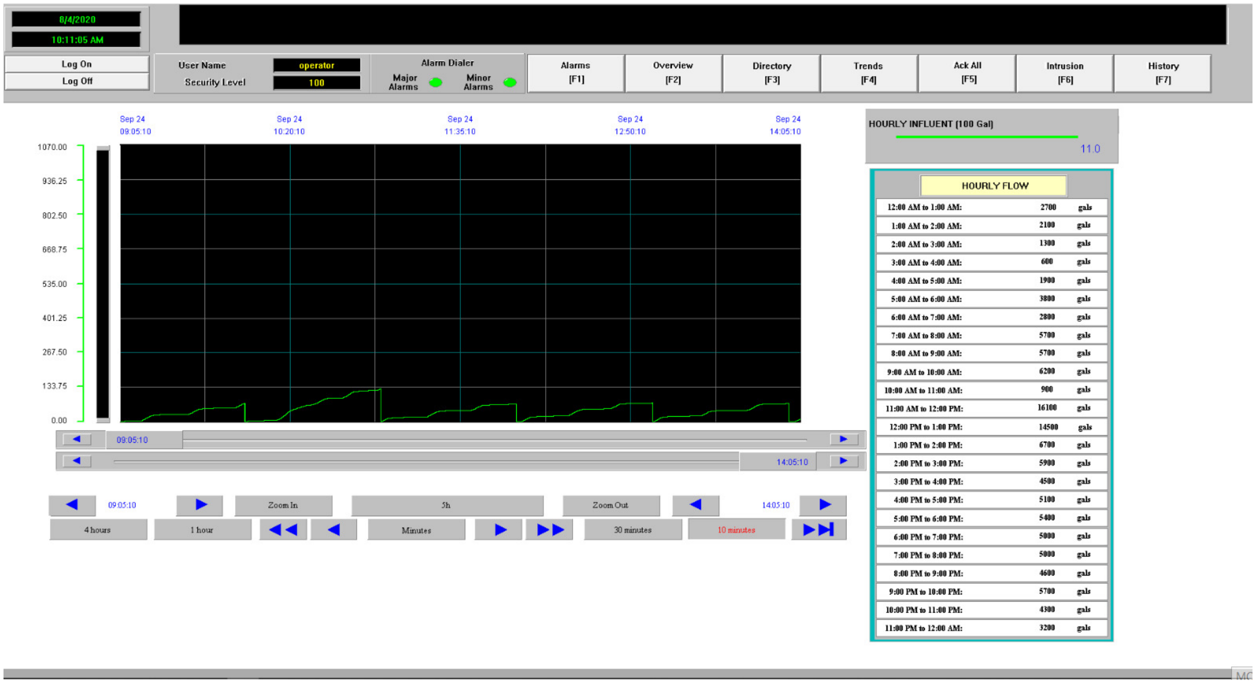
Figure 4-10. CKTP HRR pump 1 equipment pop-up window

As a troubleshooting tool, the equipment pop-up windows/screens reviewed by HDR could be further developed to provide additional value. Currently, they do not appear to be capable of providing information on active alarms or conditions external to the equipment that are inhibiting the equipment from running. Motor starts per last 1 hour and last 24 hours could also be valuable to operators and maintenance staff. With the data available from DeviceNet and EtherNet/IP networked overload relays and VFDs within the Sewer Utility's infrastructure, there are also opportunities to embed additional electrical, diagnostic, and performance data into the equipment pop-up windows/screens.

Trend Screens

The HMI trend screens reviewed by HDR consisted of preconfigured screens dedicated to specific process values (see Figure 4-11 for an example). Operators can interact with the trend screens to dynamically adjust the time axis and adjust vertical scroll bars to obtain process value information for specific time stamps. However, there appears to be no functionality for adding and removing plot lines or other means of customizing trend screens within the HMI environment. Furthermore, none of the trend screens observed indicated normal operation range, alarm set points, deadband ranges, interlock points, or other elements to improve situational awareness.

Figure 4-11. KWWTP hourly influent trend HMI screen



Alarm Screens

Historical alarm information is displayed on dedicated alarm summary or alarm history HMI screens at each WWTP. The Sewer Utility standard for these table-based alarm screens appears to include generation of a unique row with a time stamp for each change in alarm state, the sequence of which is typically as follows:

1. Alarm active and unacknowledged (displayed as UNACK_ALM)
2. Alarm active and acknowledged (displayed as ACK_ALM or ACK)
3. Alarm acknowledged and initiating state/value returned to normal (displayed as ACK_RTN)

Separate colors are used to distinguish the various alarm states, as shown in Figure 4-12, but the colors in use differ between the WWTPs. Although there is some variation in alarm table formatting between the WWTPs, along with the time stamp and alarm state information, each row typically includes the Wonderware tag associated with the alarm, a description of the alarm, and the username of the operator who acknowledged the alarm or "None" if the alarm is unacknowledged. At CKTP, there is also an active alarm HMI screen that shows a filtered list of all current active alarms, acknowledged and unacknowledged.

Figure 4-12. CKTP alarm history HMI screen

During HDR's site visit to SWWTP, Sewer Utility staff explained that the alarm summary and alarm history HMI screens at the plant SCADA PC do not automatically update. HDR confirmed that the user must right-click the screen and select "Refresh" for the screens to update with current alarm information. Requiring the operator to manually refresh alarm information runs counter to the intent of providing alarm screens as a means of alerting operators to new alarms.

When alarms first become active at CKTP, an audible notification is sounded at the SCADA PC in the SPB control room. There are two distinct audible notifications for plant-based and telemetry-based alarms. Both audible notifications continue to sound until the alarm is acknowledged. Unacknowledged alarms are also displayed as flashing text in the horizontal alarm banner at the bottom of the CKTP HMI screens. Upon alarm acknowledgement, the audible notification is silenced and the flashing alarm text in the horizontal alarm banner changes to green text until the alarm becomes inactive, at which point it is removed from the banner.

At CKTP, the volume of alarm activity appears to be considerable. During its site visits, HDR observed frequent alarm annunciations at the SCADA PC in the SPB control room with Sewer Utility staff having to repeatedly stop what they are doing to acknowledge the alarms. Much of this alarm activity is caused by recurrences of the same alarms, but it appears that Sewer Utility staff do not have a way of shelving alarms to filter out nuisance alarms or alarms associated with known issues or elements of the control system requiring maintenance. Providing select, suitably credentialed Sewer Utility staff with the ability to shelve alarms could significantly reduce unnecessary distractions for Sewer Utility staff and help prevent alarm fatigue.

One typical element that appears to be missing from the alarm information presented at the HMI screens is alarm priority or criticality. All alarms seem to be presented as equally important and there does not appear to be a means for operators to quickly sort or filter alarms by priority. Alarm priority information is crucial for operators to be able to focus their attention on the most urgent alarms. International Society of Automation (ISA)-18.2, an industry standard for alarm management (ANSI/ISA 2016), includes alarm priority as an attribute for all alarms and proposes sorting and filtering by alarm priority, along with an alarm priority color code for displaying alarms, as functional requirements of HMI design.

Based on site visit observations and discussions with Sewer Utility staff, HDR believes that the WWTP HMI systems have not been developed to include root-cause analysis and alarm suppression functionality to avoid alarm overload during process upsets. The HMI screens also do not include troubleshooting text prompts or decision tree aids, which could help operators navigate alarm conditions more efficiently.

Sewer Utility staff indicated that there was a recent Sewer Utility initiative to develop an alarm management program for the Sewer Utility with assistance from QCC, but this effort has been stalled by other priorities. Implementing an alarm management program based on the ISA-18.2 standard would improve the effectiveness of the Sewer Utility's HMI and alarm notification systems.

- The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.
- Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.
- At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.
- Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.
- Color is often the sole means of distinguishing among condition, status, and alarm state, putting operators with color blindness at a disadvantage.
- Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.
- Vivid colors are used for static HMI graphics elements as well as both on and off states, making it more difficult for operators to notice and focus on dynamic HMI screen elements that deserve more attention.
- HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.
- Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.

- Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.
- HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.
- The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.
- Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.
- Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.
- Trend screens display current values against time only and do not provide meaningful situational awareness.
- Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.
- The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.
- Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.
- Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.
- Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.
- HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.

4.3 Historian

This subsection describes the Sewer Utility's historian software as well as its configuration and implementation.

4.3.1 Central Kitsap Treatment Plant

The Sewer Utility has Wonderware Historian 2014 R2 SP1 installed on a server in the SPB control room. This is the only historian for the Sewer Utility's wastewater infrastructure and the software is currently licensed for 5,000 tags. Wonderware Historian Client 2014 R2 SP1 software is installed on the historian server and the SCADA PC in the SPB control room. As with the 2014 R2 version of Wonderware InTouch, the 2014 R2 version of Wonderware Historian and Historian Client are also in the mature support phase of the software developer's product life cycle. Mature support is the final phase in the product life cycle, during which limited support is offered and users are encouraged to upgrade licensing to current software versions.

The CKTP historian logs SCADA data for CKTP and the Sewer Utility's pump stations. Of the Wonderware tags included in the historian's historical data, just over half of the tags are related to the pump stations.

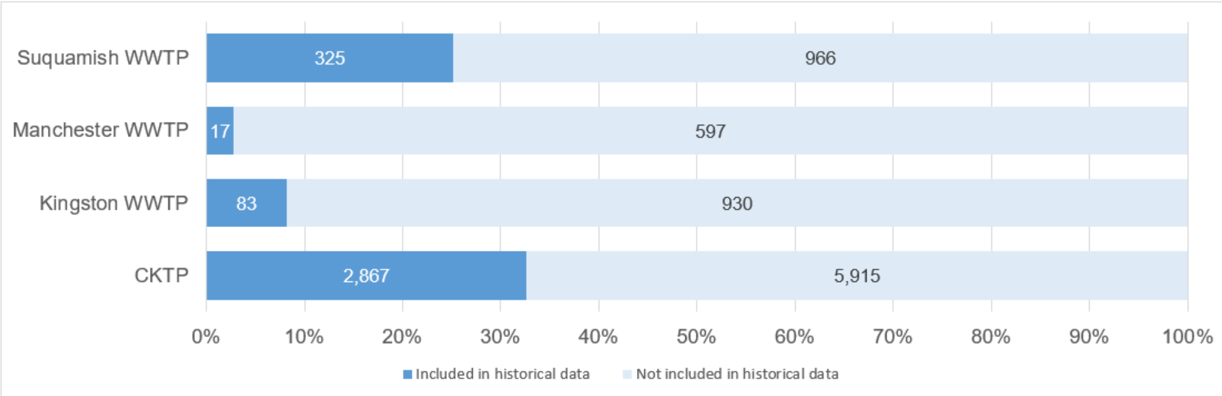
4.3.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

No historian software is installed at KWWTP, MWWTP, and SWWTP. Instead, historical SCADA data are logged once per day as an LGH file on external hard drives by the Wonderware InTouch software at the WWTPs. The historical SCADA data for each WWTP are accessible only via each WWTP's SCADA PC and have not been imported to the Sewer Utility's historian at CKTP.

4.3.3 Historical SCADA Data

To better quantify the Sewer Utility's historical SCADA data collection practices, HDR obtained recent Wonderware tag database export files along with samples of historical data available from each of the WWTPs. Figure 4-13 compares the quantity of Wonderware I/O tags included in the Sewer Utility's historical data to the quantity of I/O tags for which no historical data are available at each WWTP. Not all tags within the Sewer Utility's Wonderware systems merit recording of their historical values, and HDR did not perform a tag-by-tag review to determine the number of tags with values that may be worth recording. However, as the figure indicates, the Sewer Utility has no historical data for the overwhelming majority of its SCADA tags. This indicates that the Sewer Utility is not capturing data for several processes and equipment.

Figure 4-13. Summary of available Wonderware tags included in historical data



Note: Tag counts reflect Wonderware I/O tags only and do not include other Wonderware tag types (e.g., memory tags).

Historical data are the foundation for process and equipment performance evaluation, predictive maintenance, process control optimization, and several other modern, data-centric technologies and infrastructure management practices. Identifying these and other specific use cases for data derived from its SCADA system would help the Sewer Utility assess which data are required to obtain the information it desires. After determining its historical data requirements, the Sewer Utility would then have to augment its data collection practices by recording historical data for more of the available Wonderware tags and, most likely, integrating new data sources into its Wonderware system.

4.3.4 Sewer Utility Use of Historical SCADA Data

Sewer Utility staff have indicated that accessing historical SCADA data is cumbersome. At CKTP, staff can use the Wonderware add-in for Excel to obtain historical data for selected tags based on a user-defined period and frequency. At the other WWTPs where there is no historian, staff must use a third-party software application called LGH File Inspector to obtain historical data from the LGH files stored on the plant's SCADA PC external hard drive. Though both of these methods are capable of serving historical data, they are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.

Currently, the Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data. HDR is also not aware of any dashboards that have been developed for the Sewer Utility to contextualize real-time or historical SCADA data. Data visualization tools could greatly improve the Sewer Utility's ability to leverage its historical SCADA data.

Given the cumbersome access and manipulation requirements and lack of data visualization tools, finding applications for historical SCADA data can be challenging. Unsurprisingly, Sewer Utility staff have reported that SCADA data are not being leveraged beyond data required for mandatory reporting. HDR believes that the SCADA data used for reporting are collected via a manual process involving Excel spreadsheets and that the Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.

- The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.
- The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.
- The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.
- The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.
- SCADA data are not being leveraged beyond data required for mandatory reporting.
- The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.
- The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.

4.4 Alarm Notification Software

The Sewer Utility uses WIN-911 for its alarm notification software at all of its WWTPs. At KWWTP, MWWTP, and SWWTP, WIN-911 software is configured to send voice messages over the public switched telephone network (PSTN) via a Dialogic analog telephony card installed in the plant SCADA PC. These remote alarm notification voice messages are sent during hours when the WWTPs are unattended. Sewer Utility staff indicated that the software is configured to first dial operations staff at CKTP, then the on-call operator, followed by the on-call supervisor, advancing to the next number on the roster when acknowledgment has not been received within a set period. The software continues to cycle through the roster until the alarm is acknowledged.

Voice message call-out via PSTN is the only means of remote alarm notification for KWWTP, MWWTP, and SWWTP. There is no redundant alarm notification method, such as Short Message Service (SMS) text messages, at these WWTPs. Failure of the analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.

At CKTP, the WIN-911 software installed on the SCADA PCs in the SPB control room and management office has been configured to send both voice messages and SMS text messages simultaneously. Alarm notifications are typically sent out at all hours of the day, but can be enabled or disabled via the SCADA PC HMI screens. Voice messages are communicated over PSTN via Universal Serial Bus (USB) analog modems connected to the two SCADA PCs. SMS text messages are communicated via cellular modems connected to the SCADA PCs' Recommended Standard (RS)-232 serial interface. The redundant alarm notification methodology in place for CKTP and pump station alarms is consistent with industry best practices.

Sewer Utility staff indicated that individuals receiving alarm notification voice messages or SMS text messages are prompted to enter a code to acknowledge the alarm. However, if operators call in to the WIN-911 system to request a listing of active alarms, the system always reports that there are no active alarms. HDR did not investigate the issue to determine a root cause.

HDR did not review listings of WWTP and pump station alarms for which remote alarm notification is provided. Determination of which alarms to include in remote alarm notification should be included in the Sewer Utility's alarm management program initiative referenced previously.

- There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.
- Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.

5 Industrial Control System Documentation

This section summarizes documentation associated with the Sewer Utility's ICS. It describes the type of documents that the Sewer Utility has available along with a general description of how they are organized and maintained.

5.1 Piping and Instrumentation Diagrams

A collection of design and record drawings from past projects at its WWTPs and pump stations is hosted on the County's eO&M SharePoint site. Some P&IDs can be found throughout these documents, but the relevant record P&IDs for all WWTP or pump station processes are not maintained in consolidated P&ID drawing sets or located in one location. To navigate through the P&IDs between connected processes that were installed or modified under separate projects, the user must browse through different drawing sets.

HDR did not confirm how accurately record P&IDs reflect current conditions or the level of completion of the P&ID record documentation. However, a few general comments can be made. The most recent P&IDs found for MWWTP are from 1996 and observations made during HDR's site visit suggest that they are in need of updating. Based on the revisions to the MWWTP chemical system, abandonment of the WAS system, and revisions to the former SBRs, MWWTP will likely require an in-depth field survey to adequately document as-built conditions. Also, the available P&IDs for SWWTP are very limited. Aside from P&IDs developed for the plant's sludge thickening processes during the recent SWWTP Thickening project, no detailed P&IDs appear to be available for SWWTP.

- Record P&IDs are not maintained in consolidated drawing sets or located in one location.
- Record P&IDs for MWWTP are out of date.
- Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.

5.2 Control Strategies

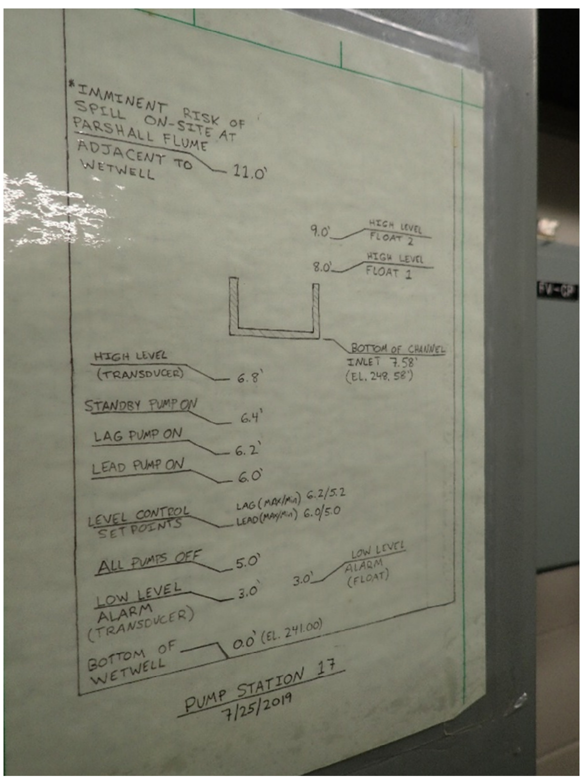
The County's eO&M SharePoint site includes narratives documenting general control descriptions for the major CKTP processes. However, the Sewer Utility has yet to add similar narratives for the processes at the other WWTPs or the wastewater pump stations. HDR understands that the County's eO&M SharePoint site is a work in progress and that the Sewer Utility is working on adding content for some of its wastewater infrastructure.

Aside from the CKTP narratives, the Sewer Utility does not maintain control strategies in electronic format that document how the WWTP and pump station processes and equipment are currently controlled locally and via SCADA. These documents are critical for understanding how WWTP and pump station processes are operating, and for evaluating their performance based on data obtained through SCADA. In the absence of record control strategy documentation, modifications to PLC programming, instrumentation, equipment configuration, and set points may go undocumented and can lead to disparities in understanding among management, operations, and other technical personnel over time. SOP documentation can also fall out of alignment with how equipment is being operated.

Sewer Utility staff indicated that operators currently log process control changes in log books kept at the WWTPs. Physical records do not provide an efficient means of reviewing past process control iterations and comparing previous settings with historical SCADA data. Also, if the log books were lost or damaged, the Sewer Utility would lose all information contained therein.

HDR observed that some of the Sewer Utility's pump stations have hand-drawn sketches taped to control panel enclosures that document the station's level set points for pump control and alarms (see Figure 5-1). HDR believes that these sketches are the most current documentation for pump control and level alarms at these stations.

Figure 5-1. PS-17 level set point documentation



- General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.
- The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.

- ✸ The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.
- ✸ PLC programming modifications may be occurring without documentation of changes made to process controls.

5.3 Control Panel Drawings and Loop Diagrams

Several sets of control panel drawings and loop diagrams can be found on the County's eO&M SharePoint site. The most useful of these drawings are the systems integrator shop drawings included in the O&M folders for the various WWTPs and pump stations. Though these shop drawings are not maintained in consolidated drawing sets, they are relatively easy to locate.

In general, documentation for recent control system additions and modifications appears to be fairly complete. One notable exception to this observation is the 2018 control system upgrade at MWWTP. Record drawings for this work were not available on the County's eO&M SharePoint site, and HDR had to request record drawings for this upgrade from QCC. Documentation for control system work executed on older projects is limited.

In addition to the electronic record drawing collection hosted on the County's eO&M SharePoint site, a hard-copy set of the control panel drawings and loop diagrams associated with a control panel can be found in most control panels.

- ✸ The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.

5.4 O&M Documentation

The Sewer Utility has documentation for several WWTP and pump station processes, equipment, and control system components available on its eO&M SharePoint site. Aside from control system drawings and documentation previously discussed in this section, HDR did not review this documentation in detail as part of its site assessment work.

5.5 ICS Standards and Governance Documentation

In its review of available documentation on the County's eO&M SharePoint site, HDR was unable to locate any ICS standards and governance documentation. Based on discussions with Sewer Utility staff, HDR believes that the Sewer Utility does not have formal documents to guide third-party design and implementation efforts. When an organization's standards are well-developed and documented, expectations for quality, work approach, and results are easily ascertainable from the standards documents. This helps an organization ensure that work is performed in a consistent and desirable manner throughout the ICS and establishes a basis for effectively managing the performance of internal and contracted staff.

In recent years, the Sewer Utility has been managing the quality of ICS implementation work at its facilities by restricting the pool of systems integrators eligible to perform the work to two local, trusted firms that are familiar with the Sewer Utility's infrastructure. Though cultivating a healthy relationship with one or two local competent systems integrators is highly recommended, it is important to take into consideration that systems integrators' workload can fluctuate and these trusted firms may not always be immediately available to perform work for the Sewer Utility. Good ICS standards documentation becomes especially important at times like these when an organization must entrust ICS work to contractors or systems integrators that may be less skilled and/or familiar with the Sewer Utility's infrastructure and preferences. ICS standards documentation can also communicate the Sewer Utility's requirements and preferences to consulting engineers so that their designs adequately capture these elements in the contract documents.

> ✸ The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.

6 Other Software Packages

This section provides an overview of the non-ICS software packages at the Sewer Utility's WWTPs that bear a relationship to the Sewer Utility SCADA system and/or the assets with which it interacts. It includes a description of the software tools and provides a general summary of their current uses at Sewer Utility facilities.

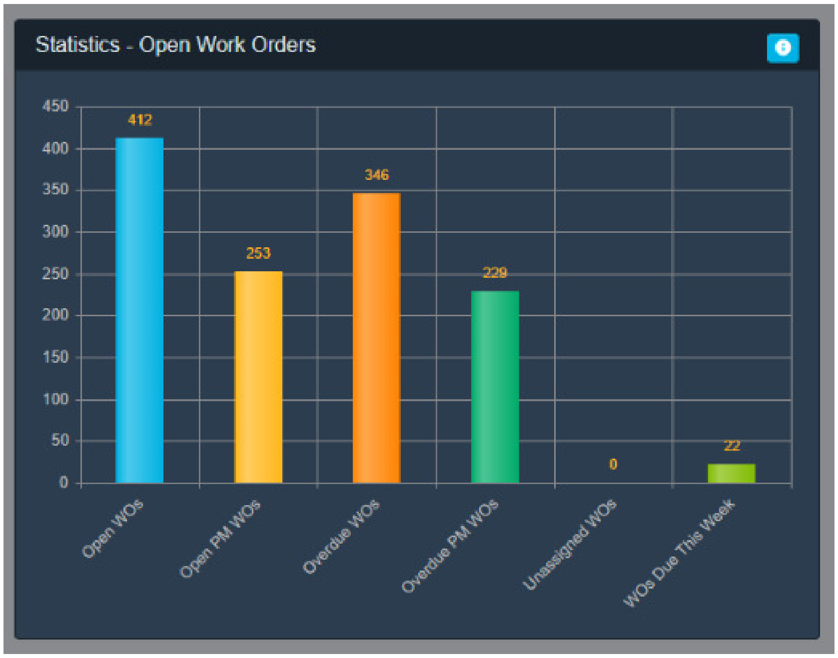
6.1 Computerized Maintenance Management System

The Sewer Utility has selected LLumin for its computerized maintenance management system (CMMS) software. LLumin software is a web browser–based application that provides management and tracking of assets, work orders, spare-parts inventory, and asset financials. The software can be extended with modular licensing to unlock additional functionality such as asset condition assessment tracking and integration with SCADA software platforms.

Sewer Utility staff are in the process of entering assets and their attributes into the LLumin database. Current focuses are adding critical assets and entering installation date and expected useful life data for assets that have already been added to the database. As part of the data entry process, the Sewer Utility is revising its asset tagging convention to establish a new tagging system that will be applied consistently throughout Sewer Utility infrastructure. At the time of HDR's site assessment visits, electrical, control, and instrumentation assets had yet to be entered for MWWTP and SWWTP. HDR also could not find any OT network equipment assets in the LLumin asset database.

The Sewer Utility is now using LLumin for scheduling and tracking reactive and preventive maintenance work orders for assets already entered into the database. Figure 6-1 shows a visualization summarizing open work orders in the LLumin system taken from a screenshot obtained by HDR during its site assessment visits. The Sewer Utility has not integrated the LLumin software with its SCADA system and CMMS and SCADA data remain siloed. Because no data exchange has been established, there are no SCADA-generated work orders based on accumulated runtime, alarms, or other events.

Figure 6-1. Open work orders visualization from LLumin home page



Sewer Utility staff indicated that the Sewer Utility has purchased the LLumin Data Collection and Condition Assessment module but that staff have yet to begin using its features. Among other things, the module will allow staff to log measurements, observations, photos, and other data via mobile devices during equipment inspections. The data collected during inspections can then be automatically compared with preset rules that trigger additional maintenance steps when field data fall outside of normal conditions. Currently, Sewer Utility O&M staff work from PCs and do not have tablets, which presents a barrier to incorporating this software tool into existing workflows.

- Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.
- The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.

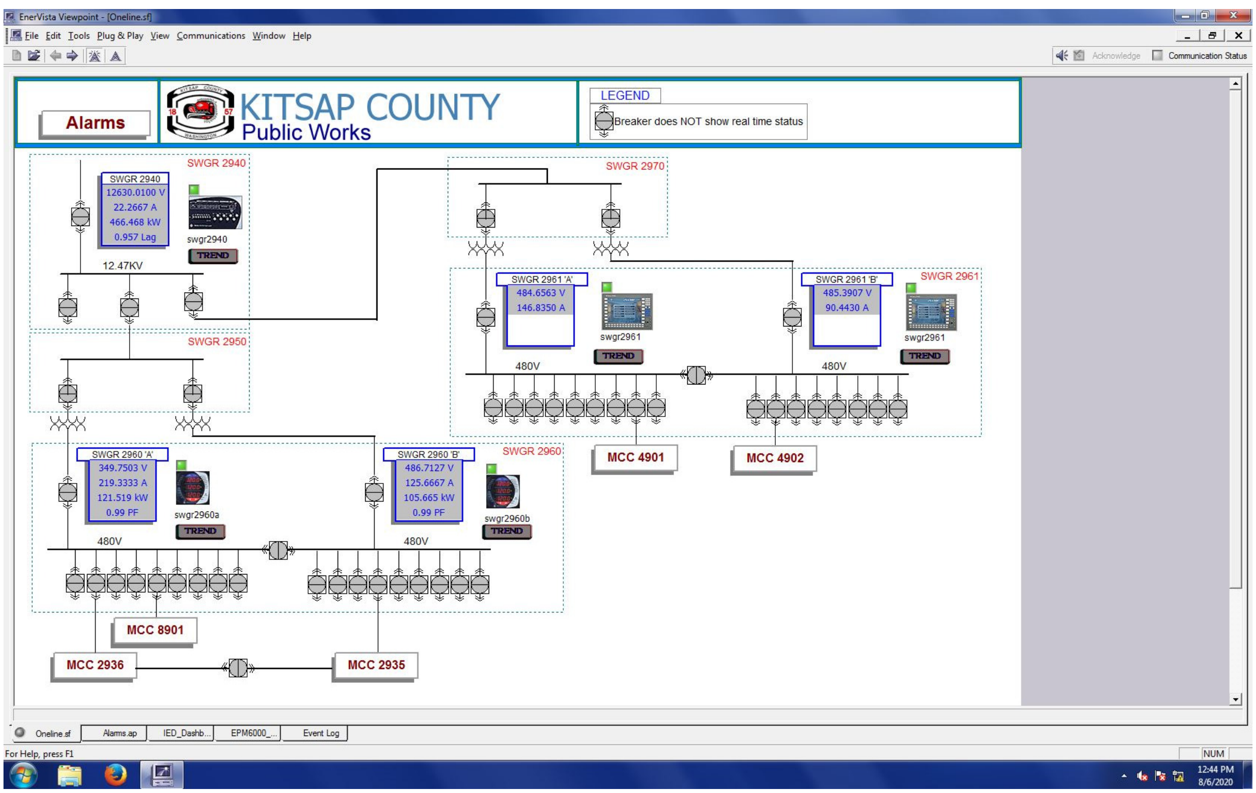
6.2 Energy Management System

At CKTP, an EMS was installed under the Resource Recovery project. This EMS consists of a dedicated EMS PC running GE's EnerVista Viewpoint software, GE Multilin EPM 6000 power monitors installed in several of the CKTP MCCs and switchgear SWGR-2960 (see Figure 6-2), a GE Multilin EPM 9650 power quality meter in CKTP's medium-voltage service entrance switchgear (SWGR-2940), and the GE Entellysis low-voltage switchgear (SWGR-2961) installed in the SPB. CKTP's EnerVista Viewpoint one-line diagram screen in Figure 6-3 depicts an overview of this EMS infrastructure.

Figure 6-2. GE EPM 6000 power monitor

Source: GE.

Figure 6-3. CKTP GE EnerVista Viewpoint one-line diagram screen



As Figure 6-3 indicates, CKTP's standby generators and large electrical loads, like the aeration blowers, have not been integrated into the EMS. Several of the CKTP MCCs and some of the power monitors installed at CKTP are also absent from the EMS. Power monitors have not been installed in the MCCs located in the digester control building (MCC 2), power/blower building (MCC 2971, MCC 2972, MCC 2973, and MCC 2974), headworks building (MCC 2975 and MCC 2976), or SPB (MCC 2981, MCC 2982, MCC 2983, and MCC 2984), so no power data are monitored by the EMS for these MCCs. The two power monitors located in the UV disinfection facility (JIT 3101 and JIT 3102) have also not been integrated into the EMS. Instead, the CKTP SCADA system monitors limited power data from the UV disinfection power monitors, of which it appears that only kilowatt (kW) values are recorded in the CKTP historian.

For the electrical distribution system buses that are included in the EMS, the EnerVista Viewpoint software has been configured to display real-time, minimum, maximum, and average values for several parameters, including phase current, line and phase voltage, power factor, real power, reactive power, apparent power, and total harmonic distortion (THD) (current and voltage). The software has also been configured to monitor several additional status and alarm parameters associated with the Entellysis low-voltage switchgear and its individual breakers. However, despite monitoring the requisite data, the various one-line diagram screens in the EnerVista Viewpoint software have not been configured to display breaker statuses for SWGR-2961. Because the EMS does not monitor breaker or switch statuses for any of the other electrical distribution system buses, the one-line diagram screens do not indicate those statuses either.

During its site visits, HDR observed that the Ethernet cable connecting the CKTP EMS PC to the network switch in the SPB control room network cabinet was not fully connected and the EnerVista Viewpoint software was not displaying real-time values. After Sewer Utility staff connected the PC to the switch, the software began displaying real-time values. However, HDR observed that the EnerVista Viewpoint software had never been set to record any of the real-time power data that it is monitoring. Unfortunately, it appears that the Sewer Utility has not generated any historical EMS data since the EMS was installed. HDR initiated the trending process within the software so that the EMS PC is now recording real-time data at a default of 1-minute intervals.

Even if historical EMS data were available, the CKTP EMS and SCADA system have not been integrated and their respective data sets remain separate. Furthermore, the Sewer Utility is not currently using power or energy data at the bus level (as monitored by the EMS) or load level (as monitored by SCADA via network VFDs and overload relays) to establish plant, process, or asset baselines or to evaluate process and equipment performance. Power and energy data are central to several KPIs used for individual equipment assets, plant processes, and WWTPs as a whole. If the Sewer Utility wishes to leverage energy-based KPIs to establish operational and/or maintenance goals and to then measure progress toward those goals, it will need to develop a strategy for collecting and managing the power and energy data that those KPIs require.

This strategy should also include the Sewer Utility’s other WWTPs and wastewater pump stations. Currently, the Sewer Utility does not have EMS software installed at KWWTP, MWWTP, or SWWTP. It also appears that the power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs. The CKTP EMS and SCADA system are also not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility’s pump stations. Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.

- CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.
- Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.
- Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.
- With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.
- The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.
- It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.
- The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.
- Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.
- The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.
- Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.

6.3 Laboratory Information Management System

Currently, the Sewer Utility is recording laboratory data with Excel spreadsheets and HDR believes that much, if not all, of the associated data entry and processing is manual. Monthly lab reports for the Sewer Utility's four WWTPs are available on the County eO&M SharePoint site. If the laboratory data included in these monthly reports also reside in a Sewer Utility database, HDR is not aware of it. Without a database for laboratory data or laboratory information management system (LIMS) software, working with the Sewer Utility's historical laboratory data is likely to be labor-intensive. Because WWTP laboratory data factor into several plant and process KPIs, it is critical that these data be easily accessible to Sewer Utility staff and available to other Sewer Utility software platforms.

At the time of this writing, HDR believes that the Sewer Utility is negotiating contract terms and conditions with Hach for the installation and licensing of Hach Water Information Management Solution (WIMS) software, which would serve as the Sewer Utility's LIMS. The Sewer Utility has already purchased server and client hardware on which to install the software and Sewer Utility staff intend to add the machines to the WWTP OT networks. Based on review of Hach's scope of work, HDR believes that Hach WIMS client software will be installed on three PCs at CKTP and one PC each at KWWTP, MWWTP, and SWWTP. Hach LAB Cal software will also be installed on one of the three PCs at CKTP. The Hach WIMS server and database software will be installed on a server located at CKTP. The Sewer Utility also intends to purchase Hach WIMS SCADA Interface software for Wonderware InTouch to enable data exchange between the two software platforms.

- HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.

6.4 Data Analytics and Visualization Software

The Sewer Utility is not currently using data analytics or visualization software to work with its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments. Data analytics and visualization software tools are often highly customizable and can be used to combine data from multiple sources to derive insights that may be difficult or impossible to achieve within the constraints of separate, purpose-built software packages that were developed to serve specific data sets. Many of these tools are also designed with large data sets in mind and can handle manipulations of large blocks of historical data that may cause performance degradation if attempted within some of the Sewer Utility's other software platforms. If the Sewer Utility wishes to pursue a more data-centric approach to the operation and maintenance of its wastewater infrastructure, data analytics and visualization software will become an essential addition to the Sewer Utility's tool set.

- The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments.

7 Organizational Improvement Categories

This section presents five organizational improvement categories that apply to utility control systems and how they will be applied within the Sewer Utility SCADA Master Plan to relate risks, deficiencies, and proposed improvements to facets of the Sewer Utility's organizational health.

7.1 Organizational Improvement Categories

Not all stakeholders involved with CIP investments in SCADA technologies or who interact with and/or rely on ICS infrastructure have the same degree of familiarity and experience with the associated hardware, software, and technical nuances. It can therefore be beneficial to correlate current risks and deficiencies, as well as proposed investments in specific technological improvements, with more widely understood facets of organizational health. These correlations can help provide context for identified shortcomings and vulnerabilities that may be rooted in technologies outside of some stakeholders' areas of expertise. They can also emphasize the organizational gains that are anticipated from a particular upgrade in a way that may be understood more readily than the technical description of the upgrade alone.

HDR presented five organizational improvement categories that apply to utility control systems during the Sewer Utility SCADA Master Plan kickoff meeting held on July 22, 2020. These organizational improvement categories, depicted in Figure 7-1, are described in the following subsections. The framework provided by these organizational improvement categories will be carried through the various Sewer Utility SCADA Master Plan TMs, contextualizing risks and deficiencies identified in TM-1, guiding development of objectives and technology selection, and relating proposed implementation plan projects to improvements in the Sewer Utility's organizational health.

Figure 7-1. Organizational improvement categories

7.1.1 Operational Optimization

This category covers deficiencies and improvements related to an organization's processes, control strategies, and procedures. Deficiencies that fall under this category might include labor-intensive data management practices, manual operation of equipment that could be automated, and unrefined control loops that result in unnecessary energy consumption (e.g., over-aeration). Operational optimization improvements may consist of equipment and instrumentation upgrades to WWTP processes, improved or increased automation, streamlined workflows, and other enhancements that lower operating costs and/or improve product quality (e.g., effluent, dewatered solids, etc.).

7.1.2 Infrastructure Stability and Modernization

This category focuses on the health and reliability of the organization's assets. Typical organizational efforts within this category include predicting and avoiding failure scenarios, replacing assets that are near the end of their useful lives, asset management initiatives, and ensuring the availability of manufacturer support for the organization's assets. Deficiencies that fall under this category might include failed instrumentation and reliance on discontinued products that are no longer supported by the manufacturer. Improvements in this category can include replacement of legacy hardware, software and firmware upgrades, and upgrading the organization's technology to obtain the benefits from enhanced functionality available in current market offerings.

7.1.3 Cybersecurity Risk Mitigation

According to DHS, critical infrastructure like wastewater facilities is facing increasing risks from cybersecurity threats. Where the technological barrier once limited the number of threat actors to individuals and organizations with intermediate to advanced skills and knowledge, several sophisticated tools have been developed and made accessible to anyone with an Internet connection. These tools have lowered the barrier to entry and increased the effectiveness of less skilled individuals, and, along with their proliferation, cyber-attacks on water and wastewater infrastructure are becoming more common.

The cybersecurity risk mitigation category is focused on improving the organization's cybersecurity posture. Deficiencies that fall under this category might include exposure of critical ICS infrastructure to the public Internet, poor password practices, and unpatched network appliances with known vulnerabilities. Improvements in this category can include modifications to network architecture, hardening of components, device configuration, and preparing for an effective response to a cybersecurity incident.

7.1.4 Critical System Resilience

Even when best practices are adopted, equipment and software can fail. Organizations can prepare for these failures by incorporating redundancy into ICS designs and establishing scripted procedures to guide staff response after failures occur. However, it is impossible for an organization to prepare for every failure scenario. Unexpected events happen and these events can disrupt ICS functionality.

The critical system resilience category is focused on identification and mitigation of potential failure scenarios before they happen as well as developing the organization's ability to recover from unplanned disruptions. Deficiencies that fall under this category might include critical ICS infrastructure without UPS battery backup power, poor data backup practices, and lack of redundancy in critical network infrastructure. Improvements in this category can include establishing redundancy for critical ICS components, revisions to network topologies, and implementing measures to protect against irrecoverable data loss.

7.1.5 Workforce Efficiency

The workforce efficiency category focuses on empowering an organization's staff and eliminating barriers to workforce performance. Many of the improvements related to this category have to do with providing staff with the information they need, when and where they need it, and introducing technologies that deepen insight and enable increased efficiency. Other enhancements in this category seek to capture institutional knowledge in the tools, documentation, and technologies used by an organization's staff to streamline knowledge transfer for new hires, accelerate the development of junior staff, and efficiently communicate organizational standards and expectations to contracted parties. Deficiencies that fall under this category might include cumbersome access to real-time and historical SCADA data, poor documentation practices, and ineffective HMI screen design that provides little situational awareness to operators.

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8 Risk and Deficiency Summary

Table 8-2 compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in previous sections of TM-1. The table includes subsection references to assist readers in locating the specific subsections where each risk and deficiency is described in more detail. The table also correlates each risk and deficiency to one or more of the organizational improvement categories introduced in Section 7. Applicable organizational improvement categories are denoted with one or more "✸" symbols in their respective columns.

To help communicate the significance of various risks and deficiencies, a ranking system has been applied based on the quantity of "✸" symbols shown for a given organizational improvement category. The ranking system is defined in Table 8-1. Risks and deficiencies from each TM-1 section are sorted in Table 8-2 so that the most significant risks and deficiencies from each section appear first.

Table 8-1. Risk and deficiency ranking system description

Ranking	Description
✸✸✸	**Major** risk or deficiency. Immediate corrective measures are recommended and/or major organizational health benefit(s) to be gained from related improvements.
✸✸	**Moderate** risk or deficiency. Near-term corrective measures are recommended and/or significant organizational health benefit(s) to be gained from related improvements.
✸	**Minor** risk or deficiency. Corrective measures are recommended, but likelihood and/or impact of failure/event may be low. Some organizational health benefit(s) to be gained from related improvements.

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.			***		
Network Architecture	2.7	A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.			***		
Network Architecture	2.13	No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.				***	
Network Architecture	2.13	Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.				***	
Network Architecture	2.3	Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.	**				*
Network Architecture	2.2	Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.				**	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.2	CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between CKTP SCADA nodes and all of the plant PLCs.				✸✸	
Network Architecture	2.2	CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.				✸✸	
Network Architecture	2.2	Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.				✸✸	
Network Architecture	2.3	Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.					✸✸
Network Architecture	2.3	The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near real-time monitoring and alarming for wastewater pump stations.		✸✸			
Network Architecture	2.3	Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.		✸✸			
Network Architecture	2.3	The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.		✸✸			
Network Architecture	2.7	Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.			✸✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	There appear to be parallel entry points to the SWWTP OT network from external networks: one via SWWTP's Tempered Networks HIPswitch and one via a secure gateway used for the SWWTP business LAN wireless access point.			✸✸		
Network Architecture	2.9	Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.			✸✸		
Network Architecture	2.9	Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.			✸✸		
Network Architecture	2.9	MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.			✸✸		
Network Architecture	2.10	The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.			✸✸		
Network Architecture	2.10	No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.			✸✸		
Network Architecture	2.10	Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.			✸✸		
Network Architecture	2.10	The Sewer Utility's Airwall edge services do not have current firmware versions installed.			✸✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.10	The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.		✸✸			
Network Architecture	2.11	Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.		✸✸			
Network Architecture	2.11	Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.			✸✸		
Network Architecture	2.12	Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.				✸✸	
Network Architecture	2.12	Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.				✸✸	
Network Architecture	2.12	KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.				✸✸	
Network Architecture	2.12	The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.				✸✸	
Network Architecture	2.13	No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.				✸✸	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.13	No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.				✸✸	
Network Architecture	2.16	The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.			✸✸		
Network Architecture	2.11	CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.	✸		✸		✸
Network Architecture	2.14	The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.	✸		✸		✸
Network Architecture	2.5	Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.		✸	✸		
Network Architecture	2.14	The Sewer Utility does not have a syslog server or other central repository for collecting CKTP OT network device logs and network event data.			✸		✸
Network Architecture	2.2	The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.		✸			
Network Architecture	2.2	KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.				✸	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.3	The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.	✸				
Network Architecture	2.4	An OM1 fiber-optic patch cable has been used to patch two OM3 fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.		✸			
Network Architecture	2.4	There are instances of UTP Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.		✸			
Network Architecture	2.5	The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.	✸				
Network Architecture	2.5	All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.		✸			
Network Architecture	2.5	Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.			✸		
Network Architecture	2.6	The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.		✸			
Network Architecture	2.7	Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.			✸		
Network Architecture	2.9	UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.			✸		
Network Architecture	2.10	On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.			✸		
Network Architecture	2.10	Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.			✸		
Network Architecture	2.10	HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.			✸		
Network Architecture	2.10	Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.				✸	
Network Architecture	2.10	Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.			✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.11	KWWTP, MWWTP, and SWWTP SCADA have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the plants.		✸			
Network Architecture	2.12	Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.			✸		
Network Architecture	2.12	Network cabinet and network panel PNL-8580A are routinely left unlocked.			✸		
Network Architecture	2.12	Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.				✸	
Network Architecture	2.13	Backups of PLC programming project files could be better organized to improve version control.				✸	
Network Architecture	2.13	The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.				✸	
Network Architecture	2.12	In general, the network switches within the Sewer Utility's OT network have no on-board power supply or external 24 VDC power supply redundancy.				✸	
Network Architecture	2.14	The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.				✸	
Network Architecture	2.15	Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.15	Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.					★
Network Architecture	2.15	Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.					★
ICS Hardware	3.5	The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an IR source fault and is not monitoring combustible-gas concentration in the odor control system.		★★★			
ICS Hardware	3.5	HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.		★★★			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.		★★★			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.		★★★			
ICS Hardware	3.5	The SWWTP process building fire alarm panel has failed so SWWTP is not currently monitoring or alarming for fires.		★★★			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-24 wet well is faulted.		★★★			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.		★★★			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.		✸✸			✸✸
ICS Hardware	3.5	The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.		✸✸			✸
ICS Hardware	3.1	The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.1	The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer's product life cycle and are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.1	HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.				✸✸	
ICS Hardware	3.2	The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.3	OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of H_2S and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is an NEC violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.				✸✸	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.3	Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.				✸✸	
ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have battery backup power.				✸✸	
ICS Hardware	3.4	Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.					✸✸
ICS Hardware	3.4	Sewer Utility staff do not have access to near real-time status and alarm information for wastewater pump stations at CKTP.					✸✸
ICS Hardware	3.5	Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.		✸✸			
ICS Hardware	3.5	Current CKTP effluent flow calculations provided by Trojan UV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.	✸✸				
ICS Hardware	3.5	Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.	✸✸				
ICS Hardware	3.5	Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.	✸✸				
ICS Hardware	3.5	The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.		✸✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.		★★			
ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.	★★				
ICS Hardware	3.5	Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.		★★			
ICS Hardware	3.5	The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.		★★			
ICS Hardware	3.5	The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.		★★			
ICS Hardware	3.5	The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.		★★			
ICS Hardware	3.5	Instrumentation within the MWWTP Trojan UV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.		★★			
ICS Hardware	3.5	The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.		★★			
ICS Hardware	3.5	The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.		★★			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.		✸✸			
ICS Hardware	3.5	PS-34 has no PLC and the station's wet well level appears to be controlled by a level indicator and controller that monitors the wet well's radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.		✸✸			
ICS Hardware	3.1	Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.		✸		✸	
ICS Hardware	3.4	The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.			✸	✸	
ICS Hardware	3.5	A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.	✸	✸			
ICS Hardware	3.5	Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.		✸			✸
ICS Hardware	3.5	Short cycling of the pumps is a common occurrence at PS-24.	✸	✸			
ICS Hardware	3.1	Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs will be discontinued by the manufacturer as of December 2020.		✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.1	The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.					✸
ICS Hardware	3.1	The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.	✸				
ICS Hardware	3.2	The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.		✸			
ICS Hardware	3.2	The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.		✸			
ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.				✸	
ICS Hardware	3.3	There is a mix of 120 VAC and 24 VDC control and power circuits within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.	✸				
ICS Hardware	3.3	The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.	✸				

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.4	The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.					✸
ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for CKTP effluent flow.	✸				
ICS Hardware	3.5	The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.					✸
ICS Hardware	3.5	Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.	✸				
ICS Hardware	3.5	The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.		✸			
ICS Hardware	3.5	One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.		✸			
ICS Hardware	3.5	The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.		✸			
ICS Hardware	3.5	The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.		✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.	★★★				★★★
ICS Software	4.2	Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.					★★★
ICS Software	4.3	SCADA data are not being leveraged beyond data required for mandatory reporting.	★★	★★			★★
ICS Software	4.3	The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.	★★	★★			★★
ICS Software	4.2	Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.	★★				★★
ICS Software	4.2	Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.	★★				★★
ICS Software	4.3	The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.	★★				★★
ICS Software	4.1	The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.	★★				
ICS Software	4.2	The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.		★★			
ICS Software	4.2	HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.					★★

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.					★★
ICS Software	4.2	HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.		★★			
ICS Software	4.2	The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.	★★				
ICS Software	4.2	Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.		★★			
ICS Software	4.2	The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.					★★
ICS Software	4.3	The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.		★★			
ICS Software	4.3	The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.					★★
ICS Software	4.3	The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.					★★

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.3	The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.					✸✸
ICS Software	4.4	There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.				✸✸	
ICS Software	4.1	Sewer Utility PLCs are running a variety of firmware versions.		✸			
ICS Software	4.2	At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.					✸
ICS Software	4.2	Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.	✸				
ICS Software	4.2	Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.		✸			
ICS Software	4.2	Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.					✸
ICS Software	4.2	Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.					✸
ICS Software	4.2	Trend screens display current values against time only and do not provide meaningful situational awareness.					✸
ICS Software	4.2	Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.	✸				✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.					✸
ICS Software	4.4	Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.					✸
ICS Documentation	5.2	The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.	✸				✸✸
ICS Documentation	5.5	The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.	✸				✸
ICS Documentation	5.1	Record P&IDs are not maintained in consolidated drawing sets or located in one location.					✸
ICS Documentation	5.1	Record P&IDs for MWWTP are out of date.					✸
ICS Documentation	5.1	Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.					✸
ICS Documentation	5.2	General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.					✸
ICS Documentation	5.2	The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.					✸
ICS Documentation	5.2	PLC programming modifications may be occurring without documentation of changes made to process controls.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Documentation	5.3	The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.					✱
Other Software Packages	6.4	The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments.	✱✱	✱✱			✱✱
Other Software Packages	6.2	It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.		✱✱			✱✱
Other Software Packages	6.2	The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.		✱✱			✱✱
Other Software Packages	6.2	Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.		✱✱			✱✱
Other Software Packages	6.1	Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.		✱✱			✱
Other Software Packages	6.1	The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.		✱			✱✱
Other Software Packages	6.3	HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.					✱✱

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Other Software Packages	6.2	Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.	✱	✱			✱
Other Software Packages	6.2	Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.	✱	✱			✱
Other Software Packages	6.2	The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.		✱			✱
Other Software Packages	6.2	CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.					✱
Other Software Packages	6.2	Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.					✱
Other Software Packages	6.2	With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.					✱
Other Software Packages	6.2	The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.					✱

9 References

ANSI/ISA (American National Standards Institute/International Society of Automation)

2016 *ANSI/ISA-18.2-2016, Management of Alarm Systems for the Process Industries.*

DHS (U.S. Department of Homeland Security)

2016 *Recommended Practice: Improving Industrial Control System Cybersecurity with Defense-in-Depth Strategies.*

NFPA (National Fire Protection Association)

2021 *NFPA 70E: Standard for Electrical Safety in the Workplace.*

2020 *NFPA 820: Standard for Fire Protection in Wastewater Treatment and Collection Facilities.*

NIST (National Institute of Standards and Technology)

2015 *NIST Special Publication 800-82, Revision 2: Guide to industrial Control Systems Security.*

Rockwell Automation

2020a *MicroLogix 1500 Programmable Logic Controller Systems.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/discontinued-products/micrologix-1500-controllers.html. Viewed on September 1, 2020.

2020b *1769 CompactLogix L3x Controllers.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/programmable-controllers/small-controllers/compactlogix-family/compactlogix-1769-controllers.html. Viewed on September 1, 2020.

2020c *Product Lifecycle Status.* https://www.rockwellautomation.com/global/support/product-compatibility-migration/lifecycle-status/overview.page. Viewed on September 1, 2020.

Schneider Electric

2020 *APC Power Saving Back-UPS 1500 Runtime Graph.* https://www.apc.com/products/runtimegraph/runtime_graph.cfm?base_sku=BR1500G&chartSize=large. Viewed on September 1, 2020.

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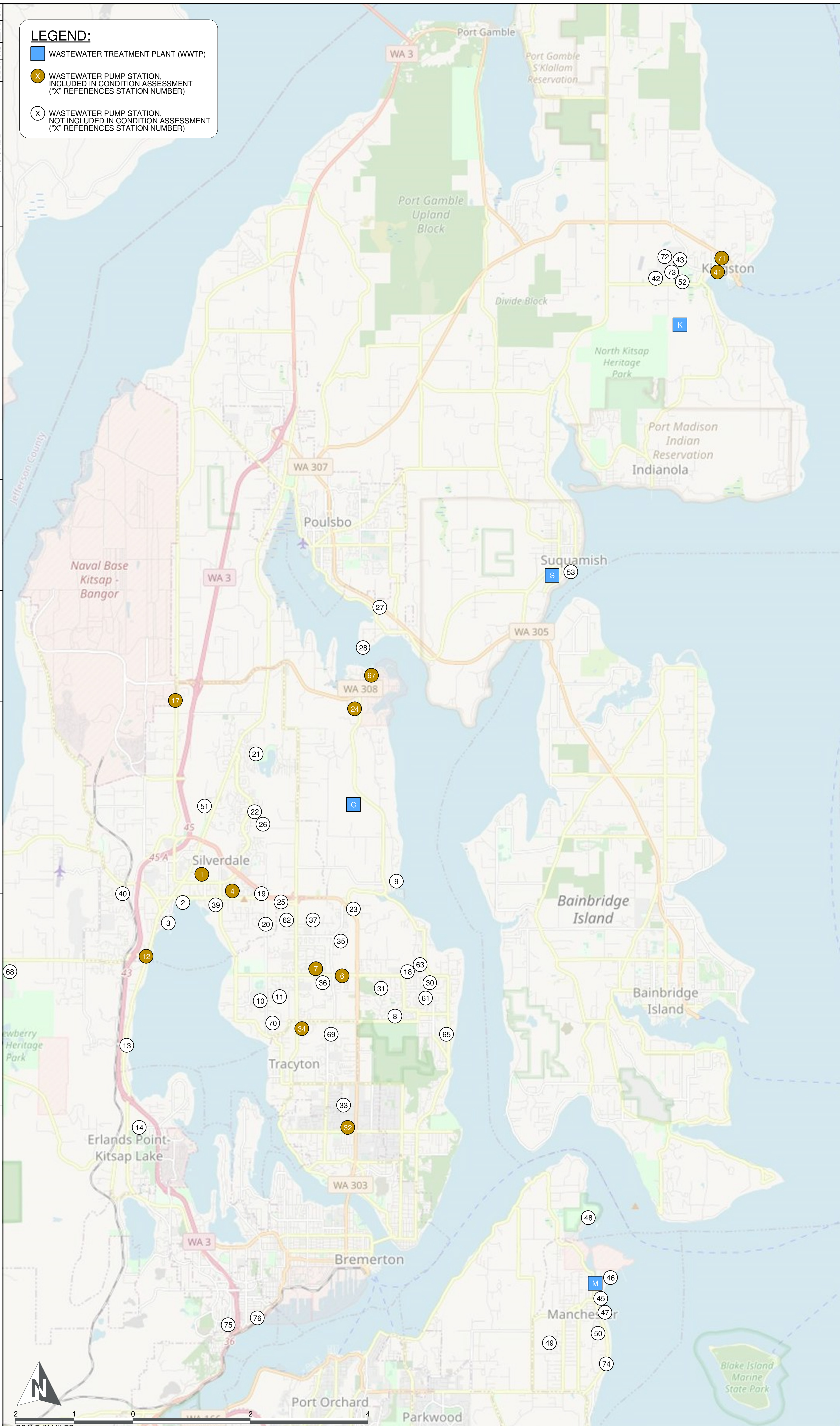
Appendix A
Site Maps



NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

Murraysmith, Inc.
600 University Street #300
Seattle, WA 98101
Phone: (206) 462-7030

HDR Engineering, Inc.
929 108th Avenue NE #1300
Bellevue, WA 98004
Phone: (425) 453-1523
Fax: (425) 453-1707

JMT	DESIGNED BY	08/31/2020 DATE
JMT	DRAWN BY	08/31/2020 DATE
XXX	CHECKED BY	XXX DATE
JMT	APPROVED BY	08/31/2020 DATE
10231983	HDR PROJECT NUMBER	
KC-205-20	CLIENT PROJECT NUMBER	

KITSAP COUNTY WASHINGTON 1857

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING

KITSAP COUNTY PUBLIC WORKS SEWER UTILITY DIVISION SEWER UTILITY SCADA MASTER PLAN

GENERAL

SITE MAP

FIGURE A1

SHT 1 OF 2

FACILITY LOCATIONS:

CENTRAL KITSAP TREATMENT PLANT (CKTP)
12351 Brownsville Highway NE
Poulsbo, WA 98370

KINGSTON WASTEWATER TREATMENT PLANT (KWWTP)
23055 S Kingston Road NE
Kingston, WA 98346

MANCHESTER WASTEWATER TREATMENT PLANT (MWWTP)
8020 E Caraway Road
Port Orchard, WA 98366

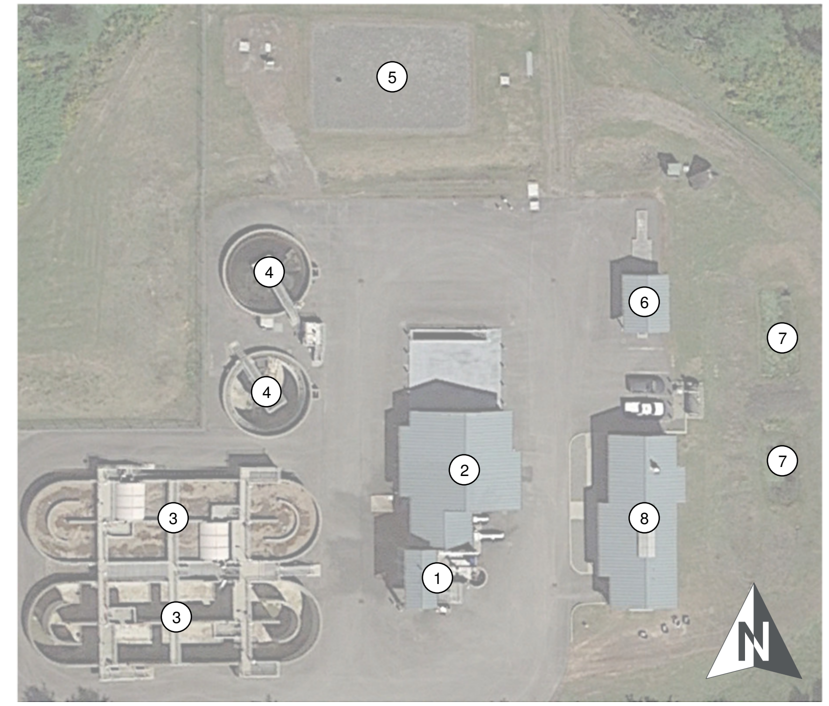
SUQUAMISH WASTEWATER TREATMENT PLANT (SWWTP)
18019 Division Avenue NE
Suquamish, WA 98392

CENTRAL KITSAP TREATMENT PLANT

250 125 0 250 500
SCALE IN FEET

CKTP SITE REFERENCE KEY: (X)

1. HEADWORKS
2. PRIMARY CLARIFIERS
3. AERATION BASINS
4. SECONDARY CLARIFIERS
5. UV DISINFECTION
6. GRAVITY THICKENERS
7. DIGESTERS
8. DIGESTER CONTROL BUILDING
9. WAS THICKENING BUILDING
10. POWER/BLOWER BUILDING
11. AERATION BASINS 3 & 4 ELECTRICAL BUILDING
12. RECLAIMED WATER BUILDING
13. SOLIDS PROCESSING BUILDING
14. CARBON ADDITION FACILITY
15. STORM WATER DECANT FACILITY
16. HEADWORKS BIOFILTER
17. COGEN AND DIGESTER GAS CONDITIONING FACILITY
18. WASTE GAS BURNER
19. ADMINISTRATION AND LAB BUILDING
20. MODULAR OFFICE (TRAILERS 103)
21. OPERATIONS FACILITIES BUILDING
22. SHOP AND EQUIPMENT MAINTENANCE BUILDING
23. SEPTAGE RECEIVING

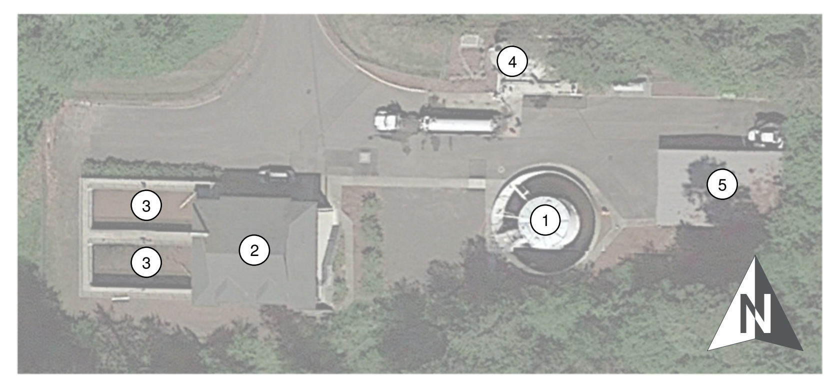


KINGSTON WASTEWATER TREATMENT PLANT

0 50 100
SCALE IN FEET

KWWTP SITE REFERENCE KEY: (X)

1. HEADWORKS
2. PROCESS BUILDING
3. OXIDATION DITCHES
4. SECONDARY CLARIFIERS
5. BIOFILTER
6. UV DISINFECTION
7. STORMWATER DETENTION PONDS
8. OPERATIONS BUILDING



SUQUAMISH WASTEWATER TREATMENT PLANT

0 25 50
SCALE IN FEET

SWWTP SITE REFERENCE KEY: (X)

1. SLUDGE STORAGE
2. PROCESS BUILDING
3. SBR BASINS
4. THICKENED SLUDGE STORAGE TANK
5. SERVICE BUILDING

MANCHESTER WASTEWATER TREATMENT PLANT

0 25 50
SCALE IN FEET

MWWTP SITE REFERENCE KEY: (X)

1. INFLUENT PUMP STATION
2. HEADWORKS
3. AERATION BASINS
4. SECONDARY CLARIFIERS
5. OPERATIONS BUILDING
6. SLUDGE LOADING FACILITY
7. GENERATOR BUILDING
8. BLOWER BUILDING
9. UV DISINFECTION
10. RAS/WAS SPLITTER BOX

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

Murraysmith, Inc.
600 University Street #300
Seattle, WA 98101
Phone: (206) 462-7030

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JMT 08/31/2020	JMT 8/31/2020
DESIGNED BY DATE	APPROVED BY DATE
MH 08/31/2020	10231983
DRAWN BY DATE	HDR PROJECT NUMBER
XXX XXX	KC-205-20
CHECKED BY DATE	CLIENT PROJECT NUMBER

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

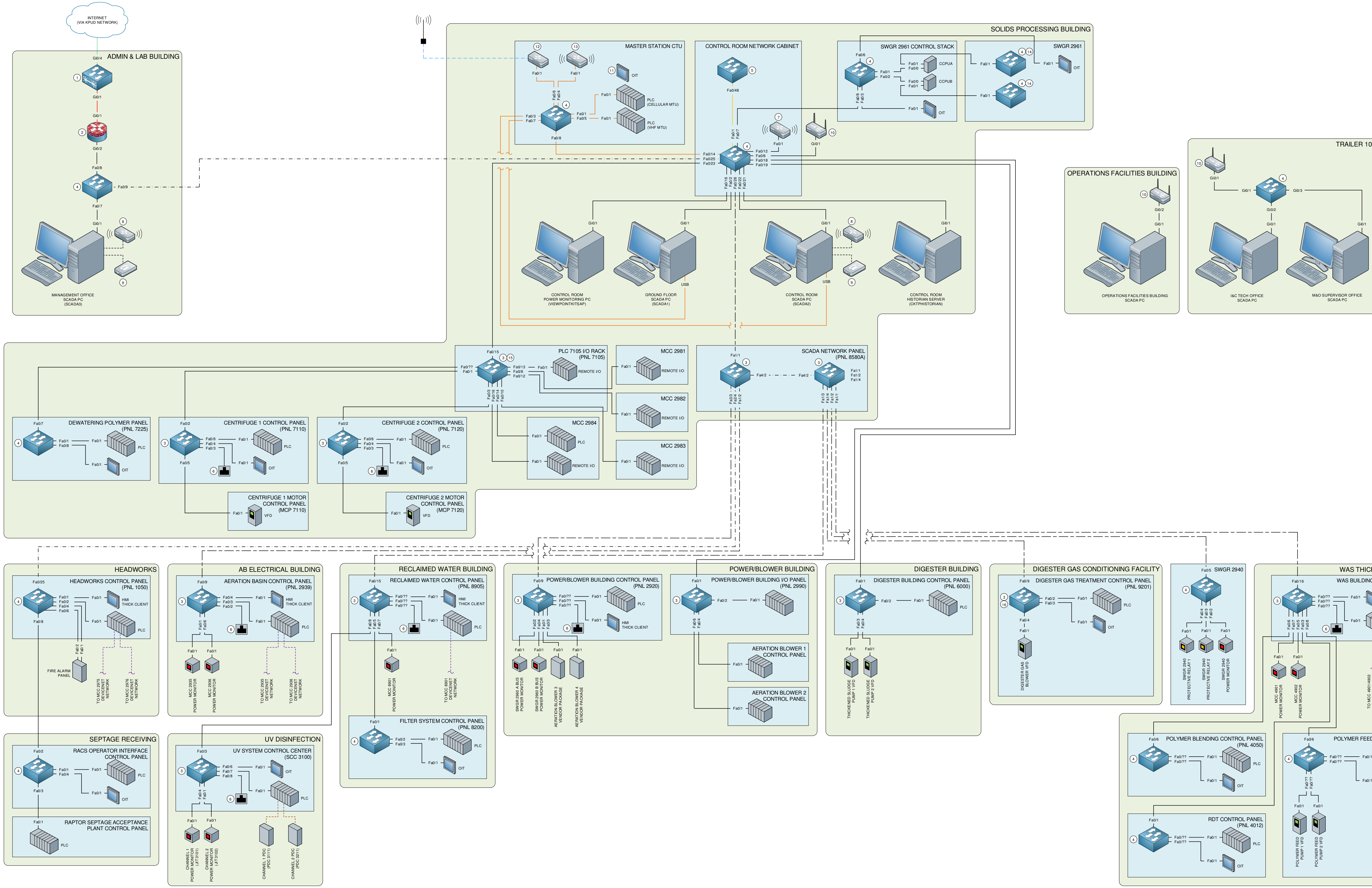
GENERAL
WWTP SITE MAPS

FIGURE A2

SHT 2 OF 2

Appendix B

Network Architecture Diagrams



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.
4. DRAWING DOES NOT SHOW STAND-ALONE CONTROL PANELS THAT ARE NOT NETWORKED TO THE PLANT PROCESS CONTROL SYSTEM (PCS).

KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
(2) TEMPERED NETWORKS HIPSWITCH, 5 MBPS THROUGHPUT
(3) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
(4) ETHERNET ACCESS SWITCH, UNMANAGED
(5) KITSAP COUNTY INFORMATION SERVICES (IS) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2). OTHER IS NETWORK CONNECTION AT SWITCH NOT SHOWN.
(6) PROGRAMMING INTERFACE
(7) CELLULAR ROUTER
(8) CELLULAR MODEM FOR ALARM NOTIFICATION SYSTEM SMS MESSAGING
(9) ANALOG MODEM FOR ALARM NOTIFICATION SYSTEM VOICE MESSAGING. CONNECTION TO CKTP PHONE SYSTEM NETWORK AND PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) NOT SHOWN.
(10) UNLICENSED 5 GHZ ACCESS POINT FOR IN-PLANT WIRELESS EXTENSION OF OT NETWORK
(11) OIT DISCONNECTED FROM PANEL ACCESS SWITCH
(12) ETHERNET RADIO FOR COMMUNICATIONS WITH LIFT STATIONS
(13) CELLULAR ROUTER FOR COMMUNICATIONS WITH LIFT STATIONS
(14) IP CONNECTIONS TO SWITCHGEAR BREAKERS NOT SHOWN
(15) TWO ETHERNET CONNECTIONS AT THIS SWITCH WERE NOT IDENTIFIED DURING HDR SITE VISITS
(16) COGEN SYSTEM CONTROL PANEL AND DIGESTER GAS CONDITIONING CHILLER CONTROL PANEL HAVE BEEN POWERED DOWN. ETHERNET CONNECTIONS FROM MANAGED SWITCH IN PNL 9201 TO DEVICES IN THESE CONTROL PANELS ARE NOT SHOWN ON THIS DRAWING.

LEGEND:

ETHERNET (COPPER)
ETHERNET (COAXIAL)
CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
ETHERNET (MULTI-MODE [OM1] FIBER-OPTIC)
ETHERNET (MULTI-MODE [OM3] FIBER-OPTIC)
SERIAL (COPPER)
SUQUAMISH WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
CKTP BUSINESS LAN
KITSAP COUNTY SEWER UTILITY OT VHF RADIO WAN
DEVICENET
TRUNKED NETWORKS
CKTP PUMP STATION TELEMETRY SUBNET
MODBUS RTU
Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #
Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

murraysmith
Murraysmith, Inc.
600 University Street #300
Seattle, WA 98101
Phone: (206) 462-7030

HDR Engineering, Inc.
929 108th Avenue NE #1300
Bellevue, WA 98004
Phone: (425) 453-1523
Fax: (425) 453-1707

JMT 08/26/2020	JMT 08/26/2020
DESIGNED BY DATE	APPROVED BY DATE
JMT 08/26/2020	10231983
DRAWN BY DATE	HDR PROJECT NUMBER
OA xxx	KC-205-20
CHECKED BY DATE	CLIENT PROJECT NUMBER

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

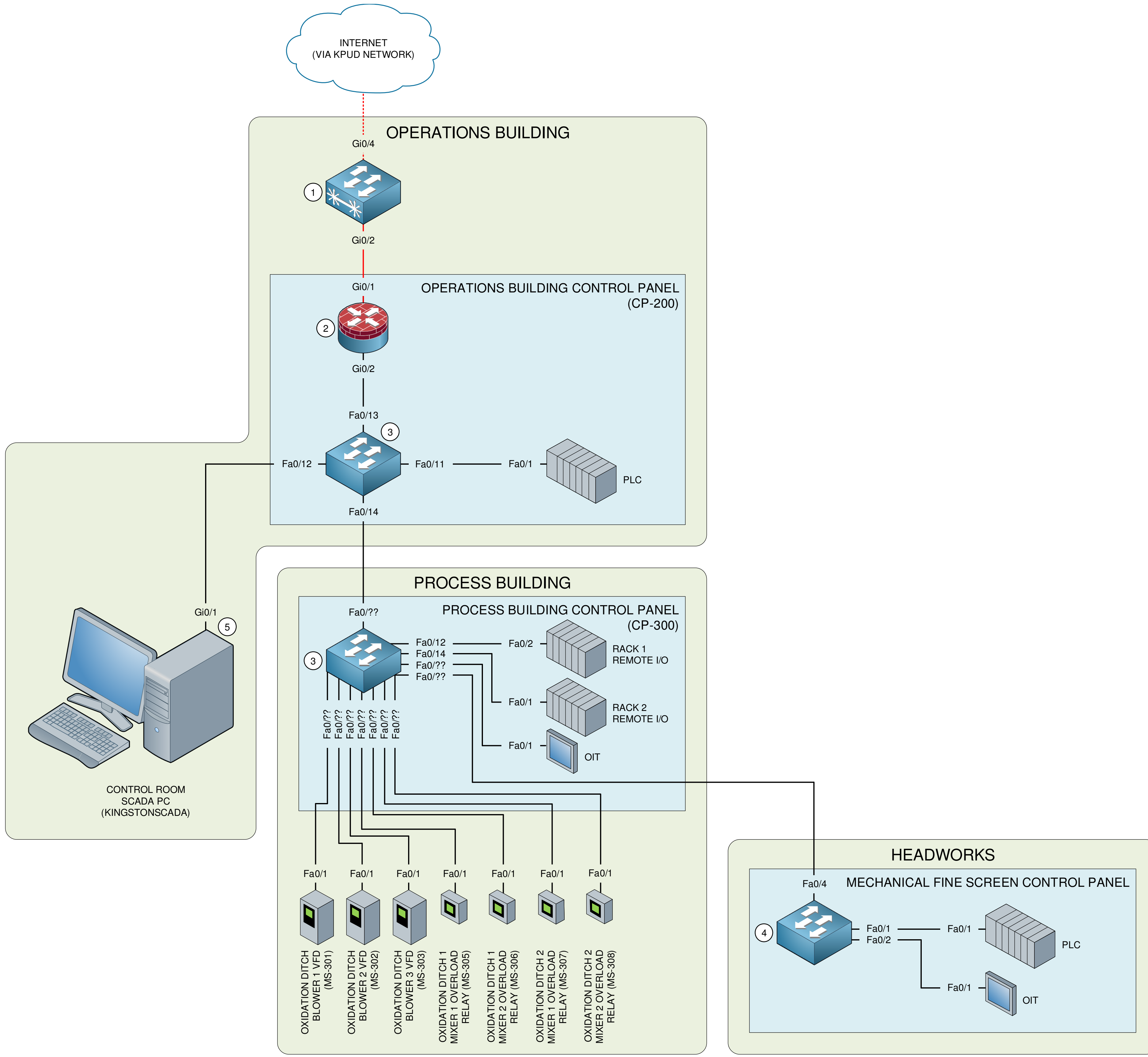
BAR IS 1 INCH ON ORIGINAL 22"x34" DRAWING 0 1"

GENERAL

CENTRAL KITSAP TREATMENT PLANT PHYSICAL NETWORK DIAGRAM

FIGURE B1

SHT 1 OF 4



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.

KEY NOTES:

1. KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
2. TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT
3. ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
4. ETHERNET ACCESS SWITCH, UNMANAGED
5. ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

- ETHERNET (COPPER)
- ETHERNET (COAXIAL)
- CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
- KINGSTON WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
- KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
- Fax/y — FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #
- Gix/y — GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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HDR Engineering, Inc.
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Fax: (425) 453-1707

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OA	xxx	KC-205-20	
CHECKED BY	DATE	CLIENT PROJECT NUMBER	

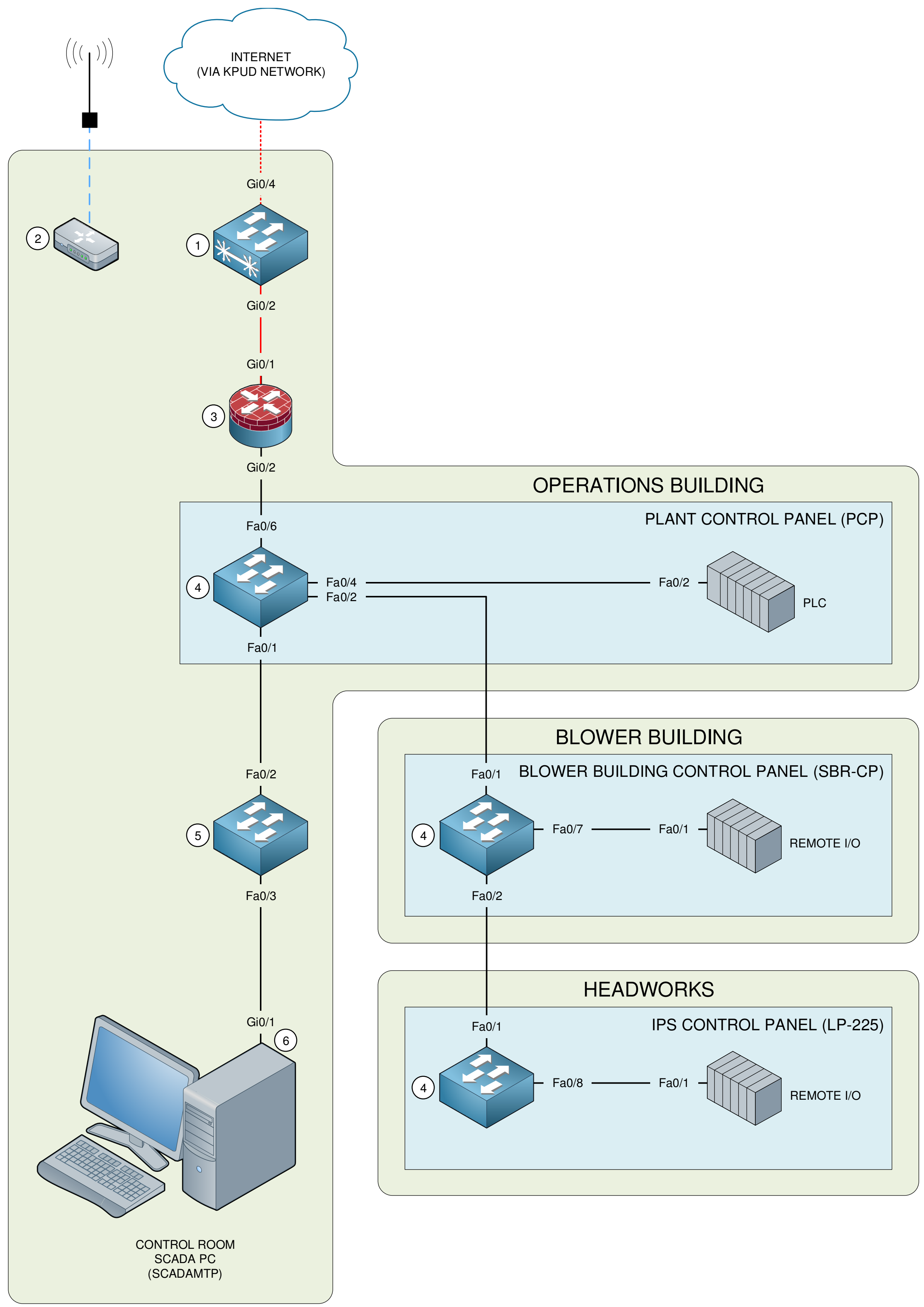
Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL
KINGSTON WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B2 SHT 2 OF 4



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.

KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
(2) ETHERNET RADIO FOR FUTURE COMMUNICATIONS WITH MANCHESTER AREA LIFT STATIONS. VHF FREQUENCY TO BE DETERMINED.
(3) TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT
(4) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
(5) ETHERNET ACCESS SWITCH, UNMANAGED
(6) ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

ETHERNET (COPPER)
ETHERNET (COAXIAL)
CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
MANCHESTER WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
KITSAP COUNTY SEWER UTILITY OT VHF RADIO WAN
Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #
Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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JMT	08/26/2020	10231983	
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OA	xxx	KC-205-20	
CHECKED BY	DATE	CLIENT PROJECT NUMBER	

KITSAP COUNTY WASHINGTON 18 57

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

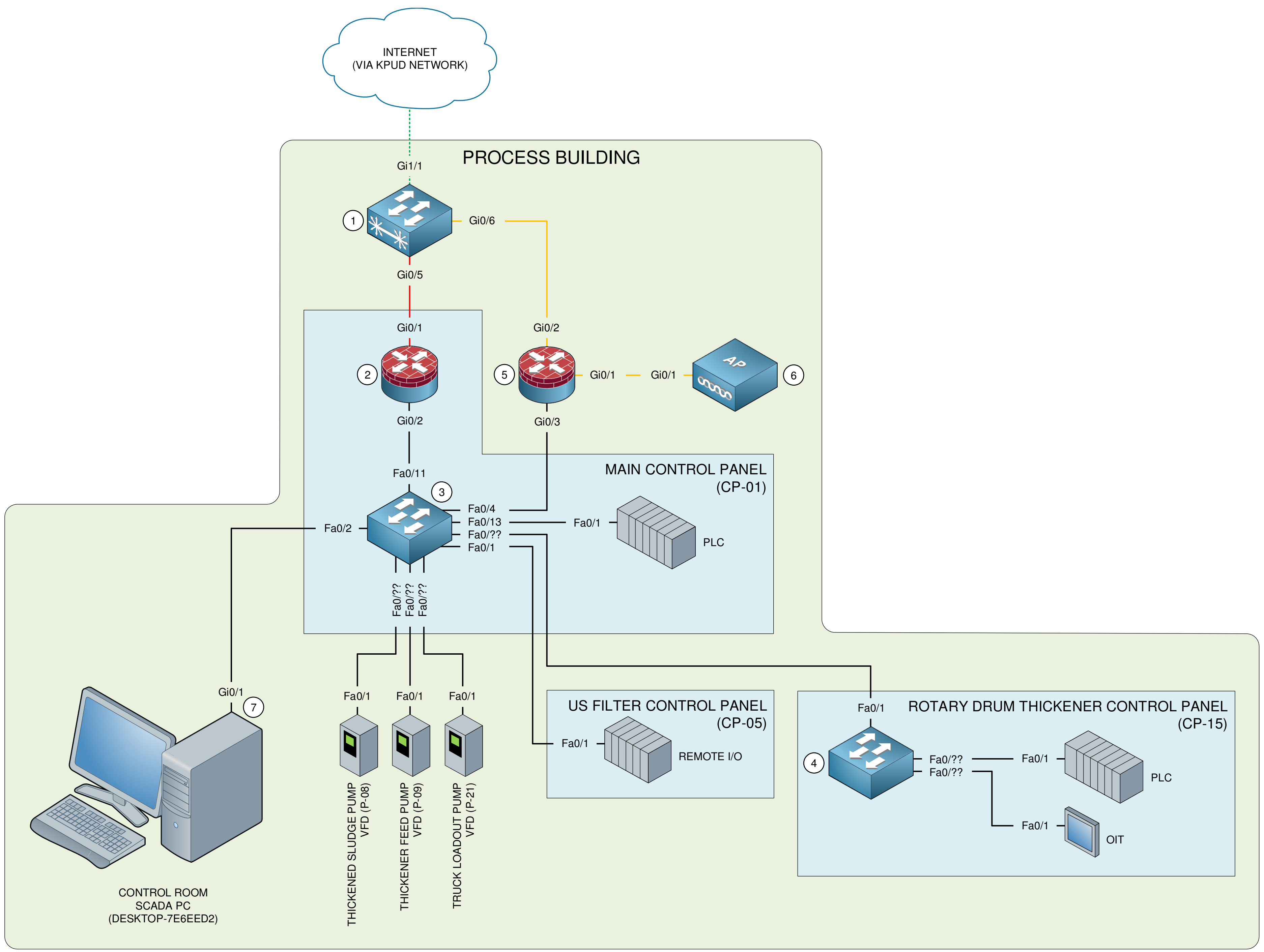
BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL

MANCHESTER WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B3

SHT 3 OF 4



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.

KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
(2) TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT
(3) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
(4) ETHERNET ACCESS SWITCH, UNMANAGED
(5) KITSAP COUNTY INFORMATION SERVICES (IS) SECURE GATEWAY (FIREWALL AND ROUTER)
(6) WIRELESS ACCESS POINT
(7) ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

- ETHERNET (COPPER)
- ETHERNET (COAXIAL)
- CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
- SUQUAMISH WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
- KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
- SUQUAMISH WWTP BUSINESS LAN
- TRUNKED NETWORKS

Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #

Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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JMT	08/26/2020	10231983	
DRAWN BY	DATE	HDR PROJECT NUMBER	
OA	xxx	KC-205-20	
CHECKED BY	DATE	CLIENT PROJECT NUMBER	

KITSAP COUNTY WASHINGTON 18 57

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL

SUQUAMISH WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B4

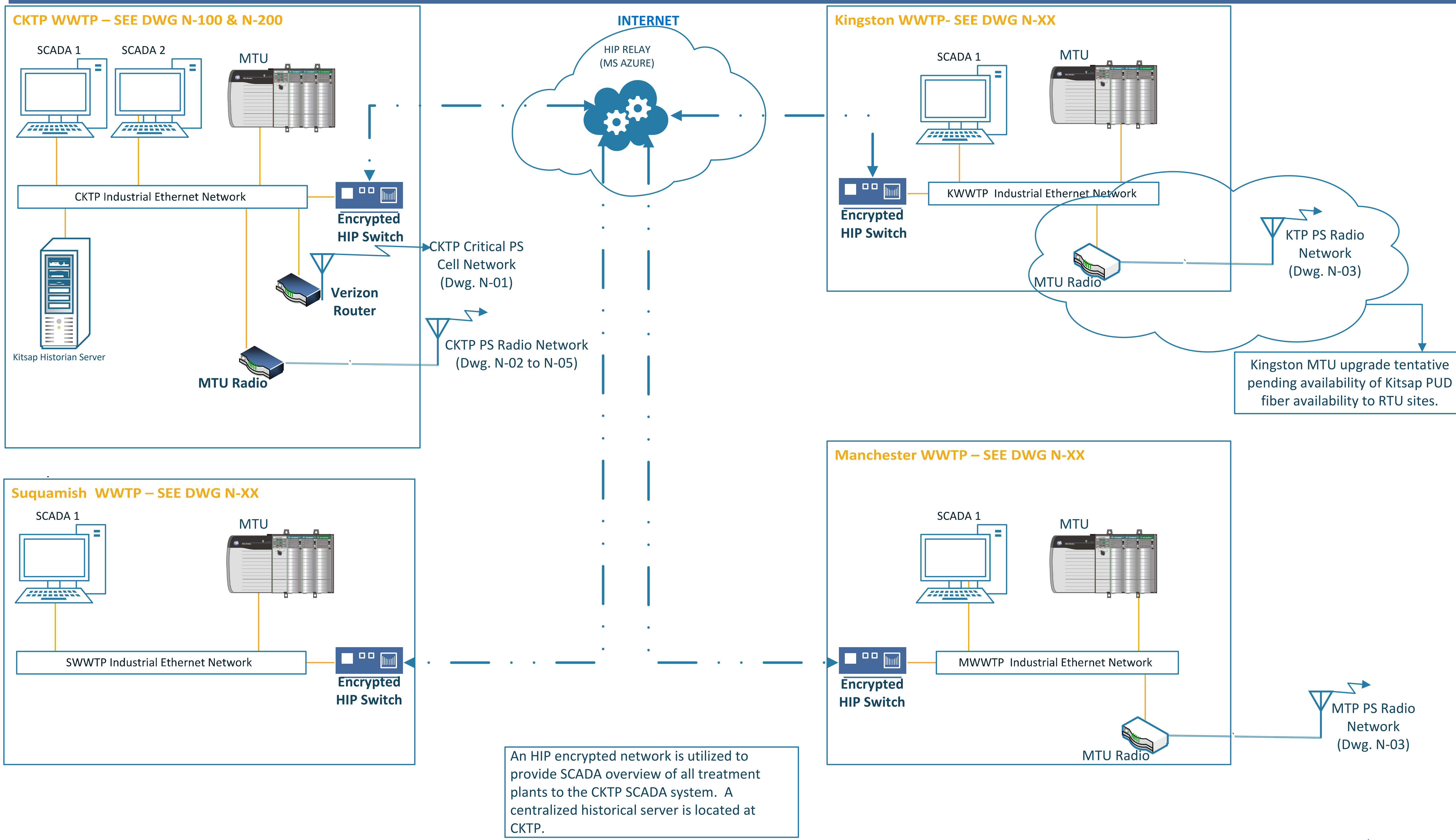
SHT 4 OF 4

Appendix C

QCC Network Design Diagrams

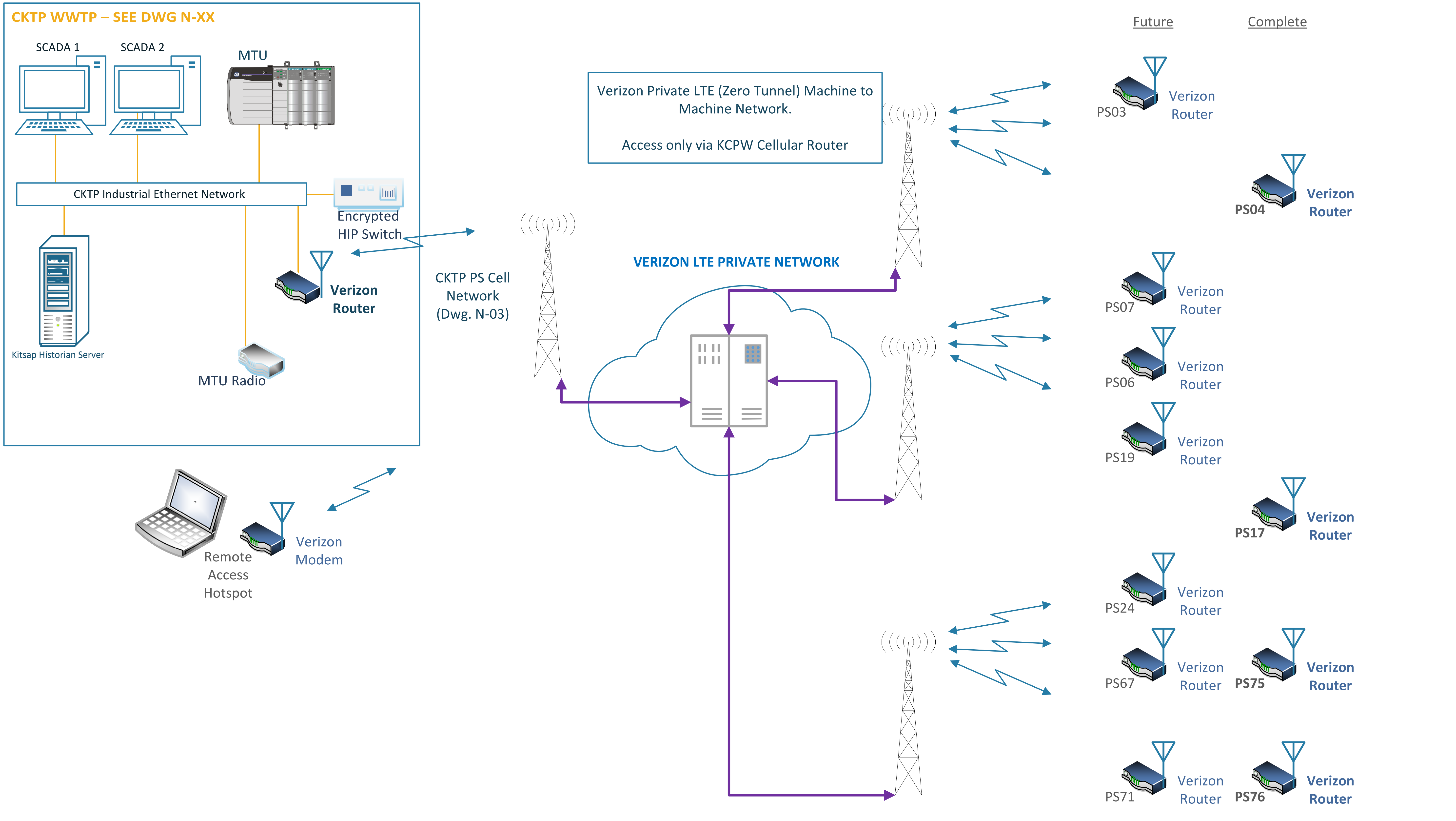
Wastewater Treatment Plants SCADA Network Overview

August 20, 2020



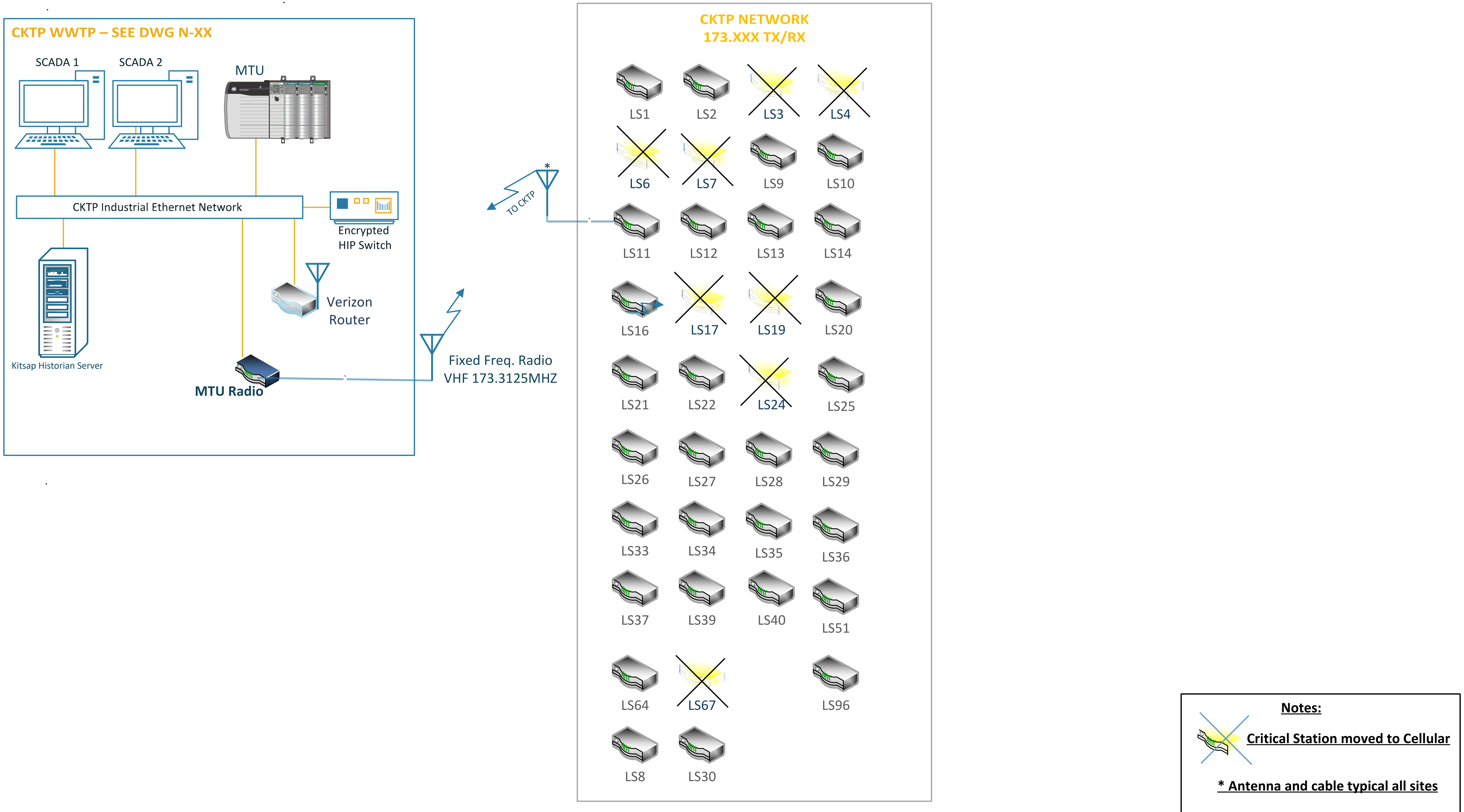
Pump Station Telemetry – Private Cellular (Critical Sites)

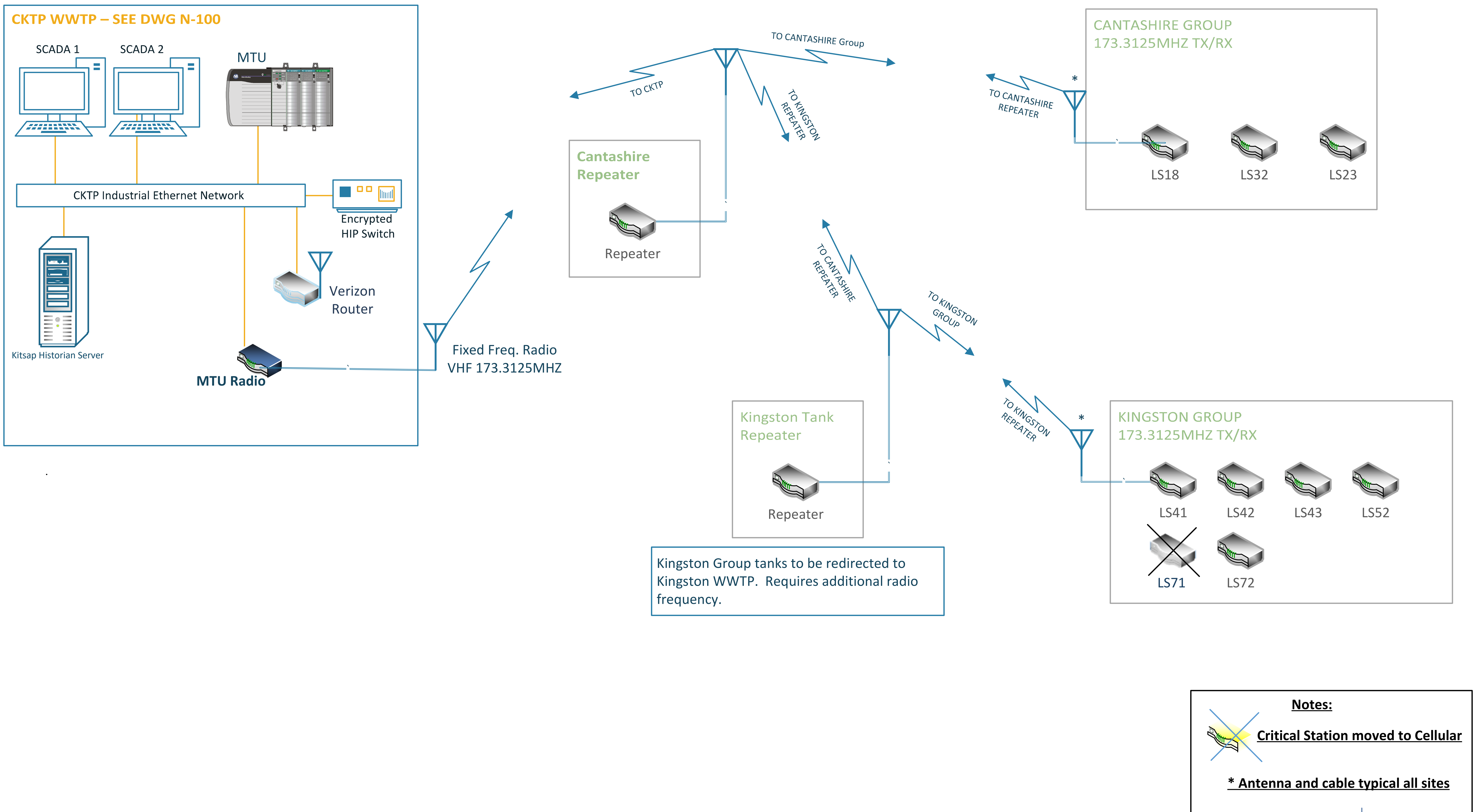
August 20, 2020



Pump Station Telemetry – Private Radio | CKTP Direct Sites

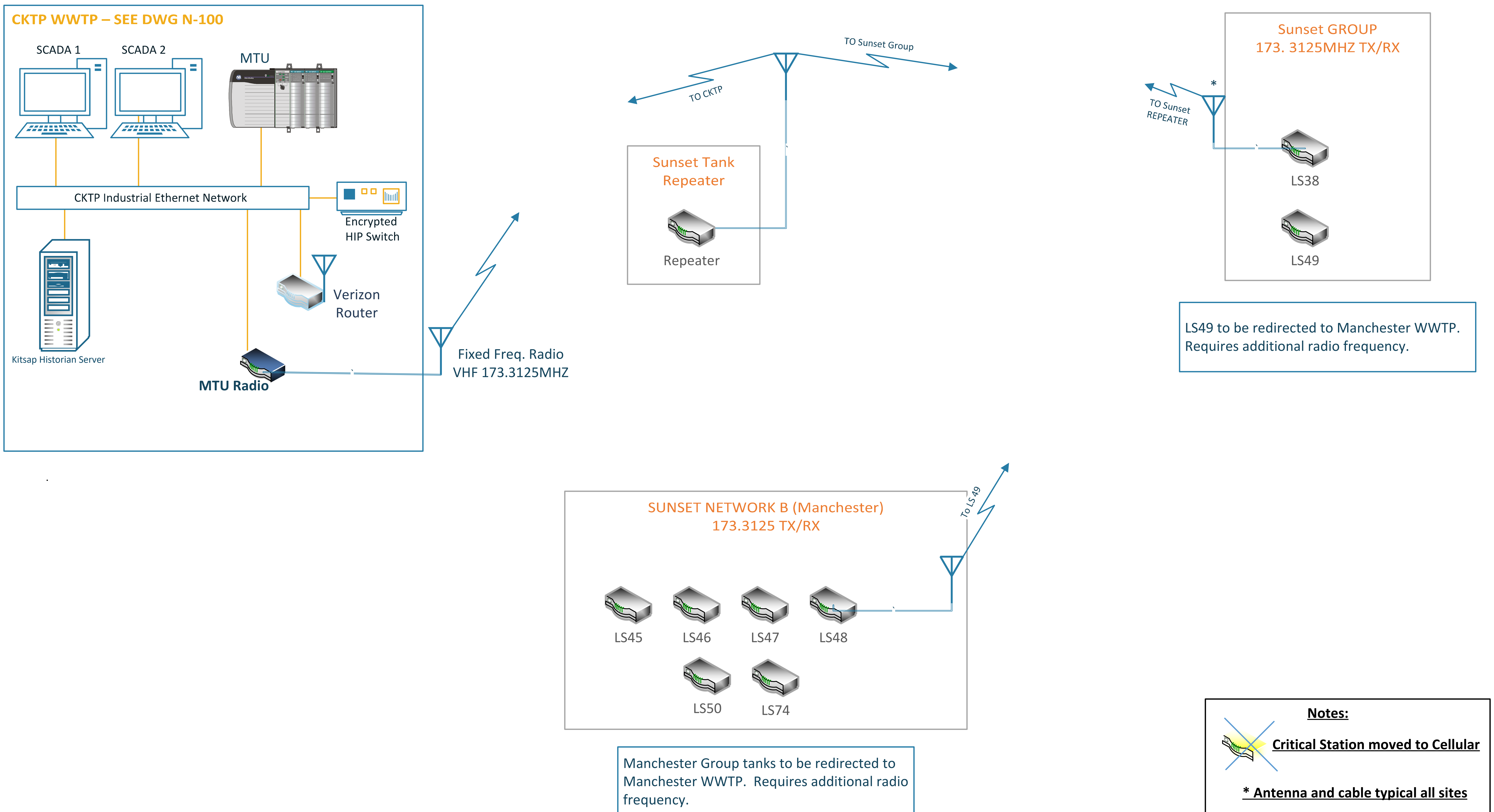
August 20, 2020

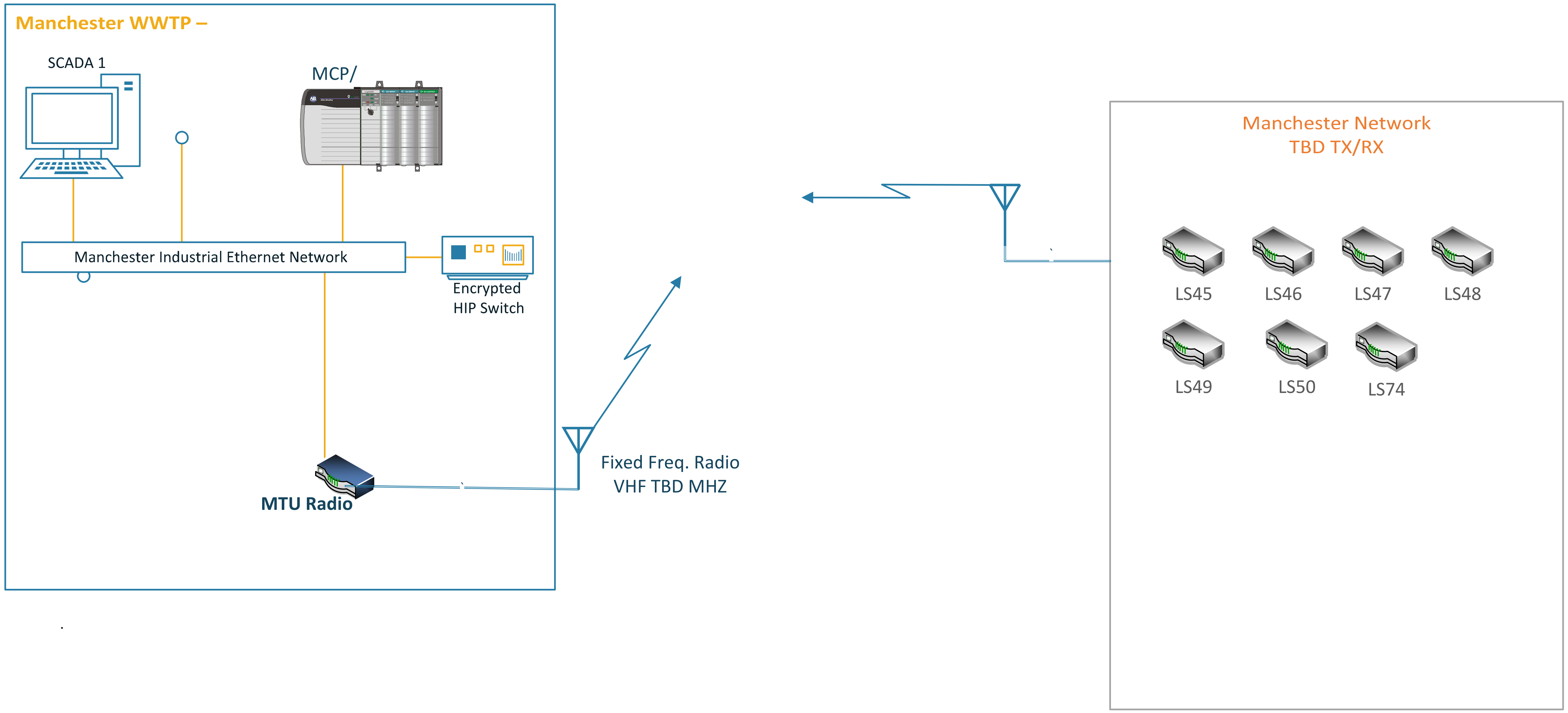



CKTP WWTP – SEE DWG N-100
SCADA 1
SCADA 2
MTU
CKTP Industrial Ethernet Network
Encrypted HIP Switch
Kitsap Historian Server
Verizon Router
MTU Radio
Fixed Freq. Radio VHF 173.3125MHZ
TO CKTP
TO CANTASHIRE Group
TO KINGSTON REPEATER
Cantashire Repeater
Repeater
TO CANTASHIRE REPEATER
TO KINGSTON GROUP
CANTASHIRE GROUP 173.3125MHZ TX/RX
TO CANTASHIRE REPEATER
*
LS18
LS32
LS23
Kingston Tank Repeater
Repeater
Kingston Group tanks to be redirected to Kingston WWTP. Requires additional radio frequency.
TO KINGSTON REPEATER
*
KINGSTON GROUP 173.3125MHZ TX/RX
LS41
LS42
LS43
LS52
LS71
LS72
Notes:
Critical Station moved to Cellular
* Antenna and cable typical all sites

Pump Station Telemetry – Private Radio | Sunset Repeater

August 20, 2020





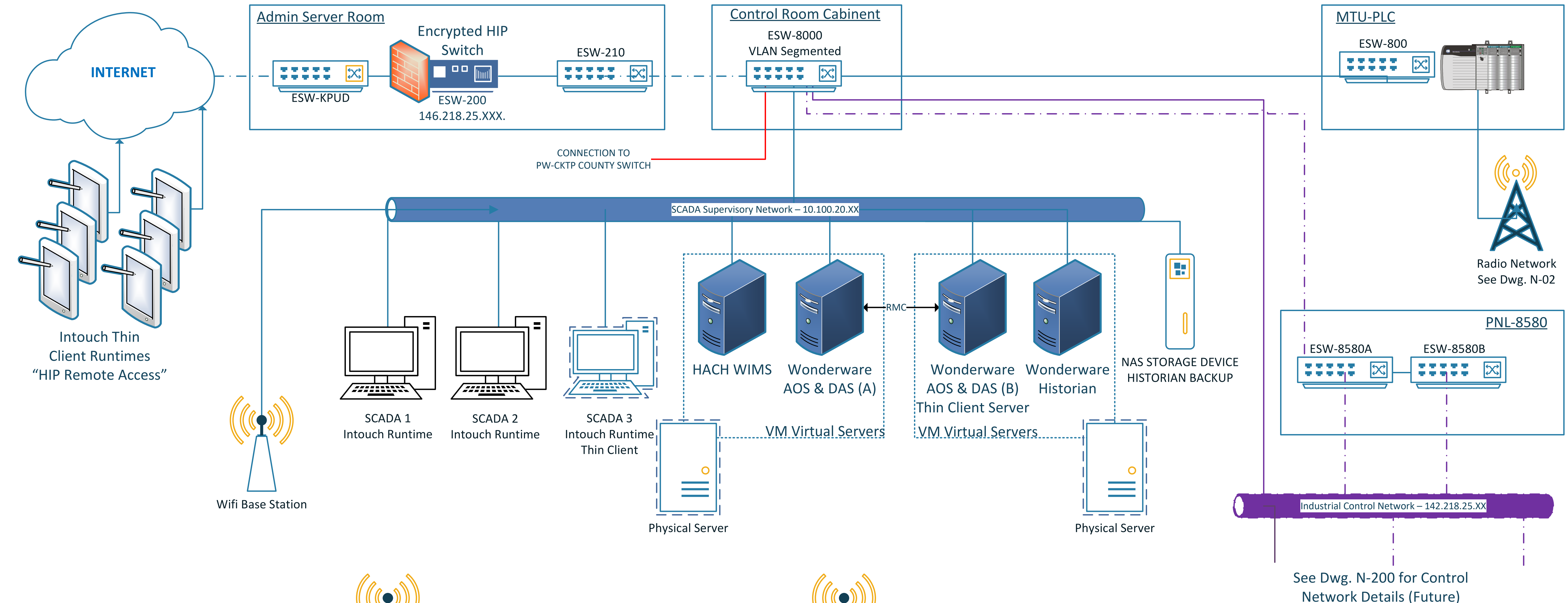
Notes:

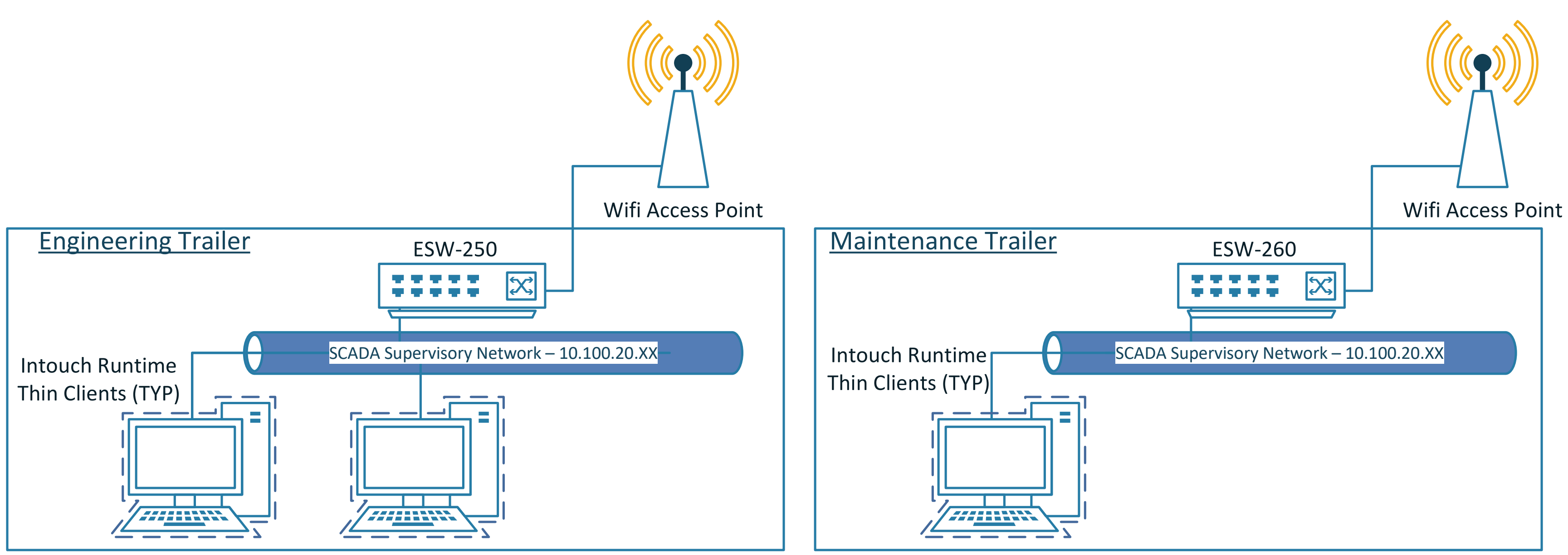
Critical Station moved to Cellular

*** Antenna and cable typical all sites**

CKTP INDUSTRIAL SCADA SUPERVISORY NETWORK - PRELIMINARY

August 20, 2020





Notes:

- New Supervisory SCADA network VLAN to be built for upgraded SCADA System. (IP Subnet TBD ex. 10.100.20.xx / 24). Configure existing ESW-8000 (Ntron 526FX) for overlapping VLAN port configurations per Ethernet Switch Schedule.
- Move MTU to new Supervisory SCADA Network.
- Configure HIP switch for remote user access to Thin Client Server.
- Configure HIP switch for remote WWTP for Historian connections.
- Control Panel HMI's to remain and be configured as thin clients.

Appendix D

WWTP PLC I/O Summary and PLC and Remote I/O Module Summary

WWTP PLC Hardwired I/O Summary

Data collected by:	John Thomas
Dates collected:	August 2020

Facility	Building/area	Panel tag	PLC panel description	# of remote I/O drops	AI (4-20 mA)	AO (4-20 mA)	DI (24 VDC)	DI (120 VAC)	DO (24 VDC)	DO (120 VAC)	DO (relay)	Total I/O points
CKTP	Aeration basins 3 & 4 electrical building	PNL 2939	Aeration basins 3 & 4 electrical building control panel	0	33	12	0	27	0	2	0	74
CKTP	Digester control building	PNL 6000	Digester control building control panel	0	10	0	28	0	0	12	0	50
CKTP	Digester gas conditioning facility	PNL 9201	Digester gas treatment control panel	0	11	1	17	0	0	0	8	37
CKTP	Headworks building	PNL 1050	Headworks control panel	0	11	2	0	46	0	0	5	64
CKTP	Power/blower building	PNL 2920	Power/blower building blower room control panel	0	26	9	0	35	0	9	0	79
CKTP	Power/blower building	PNL 2990	Power/blower building electrical room control panel	1	29	13	105	3	0	31	0	181
CKTP	Reclaimed water building	PNL 8200	Filter system control panel	0	13	0	5	0	0	0	13	31
CKTP	Reclaimed water building	PNL 8905	Reclaimed water control panel	0	20	6	0	42	0	5	0	73
CKTP	Septage receiving	PNL 5010	Raptor septage acceptance plant control panel	0	2	0	0	18	0	0	14	34
CKTP	Septage receiving		RACS operator interface control panel	0	1	0	2	0	0	0	1	4
CKTP	Sludge processing building	MCC 2984	MCC 2984 control section	5	29	18	30	58	8	9	29	181
CKTP	Sludge processing building	PNL 7110	Centrifuge 1 control panel	0	12	3	35	0	0	0	18	68
CKTP	Sludge processing building	PNL 7120	Centrifuge 2 control panel	0	10	3	32	0	0	0	18	63
CKTP	Sludge processing building	PNL 7225	Dewatering polymer panel	0	8	2	32	0	15	0	0	57
CKTP	UV disinfection	SCC 3100	UV system control center	0	7	0	15	0	11	0	0	33
CKTP	WAS thickening building	PNL 4012	Rotary drum thickener control panel	0	0	3	0	12	0	7	0	22
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel	0	7	1	0	12	0	0	8	28
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel	0	1	0	0	4	0	0	4	9
CKTP	WAS thickening building	PNL 4905	WAS thickening building control panel	0	22	1	0	45	0	23	0	91
				CKTP TOTALS:	252	74	301	302	34	98	118	1,179
Kingston WWTP	Operations building	CP-200	Operations building control panel	2	23	2	109	0	92	0	0	226
				Kingston WWTP TOTALS:	23	2	109	0	92	0	0	226
Manchester WWTP	Operations building	PCP	Plant control panel	2	10	5	0	79	0	12	24	130
				Manchester WWTP TOTALS:	10	5	0	79	0	12	24	130
Suquamish WWTP	Process building	CP-01	Main control panel	1	17	6	57	42	41	0	0	163
Suquamish WWTP	Process building	CP-15	Rotary drum thickener control panel	0	3	4	0	11	0	0	6	24
				Suquamish WWTP TOTALS:	20	10	57	53	41	0	6	187

WWTP PLC and Remote I/O Module Summary

Data collected by:	John Thomas
Dates collected:	August 2020

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
CKTP	MCC 2981	MCC 2981 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	0	16
					3	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	7	16
CKTP	MCC 2982	MCC 2982 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					2	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	MCC 2983	MCC 2983 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	15	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	14	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	4	16
					4	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	15	16
					5	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	7	16
CKTP	MCC 2984	MCC 2984 control section	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	12	32
					2	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	9	16
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
			RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	5	16
					3	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	2	16
CKTP	PNL 1050	Headworks control panel	PLC	1	0	SLC 5/05	1747-L552	Controller	EtherNet/IP	N/A	N/A
					1	SLC 500 I/O	1747-SDN	Scanner	DeviceNet	N/A	N/A
					2	SLC 500 I/O	1747-SDN	Scanner	DeviceNet	N/A	N/A
					3	SLC 500 I/O	1746-IA16	DI	120 VAC	16	16
					4	SLC 500 I/O	1746-IA16	DI	120 VAC	16	16
					5	SLC 500 I/O	1746-IA16	DI	120 VAC	14	16
					7	SLC 500 I/O	1746-OW16	DO	Relay (VAC/VDC)	5	16
					9	SLC 500 I/O	1746-NI8	AI	4-20 mA	8	8
					10	SLC 500 I/O	1746-NI8	AI	4-20 mA	3	8
					12	SLC 500 I/O	1746-NO4I	AO	4-20 mA	2	4
CKTP	PNL 2002	Aeration blower 2 control panel	RIO	1	0	POINT I/O	1734-AENT/B	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	POINT I/O	1734-OE2C/C	AO	4-20 mA	2	2
					2	POINT I/O	1734-IA4/C	DI	120 VAC	3	4
CKTP	PNL 2920	Power/blower building blower room control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					7	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
				2	9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	5	16
					14	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	4	16
CKTP	PNL 2939	Aeration basins 3 & 4 electrical building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					2	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					6	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
				2	9	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					10	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					11	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					13	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16
					14	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					15	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					16	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	2	16
CKTP	PNL 2990	Power/blower building electrical room control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	28	32
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	31	32
					3	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	30	32
					4	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	16	32
					5	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	15	16
					6	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	16	16
				2	7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					8	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					9	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					10	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					11	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					13	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
CKTP	PNL 4012	Rotary drum thickener control panel	PLC	1	0	CompactLogix 5370	1769-L30ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					2	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	7	16
					3	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	3	8
CKTP	PNL 4050	Polymer blending control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	3	4
					5	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	1	4
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	8	16
CKTP	PNL 4080	Polymer feed control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	1	4

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	4	16
					3	Bulletin 1769 Compact I/O	1769-OW8/A	DO	Relay (VAC/VDC)	4	8
CKTP	PNL 4905	WAS thickening building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	1	4
				2	8	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	15	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	11	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
CKTP	PNL 5010	Raptor septage acceptance plant control panel	PLC	1	0	MicroLogix 1100	1763-L16AWA	AI	4-20 mA	2	2
								DI	120 VAC	10	10
								DO	Relay (VAC/VDC)	6	6
					1	MicroLogix I/O	1762-IA8	DI	120 VAC	8	8
					2	MicroLogix I/O	1762-OW8	DO	Relay (VAC/VDC)	8	8
CKTP	PNL 6000	Digester control building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	18	32
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	10	32
					3	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	2	4
CKTP	PNL 7105	PLC 7105 I/O rack	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	6	16
					2	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	1	16
					3	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					5	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
				2	8	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					10	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
					11	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	0	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					13	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					14	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					15	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
CKTP	PNL 7110	Centrifuge 1 control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					3	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					8	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	PNL 7120	Centrifuge 2 control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					3	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	10	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					8	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	PNL 7225	Dewatering polymer panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					3	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16
					4	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	13	16
					5	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	2	16
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					8	Bulletin 1769 Compact I/O	1769-OF2/A	AO	4-20 mA	2	2
CKTP	PNL 8200	Filter system control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	5	16
					2	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	5	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
CKTP	PNL 8905	Reclaimed water control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					7	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
				2	9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	3	16
					14	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	2	16
CKTP	PNL 9201	Digester gas treatment control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	2	16
					3	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	8	16
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	1	4
CKTP	SCC 3100	UV system control center	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					1	ProSoft Technology	MV169E-MBS/A	Comm	Modbus RTU	N/A	N/A
					2	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	4	4
					3	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	11	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
CKTP		Master station CTU (VHF PLC)	PLC	1	0	CompactLogix L3x	1769-L35E	Controller	EtherNet/IP	N/A	N/A
CKTP		Master station CTU (Cellular PLC)	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
CKTP		RACS operator interface control panel	PLC	1	0	MicroLogix 1100	1763-L16BWA	AI	4-20 mA	1	2
								DI	24 VDC	2	10
								DO	Relay (VAC/VDC)	1	6
Kingston WWTP	CP-200	Operations building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	6	16
					3	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	15	16
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	6	16
					5	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	0	4
Kingston WWTP	CP-300	Process building control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					3	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	5	16
					7	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					8	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	1	16
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					10	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
			RIO	2	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					2	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					3	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	9	16
					5	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	14	16
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					8	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					10	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	2	4
Manchester WWTP	PCP	Plant control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	7	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	6	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					4	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	3	16
					5	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16
					7	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					8	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	5	8
					9	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
					10	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					11	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	2	8
Manchester WWTP	LP-225	Influent pump station control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	7	16
					4	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8
					5	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	4	8
					6	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	0	8
					7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					8	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	3	8
Manchester WWTP	SBR-CP	Aeration basins control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	6	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	0	16
					3	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	3	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	1	8
Suquamish WWTP	CP-01	Main control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	5	8
					3	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	2	4
					5	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	1	16
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	16	16
					7	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	14	16
					8	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					9	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	4	16
Suquamish WWTP	CP-05	US Filter control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	26	32
					3	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	31	32
					4	Bulletin 1769 Compact I/O	1769-OB32/A	DO	24 VDC	32	32
					5	Bulletin 1769 Compact I/O	1769-OB32/A	DO	24 VDC	5	32
Suquamish WWTP	CP-15	Rotary drum thickener control panel	PLC	1	0	CompactLogix 5370	1769-L30ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					2	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4

TM-2: SCADA Use Cases and Operational Needs

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

April 30, 2021

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-2: SCADA Use Cases and Operational Needs

April 30, 2021

Prepared by:

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

Tables

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Abbreviations

A	ampere(s)
AAA	authentication, authorization, and accounting
AC	alternating current
ACP	access control policy
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
AOI	Add-on Instruction
AUP	acceptable use policy
BI	Business Intelligence
BNR	biological nutrient removal
BOD	biological oxygen demand
CIP	capital improvement program
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
CMP	change management policy
CO_2	carbon dioxide
COD	chemical oxygen demand
County	Kitsap County
CTU	central telemetry unit
DHS	U.S. Department of Homeland Security
DLR	device-level ring
DO	dissolved oxygen
DMR	Discharge Monitoring Report
DMZ	demilitarized zone
DNP3	Distributed Network Protocol 3
EMS	energy management system
eO&M	electronic operation and maintenance
ERP	enterprise resource planning
ft^3	cubic foot
FVNR	full-voltage non-reversing
FVR	full-voltage reversing
GbE	gigabit(s) Ethernet
GBT	gravity-belt thickener
GE	General Electric
H_2S	hydrogen sulfide
HDR	HDR Engineering, Inc.
HIM	human interface module
HIP	Host Identity Protocol
HMI	human-machine interface
HOA	Hand-Off-Auto
HPHMI	high-performance human-machine interface
hp	horsepower
HRT	hydraulic retention time
HTML5	Hypertext Markup Language revision 5
HTTPS	Hypertext Transfer Protocol Secure
Hz	hertz
I&C	instrumentation and controls
IAPP	International Association of Privacy Professionals

ICS	industrial control system
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IGMP	Internet Group Management Protocol
I/O	input/output
IP	Internet Protocol
IR	infrared
IS	Information Services
ISA	International Society of Automation
ISP	information security policy
IT	Information Technology
KPI	key performance indicator
KPUD	Kitsap Public Utility District
kVA	kilovolt-ampere(s)
kVAR	kilovolt-ampere(s) reactive
kW	kilowatt(s)
kWh	kilowatt-hour(s)
KWWTP	Kingston Wastewater Treatment Plant
LAN	local area network
lb	pound
LEL	lower explosive limit
LIMS	laboratory information management system
mA	milliampere(s)
Master Plan	Sewer Utility SCADA Master Plan
Mbps	megabit(s) per second
MCC	motor control center
MDM	mobile device management
MFA	multi-factor authentication
MG	million gallons
M&O	maintenance and operations
MQTT	MQ Telemetry Transport
MTU	master telemetry unit
MWWTP	Manchester Wastewater Treatment Plant
N/A	not applicable
NAAT	North American Access Technologies, Inc.
NAS	network attached storage
NEC	National Electrical Code
NIST	National Institute of Standards and Technology
OIT	operator interface terminal
O&M	operation and maintenance
OM1	Optical Multi-mode 1
OM3	Optical Multi-mode 3
OOP	object-oriented programming
OSI	Open Systems Interconnection
OT	Operational Technology
P	phosphorus
P&ID	piping and instrumentation diagram
PC	personal computer
PDU	power distribution unit
PE	population equivalent
PF	power factor
PID	proportional-integral-derivative
PLC	programmable logic controller
PNL	panel
PS	pump station

QCC	Quality Controls Corporation
QoS	Quality of Service
RACS	Raptor Acceptance Control System
RAS	return activated sludge
RDP	Remote Desktop Protocol
RDS	Remote Desktop Services
RDT	rotary-drum thickener
RIO	remote input/output
RTU	remote telemetry unit
RVSS	reduced-voltage soft starter
SaaS	software as a service
SANS	SysAdmin, Audit, Network, and Security
SBR	sequencing batch reactor
SCADA	supervisory control and data acquisition
SD	Secure Digital
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SIM	subscriber identification module
SNMP	Simple Network Management Protocol
SOP	standard operating procedure
SPB	solids processing building
SRT	solids retention time
SWGR	switchgear
SWWTP	Suquamish Wastewater Treatment Plant
Syslog	System Logging Protocol
TCP	Transmission Control Protocol
THD	total harmonic distortion
TM	technical memorandum
TN	total nitrogen
TS	total solids
TSS	total suspended solids
TWAS	thickened waste activated sludge
UDT	User-defined Data Type
UPS	uninterruptible power supply
UTP	unshielded twisted pair
UV	ultraviolet
V	volt(s)
VA	volt-ampere(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VFD	variable-frequency drive
VHF	very high frequency
VLAN	virtual local area network
VM	virtual machine
VNC	Virtual Network Computing
VPN	virtual private network
W2	potable water
W3	service water
WAN	wide-area network
WAS	waste activated sludge
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This SCADA Use Cases and Operational Needs Technical Memorandum (TM)-2 documents Kitsap County (County) Public Works Sewer Utility Division's (Sewer Utility's) core objectives for its supervisory control and data acquisition (SCADA) system along with the system functionality required to meet the organization's future operational needs. TM-2 also includes recommended improvements for the SCADA system to resolve risks and deficiencies identified in TM-1 and gaps between existing functionality and the Sewer Utility's future needs. The content of TM-2 is based on information that HDR Engineering, Inc. (HDR) obtained from the County during workshops and staff interviews and field data already collected by HDR during site assessment visits conducted in August 2020.

1.1 Approach

TM-2 completes the second phase of the Sewer Utility SCADA Master Plan (Master Plan), assessing the future use and needs of the SCADA system with recommendations on how to fulfill identified future requirements. To begin this phase of the Master Plan, HDR facilitated an industry trends and core objectives workshop to provide a high-level overview of challenges that similar water and wastewater utilities are facing, currently available technology, and industry best practices that the Sewer Utility may wish to consider for its future SCADA system. The Sewer Utility was asked to prepare a list of core objectives for its future SCADA system prior to the workshop, and the latter half of the workshop was used to discuss these objectives and further define future system requirements.

The workshop was followed by several videoconference interviews with individuals responsible for operating and maintaining the Sewer Utility infrastructure. These interviews were used to discuss Sewer Utility staff experiences with the existing SCADA system, opportunities for increased automation, and future SCADA system functionality that they would find most valuable. The interviews also covered SCADA-derived data that are important to the various stakeholders and the information that these individuals would like to have more readily accessible in the future.

1.2 Technical Memorandum Organization

This subsection describes the structure of the TM and the annotation used to emphasize risks and deficiencies and recommended improvements.

1.2.1 Structure

TM-2 is organized into 11 sections, as described below.

Section 1: Introduction summarizes TM organization and the approach taken for the second phase of the Master Plan in preparation for TM-2.

Section 2: Industry Trends and Core Objectives Workshop includes an overview of the industry trends and core objectives workshop that HDR facilitated with Sewer Utility stakeholders along with key findings from the workshop.

Section 3: Core Objectives for Future SCADA System documents the core objectives for the Sewer Utility's future SCADA system.

Section 4: Sewer Utility Staff Interviews includes an overview of the Sewer Utility staff interviews that HDR facilitated with Sewer Utility stakeholders along with key findings from these interviews.

Section 5: Network Architecture: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its Operational Technology (OT) network architecture and describes the information and functionality that Sewer Utility staff would like to obtain from the OT network in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the OT network.

Section 6: ICS Hardware: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its industrial control system (ICS) hardware and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS hardware in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS hardware.

Section 7: ICS Software: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its ICS software and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS software in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS software.

Section 8: ICS Documentation: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its ICS documentation and describes the information that Sewer Utility staff would like to develop and maintain. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for ICS documentation.

Section 9: Other Software Packages: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to non-ICS software packages and describes the information and functionality that Sewer Utility staff would like to obtain from the software in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for non-ICS software.

Section 10: Risks and Deficiencies with Recommended Improvements Summary compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in TM-1 and previous sections of TM-2 and pairs them with the recommended improvement(s) that will mitigate the risk or resolve the deficiency.

Section 11: References lists the supporting source materials cited in TM-2.

1.2.2 Means of Emphasis

In any subsection where a risk or deficiency is identified, a summary risk or deficiency description is presented at the end of that subsection, as shown below, so that these risks and deficiencies are easily visible and can be quickly located.

> ✸ Identified risks and deficiencies are shown in condensed highlighted form like this throughout the TM.

In any subsection where a recommended improvement is proposed that will address one or more identified risks and deficiencies, a summary recommended improvement description is presented at the end of that subsection, as shown below, so that these recommended improvements are easily visible and can be quickly located.

> ✪ Recommended improvements are shown in condensed highlighted form like this throughout the TM.

Risks and deficiencies from TM-1 and TM-2 and the proposed recommended improvements are compiled in Section 10 in Table 10-2. The table is structured to associate the risks and deficiencies with the recommended improvements being proposed as a means of mitigating them.

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2 Industry Trends and Core Objectives Workshop

This section includes an overview of the industry trends and core objectives workshop that HDR facilitated with Sewer Utility stakeholders along with key findings from the workshop.

On November 16, 2020, HDR facilitated an industry trends and core objectives workshop with key stakeholders representing Sewer Utility management, operations, instrumentation and controls (I&C) technicians, and construction management. The goal of the workshop was to present currently available technology, applicable industry best practices, and modern approaches to SCADA system development and utility management for the Sewer Utility to consider before the SCADA master planning effort shifted to discussions that would document the future requirements of the SCADA system. The workshop was then used to discuss the Sewer Utility's core objectives for its SCADA system and further define some of the future requirements. The Sewer Utility capital improvement program (CIP) schedule was also discussed to identify established CIP projects where there may be an opportunity to implement recommended SCADA system improvements. Key presentation points from the workshop are highlighted in the following subsections.

2.1 Industry Challenges

The water and wastewater industry faces significant challenges including aging assets, budget constraints, stricter regulations, a workforce gap, and cybersecurity. Utilities with older programmable logic controller (PLC) technology now depend on systems that have reached the end of their useful life and/or are experiencing manufacturers phasing out technical support and replacement parts for the product line. Product life cycles for several ICS hardware and software elements are becoming shorter, requiring more frequent upgrades. The industry's migration to Internet Protocol (IP)-based networks and open operating systems (i.e., Windows) has introduced new cybersecurity risks and new skill-set requirements to mitigate them. Available technology promises to provide great value, but it is often complex and rapidly evolving. Many utilities are finding that they do not have enough staff with the necessary skill sets to keep up with current technology and address cybersecurity while continuing to operate and maintain the utility infrastructure.

To put new technology to work and modernize their control systems, utilities are also having to revisit their approach to data. Many utilities are data rich and information poor. Data are commonly trapped in silos that are difficult to access and that present barriers to combining diverse data sets to pursue the operational insights that will help the Sewer Utility improve. In the interest of raising current operational baselines, many utilities are pausing to look beyond more immediate needs so as to develop a road map toward an improved data program.

2.2 Current Technology

HDR presented a selection of current technology for the Sewer Utility to consider as potential elements for its future SCADA system. Because the Sewer Utility has already standardized on Allen-Bradley PLCs and Wonderware (now called AVEVA) HMI and historian software, the workshop highlighted current offerings from Rockwell Automation and AVEVA in addition to other relevant hardware and software technology. Some of these current offerings included:

- Allen-Bradley's latest ControlLogix 5580 and CompactLogix 5380 controller families
- Software elements of AVEVA System Platform 2020
- Motor controllers with Ethernet communication capability and their role in energy management and predictive maintenance programs
- Remote sensor solutions for conveyance applications
- Data analytics and visualization software platforms
- Offline and online applications of wastewater treatment plant (WWTP) models to derive operational set points

To demonstrate how data analytics and visualization software tools can combine diverse data sets to produce insightful visualizations, HDR presented two dashboards it developed using Sewer Utility historian and laboratory data obtained during the condition assessment phase of the Master Plan. Screen captures of the two dashboards are shown in Figure 2-1 and Figure 2-2. It should be noted that HDR made some broad assumptions to generate the liquid stream capacity summary portion of the dashboard depicted in Figure 2-1. The focus of the workshop's dashboard presentation was not about identifying actual process or operational deficiencies, but to provide Sewer Utility staff with the opportunity to see data analytics and visualization software in action and, hopefully, to spark some ideas for other insights staff would like to pursue in the future.

Figure 2-1. CKTP liquid stream and solids removal summary dashboard

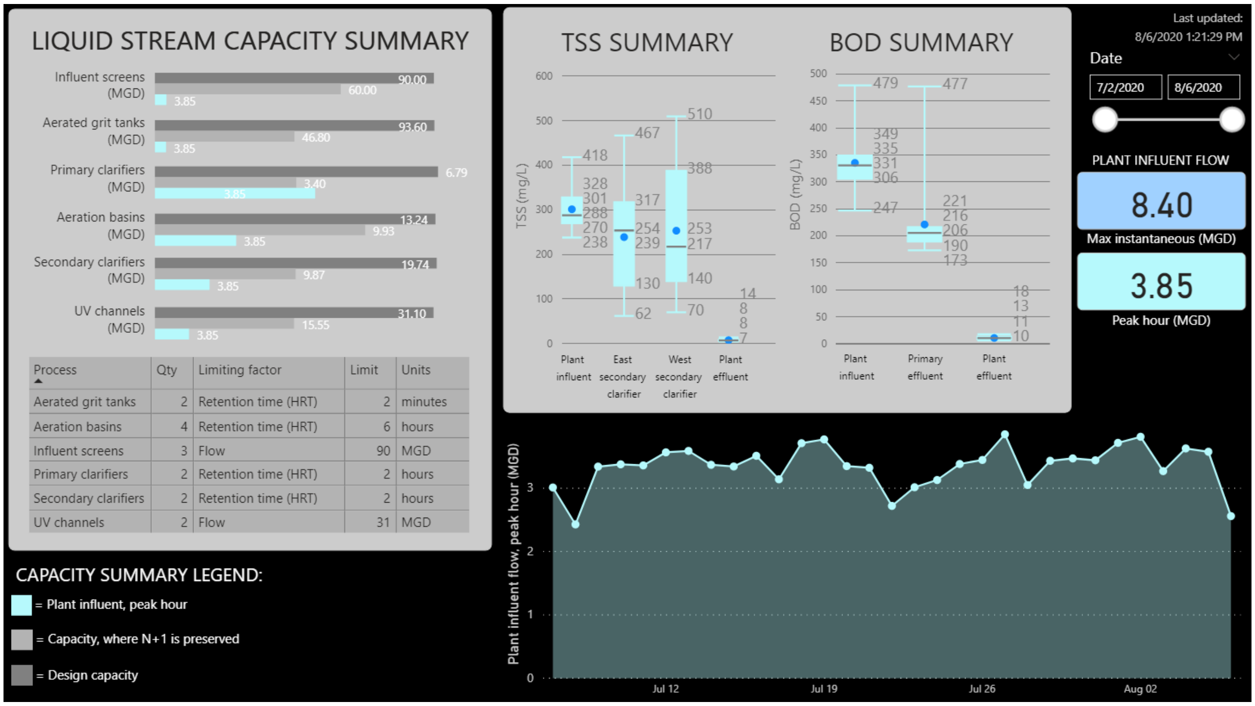
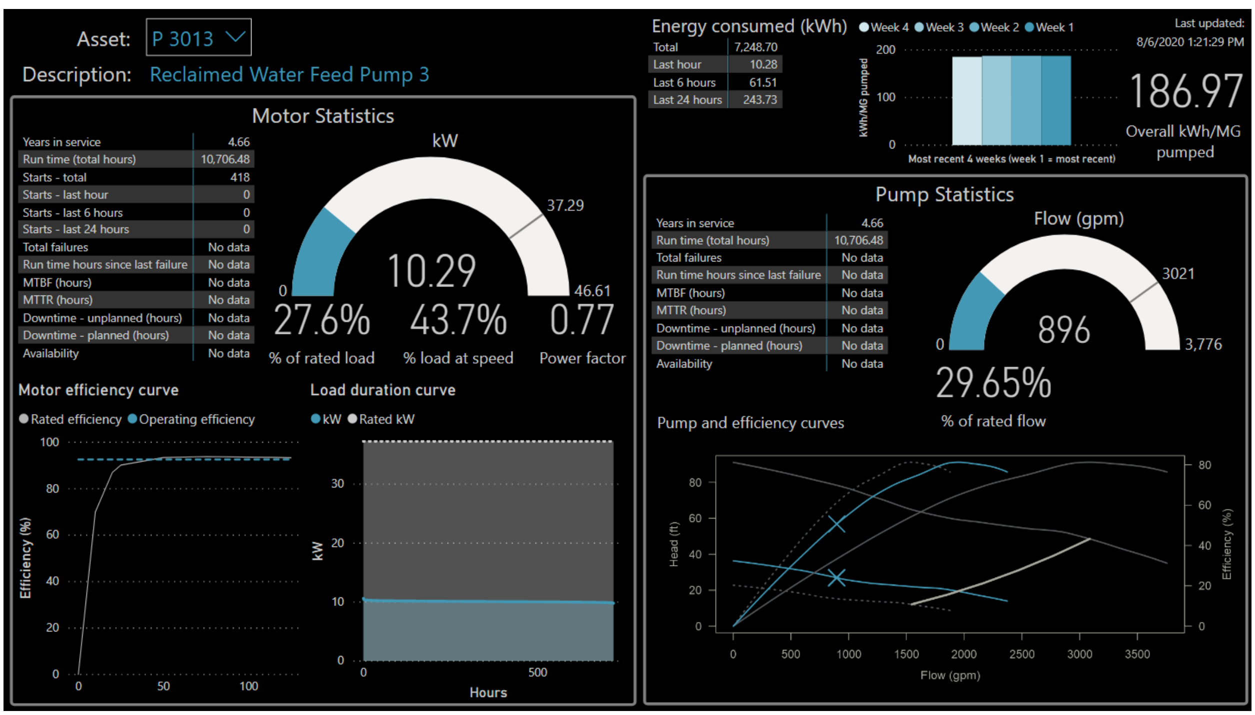


Figure 2-2. Pump asset health and performance dashboard



2.3 Best Practices

The best practices segment of the workshop focused on some of the approaches other utilities have taken to improve their operations that are considered industry best practices and would likely benefit the Sewer Utility. HDR discussed high-performance human-machine interface (HPHMI) principles that are guiding human-machine interface (HMI) screen development throughout much of the industry and have been integrated into industry standards like International Society of Automation (ISA) 101.01 (ANSI/ISA 2015). Examples of HPHMI concepts and how they have been applied to HMI platforms at other client facilities were presented in a before-and-after fashion to illustrate the migration from traditional to HPHMI screens. HDR emphasized the benefits of virtualization for ICS servers and presented an industrial demilitarized zone (DMZ) network architecture as a secure method for bridging the Sewer Utility Operational Technology (OT) and Information Technology (IT) networks. HDR also described how store-and-forward and report-by-exception functionality inherent to communication protocols like Distributed Network Protocol 3 (DNP3) and MQ Telemetry Transport (MQTT) could eliminate data gaps and reduce delays in alarm reporting for the Sewer Utility's remote pump stations.

2.4 Core Objectives for Future SCADA System

Prior to the workshop, the Sewer Utility provided HDR with a draft list of core objectives for its future SCADA system. These core objectives were discussed during the workshop to allow Sewer Utility staff to describe some of the drivers behind the objectives in more detail. The workshop participants also discussed various operational constraints and requirements in order to develop quantitative goals for certain elements of the future system, such as uninterruptible power supply (UPS) battery backup time requirements. Discussing the objectives also allowed the Sewer Utility to make some preliminary decisions on how certain technologies would be applied. For example, Sewer Utility staff concluded that they would like to migrate toward HPHMI graphics screens and standardize on Ethernet motor controllers, using hardwiring for the core control and monitoring signals and Ethernet data exchange for power and energy parameters and detailed alarm and warning information.

2.5 CIP Schedule and Budget Constraints/Opportunities

In an effort to identify projects in the CIP schedule that may be candidates for implementing some of the improvements recommended in the Master Plan, HDR walked through several pump station and WWTP projects included in Sewer Utility planning documents. Sewer Utility staff provided project status updates and, based on staff feedback, the Sewer Utility Six-Year Capital Facilities Plan 2020–2025 was determined to be the most relevant planning document (Sewer Utility 2019). Of the established projects at remote pump stations, the pump station upgrade planned for pump station (PS)-4 was determined to be a good candidate for a pilot project or first-out initiative for the remote pump station ICS infrastructure given the project's position in the CIP schedule.

2.6 Workshop Findings

Key findings that came out of the industry trends and core objectives workshop helped establish some of the requirements for the future Sewer Utility SCADA system. Some of these findings re-emphasized risks and deficiencies documented in TM-1. Table 2-1 provides a summary of the industry trends and core objectives workshop findings.

Table 2-1. Industry trends and core objectives workshop findings summary

Topic	Findings
Staff technological proficiency	Advancing the Sewer Utility's ICS technology without improving the current level of technological proficiency among Sewer Utility staff members is not likely to be successful. Staff will require training on new and existing technology. Documenting preferred workflows and standard operating procedures (SOPs) for the ICS technology that staff interact with would help supplement the training and provide staff with a self-service resource when they need a refresher.
	The Master Plan should identify two tiers of training for Sewer Utility staff: in-depth training for super-users like I&C technicians, and basic training for end users of technology.
Motor controllers	The Sewer Utility would like to standardize on Ethernet motor controllers for future projects. The Sewer Utility is interested in expanding the current practice of monitoring and archiving limited data from networked motor controllers to include more robust power, energy, alarm, and warning data. Hardwired signals will still be used for the core monitoring and control of the equipment.
	The Sewer Utility wants to eliminate DeviceNet from its infrastructure.
PLCs	The Sewer Utility does not believe that there are sufficient drivers at its facilities to justify the expense and additional complexity of hot-standby redundant controllers.
Historian	Quality Controls Corporation (QCC) will be implementing store-and-forward functionality as part of the AVEVA upgrades it is performing at the Sewer Utility remote WWTPs. This will allow the AVEVA software at the remote WWTPs to buffer data during loss of communications with the Central Kitsap Treatment Plant (CKTP) and forward the buffered data to the CKTP historian after communications are restored.
	QCC will be installing AVEVA Historian Client at the Sewer Utility WWTPs to provide staff with easier static and ad hoc trending functionality and improved access to historian data.
HPHMI	The Sewer Utility anticipates some resistance to HPHMI graphics screens from some veteran staff members but would like the Master Plan to include a migration to HPHMI concepts for the future Sewer Utility SCADA screens.
	HDR recommended that the Sewer Utility and QCC hold workshops with Sewer Utility stakeholders to develop standard color palette, symbols, color usage, screen hierarchy and layout, and other elements of the future SCADA graphics. This will help get stakeholder buy-in during the development process and guide QCC according to Sewer Utility preferences. The Sewer Utility is planning to have the first workshop with QCC in Q1 2021.
Industrial DMZ	The Sewer Utility would like the Master Plan to include an industrial DMZ approach to bridging the OT and IT networks.
	Once the Master Plan is complete, the Sewer Utility will have documentation that it can use to coordinate with the County Information Services (IS) department about required modifications to IS-managed infrastructure. Because of this coordination requirement, the County may need to find temporary solutions for remote access and other functionality through additional development of the Sewer Utility OT network.
OT network cable path redundancy	The Sewer Utility does not view network cable path redundancy as an immediate need for its WWTP OT networks, but would like it to be considered as a mid-term priority in the Master Plan.
Alarm notification system	The Sewer Utility's order of preference for on-call staff alarm notification and acknowledgment is: mobile app interface (e.g., WIN-911 Mobile), text message, and voice message.

Table 2-1. Industry trends and core objectives workshop findings summary

Topic	Findings
Sewer Utility ICS standards	The Sewer Utility would like to develop ICS standards documentation that could be handed to consultants and systems integrators to guide design and implementation. The standards would be required to be referenced in consultant specifications so that they become part of the contractor's scope.
	Sewer Utility ICS standards should include tagging conventions. Staff are challenged by lack of standard tagging conventions in existing programming.
ICS battery backup requirements	Minimum of 15 minutes for PLC control panels at CKTP.
	Minimum of 4–6 hours for CKTP ICS infrastructure required to maintain monitoring of remote pump stations and WWTPs and on-call staff alarm notification functionality.
	Minimum of 4–6 hours for ICS infrastructure at remote WWTPs that is required to maintain communication of active alarms to CKTP.
	Several hours for ICS infrastructure at critical pump stations that is required to maintain communication of wet well level and active alarms to CKTP.
	Battery backup times at less critical pump stations are not a priority for the Sewer Utility.
Remote access to SCADA screens	For the remote pump stations, the Sewer Utility would like to establish view-only remote monitoring and alarming via tablets, with the possibility of introducing control capability in the future.
	For the WWTPs, the Sewer Utility would like to establish remote monitoring and alarming via tablets, with limited control capability on a case-by-case basis.
	The Sewer Utility would like staff at all four WWTPs to have access to all Sewer Utility SCADA screens from the HMI workstations.
	The Sewer Utility would like to establish view-only monitoring and alarming of all Sewer Utility infrastructure at the County Public Works Annex facility in Bremerton.
Backup ICS servers	The Sewer Utility would like the Master Plan to consider implementing backup ICS server(s) at the County Public Works Annex facility.
Processes with high priority for automation/ICS improvements	The Sewer Utility indicated that the following processes and facilities were a higher priority for automation and/or ICS upgrades: • Biological nutrient removal (BNR) processes • CKTP septage receiving • CKTP digesters • The Suquamish WWTP, in general, because of highly manual operation • CKTP liquid balancing • CKTP solids balancing • CKTP recycled water
Alignment of Master Plan implementation plan and CIP schedule	The PS-4 upgrade project in the Sewer Utility CIP would be a good candidate for a pilot project or first-out initiative for the remote pump station ICS infrastructure.

3 Core Objectives for Future SCADA System

This section documents the core objectives for the Sewer Utility's future SCADA system. These core objectives will guide the remainder of the SCADA master planning efforts and serve as a benchmark for follow-on implementation work.

3.1 Core Objectives Development

HDR requested that the Sewer Utility develop draft core objectives for its future SCADA system prior to the industry trends and core objectives workshop. The draft core objectives were discussed during the workshop and the Sewer Utility had the opportunity to refine them based on the workshop discussion and subsequent stakeholder interviews.

3.2 Core Objectives for Future SCADA System

The Sewer Utility's core objectives for its future SCADA system are listed below:

1. *Design, build, and maintain a secure and stable ICS*
    - 1.1. *Continue development of the Sewer Utility industrial network*
    - 1.2. *Upgrade Wonderware and alarm monitoring/dial-out software*
    - 1.3. *Develop standards and naming conventions and reflect in future specifications*
    - 1.4. *Identify control power backup system requirements*

2. *Improve access to and use of SCADA*
    - 2.1. *Provide stable remote access to SCADA from all treatment plants and Public Works Annex*
    - 2.2. *Standardize HMI and alarm screens—programming object and visualizations*
    - 2.3. *Make improvements to SCADA Historian including:*
        - 2.3.1. *Backup procedures, tag identification and hierarchy, operator access to trending features*
        - 2.3.2. *Integration with business and operating software platforms (i.e., Hach WIMS, CMMS, and other Business Intelligence platforms)*
    - 2.4. *Implement use of SCADA remote tablets for unattended monitoring of plants and pump stations*

3. *Develop an Automation and Information Technology Plan*
    - 3.1. *Develop pump station (and WWTP) monitoring and control strategy: improved monitoring in the short term with potential control capability in the long term*
    - 3.2. *Identify near-term and long-term automation improvements to maintain treatment process control and/or provide operational resilience*
    - 3.3. *Incorporate energy monitoring software/hardware to support Strategic Energy Management Plan*
    - 3.4. *Identify opportunities to improve regulatory compliance monitoring*
    - 3.5. *Identify workgroup dashboards*

4. *Develop administrative program for maintaining Sewer Utility ICS*

4.1. Staffing to support to include skill sets/abilities, roles, and responsibilities
4.2. Develop backup procedures for server information, programming files, etc.
4.3. Implement Alarm Management Philosophy procedures
4.4. Develop procedures for firmware management

4 Sewer Utility Staff Interviews

This section includes an overview of the Sewer Utility staff interviews that HDR facilitated with Sewer Utility stakeholders along with key findings from these interviews.

4.1 Operations Staff Interview

On November 24, 2020, HDR held an interview with Sewer Utility operations staff members to discuss their current interaction with SCADA HMI screens, known ICS deficiencies, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-1 provides a summary of the key findings from the interview.

Table 4-1. Operations staff interview key findings summary

Topic	Findings
Lack of process flow measurement	Manchester Wastewater Treatment Plant (MWWTP) does not have a flowmeter for monitoring waste activated sludge (WAS) flow to the WAS tanks. Operations staff currently operate based on level in the WAS tanks and would prefer to have WAS flow information like they do at Kingston Wastewater Treatment Plant (KWWTP) and CKTP.
	None of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities. Lack of flow/volume measurement has led to issues where truck operators stop loading too early to avoid drawing down the thickened sludge storage tanks too far. Operating off of level or sight glass has proved challenging, particularly at the Suquamish Wastewater Treatment Plant (SWWTP), where the thickened sludge blending tank has a conical bottom. The Sewer Utility is basing CKTP incoming thickened sludge volumes from the remote WWTPs based on the assumption of full truckloads and is likely overestimating volumes if trucks are partially full.
Analytical probes for MWWTP and SWWTP	Sewer Utility operations staff expressed a desire to reintroduce analytical probes to the basins at MWWTP and SWWTP. These instruments would reduce the amount of manual probe measurements required by operations staff and would enable more automated control of the process. Lack of analytical instruments for these WWTPs was identified as a deficiency in TM-1.
Alarms	SWWTP recently had an issue where a PLC went offline and there was no alarm to alert operators that SCADA HMI screens were not being refreshed. Sewer Utility staff believe that this issue has since been corrected but believe that other WWTPs may not be receiving communication alarms for PLCs.
	Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments. An event occurred at MWWTP where the influent pump station level continued to report a static normal wet well level, but the wet well was actually much higher, and a manual pump down had to be initiated.
	No alarms are in place for composite samplers at all WWTPs. Power bumps have thrown off sampler performance and operators are not notified that there is a problem.
	Sewer Utility operations staff report that power bumps also cause some variable-frequency drives (VFDs) to go into an alarm state and, when VFD faults are not monitored at SCADA, operators are not notified of the problem.

Table 4-1. Operations staff interview key findings summary

Topic	Findings
	Power bumps can cause the MWWTP mixing channel blower to go into an alarm state that is indicated only locally. Operators have to regularly enter the building on their rounds to confirm that the alarm is not active.
	Sewer Utility operations staff believe that the high level alarm for MWWTP waste tanks is set at a level where both tanks need to be nearly full before the alarm activates. A baffle at roughly 9 feet is below this alarm set point. Once the level in the first waste tank exceeds baffle height, the process spills into the second tank. Operators would like to receive a warning when level reaches or nears this baffle height so that they are alerted when the second tank begins to fill. HDR reviewed SCADA HMI screens and it appears that the WAS tank high level alarm set points can be adjusted as desired via the HMI.
Improved automation	The MWWTP blowers are constant speed and operate on a fixed time sequence where they run in a 4-hour sequence, 5 days per week. During power bumps, this time sequence can be disrupted and operators have to manually place blowers in auto at noon to restore the sequence. Operations staff would like to have operator-adjustable scheduling and timer functionality at the SCADA HMI so that they could have more flexibility in operating the blowers. Operators would also like to see the constant-speed blowers changed to variable speed, which will likely happen as part of the upgrade to the plant for new total nitrogen (TN) limits.
	MWWTP is the only remote plant that does not have a SCADA-controlled sludge wasting valve. Sludge wasting is still a manual process and operators would like it to be automated.
Additional information at SCADA HMI screens	Sewer Utility operations staff would like to have more detailed information on ultraviolet (UV) systems available at the HMIs for all plants. They would like to see which bulbs are failed, UV intensities, and other parameters to help them better monitor system performance.
	Sewer Utility operations staff indicated that they would find more detailed information and alarming from vendor systems and motor controllers useful if it were made available at the HMI screens.
	Sewer Utility operations supervisors indicated that they would be very interested in monitoring process key performance indicators (KPIs) like hydraulic retention time (HRT) and solids retention time (SRT) at the SCADA HMI screens—particularly for aeration basins and clarifiers.
	In addition to alarming for composite sampler faults at the SCADA HMIs, Sewer Utility operations staff would like to be able to monitor sample counts and when samples are being taken.
CKTP control room upgrade	Sewer Utility operations staff would like to be able to see the same SCADA HMI screens that are at the remote WWTPs from the CKTP control room.
	Sewer Utility operations staff would like to have large-format displays at the CKTP control room where they can see overview screens at a glance.
Reporting	Current reporting methodology is to manually enter flow data into Excel spreadsheets to give to the lab for Discharge Monitoring Report (DMR) reporting.
	Sewer Utility operations staff indicated that having these flow data and laboratory data available in one pane of glass would be useful. They believe that Hach Water Information Management Solution (WIMS) software will provide this functionality.

- MWWTP does not have a flowmeter for monitoring WAS flow to the WAS tanks.
- The Sewer Utility is likely overestimating the thickened sludge volumes received at CKTP from remote WWTPs because none of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities.
- PLC status monitoring and alarming may not be effectively applied for all WWTP PLCs.
- Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments.
- There are no SCADA alarms or monitoring in place for composite samplers at all WWTPs.
- Some WWTP VFDs do not have VFD fault alarms monitored at SCADA.
- MWWTP headworks mixing channel blower fault is not monitored at SCADA.
- Operators have no means of managing the MWWTP blower operating time sequence via the SCADA HMI screens.
- MWWTP lacks SCADA control for the sludge wasting valve so the sludge wasting process is entirely manual.
- Sewer Utility operations staff would like to have more detailed information on UV systems available at the HMIs for all plants.

4.2 I&C Technician Staff Interview

On November 25, 2020, HDR held an interview with Sewer Utility I&C technician staff to discuss known ICS deficiencies, current challenges, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-2 provides a summary of the key findings from the interview.

Table 4-2. I&C technician staff interview key findings summary

Topic	Findings
High-priority improvements	I&C technicians consider the following items to be high priorities for near-term improvements to the Sewer Utility ICS: • Implement HPHMI graphics concepts at WWTP SCADA screens • Standardize on PLC firmware versioning throughout WWTPs and pump stations • Improve remote pump station telemetry • Eliminate DeviceNet networks, with the CKTP headworks motor control centers (MCCs) being a high priority because of multiple past maintenance events

Table 4-2. I&C technician staff interview key findings summary

Topic	Findings
Tag naming convention	The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system. I&C technicians like descriptive tags because the association to actual equipment is more obvious. Including equipment tags in the SCADA tag has value in maintaining a link to the piping and instrumentation diagrams (P&IDs). A facility code will also need to be included in the SCADA tags to support integration of tags from all WWTPs. The Sewer Utility intends to develop a preferred tag naming convention internally and in coordination with QCC.
SCADA thin clients	The Sewer Utility has decided to transition to SCADA HMI thin client configuration for panel personal computers (PCs) in the electrical rooms at CKTP. Preservation of local HMI functionality during an OT network outage was discussed, and the Sewer Utility is comfortable running the plant in manual without SCADA HMIs and believes that the benefits of centralized SCADA management outweigh the ability to preserve limited local control during OT network outages.
In-house automation programming capabilities	As mentioned in TM-1, the SCADA system is currently monitoring significantly more tags than the historian is archiving. If possible, the Sewer Utility would like to handle adding select currently available tags to the historian. I&C technicians indicated that they may need some training to get them started down the right path.
	I&C technicians are less comfortable making PLC programming and HMI configuration changes to incorporate additional alarms or standardize input/output (I/O) for different assets. This work may be done in-house as a mid-term project once more training has been provided.
ICS set point management	I&C technicians would like the ability to track ICS set point changes made at the SCADA HMI and know when changes were made and by whom.
	I&C technicians would like to have appropriate set points documented somewhere so that the Sewer Utility had an authoritative document to help manage set point drift.
Training and staffing	Sewer Utility staff will require training to support the modernization of the Sewer Utility ICS and OT network. Some of the required training will be focused on improving operations staff proficiency with Windows and general technology elements, which will hopefully reduce the amount of IT help desk type issues that I&C technicians are required to respond to. Other identified training will be centered around I&C technicians, including: • Network technology and communications • Network management • AVEVA software training
	The Sewer Utility has had difficulty sourcing I&C technicians and may need to consider grooming younger operations staff who demonstrate an interest in ICS technology.
	It is likely that the Sewer Utility will eventually require a more senior resource with network experience to manage the Sewer Utility OT network.
Instrument calibration	The laboratory staff currently provides preventive maintenance on analytical instruments at the WWTPs.
	Sewer Utility preference is to keep instrument calibration responsibilities under operations and/or laboratory staff. This will leave I&C technicians free to focus on other tasks for which they have unique skill sets.

> ✸ The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system.

4.3 Construction and CIP Staff Interview

On December 3, 2020, HDR held an interview with Sewer Utility construction and CIP staff to discuss the need for Sewer Utility ICS standards, current state of control strategy documentation, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-3 provides a summary of the key findings from the interview.

Table 4-3. Construction and CIP staff interview key findings summary

Topic	Findings
Sewer Utility ICS standards	Lack of Sewer Utility ICS standards has contributed to one-off implementations and recent project shortcomings. This deficiency was documented in TM-1.
	The Sewer Utility would prefer to include development of ICS standards documentation as an amendment to ongoing facilities planning efforts rather than executing a separate project.
	The Sewer Utility and QCC have scheduled workshops for January to begin fleshing out requirements for HPHMI screen development. These workshops will be the first step toward standardization of Sewer Utility SCADA HMI screens.
	Once Sewer Utility ICS standards documentation is developed, the Sewer Utility would like to establish annual reviews of the standards documentation and ICS infrastructure to keep the standards current and to identify upcoming ICS upgrade/replacement projects that need to be included in CIP planning. Monitoring for hardware and software obsolescence should be a factor in these periodic reviews.
Control strategies	In general, the Sewer Utility lacks good control strategy documentation that reflects current ICS implementation. This deficiency was documented in TM-1.
	Some documentation from recent construction projects could be used as a starting point. Some past design projects have control strategies in the design specifications, but these are unlikely to have been updated based on programming implemented during construction phases.

4.4 Laboratory Staff Interview

On December 3, 2020, HDR held an interview with Sewer Utility laboratory staff to discuss their current use of SCADA data, known ICS deficiencies, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-4 provides a summary of the key findings from the interview.

Table 4-4. Laboratory staff interview key findings summary

Topic	Findings
Access to SCADA system for laboratory staff	Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.
	Sewer Utility operations staff enter daily WWTP flow data into Excel spreadsheets and transfer to laboratory staff via email or thumb drive.

Table 4-4. Laboratory staff interview key findings summary

Topic	Findings
	Laboratory staff would like to know what mode the WWTPs are running in. Without access to SCADA HMI screens, laboratory staff rely on operators to inform them when CKTP transitions from winter to summer operations.
	Sewer Utility staff would like to implement read-only access to SCADA HMI screens for all WWTPs at the laboratory. One or more large-format displays would be helpful in providing laboratory staff with an at-a-glance view of operating conditions and alarms for all WWTPs.
Current and future SCADA data needs at the laboratory and additional instrumentation	Flow data are and will continue to be very important information for the laboratory. The following are some of the higher-priority WWTP flow data identified: • Influent and effluent flows are required for DMR reporting • Thickened sludge flows • Blended sludge tank flows • Scum pump flows • Flow to CKTP sand filters • Flow from CKTP recycled water system • Flow from potable water (W2)/service water (W3) pumps
	Laboratory staff would also like to receive data from analytical instruments, including: • Primary parameter: dissolved oxygen (DO), pH, ammonia, nitrate, nitrite, etc. • In addition to analog values from the probes, laboratory staff would like low and high alarms, as well as calibration and out-of-range alarms • Turbidity on CKTP reclaimed water from existing turbidimeter
	KWWTP and MWWTP currently have pH probes and data may be logged on Secure Digital (SD) cards. Integrating analog inputs from these probes to SCADA would be beneficial.
	UV transmittance data would be very beneficial for laboratory staff so that they do not need to manually obtain data.
	Laboratory staff would like to have alarms and other data from composite samplers. Laboratory staff need to know when samplers fail.
	For WWTP solid stream, flows are the most important data but gas production and carbon dioxide (CO_2) percentages could also be helpful down the road.
	Suspended solids probes in the aeration basins and return activated sludge (RAS) lines would be beneficial to the laboratory for SRT calculations and other uses.
	The Sewer Utility would like to be able to record the volume for thickened sludge that is transported from the remote WWTPs to CKTP. Currently, the Sewer Utility assumes full truck volumes, but this may not be the case. If flowmeters were installed on truck loadout stations, volume could be calculated via the flowmeter and recorded, allowing for tracking of more accurate volumes.
	The Sewer Utility would like to have a septage receiving station that records incoming septage flows. Currently, the Sewer Utility bases incoming septage volume on truck weight.
Composite samplers	The existing composite samplers at the WWTPs are reaching the end of their useful life and replacement parts are becoming unavailable. The Sewer Utility is in the process of getting quotes for samplers that they believe will be less maintenance intensive.

✸ Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.

4.5 Maintenance Staff Interview

On December 10, 2020, HDR held an interview with Sewer Utility maintenance staff to discuss their current use of SCADA HMI screens, current and planned use of the LLumin computerized maintenance management system (CMMS), potential SCADA integration with LLumin, future predictive maintenance efforts, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-5 provides a summary of the key findings from the interview.

Table 4-5. Maintenance staff interview key findings summary

Topic	Findings
Maintenance staff current interaction with SCADA HMI screens	The Public Works Facilities crew already monitors pump station SCADA screens remotely, mainly for alarms.
	The Sewer Utility maintenance and operations (M&O) supervisor and CMMS manager each have a SCADA PC at their desks. The CMMS manager currently handles monitoring of alarms and communicating alarms to maintenance and facilities staff. SCADA alarm monitoring and response coordination duties will eventually be transitioned to an individual within the Public Works Facilities crew.
Current preventive and corrective maintenance practices	Staff still fill out paper-based malfunction reports, which are then manually entered into LLumin.
	Equipment runtimes are manually collected and entered into LLumin.
	LLumin is cloud-hosted software as a service (SaaS) and maintenance staff are currently accessing via tablets, mobile phones, and PCs.
Remaining implementation effort and future goals for LLumin system	The first step is to complete development of an accurate active inventory of Sewer Utility assets within LLumin. The Sewer Utility is implementing an asset hierarchy using a parent-child relationship.
	Sewer Utility maintenance staff would like to migrate from calendar-based preventive maintenance to automated scheduling for preventive maintenance based on equipment runtimes.
	Sewer Utility staff would like to explore integrating SCADA alarms related to maintenance activity into LLumin, so that corrective maintenance work orders could be automated rather than having to rely on word-of-mouth.
	Sewer Utility staff would like to start using LLumin performance dashboards to forecast maintenance requirements, trend asset performance, and display uptime/availability statistics for assets.
	Sewer Utility staff would like to see maintenance staff start entering in log data for maintenance activity into the work orders in LLumin so that other staff can keep abreast of status and findings. This functionality is already built into LLumin.
	Sewer Utility staff would also like to start using the inventory management functionality within LLumin to manage spare-parts inventory.
SCADA integration with LLumin	The Sewer Utility has already purchased the SCADA integration module for LLumin, but has not deployed it because of County IS department challenges and security concerns. This lack of SCADA integration has prevented the Sewer Utility from leveraging many of LLumin's advanced features.
Future predictive maintenance use cases	The Sewer Utility does not currently have staff for a full-fledged predictive maintenance program, including oil sample analysis.
	Sewer Utility staff are interested in force main pressure monitoring as a predictive maintenance input in the future.

Table 4-5. Maintenance staff interview key findings summary

Topic	Findings
	Future predictive maintenance initiatives would begin with the most critical assets. Also, the cogeneration system at CKTP, if the Sewer Utility is required to bring that system back online someday.
Dashboarding and data visualization	Sewer Utility management staff would like to have a heat map dedicated to each of the four drainages and the WWTPs and pump stations associated with them. These heat maps would provide an at-a-glance, color-based indication of capacity and current maintenance issues. For example, a lead/lag pump station that is down one pump might be displayed in yellow, while a station that is offline for maintenance might be displayed in red.
	Discussed how dashboarding/data visualization software tool may be the best option for customizing heat maps and visualizations for runtimes, availability, and other asset performance data. This would enable more flexibility and control over the outcome. • LLumin may be able to offer some valuable visualizations, but will likely not meet all of the Sewer Utility’s needs • It would be expensive and more difficult for Sewer Utility staff to maintain if visualizations were done in SCADA • Hach WIMS is not likely to have much native functionality to support this type of content
Future SCADA access requirements for maintenance staff	The CMMS manager will not require access to SCADA HMI screens after alarm monitoring and response coordination duties are transitioned to Public Works Facilities staff.
	The Sewer Utility M&O supervisor will still require a SCADA PC in his office.
	There should be a common SCADA PC in the new modular offices that will be shared by various staff.
	The Sewer Utility operations manager does not need a SCADA PC in his office and could use one in a common area within the administration and laboratory building at CKTP.
	The lead mechanic specialist at CKTP and the lead maintenance technician in the Public Works Facilities group responsible for Sewer Utility infrastructure will both need SCADA PCs.

✸ Equipment runtimes are manually collected and entered into Sewer Utility CMMS.

4.6 Public Works Management and Stormwater Division Staff Interview

On December 10, 2020, HDR held an interview with Public Works management and Stormwater Division staff to provide a project status update, share some of the technology presented in the industry trends and core objectives workshop that may be of interest to the Stormwater Division, and discuss information that management staff would find valuable if SCADA data were made more readily available. Table 4-6 provides a summary of the key findings from the interview.

Table 4-6. Public Works management and Stormwater Division staff interview key findings summary

Topic	Findings
Management access to SCADA data	Sewer Utility management staff would like to have access to real-time flow data and other engineering-focused data.
	Sewer Utility management staff would be interested in getting email notifications when certain parameters exceed or fall below set thresholds.
	Public Works management staff would be very interested in integrating financial data with SCADA and other data sets. Having financially based metrics for forecasting operating costs would be a big benefit.
Remote field instrumentation and telemetry for Stormwater Division	Stormwater Division staff are interested in further discussions of how they might implement field instrumentation monitoring.
Current Sewer Utility management dashboarding and visualization practices	Sewer Utility management currently uses dashboards native to ArcGIS software.
Other potential data unification use cases at Public Works	Public Works management discussed how integrating customer metering into SCADA infrastructure or other County-maintained networks would eliminate manual data collection for meter readings.
Public Works ERP software	Public Works will be implementing Workday ERP for its enterprise resource planning (ERP) software most likely in late summer 2021. The Workday ERP system would be the source for Sewer Utility financial data.

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5 Network Architecture: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its OT network architecture and describes the information and functionality that Sewer Utility staff would like to obtain from the OT network in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the OT network.

5.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the OT network.

5.1.1 Central Monitoring Location for Sewer Utility Pump Stations and WWTPs

The Sewer Utility wants to establish a central monitoring location at the Central Kitsap Treatment Plant (CKTP) where staff can monitor all conveyance system pump stations and WWTPs. This central hub will enable utility-wide visibility and eliminate key technical barriers that have prevented the organization from operating as a unified utility rather than separate, distributed operational groups. To establish this central monitoring location, the Sewer Utility will need secure and reliable communications between CKTP and the remote pump stations and WWTPs. The central monitoring location will also require improvements to the existing CKTP control room to incorporate workstations, large-format displays, network components, and other functional requirements.

5.1.2 Secondary Monitoring Location for Sewer Utility Pump Stations and WWTPs

The Sewer Utility wants to establish a secondary monitoring location at the County Public Works Annex facility in Bremerton. This facility will provide the Sewer Utility with another location for monitoring all pump stations and WWTPs and viewing active alarms. Access to the Sewer Utility SCADA screens from this facility should be view-only.

5.1.3 Improved Remote Pump Station Telemetry

A significantly improved telemetry solution is necessary to establish near-real-time monitoring and alarming for the remote pump stations. The Sewer Utility requires more immediate notification of critical pump station alarms (e.g., high wet well level) than the current approach of round-robin polling via VHF licensed radio telemetry can provide, with current polling cycle times of around 8 minutes. To improve visibility into remote pump station operations and performance, the Sewer Utility also needs a means of closing the data gaps that come from traditional round-robin polling, where the CKTP

SCADA system receives a snapshot of current pump station statuses each time the pump station is polled but is left with no data for the time between polls.

5.1.4 Mobile Access

The Sewer Utility would like to establish secure remote access to WWTP and pump station SCADA screens for on-call operators from County-issued tablets. Initially, remote access for operations staff would be view-only monitoring for the pump stations and WWTPs, with some case-by-case exceptions for limited control capability at the WWTPs. However, the Sewer Utility would like the ability to expand the control capabilities of operations staff in the future.

Sewer Utility I&C technicians will also require a secure means of accessing the OT network from County-issued laptops so that they can assess conditions and assist with troubleshooting remotely. This remote access would enable I&C technicians to better diagnose ICS conditions remotely and determine whether an immediate response is necessary, potentially reducing the number of after-hours site visits for I&C technicians.

In the coming years, the Sewer Utility would also like to implement tablet-based workflows for on-site staff that involve other software applications, such as the Sewer Utility's CMMS, LLumin.

5.1.5 Secure Access to ICS Data from the Business LAN

To leverage ICS data fully, they must be made more accessible. Several Sewer Utility staff members on the Sewer Utility business local area network (LAN) base decisions on ICS data but do not require direct access to SCADA screens or other ICS software applications. These users will need a means of accessing ICS data stores securely from personal computers (PCs) and laptops that also provide them with access to the Internet. ICS data may also need to be available to software applications hosted on the business LAN to enable merging of ICS data with financial information and other organizational data stores hosted on the business LAN.

5.1.6 Improved OT Network Resilience

As the Sewer Utility becomes more reliant on ICS and other data for day-to-day operations, decision making, and planning, the network architecture serving these data will need to be highly available. With the expansion of the Sewer Utility's remote monitoring capabilities, the network components that establish the Sewer Utility's ability to monitor remote pump stations and WWTPs from CKTP will become critical. Revisions to the CKTP OT network topology will be required to reduce single points of failure and to provide redundancy for certain critical network components, servers, and cable paths. Unmanaged switches at critical locations within the OT network will need to be replaced with managed switches to support segmentation, packet filtering, and other means of establishing a more fault-tolerant network. The migration to physical redundancy for some of the more critical elements will also require software and component configuration.

The Sewer Utility has indicated that establishing cable path redundancy is not considered an immediate need, especially for the remote WWTPs. Furthermore, the funding required for a standalone project to establish a more resilient network topology, in terms of cable path redundancy, would be difficult to justify. Instead, the Sewer Utility would like to take advantage of opportunities presented by other CIP projects to install redundant cable paths in the future. Most likely, cable path redundancy for critical network segments will be achieved in phases, and the Master Plan will prioritize redundant cable paths that can be achieved with minimal cost and effort.

5.1.7 Extend OT Network and ICS Infrastructure Battery Backup Power Duration for Critical Components

The Sewer Utility would like to establish a minimum of 4 to 6 hours of UPS battery backup power for ICS servers and all network components involved in the communication of alarms from remote WWTPs to CKTP and from CKTP out to on-call staff. The Sewer Utility would also like to maintain several hours of battery backup power for wet well high level and other alarms at critical remote pump stations. For individual PLC control panels at CKTP, the Sewer Utility would like to maintain a minimum of 15 minutes of UPS battery backup power.

5.1.8 Increased Network Throughput

The industrial automation industry is migrating away from Fast Ethernet (100 megabits per second [Mbps]) port speeds and is establishing 1-gigabit Ethernet (GbE) as the new standard for Ethernet ports on many new PLCs, panel PCs, and industrial Ethernet switches. Currently, nearly all Ethernet switches within the Sewer Utility OT network are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As the Sewer Utility modernizes its SCADA system, additional devices will be added to the OT network, data flow between servers and clients will increase, and, as new software tools make data repositories more accessible, staff interaction with the SCADA system will increase. These and other factors will contribute to an increase in OT network traffic. The Sewer Utility will need to increase throughput at some locations within the OT network to avoid performance degradations in the coming years and to take advantage of the higher port speeds that come with modern devices. Communication paths for the remote WWTPs will also require sufficient throughput to support the necessary data exchange between facilities.

5.1.9 Improved Backup Procedures and Business Continuity Preparedness

The Sewer Utility needs to implement routine backup procedures for its ICS servers. This will prevent significant loss of ICS historical data, configuration files, and programming files in the event of a server failure. The ICS server backup solution should include backing up ICS data and files to a cloud or off-site location to guard against a catastrophic event at CKTP where both production and backup servers are impacted. As an off-site backup location, the Sewer Utility would like to implement a backup server at the County Public Works Annex facility in Bremerton.

The Sewer Utility also needs to improve its business continuity and emergency response planning and adopt an approach for its ICS servers that will limit the time and effort required to replace the physical hardware, install and configure the software, and restore the device to full functionality. If the Sewer Utility has formal emergency response plan and/or business continuity plan documentation, at a minimum, these documents should identify ICS stakeholders and the individuals who should be contacted to assess and restore the ICS during an emergency.

5.1.10 Improved Cybersecurity Measures

The Sewer Utility would like to apply cybersecurity mitigations within its existing OT network to lessen risks to an acceptable tolerance by implementing a more secure foundation for the OT network's expansion in the future. The future OT network architecture needs to be consistent with information security industry best practices and recommendations of industry authorities like the U.S. Department of Homeland Security (DHS), ISA, and National Institute of Standards and Technology (NIST). Part of improving the Sewer Utility's cybersecurity posture will require having adequately trained staff and established procedures. Staff will need to be trained in the identification of cybersecurity incidents and will need to have a documented program for responding to these events.

5.1.11 OT Network and Telemetry Monitoring Capability

With an increased reliance on the OT network, the Sewer Utility will need a means of monitoring OT network activity and performance to alert staff to abnormalities, inform network troubleshooting efforts, and establish accounting of individual user activities. Monitoring network performance will allow the Sewer Utility to establish baselines for bandwidth usage at critical network appliances, typical telemetry uptime for the remote sites, and typical traffic patterns of connected devices. These baselines will enable the Sewer Utility to respond when conditions diverge from normal, potentially preempting network outages and other significant performance degradations.

Accounting of user activity will enable the Sewer Utility to attribute ICS set point adjustments, file modifications, and other changes to specific users. Accounting information can help the Sewer Utility ensure that established operational procedures are being followed, identify authors of changes who may have more information for why the changes were made, and determine where additional staff education may be required. Accounting and auditing are also critical cybersecurity measures.

In addition to network performance monitoring and accounting of user activity, the Sewer Utility's OT network monitoring capability will need to include monitoring of critical OT network devices. This includes alarms and warnings related to communication status for critical OT network devices like PLCs and servers as well as alarms for the UPSs and 24-volt direct current (VDC) power supplies that keep these critical devices powered.

5.2 Recommended Improvements

This subsection describes the recommended improvements related to the OT network. Note, the recommended improvements related to cybersecurity are based on current information security industry best practices and recognized standards. However, the Sewer Utility will still need to evaluate them against its risk tolerance. Also, the cyber threat landscape is continually changing and new vulnerabilities and tactics are emerging constantly. HDR recommends that the Sewer Utility re-review the recommended improvements shortly before design and/or implementation efforts to ensure that they remain consistent with changes to cyber threats, recognized mitigations, industry-recognized standards, and the Sewer Utility's risk tolerance.

5.2.1 Upgrade CKTP Control Room

An upgrade to the existing control room in the solids processing building (SPB) at CKTP will be required to convert the space into a suitable centralized monitoring location for all Sewer Utility pump stations and WWTPs. Large-format displays are recommended for both static display of overview screens for the remote pump station and WWTPs and for ad hoc display of operator-selected screens to support group discussion and decision making. A minimum of two SCADA PCs with access to HMI screens and historian client and data visualization and dashboarding software applications are also recommended. Four monitors are recommended for each PC to enable simultaneous display of multiple software application screens and to provide operators with the flexibility to customize display content according to their preferences. An example of one possible configuration for a control room operator workstation with four monitors and large-format displays is depicted in Figure 5-1.

Figure 5-1. Example four-monitor operator workstation configuration with large-format displays

Source: HydroLogic Research (2021).

To meet the Sewer Utility's goal for maintaining remote pump station and WWTP monitoring and alarm capability during power outages at CKTP, a minimum of 4 hours of battery backup power should be provided for the control room workstations and large-format display hardware. The same duration of battery backup power should also be provided for the servers and network components serving the HMI screen content.

5.2.2 Extend OT Network to County Public Works Annex Facility

To support the Sewer Utility's goal of establishing a secondary monitoring location for its WWTPs and remote pump stations at the County Public Works Annex facility in Bremerton, the OT network will need to be extended to incorporate dedicated hardware at that facility. HDR recommends that the Sewer Utility install a Host Identity Protocol (HIP)switch at the facility and include a dedicated SCADA PC at that facility within the Sewer Utility's Tempered Networks Airwall system deployment. If the Sewer Utility decides to install backup ICS server(s) at the facility, this hardware would also be included in the Tempered Networks Airwall system to enable backups to occur between CKTP and the facility.

5.2.3 Remote Pump Station and WWTP Telemetry Improvements

Migrate Pump Stations from VHF Licensed Radio WAN to Cellular WAN

To help reduce long polling times for its remote pump stations, the Sewer Utility will need to transition to a wireless communication technology with higher bandwidth. Given the lack of clear line-of-sight between most pump stations and the nearest WWTP and the high costs of installing fiber-optic cable to the remote stations, HDR recommends that the Sewer Utility continue the work it began with Quality Controls Corporation (QCC) to migrate its remote pump stations to the cellular wide-area network (WAN). Critical pump stations and those with historically poor communications should be prioritized for near-term migration, while less critical pump stations could be transitioned over a longer period as time and funding allow. Prior to planning the cutover for each site, a site survey should be performed to assess the signal strength of the Verizon Wireless network at the pump station location. Sites with poor signal strength may require outdoor and/or directional antennas to establish acceptable signal strength for a pump station telemetry application.

Latency with cellular networks is difficult to predict because of several variables that are beyond the end user's control, many of which have to do with the cellular service provider's infrastructure. As the number of pump stations introduced to the cellular WAN increases, the Sewer Utility may find that a second cellular router at CKTP will be required to mitigate latency and performance issues encountered with all remote pump stations communicating through one cellular router. A second cellular router would also provide a layer of redundancy for the communication links between the remote pump stations and CKTP. If a second cellular router is implemented, the idea would be to split the remote pump stations between the two routers so that remote pump station telemetry is divided into two parallel channels handling half of the remote pump station communication traffic. The Sewer Utility would also configure to two cellular routers at CKTP for redundancy so that pump stations communicating through one of the routers fail over to the other router during sustained loss of communications through their primary router.

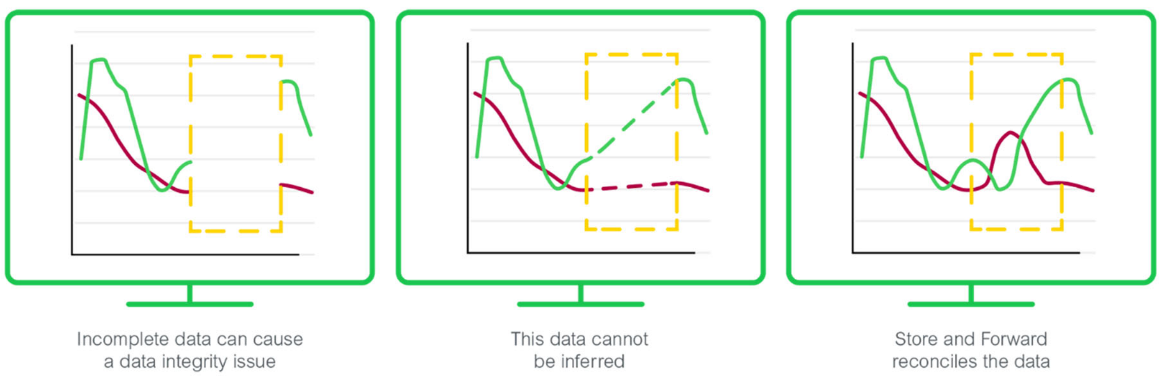
HDR recommends leaving the very high frequency (VHF) licensed radios in place for the more critical stations and implementing routing and communication driver configuration so that the stations revert to the VHF licensed radio WAN when communications over the cellular WAN are lost.

Implement Store-and-Forward and Exception Reporting for Remote Pump Station Telemetry and Eliminate PLC Data Concentrator for Cellular WAN

Migrating the remote pump stations to the cellular WAN will certainly improve polling times, but this measure alone will not be sufficient to achieve the Sewer Utility's goal of near-real-time monitoring and alarming for its remote pump stations. Even with the higher bandwidth of cellular communications, round-robin polling for the 62 pump stations could take up to 2 or 3 minutes to complete a polling cycle. This approach would still leave the utility with sporadic snapshots of each pump station's status and no means of monitoring continuous analog values or determining time stamps of when events and state changes actually occur. Similarly, the Sewer Utility would have no way of backfilling pump station data in the event of communications outages.

To resolve this issue, HDR recommends that the Sewer Utility implement a remote pump station telemetry solution that incorporates store-and-forward functionality. As depicted in Figure 5-2, store-and-forward eliminates data loss due to polling cycle times and communication outages. Real-time data are time-stamped and stored in a PLC, gateway, or software buffer to be forwarded when data communications are available. Two common open protocols that support this functionality are DNP3 and MQTT. The existing Allen-Bradley MicroLogix 1400 PLCs installed in the remote telemetry unit (RTU) panels at the pump stations support DNP3, which makes this protocol an attractive option because the Sewer Utility's investment in the existing hardware could be preserved.

Figure 5-2. Depiction of store-and-forward functionality

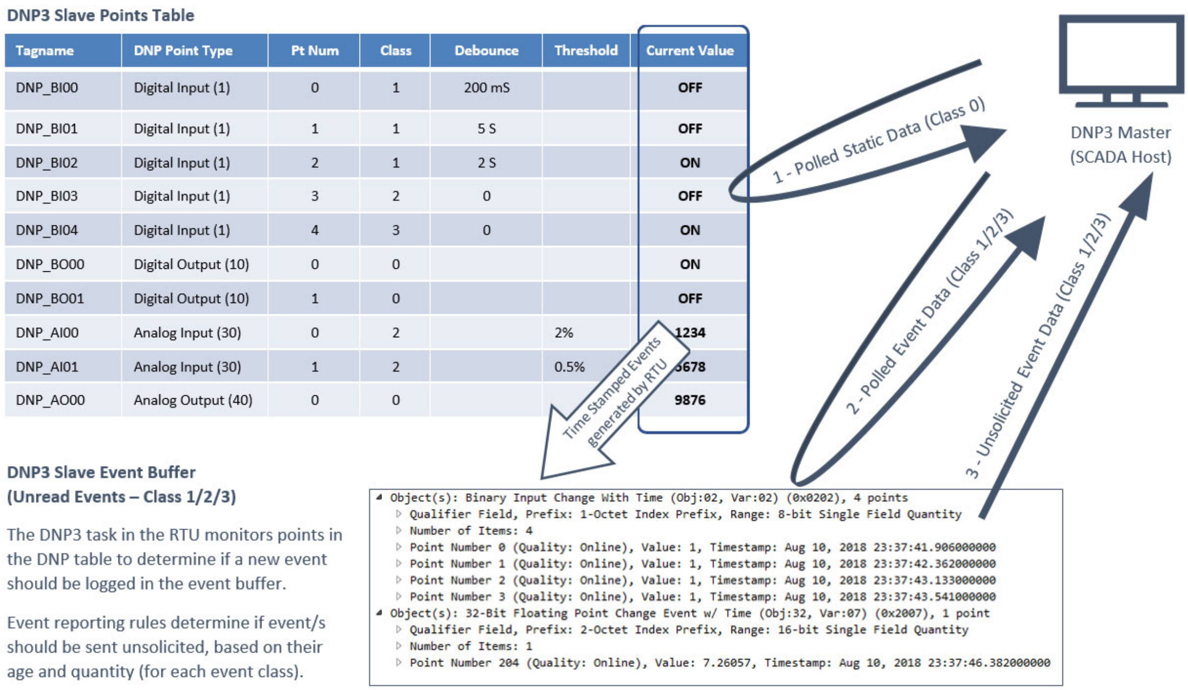


Source: Schneider Electric.

In addition to implementing store and forward, HDR recommends that the Sewer Utility replace round-robin polling with a report-by-exception telemetry solution. This would transition the remote pump station telemetry to event-based communications, where data exchange is tailored to capture changes in state, alarms, and deadband traversals for analog values. Compared with round-robin polling, where the same parameters are polled every cycle regardless of whether they communicate new information, report by exception can reduce data exchange volumes significantly. This is ideal for low-bandwidth environments like cellular applications where data usage rates apply.

Report-by-exception schemes typically consist of scheduled event and integrity polls, where time-stamped events are polled at a set interval and all current values are polled at a significantly longer interval, the latter polling cycle functioning in much the same way as round-robin polling. However, typical report-by-exception implementations also include functionality to enable the remote station to initiate communications with the master to communicate high-priority events (e.g., wet well high level, in the case of a wastewater pump station application) as well as events that have resided in the event buffer without being polled for a set period. Figure 5-3 illustrates how report by exception is handled by DNP3, one of the common open protocols designed with this functionality in mind. Again, the existing Allen-Bradley MicroLogix 1400 PLCs installed in the RTU panels at the pump stations support DNP3.

Figure 5-3. DNP3 report-by-exception functionality summary

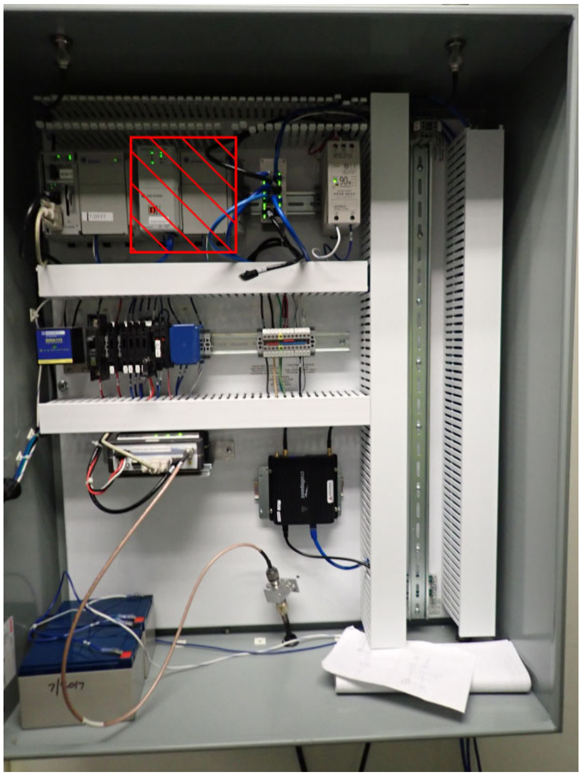


Tagname	DNP Point Type	Pt Num	Class	Debounce	Threshold	Current Value
DNP_BI00	Digital Input (1)	0	1	200 mS		OFF
DNP_BI01	Digital Input (1)	1	1	5 S		OFF
DNP_BI02	Digital Input (1)	2	1	2 S		ON
DNP_BI03	Digital Input (1)	3	2	0		OFF
DNP_BI04	Digital Input (1)	4	3	0		ON
DNP_BO00	Digital Output (10)	0	0			ON
DNP_BO01	Digital Output (10)	1	0			OFF
DNP_AI00	Analog Input (30)	0	2		2%	1234
DNP_AI01	Analog Input (30)	1	2		0.5%	5678
DNP_AO00	Analog Output (40)	0	0			9876

Source: Brodersen (2020).

Currently, the Sewer Utility has a master telemetry unit (MTU) PLC installed at CKTP that is serving as a data concentrator for the few remote pump stations on the cellular WAN (see Figure 5-4, where data concentrator PLC is indicated by a red box with diagonal hatching). The PLC is an Allen-Bradley CompactLogix 1769-L33ER processor, which does not support DNP3 natively. QCC has implemented a form of report-by-exception functionality via PLC programming logic for the sites on the cellular WAN, where the remote sites initiate communication for significant state and analog value changes and the MTU PLC polls the remote pump stations when no exception reports are received within a set time interval. This solution is a significant improvement over the round-robin polling on the VHF licensed radio WAN, but it does not provide store-and-forward functionality or time-stamped events that would allow the Sewer Utility to assign accurate times to events and eliminate data loss due to communication outages.

Figure 5-4. Cellular WAN data concentrator PLC at CKTP SPB control room



Though third-party communication modules could be incorporated into the existing MTU PLC implementation to have the PLC serve as a DNP3 master so that the Sewer Utility could receive the benefits of the DNP3 protocol, the MTU PLC is serving only as a middleman in the data exchange between the existing Wonderware system and the remote pump stations. A much simpler approach would be to eliminate the MTU PLC and have the SCADA server at CKTP serve as the DNP3 master. AVEVA (formerly Wonderware) offers Telemetry Server software that integrates with its System Platform offering. The software is purpose-built for remote site telemetry applications, supports DNP3, and has a relatively simple user interface that would be easier for Sewer Utility staff to configure and maintain than the PLC programming logic within the MTU PLC. Furthermore, eliminating the MTU PLC would reduce the number of single points of failure in the remote pump station telemetry communication pathway and reduce overall telemetry latency by removing an additional processing step.

Improve Communication Status Monitoring and Alarming for Remote Pump Station Telemetry

The Sewer Utility needs to have an accurate picture of remote pump station communication status and performance so that alarms can be generated when communications are lost and corrective action can be taken to remedy consistently poor performance. At a minimum, uptime percentages should be calculated as a ratio of successful versus attempted polls for each pump station. HDR recommends that uptime percentages be displayed at the HMI for the previous 24 hours and all history since the last manual reset. Pump stations that retain backup VHF licensed radio links should have separate uptime percentages calculated and displayed for cellular and VHF licensed radio links. Sewer Utility staff should have the ability to configure the timer interval and/or number of consecutive unsuccessful polls that would initiate a loss of communications alarm via the HMI.

Implement HIPswitch Cellular Failover Functionality to Establish Communication Link Redundancy for WWTPs

Currently, the Sewer Utility's HIPswitches at the WWTPs are configured only for wired communications. An outage within the Kitsap Public Utility District (KPUD) network has the potential to disrupt communications between one or more remote WWTPs and CKTP. Though store-and-forward functionality is recommended for the remote WWTP SCADA servers to avoid data loss in the event of a communication outage (discussed in Section 7), this functionality will not resolve the loss of alarm notification at CKTP for the WWTP(s) impacted by the KPUD network outage. To preserve alarm notification for the remote WWTPs in the event of a KPUD network outage, HDR recommends that the WWTP HIPswitches be configured for failover to cellular communications. This will require that the HIPswitches be provisioned with a cellular expansion module and a subscriber identification module (SIM) card activated on the Sewer Utility's cellular WAN.

5.2.4 CKTP OT Network Upgrades

Consolidate CKTP OT Network Servers, Distribution Switches, and Other Appliances in a Network Rack Environment within the SPB

HDR recommends standardizing on rack-mounted servers and distribution switches for the OT network and consolidating this infrastructure in one or more enclosed network racks within the CKTP SPB. Consolidating this equipment in a network rack environment will provide several benefits:

- Equipment will be located in an enclosure that can be locked to restrict access
- Rack-mounted power distribution units (PDUs) allow for a clean and simple redundant power supply solution using factory-issued power cords for the equipment
- Cable management hardware mounted to the rack will allow the Sewer Utility to establish clean and organized patch cabling between devices
- Reduces cabling that needs to be run throughout the building
- Greatly simplifies maintenance and replacement of equipment
- Results in a smaller equipment footprint compared with tower servers and having devices distributed throughout the building

Network racks should be sized for standard 19-inch equipment and have seismic testing certifying their suitability for installation in the seismic zone applicable to CKTP. The rack cabinet enclosures should also be sufficiently wide to accommodate vertical cable management hardware on either side of the rack. An example four-post network rack cabinet certified to meet Zone 4 requirements is depicted in Figure 5-5.

Figure 5-5. Example four-post seismic network rack cabinet

Source: Chatsworth (2020).

The SPB control room and the space identified in the ground floor of the SPB annex in TM-1 are the two best candidates for locating the future network racks. The SPB annex location has the benefit of providing a dedicated space for critical OT network servers and components where room access could be restricted to the few Sewer Utility staff members qualified to service the equipment by means of a key card access system. However, significant costs would be involved with repurposing the space and routing network and power cabling to that location, as described in TM-1. The SPB control room has the advantage of significantly reduced costs because the room is already climate-controlled and incoming communication cables already terminate at that location. However, servers and network equipment generate noise, which may impact the quality of the control room environment for Sewer Utility staff. Sound mitigation may be required at this location. The control room will also be accessed by several staff members, reducing the physical security measures in place for the network rack(s).

Once a better idea of spatial requirements is determined for the network rack(s) in Phase 4 of the Master Plan, the future location for this infrastructure should be discussed further with Sewer Utility stakeholders.

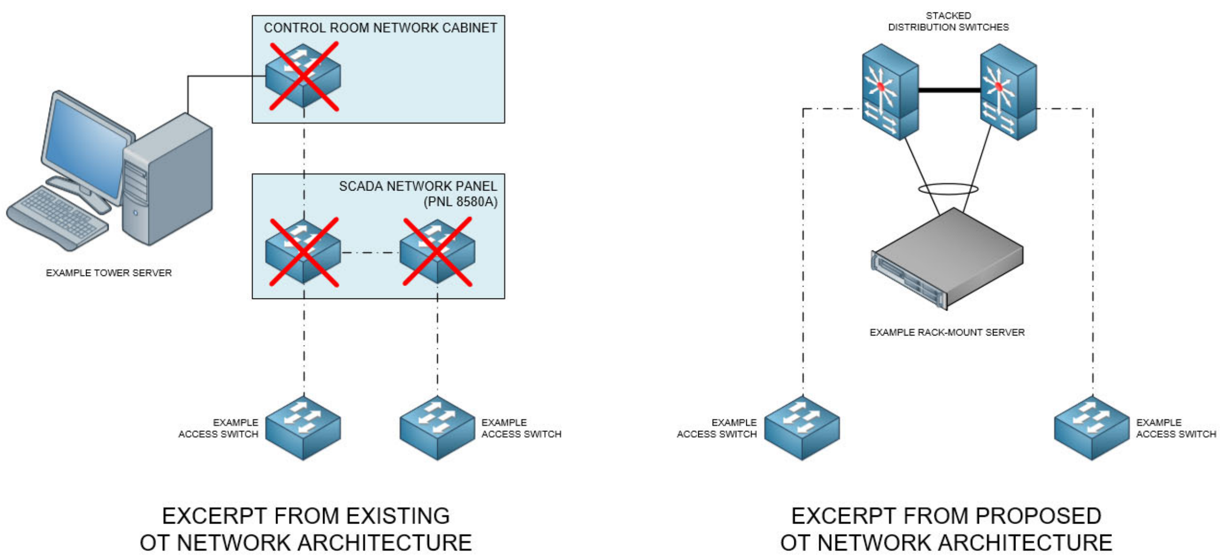
Upgrade to Stacked Layer 3 Distribution Switches at CKTP SPB

Currently, the most critical switch in the Sewer Utility OT network is an unmanaged switch in the SPB at CKTP. This switch is handling all traffic between ICS servers, SCADA clients, and PLCs at CKTP, as well as remote connections to the CKTP OT network established via the Tempered Networks WAN. To eliminate this single point of failure and to establish routing capabilities at the OT network distribution layer that will enable segmentation of the network, HDR recommends replacing the unmanaged switch with stacked Layer 3 distribution switches.

The stacking capability of these switches will provide switch-level redundancy for critical ICS servers and downstream access switches for which cable path redundancy is provided. The Layer 3 functionality of these multilayer switches allows for network traffic to be routed between subnets and virtual local area networks (VLANs). This will enable the Sewer Utility to instate some network security best practices such as placing devices that do not need to communicate with one another in separate broadcast domains while maintaining their ability to communicate with ICS servers and other shared resources. For reference, Layer 3 refers to a specific layer within the Open Systems Interconnection (OSI) Model (see Figure 2-11 in TM-1). Layer 3 switches handle network packets and recognize IP addresses and other packet header information required to route packets between broadcast domains.

To eliminate additional single points of failure and a potential bottleneck in the CKTP OT network, HDR also recommends eliminating the two managed switches in panel (PNL) 8580A (also located in the SPB). The fiber-optic cable connections received by these switches from the various access switches throughout the plant would instead be patched directly to the proposed stacked Layer 3 distribution switches, eliminating an unnecessary hop in the OT network architecture. Figure 5-6 depicts how the relevant excerpt of the existing CKTP OT network would be modified to eliminate the existing switches discussed above (shown crossed out with red Xs in the figure) and to replace them with stacked Layer 3 distribution switches. For reference, the complete physical network diagram for the existing CKPT OT network can be found in Appendix B of TM-1.

Figure 5-6. Excerpts from existing and proposed CKTP OT network architecture



Modifications to CKTP Administration and Laboratory Building Electrical Room

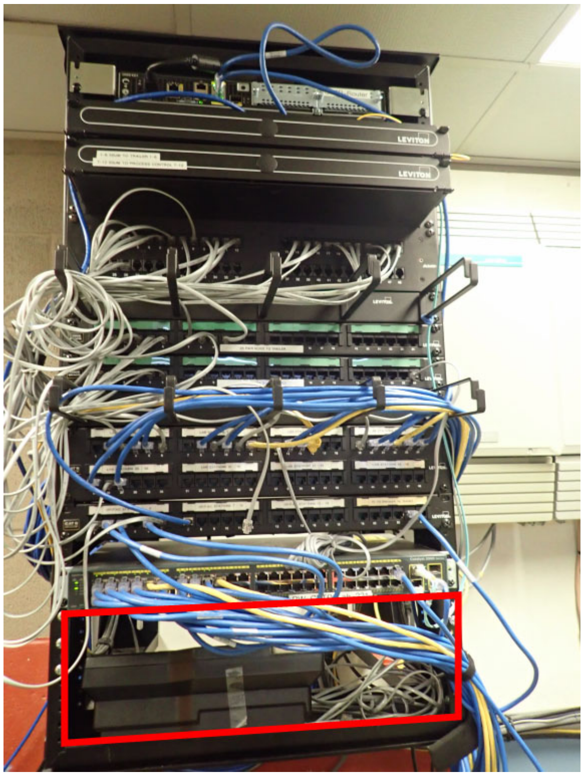
The CKTP administration and laboratory building electrical room contains mechanical and electrical equipment along with network components for both the OT network and business LAN. The costs involved with relocating the mechanical equipment and rerouting the air and water lines to eliminate the impact to the electrical and network equipment because of equipment failure or a burst or leaking pipe would likely be considerable. An exploration of the work required is also beyond the scope of the Master Plan. Relocating the electrical and business LAN network rack and rerouting all new power and communications cables would also be costly and would require a significant disruption to Sewer Utility operations in the building.

Assuming that the mechanical equipment, water and air piping, and electrical and network equipment will continue to share the electrical room, HDR recommends relocating the OT network HIPswitch to the new network rack(s) location in the SPB. The HIPswitch is critical for maintaining communication with the remote WWTPs and its relocation will result in a less risk-prone environment for the device while also reducing the need for Sewer Utility staff to enter the administration and laboratory building electrical room to maintain the OT network. To facilitate the relocation in the near term, a 1 GbE, multi-mode fiber-optic small form-factor pluggable (SFP) module would be introduced to the combination port on the KPUD Carrier Ethernet switch where the existing Category cable connection to the HIPswitch is made (see Figure 5-7). The SFP module could then be patched to the existing fiber-optic patch panel mounted to the electrical room communications backboard to establish a connection to the SPB communications cabinet via the existing fiber-optic cable between the two buildings. The Category cable along with the HIPswitch, 24 VDC power supply components, and OT network switch mounted to the communications backboard would be removed.

Figure 5-7. Proposed SFP module installation in KPUD Carrier Ethernet combination port

The UPS sitting on the floor of the electrical room that is powering the 24 VDC power supply for the OT network components will no longer be necessary and is in a risk-prone location to begin with. This UPS should be removed. However, HDR recommends that UPS power be provided for the KPUD Carrier Ethernet switch located in the electrical room network rack because the device is a critical component that the OT network relies on for wired communications to endpoints outside of CKTP. One option for providing UPS power to the device would be to install a UPS in the existing electrical room network rack. There appears to be sufficient space at the bottom of the rack if the telephone equipment and cabling placed there were to be removed (see Figure 5-8). If the UPS were dedicated to the KPUD Carrier Ethernet switch and were not also used to power all of the business LAN components also installed in the network rack, a 1,500-volt-ampere (VA) UPS should be more than enough to meet the Sewer Utility's goal of 4 to 6 hours of battery backup time.

Figure 5-8. Proposed location of UPS in existing administration and laboratory building network rack



5.2.5 General OT Network Upgrades

Establish Standard Layer 2 Managed Access Switch with Gigabit Downlink Ports for Future OT Network Applications and Replacement of Select Unmanaged Switches

To provide Sewer Utility staff with a uniform management interface for maintaining OT network access switches and to reduce spare switch inventory requirements in the future, HDR recommends that the Sewer Utility standardize on a managed access switch for the OT network. The standard switch should support Layer 2 management functionality to allow for network segmentation, traffic filtering (Internet Group Management Protocol [IGMP] snooping, in particular), and implementation of cybersecurity controls. Full-duplex switching to mitigate packet collisions and Simple Network Management Protocol (SNMP) and port-mirroring capabilities to facilitate network monitoring and troubleshooting are additional recommended features of the standard switch. The switch should also have gigabit downlink ports to accommodate the gigabit port speeds of modern ICS devices.

Once the new standard OT network access switch is selected, HDR recommends that it be used to replace the unmanaged switches recommended for replacement in TM-1. The Sewer Utility's standard OT network access switch should also be documented in the Sewer Utility ICS standards proposed later in this TM so that future design projects incorporate the standard into their contract documents.

Establish Cable Path Redundancy for Critical Segments of the OT Network

The current OT network at the Sewer Utility WWTPs consists of single fiber-optic and copper Category cable connections between buildings and process areas. For increased OT network resilience, HDR recommends that the Sewer Utility establish redundant cable paths for critical OT network segments, particularly between building access switches at CKTP and the proposed distribution switch stack in the SPB. The recommended topology for this physical layer redundancy is a redundant star (as shown in Figure 5-9). The advantages and disadvantages of a redundant star topology, as compared with other common network topologies (ring, star, and linear), are provided in Table 5-1.

Figure 5-9. Redundant star topology

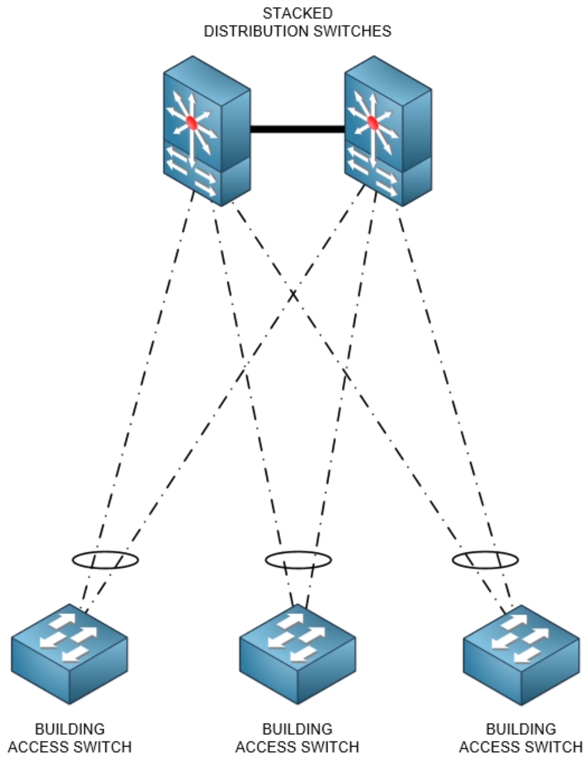


Table 5-1. Network topology advantages and disadvantages

Topology	Advantages	Disadvantages
Redundant star	• Fast convergence in the event of connection loss. • Predictable and consistent network performance because of consistent number of hops. • Provides resilience for multiple connection losses. • No inherent bottlenecks in design reduces likelihood of segment over-subscription.	• Additional cables, conduits, and associated costs. • Increased configuration complexity (compared to start, linear, or extended-star topologies).

Table 5-1. Network topology advantages and disadvantages

Topology	Advantages	Disadvantages
Ring	• Fewer cables and conduits and lower associated costs. • Provides resilience for one connection loss. • Reduced bottleneck potential (when compared to extended-star) with two potential paths. This reduces likelihood of segment over-subscription.	• Longer convergence times in the event of connection loss. • Most complex configuration. • Less predictable and consistent network performance because of variable number of hops. • Bottlenecks can still occur on segments near distribution switches resulting in segment over-subscription.
Linear, star, or extended-star	• Least amount of cables and conduits and lowest associated costs. • Simple implementation.	• No resilience. Connection loss results in communication outage. • Inherent bottlenecks on segments near distribution switches (in the case of linear or extended-star topologies). These bottlenecks can result in segment over-subscription.

Though a redundant star topology is recommended, there will be cases where the cost of implementing this topology is prohibitive. In these cases, a portion of the OT network might be broken out into a ring topology, or a non-critical access switch connected via one duct bank might be left with one fiber-optic path to the distribution switch stack. Similarly, the best practice of physically separate routes for the redundant cables must also be considered with the cost of implementation. For example, the cost of installing a new 100-foot-long duct bank to provide a completely separate physical fiber path may be hard to justify when a spare conduit exists in an existing duct bank where the other redundant fiber-optic cable is already installed.

As redundant fiber-optic cable paths are considered, HDR recommends that the Sewer Utility consider transitioning to single-mode fiber-optic cable for communication links where significant network traffic volumes are anticipated. Single-mode fiber-optic cable supports significantly increased throughput, which will allow the Sewer Utility to benefit from the multi-gigabit throughput capabilities of today's network components and be better positioned to take advantage of the throughput capabilities of future technology. In particular, the existing fiber-optic cable between the CKTP administration and laboratory building electrical room and the SPB is recommended for near-term replacement with single-mode fiber-optic cable. All traffic associated with remote WWTPs, remote access to the OT network, and access to the ICS DMZ from the Sewer Utility business LAN will occur over this fiber, and the length of the existing multi-mode (Optical Multi-mode 1 [OM1]) cable is already at or near the cable's maximum distance threshold for theoretical 1 GbE.

5.2.6 ICS and OT Network Power Supply Improvements

Establish Robust UPS Battery Backup Solution for ICS and OT Network Infrastructure

To meet the Sewer Utility's goals of establishing a minimum of 4 to 6 hours of battery backup power for CKTP ICS infrastructure required to maintain monitoring of remote pump stations and WWTPs and on-call staff alarm notification functionality, the Sewer Utility will need to implement an improved UPS solution for the CKTP SPB. Though dedicated industrial-grade UPSs installed in network racks and cabinets and at critical PCs could meet the Sewer Utility's goals, a centralized approach to UPS power distribution would reduce the number of UPSs that need to be maintained and monitored while providing more flexibility for future modifications to the ICS infrastructure.

HDR recommends installing a three-phase, 120/208-volt alternating current (VAC), online double-conversion type UPS system at the CKTP SPB. The UPS system would consist of a UPS cabinet with a modular design to allow for expansion of capacity in the future, a battery cabinet, and a combination transformer/maintenance bypass cabinet to step down a three-phase 480 VAC power feed to 208 VAC and allow Sewer Utility staff to bypass the UPS system for maintenance. The UPS system would feed a downstream three-phase 120/208 VAC panelboard for distribution of UPS power to the critical ICS loads within the SPB. An example of such a system that HDR recently designed for a local wastewater utility is depicted in Figure 5-10.

Figure 5-10. Example three-phase UPS system recently installed at a local wastewater utility

Because of the significantly smaller scale of the ICS infrastructure at the remote WWTPs, it is likely that the Sewer Utility can meet its goal of establishing a minimum of 4 to 6 hours of battery backup power for ICS infrastructure required to maintain communication of active alarms to CKTP by installing one or more standalone online double-conversion UPSs with an extended runtime option and external battery packs. ICS and related infrastructure requiring UPS power at the remote WWTPs would include the HIPswitches, KPUD Carrier Ethernet switches, SCADA server(s) and PC(s), main plant PLC, telephony or cellular modems required for the alarm notification system, and network switches involved in maintaining communication between these devices. Depending on the critical ICS loads requiring UPS power, these UPSs may be single-phase 120 VAC or three-phase 208 VAC.

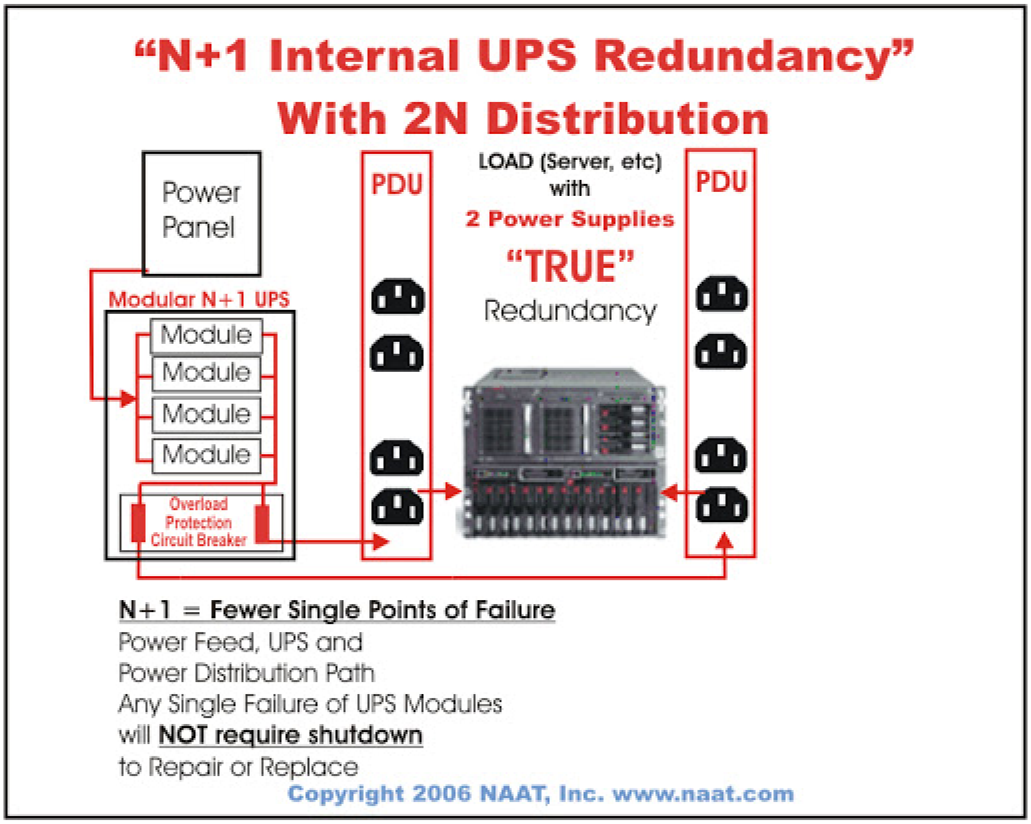
The approach of a standalone online double-conversion UPS is also recommended for the Sewer Utility's PLC and remote input/output (RIO) control panels currently without battery backup power at its WWTPs and remote pump stations, as indicated in TM-1. Per Sewer Utility goals for battery backup times, PLC control panels at CKTP would need to be sized for a minimum of 15 minutes of battery backup power. Other PLCs and RIO panels at remote WWTPs and pump stations would be subject to the 4- to 6-hour battery backup requirement.

HDR recommends that all UPSs provided for Sewer Utility ICS and OT network infrastructure be monitored by the SCADA system and that UPS status, warnings, and alarms be integrated into the Sewer Utility's SCADA HMI screens and alarm notification system. This includes the dedicated UPSs installed in the WWTP PLC panels. Most of the existing UPSs in WWTP PLC panels have no status and alarm contacts or capability for remote monitoring over Ethernet. HDR recommends that these UPSs be replaced with online double conversion UPSs with status and alarm contacts and/or Ethernet communication options that support integration with SCADA software via standard industrial Ethernet protocols like Modbus Transmission Control Protocol (TCP).

Standardize on Redundant Onboard Power Supplies and 24 VDC Power Supplies for ICS and OT Network Infrastructure

To avoid a scenario where the power supply redundancy provided by a UPS is undermined by failure of a single onboard power supply or a single 24 VDC power supply downstream from the UPS, HDR recommends that the Sewer Utility standardize on carrying through power supply redundancy to the ICS and OT network devices. For rack-mounted OT network switches, servers, and other network appliances, this would mean standardizing on dual onboard power supplies. Network racks would be provisioned with two PDUs, each powered from a separate circuit in the upstream UPS panelboard. The dual onboard power supplies of each device would be split between the two PDUs. Figure 5-11 depicts a simplified overview of this approach.

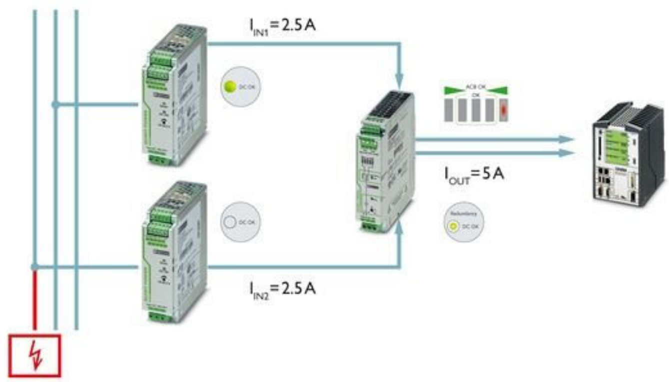
Figure 5-11. Overview of power supply and distribution redundancy for network rack components



Source: NAAT (2021).

For DIN-rail mounted components, this would mean standardizing on redundant 24 VDC power supplies and a redundancy module in control panels so that a failure of one power supply does not result in loss of all ICS and OT network components served by the control panel's 24 VDC power distribution. The redundancy module is required to effectively isolate the two 24 VDC power supplies so that a fault impacting one of the supplies does not impact the other and undermine the component-level redundancy. Figure 5-12 depicts an example 24 VDC power supply implementation where two 24 VDC power supplies and a redundancy module are used.

Figure 5-12. Example redundant 24 VDC power supply application



Source: Phoenix Contact (2021).

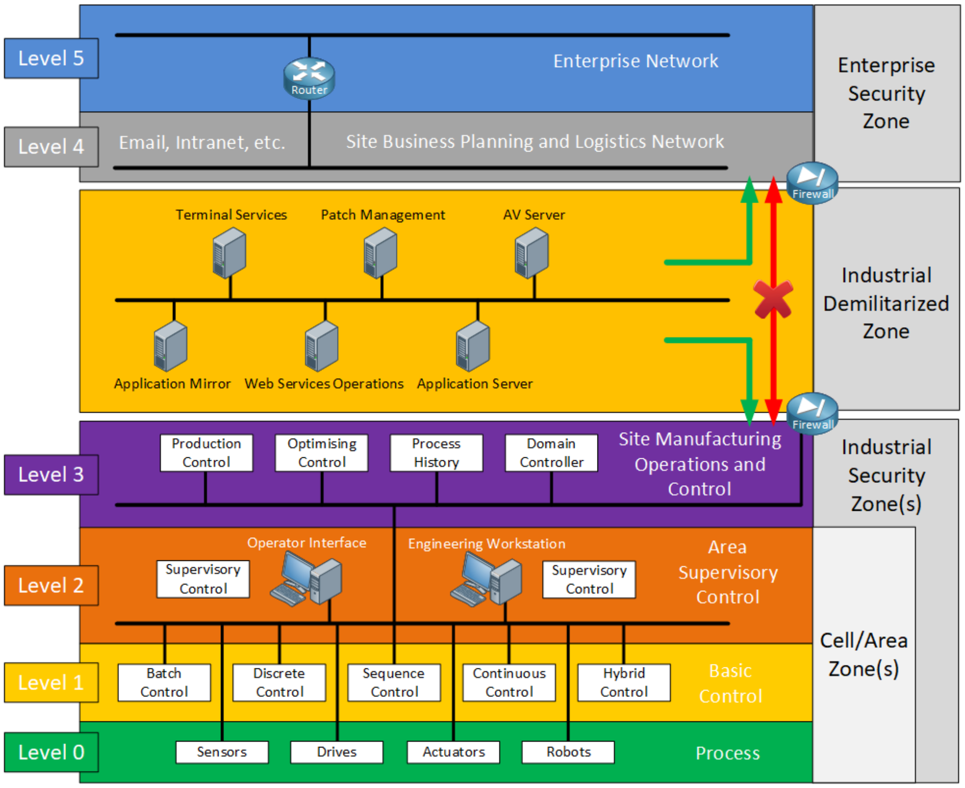
To implement this approach, upgrades to existing control panel 24 VDC power distribution could be made as time and operation and maintenance (O&M) budget allow and/or coordinated with other recommended improvements affecting the control panels. To ensure that future control panels and OT network upgrades adhere to this standard approach, these requirements should also be documented in the Sewer Utility ICS standards proposed later in this TM so that future design projects incorporate the standard into their contract documents.

5.2.7 Secure Remote Access and Data Exchange with Business LAN

Establish an Industrial DMZ between Sewer Utility Business LAN and OT Network

Critical infrastructure networks like the Sewer Utility's OT network require isolation from the Internet and less trusted networks (e.g., the Sewer Utility business LAN) within the enterprise zone to protect them from external threats. However, there are many benefits to establishing controlled data exchange between enterprise zone assets and industrial zone (OT network) assets that can allow an organization to optimize its operations and increase efficiency. To securely implement data flows between these two zones, information security industry best practices dictate that all cross-zone traffic be handled by applications and services residing in an industrial DMZ. This network architecture establishes a single entry to the industrial DMZ from the enterprise zone via a firewall and a single entry to the industrial zone from the industrial DMZ via a firewall. A general depiction of the proposed industrial DMZ is shown in Figure 5-13, between Levels 3 and 4 of the Purdue Model for Control Hierarchy, an industry standard used to organize networks into functional and security zones. Because the applications and services within the industrial DMZ will be either the endpoint of all inbound traffic to the industrial DMZ or the originator of all outbound traffic from the industrial DMZ, a direct connection between enterprise zone and industrial zone assets is avoided. It is recommended that the Sewer Utility implement an industrial DMZ to handle data exchange between the industrial and enterprise zones and improve the security provided for ICS assets.

Figure 5-13. Purdue Model for Control Hierarchy



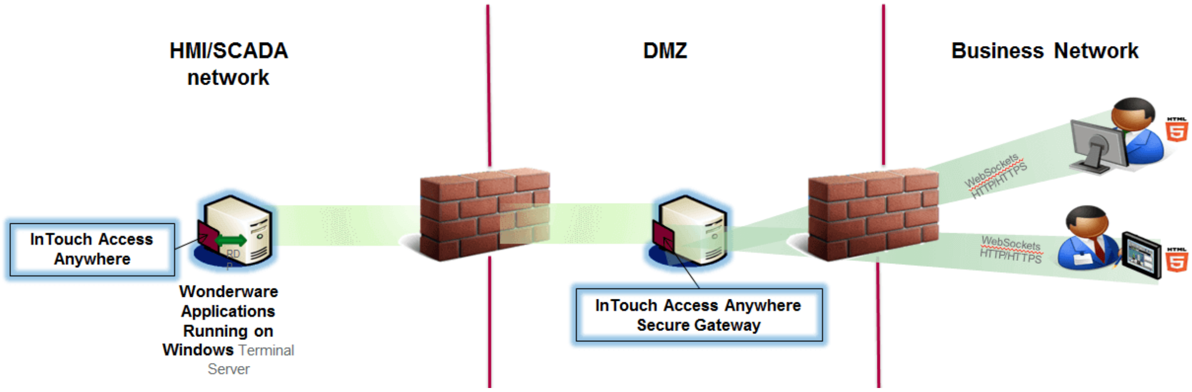
Source: NetworkLessons.com

Implement Secure Mobile Access to SCADA HMI Screens for Remote and On-site Staff

With the exception of Sewer Utility I&C technicians and third-party systems integrators, most Sewer Utility staff will not need mobile access to OT network resources beyond the SCADA HMI screens for the remote pump stations and WWTPs. To adhere to the information security industry Principle of Least Privilege, these users should be granted access only to the resources that they need to interface with to perform their job function. Read or read/write privileges should also be tailored to the specific user and his/her responsibilities.

The Sewer Utility's SCADA software platform vendor, AVEVA, offers a remote access solution developed specifically for operators, supervisory staff, and other users whose remote access to the OT network is limited to SCADA HMI screens. This software, called AVEVA InTouch Access Anywhere, is designed to work with Microsoft Remote Desktop Services (RDS) where remote connections to a Remote Desktop Server hosting the InTouch Access Anywhere software application are established via a Remote Desktop Gateway, typically located in an industrial DMZ. Figure 5-14 presents a simplified diagram of a typical AVEVA Intouch Access Anywhere deployment. This solution allows mobile users to access SCADA HMI screens via a Hypertext Markup Language revision 5 (HTML5)-compliant web browser and requires no client software installation or maintenance on the mobile device.

Figure 5-14. Typical AVEVA Intouch Access Anywhere network architecture



Source: AVEVA (2020).

The use of RDS and an industrial DMZ for remote access to OT networks is a widely deployed framework endorsed by DHS, NIST, Rockwell Automation, Cisco, and several other industry organizations and manufacturers. This approach also leverages AVEVA's standard offering for remote access applications, for which support and security patches can be expected from the software vendor. For these reasons, HDR recommends that the Sewer Utility implement AVEVA InTouch Access Anywhere for mobile access to the Sewer Utility's SCADA HMI screens.

It should be noted that this approach will require mobile users to access the industrial DMZ in a secure manner that should include multi-factor authentication (MFA). The standard approach would be for users to access the industrial DMZ through the Sewer Utility business LAN via the virtual private network (VPN) service maintained by the County IS department. This approach would require coordination and involvement with the County IS department but would allow the Sewer Utility to make use of existing IT infrastructure and software licensing. Alternatively, the Sewer Utility could consider establishing mobile access to the industrial DMZ via the Tempered Networks Airwall system. This approach would involve installing Airwall client software on County-issued mobile devices and implementing a specific-use overlay network that provides the mobile devices with access only to the Remote Desktop Gateway. While this approach would reduce or eliminate County IS department involvement, it would incur the costs of additional Airwall client licenses. Because tablet-based workflows for Sewer Utility staff are anticipated to eventually involve dashboards and data visualizations served by software application(s) hosted on the Sewer Utility business LAN, HDR recommends that the Sewer Utility aim for the standard approach in the long term. However, the Sewer Utility could consider access via the Tempered Networks Airwall system as a temporary solution pending coordination with the County IS department.

An additional recommendation is that mobile device management (MDM) software be used to monitor, control, and update County-issued mobile devices, if this is not already implemented by the County IS department. This software would allow the County IS department to manage content on the devices, deploy operating system updates and software patches, monitor use, and make use of device location tracking. In the event that mobile devices are lost or stolen, MDM software can be used to remotely lock the device and/or wipe data and software from the device.

Implement Secure Remote Access to OT Network for I&C Technicians and Contracted Systems Integrators

Sewer Utility I&C technicians and contracted systems integrators will require remote access to additional OT network resources beyond the SCADA HMI screens to maintain and troubleshoot the OT network remotely. While the current Virtual Network Computing (VNC)-based remote access solution is capable of providing these users with the access they require, HDR recommends transitioning to a remote access solution without the inherent security risks of VNC. For the same reasons indicated for mobile access to the Sewer Utility SCADA HMI screens, HDR recommends that RDS be used to establish remote access for more technical users who require greater privileges and permissions on the OT network.

These users would initiate remote connections using Remote Desktop Protocol (RDP) from County-issued or whitelisted systems integrator laptops to engineering workstation(s) on the OT network where necessary applications reside. Remote sessions would be established via the same Remote Desktop Gateway in the industrial DMZ that is used by the Sewer Utility's mobile users. As with the mobile access solution proposed above, the same two methods of accessing the industrial DMZ apply (County IS department managed VPN service or Tempered Networks Airwall system) and HDR recommends that MFA also be included in the remote access for these more privileged users.

The Sewer Utility should consider the use cases for privileged remote access carefully. The ability to edit PLC programming and HMI graphics remotely can potentially reduce emergency response times and costs associated with systems integrator site visits. However, in general, the associated permissions should not be left in place indefinitely. Also, remote access to servers and network switches with administrator-level privileges is not recommended.

5.2.8 OT Network Configuration, Management, and Backup Improvements

Develop and Implement an Improved OT Network Segmentation Scheme

To reduce cybersecurity risks and adopt industry best practices, HDR recommends that the Sewer Utility discontinue use of public IP addresses for OT network devices. The existing subnetting scheme also needs to be modified to both accommodate additional IP devices in the future (the CKTP OT network is currently limited to 254 devices) and to establish zones and conduits consistent with ISA/International Electrotechnical Commission (IEC) 62443 recommendations to limit the network traffic to required operational functions (ISA/IEC 2020). For example, once the CKTP control panel operator interface terminals (OITs) are migrated to a thin client implementation, they will require communication with the SCADA server(s) but will not require direct communication with any of the plant PLCs. Partitioning the OITs onto a separate subnet from the plant PLCs is one example of how the OT network could be segmented. HDR will propose recommendations for OT network segmentation in Phase 4 of the Master Plan as part of the system architecture conceptual design.

Implement a Domain for the CKTP OT Network

HDR recommends that the Sewer Utility implement a domain for the CKTP OT network to reduce the labor involved with maintaining the network as it evolves and to enable PCs and servers on different subnets to communicate after the network is segmented. Once recommended authentication, authorization, and accounting (AAA) measures are in place, there will be several users, PCs, and servers for which security and permissions need to be managed. Having one server from which to manage all of these settings will eliminate the need to separately configure them on each PC and server and eliminate the possibility of user permissions not being universally applied to the various OT network resources. Establishing a secondary domain controller as a resilience measure should also be considered, as this would allow remote users to continue accessing the OT network and other software packages that rely on Active Directory to authenticate users to continue functioning in the event of an outage to the primary domain controller.

Because of the very small size of the OT networks at the remote plants, there would be little to no benefit of establishing a domain for each of the remote plants. HDR recommends that these plants remain as workgroups.

Improve AAA Measures for OT Network

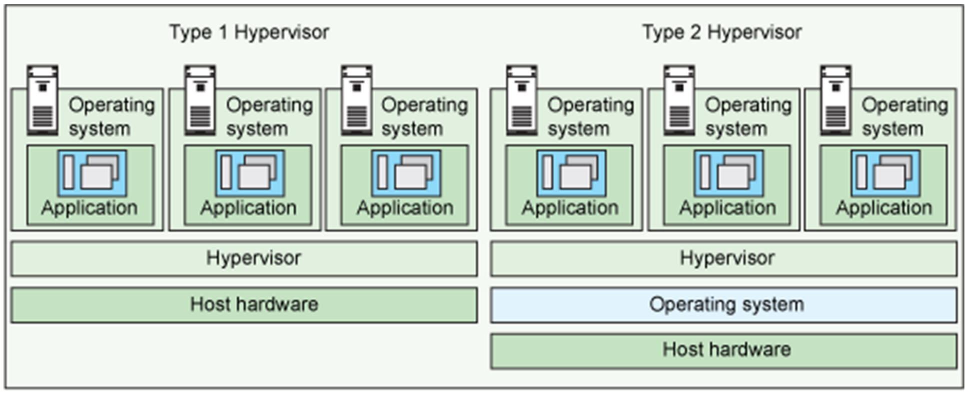
HDR recommends establishing unique user accounts for each individual requiring access to the OT network PCs and servers. Shared user accounts should be eliminated. To simplify management of user accounts, security policies and permissions are best made at the group level rather than for each user account. This allows for role-based permissions to be established for each type of user (group) and then universally applied to all users added to the corresponding group. While on site at the Sewer Utility WWTPs, users should be required to log in to PCs and servers with their unique usernames and passwords and the operating systems for these devices should be configured to log the user out on inactivity. Concurrent logins should also be restricted.

HDR also recommends that the Sewer Utility begin logging and monitoring user activity on the OT network. Though login attempts, session times, and various event data can be viewed via operating system logs and Microsoft Active Directory (software that will be introduced as part of the CKTP OT network domain implementation), third-party software tools for network and user activity monitoring can provide much simpler user interfaces, which will be more approachable for Sewer Utility staff as they acquire network management experience. The selected network monitoring software should have functionality to send alerts to Sewer Utility staff tasked with administering the OT network for potential security events such as multiple failed login attempts. Maintaining user activity logs will also allow Sewer Utility staff to research specific events that occur on the network and attribute them to individual user accounts.

Establish Virtualized Environments for all ICS Servers

To benefit from the advantages of virtualization described in TM-1, HDR recommends that the Sewer Utility establish virtualized environments for all ICS servers. This will require selection of a Type 1 (or bare-metal) hypervisor to standardize on for the Sewer Utility OT network. A Type 1 hypervisor differs from a Type 2 hypervisor in that the software runs directly on the physical server (or host) hardware and not on a host operating system (see Figure 5-15). This yields significant performance and stability benefits because the hypervisor has direct control over the server system resources and is not having to broker commands through an operating system or sacrifice system resources to operating system overhead. Physical servers running Type 1 hypervisors are dedicated to virtualization purposes and cannot be used for anything other than serving guest virtual machines (VMs).

Figure 5-15. Type 1 and Type 2 hypervisor environments



Source: IBM (2020).

Two widely used Type 1 hypervisors that are both supported by AVEVA System Platform 2020, the current offering of the Sewer Utility's SCADA HMI software, are Microsoft Hyper-V and VMware ESXi. Either hypervisor would be suitable for the Sewer Utility's needs. Hyper-V licensing is typically less expensive than VMware, but VMware has several software offerings to expand the functionality of its virtualization services. In HDR's opinion, a significant factor in the selection of a hypervisor should be the level of familiarity that County staff and QCC have with the two hypervisors. If the individuals likely to be supporting the virtualized infrastructure have more experience or a strong preference for one hypervisor over another, that would be good grounds for a selection to be made. QCC may have already made a determination as to which hypervisor to use as part of the ongoing AVEVA System Platform upgrade.

In general, most of the PCs on the OT network should be relatively uniform in terms of setup and configuration and should not be hosting important ICS files or applications locally. ICS files and applications should be hosted on the ICS servers. Therefore, there should not be a driver to virtualize the OT network PCs. However, the Sewer Utility I&C technicians will likely require a Type 2 hypervisor to have access to various versions of Rockwell applications and other automation software and to contain those applications in a controlled environment so that they do not bog down host machine resources. There are also several network monitoring and security applications that run more effectively in a Linux environment, so I&C technicians would benefit from the ability to host a Linux distribution on their PCs in the future.

Establish Automated Backup Procedures for ICS Servers That Includes On-premise and Off-site Storage

HDR recommends that the Sewer Utility implement automated backup procedures for critical ICS servers to prevent significant data loss and improve the Sewer Utility's ability to recover from hardware failures, cyberattacks, and catastrophic events. At a minimum, the Sewer Utility's backup solution should include daily image-level backups of VMs and weekly bare-metal backups (a backup procedure that allows staff to recreate the host server on a new physical machine with minimal reinstallation and configuration) for critical ICS servers at the four WWTPs. Backups should be saved to a physically separate backup server or network attached storage (NAS) device at CKTP as well as an off-site data store. For the off-site data store, the Sewer Utility could implement a dedicated backup server at the County Public Works Annex facility in Bremerton and/or lease cloud storage. The Sewer Utility should also incorporate the practice of periodic file recovery from backup testing to confirm the integrity of backups and ensure that backup procedures are occurring as intended.

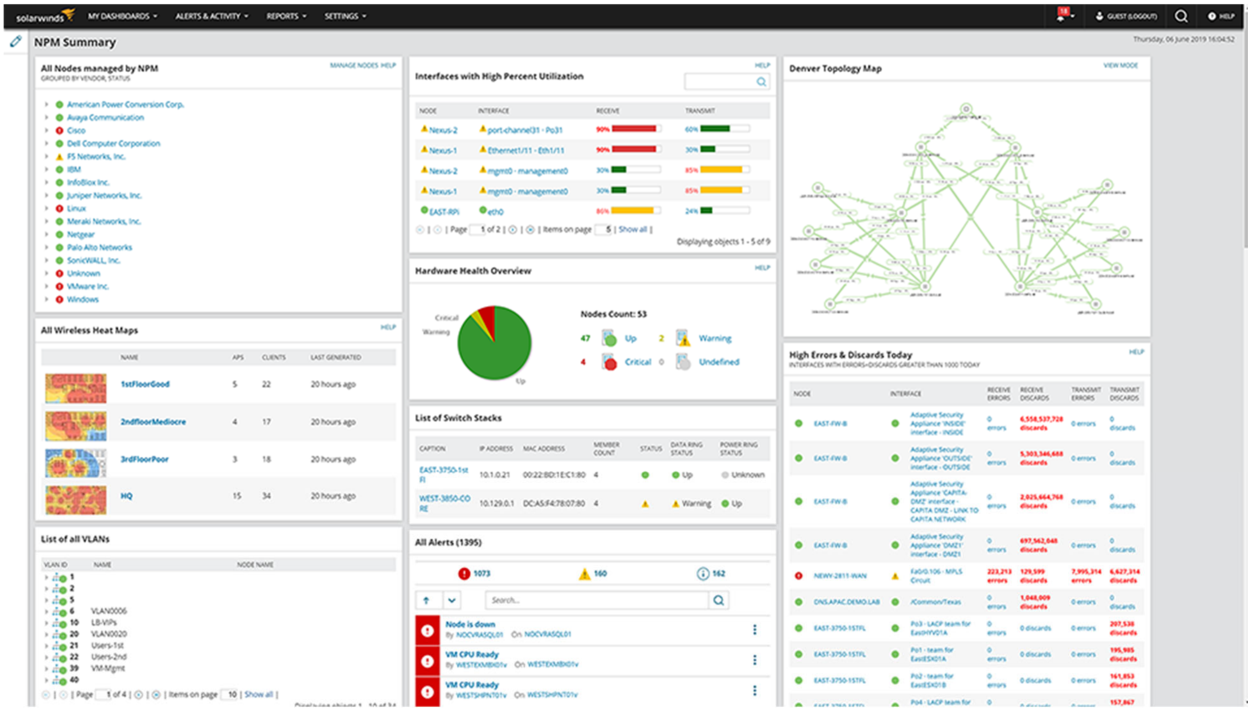
Though it is possible to automate backup processes by developing scripts and scheduling backup tasks at the operating system level, this process is labor-intensive and requires a level of expertise that may take some time for the Sewer Utility to develop with in-house staff. Backups over WANs can also become challenging because of throughput limitations and can greatly benefit from WAN acceleration services provided via third-party backup software solutions. Third-party backup software providers, such as Veeam and Altaro, offer extremely simplified user interfaces that allow users with limited technical background to easily configure and schedule backups of VMs and physical servers to on-premise, off-site, and cloud data stores. HDR recommends that the Sewer Utility leverage a solution from a third-party backup software provider to simplify the associated OT network management effort for Sewer Utility staff and to optimize the backup-related data exchange occurring over the Tempered Networks WWTP WAN.

Implement OT Network Performance Monitoring and Logging Capabilities

Several new devices will be introduced to the OT network in the coming years that will increase the network's complexity and the maintenance burden on Sewer Utility staff. As ICS and other data trafficked by the OT network become more readily accessible to Sewer Utility staff and those data sets are made integral to decision-making and planning processes, the Sewer Utility will become more reliant on the OT network for day-to-day operations. With this in mind, the Sewer Utility will require a means of efficiently monitoring network performance and logging network events to alert staff to potential issues before they degrade into significant network outages and to support troubleshooting and root-cause analysis efforts.

There are a vast number of approaches to network performance monitoring and logging, and, not surprisingly, the opinions of systems administrators on this topic are varied. Because Sewer Utility staff do not have a background in network administration, HDR recommends that the Sewer Utility implement a solution based on licensed software that includes vendor support, high-quality documentation, and access to training for Sewer Utility staff. Many of these software offerings feature relatively intuitive, customizable dashboards to help focus the user's attention on important metrics and information. An example dashboard from one vendor offering is shown in Figure 5-16.

Figure 5-16. Example network performance monitoring dashboard from SolarWinds



Source: SolarWinds Worldwide (2021).

Included in the Sewer Utility's solution should be a System Logging Protocol (Syslog) server on the OT network that receives Syslog messages, SNMP traps, and Windows event logs from OT network switches, firewalls, servers, PCs, and other network appliances. The Syslog server will establish a central logging repository for all OT network infrastructure, which will simplify monitoring and backup efforts. The Sewer Utility will also require software running on a separate server (virtual, not necessarily physical) to provide Sewer Utility staff with an intuitive user interface for monitoring network performance, auditing logs, and troubleshooting network events.

HDR recommends that the Sewer Utility implement a separate subnet dedicated to network management. This will establish a degree of isolation between network management traffic and critical network traffic related to SCADA and PLC-to-PLC communications, and allow the Sewer Utility to prioritize the latter (e.g., leveraging Quality of Service [QoS]). By placing network management traffic out-of-band from the production environment, the Sewer Utility will increase the likelihood that staff can access OT network devices during a network disruption affecting the production environment. Establishing a separate subnet for network management will also allow the Sewer Utility to more tightly control access to the Syslog server, making it more difficult for malicious actors to modify or delete logs to cover their tracks.

5.2.9 Cybersecurity Improvements

Perform ICS Server, PC, and OT Network Device Hardening to Mitigate Common Cybersecurity Risks

HDR recommends that the Sewer Utility perform an initial vulnerability assessment for its ICS server, PC, and OT network device infrastructure to provide configuration changes that will harden the devices against common cybersecurity vulnerabilities. Typical hardening procedures include, but are not limited to, changing default usernames and passwords; disabling unused network switch ports and assigning them to an unused VLAN (i.e., black hole VLAN); removal of non-essential programs on servers and PCs; upgrading to current firmware, software version, and security patches; and requiring the use of Hypertext Transfer Protocol Secure (HTTPS) when accessing web interfaces for device configuration. This effort should also include enabling Advanced Encryption Standard (AES) encryption on the radios involved in the Sewer Utility pump station VHF licensed radio WAN.

As part of the initial device hardening effort, the implemented hardening measures should be recorded in internal documentation that can be used as a reference for hardening devices added to the OT network at a later date. The internal documentation can also be used as the basis for scheduled configuration audits, where the Sewer Utility conducts a periodic review of ICS server, PC, and OT network device configurations to bring devices into compliance with standard hardening measures as well as updating the standard measures to address current firmware versions and known vulnerabilities. Non-sensitive information captured in this internal documentation should be included in the proposed Sewer Utility ICS standards so that contractors on future projects are held to minimum configuration and device hardening requirements.

Establish Unique User Accounts and Implement MFA for Tempered Networks Conductor Management

The Sewer Utility's Tempered Networks Conductor instance is cloud-hosted and requires users to authenticate over the Internet. Because the Conductor serves a critical role in establishing security policies and permissions for much of the Sewer Utility's OT network, access to the Conductor's web interface needs to be tightly controlled and changes to configurations and security policies should be attributable to specific individuals. HDR recommends that the Sewer Utility discontinue the use of generic user accounts for the Conductor and establish unique user accounts for the few individuals who require access to the Conductor. A general administrator account with full permissions should still be maintained for the purposes of creating and removing user accounts, but HDR recommends that login credentials for the administrator account not be shared with contracted systems integrators or other external parties. Once unique user accounts have been established, HDR recommends that the Sewer Utility implement MFA for accessing the Conductor web interface as an additional security control. MFA would apply to both the administrator account and unique user accounts.

Implement Role-based Overlay Networks for the Sewer Utility Tempered Networks Airwall System

HDR recommends implementing role-based overlay networks for the Sewer Utility Tempered Networks Airwall system that are configured to restrict access for member devices according to the Principle of Least Privilege. The following preliminary overlay networks are recommended. Note, these recommended overlay networks may be modified as the system architecture conceptual design is developed in Phase 4 of the Master Plan:

- **KWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Kingston Wastewater Treatment Plant (KWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to KWWTP from CKTP.
- **MWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Manchester Wastewater Treatment Plant (MWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to MWWTP from CKTP.
- **SWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Suquamish Wastewater Treatment Plant (SWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to SWWTP from CKTP.
- **Remote facilities:** This new overlay network would be dedicated to providing each remote WWTP and the County Public Works Annex with access to SCADA HMI screens for other WWTPs and the remote pump stations. Static membership would include a SCADA PC at each remote WWTP, a dedicated PC at the County Public Works Annex facility, and the Remote Desktop Gateway at CKTP.
- **Public Works Annex:** This new overlay would be dedicated to the data exchange between the CKTP SCADA servers and the backup server(s) at the County Public Works Annex facility required to support recommended off-site backup procedures. Static membership would include the CKTP SCADA servers, the County Public Works Annex facility backup server(s), and any other OT network resource necessary to support backup procedures.

  Note, if the Sewer Utility decides not to implement backup server(s) at the County Public Works Annex facility, this overlay network would not be necessary.
- **Kitsap IC:** This existing overlay network would be dedicated to the Sewer Utility I&C technicians and their immediate remote access needs. Static membership would include the Sewer Utility I&C technician laptop(s) and the Remote Desktop Gateway servers at the WWTPs. The static overlay network configuration would allow I&C technicians to establish remote desktop connections to servers and PCs at the various WWTPs via the Remote Desktop Gateway servers. For scenarios where I&C technicians require direct remote access to a PLC or other OT network resource that cannot be accessed via one of the PCs at the WWTPs, I&C technicians could temporarily add the device to the Kitsap IC overlay network. Once I&C technicians are finished with remote maintenance or troubleshooting for the device, it is recommended that they remove it from the overlay network.

  Note, if the Sewer Utility elects to provide I&C technicians with remote access to the WWTP Remote Desktop Gateway servers via the VPN service managed by the

County IS department, the static overlay network membership would include only the I&C technician laptop(s).

- **Remote support:** This existing overlay network would be dedicated to contracted systems integrators and their immediate remote access needs. Static membership would include one systems integrator laptop or PC at a time. This static overlay network configuration would not allow contracted systems integrator access to Sewer Utility OT network resources by default. When systems integrators require remote access to the OT network, the scope of their access requirements should be clearly defined so that Sewer Utility I&C technicians can add the appropriate servers, PCs, PLCs, and/or other OT network resources to the overlay network as needed. Once the systems integrator is finished with his/her work, all Sewer Utility OT network resources should be removed from the overlay network.
- **Mobile SCADA:** This new overlay would be dedicated to Sewer Utility staff requiring mobile access to the SCADA HMI screens. Static membership would include operations and supervisory staff tablets and/or laptops and the Remote Desktop Gateway server at CKTP.

  Note, if the Sewer Utility elects to provide staff with remote access to the CKTP Remote Desktop Gateway server via the VPN service managed by the County IS department, this overlay network would not be necessary.

Introduce OT Network Firewall Layer Upstream from WWTP Tempered Networks HIPswitches

The HIPswitches deployed at the Sewer Utility WWTPs are providing a single layer of defense at the periphery of the WWTP OT networks. HDR recommends introducing a firewall upstream from each WWTP HIPswitch as an additional security layer. In general, these firewalls would be configured to deny all except for necessary routes, ports, and protocols. The upstream firewall will also provide the Sewer Utility with the benefit of auditable firewall logs, which can be analyzed to detect abnormal activity originated from inside or outside of the OT network. If the Sewer Utility will be responsible for auditing the firewall logs, the logs should be pushed to the proposed Syslog server on the OT network. Otherwise, the logs would be routed as directed by the County IS department according to its logging practices.

Develop a Formal Cybersecurity Incident Response Program

HDR recommends that the Sewer Utility establish a formal cybersecurity incident response program that meets the following criteria:

- Establishes procedures to prepare for cybersecurity threats
- Enables staff to identify when cybersecurity incidents occur
- Indicates which individuals and agencies to contact once a cybersecurity incident is discovered
- Guides response to cybersecurity incidents
- Identifies coordination points and dependencies involving County IS and/or third-party service providers (e.g., Verizon Wireless)

- Includes guidelines for adequately documenting cybersecurity incidents and their resolutions
- Defines disaster recovery procedures, including definition of recovery time and recovery point objectives

Once this program is developed, it should be updated and practiced at regular intervals so that Sewer Utility staff can respond quickly and effectively should a cybersecurity incident occur.

- ✪ Upgrade CKTP control room.
- ✪ Extend OT network to County Public Works Annex facility.
- ✪ Migrate pump stations from VHF licensed radio WAN to cellular WAN.
- ✪ Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.
- ✪ Improve communication status monitoring and alarming for remote pump station telemetry.
- ✪ Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.
- ✪ Consolidate CKTP OT network servers, distribution switches, and other appliances in a network rack environment within the SPB.
- ✪ Upgrade to stacked Layer 3 distribution switches at CKTP SPB.
- ✪ Modifications to CKTP administration and laboratory building electrical room.
- ✪ Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.
- ✪ Establish cable path redundancy for critical segments of the OT network.
- ✪ Establish robust UPS battery backup solution for ICS and OT network infrastructure.
- ✪ Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.
- ✪ Establish an industrial DMZ between Sewer Utility business LAN and OT network.
- ✪ Implement secure mobile access to SCADA HMI screens for remote and on-site staff.

- ✪ Implement secure remote access to OT network for I&C technicians and contracted systems integrators.
- ✪ Develop and implement an improved OT network segmentation scheme.
- ✪ Implement a domain for the CKTP OT network.
- ✪ Improve AAA measures for OT network.
- ✪ Establish virtualized environments for all ICS servers.
- ✪ Establish automated backup procedures for ICS servers that include on-premise and off-site storage.
- ✪ Implement OT network performance monitoring and logging capabilities.
- ✪ Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.
- ✪ Establish unique user accounts and implement MFA for Tempered Networks Conductor management.
- ✪ Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.
- ✪ Introduce OT network firewall layer upstream from WWTP Tempered Networks HIPswitches.
- ✪ Develop a formal cybersecurity incident response program.

6 ICS Hardware: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS hardware and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS hardware in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS hardware.

6.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the ICS hardware.

6.1.1 Establish the Next PLC Platform Standard for the ICS

The Sewer Utility needs to select PLC technology to replace existing PLCs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The Sewer Utility needs to standardize on PLC platform(s) for both WWTP process control applications and for remote pump station control applications. The selected PLC platform(s) must meet the Sewer Utility's technical requirements, support integration of an increasing number of Ethernet devices, be compatible with existing PLC programming logic, and be actively supported by the manufacturer for the next 10 to 15 years. The Sewer Utility has identified that hot-standby controller redundancy is not required for any of the WWTP or pump station applications. Because the Sewer Utility has already standardized on Allen-Bradley for PLCs throughout its ICS infrastructure, the selection will be made from Allen-Bradley's most current product offerings.

Note, because the Sewer Utility has already standardized on MicroLogix 1400 PLCs for remote pump station RTU applications and has recently installed these PLCs at remote pump stations, Phase 3 of the Master Plan will focus on identifying standard applications for these PLCs and will not evaluate a replacement product.

6.1.2 Motor Controllers

Standardize on Motor Controllers with Ethernet Capability and Hardwired Signals for Control and Core Monitoring

The Sewer Utility would like to standardize on Ethernet motor controllers for future projects. The Sewer Utility is also interested in expanding the current practice of monitoring and archiving limited data from networked motor controllers to include more robust power, energy, alarm, and warning data. Hardwired signals will still be used for core monitoring (e.g., running, in auto, and in hand status, motor high temperature, etc.) and control of the equipment.

Eliminate DeviceNet Networks at CKTP

The Sewer Utility would like to eliminate DeviceNet networks within the CKTP motor control centers (MCCs). Replacement overload relays, variable-frequency drives (VFDs), and reduced-voltage soft starters (RVSSs) will require Ethernet communication capability to conform to the Sewer Utility's desired standard for motor controllers. The Sewer Utility would like to prioritize elimination of the DeviceNet networks within the CKTP headworks MCCs because these networks have been in service the longest and have generated more maintenance issues.

6.1.3 Establish the Next OIT Standard for the ICS

The Sewer Utility needs to select OIT technology to replace existing OITs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The Sewer Utility needs to standardize on an OIT solution that meets the Sewer Utility's technical requirements, integrates easily with Allen-Bradley PLCs, and is actively supported by the manufacturer for the next 5 to 10 years.

6.1.4 Thickened Sludge Truck Loadout Flow Monitoring at Remote WWTPs

The Sewer Utility would like to have a more accurate accounting of thickened sludge volumes received at CKTP from the remote WWTPs. Truck operators currently rely on thickened sludge storage tank level measurement and sight glasses to draw down the tanks and, without a means to measure actual volumes received by the trucks, the Sewer Utility is assuming full truck volumes for each trip. The Sewer Utility would like to install flowmeters for thickened sludge storage tank truck loadout stations at the remote WWTPs to establish a means for determining actual thickened sludge volumes transported to CKTP.

6.1.5 Implement Monitoring and Alarming for Composite Samplers

The Sewer Utility would like to implement monitoring and alarming for the composite samplers at its WWTPs. Sewer Utility staff need to be alerted to composite sampler faults via the SCADA system and would also like to view sample counts and when samples are in progress at the SCADA HMI.

6.1.6 Improved SCADA Monitoring of UV System at Remote WWTPs

Sewer Utility staff would like to have more detailed information on the remote WWTP ultraviolet (UV) systems available at the SCADA HMI screens. The ability to see which bulbs are failed, UV intensities, and other parameters would help them better monitor system performance. Having access to real-time and historical UV transmittance would also reduce the manual data collection effort for laboratory staff.

6.1.7 Implement CKTP Instrumentation and Automation Improvements

Establish an Improved Means of Plant Effluent Flow Monitoring

The Sewer Utility would like to improve its current approach to CKTP effluent flow monitoring described in TM-1. If implementing direct flow measurement is infeasible, the Sewer Utility would like to refine current indirect flow derivation to maximize accuracy and reduce the manual effort involved in the review and management of flow totals.

Automate and Optimize BNR Process Control

The Sewer Utility needs to transition from manual aeration control to automated control of the biological nutrient removal (BNR) process at CKTP. The Sewer Utility has already identified this as a high-priority initiative prior to the Master Plan and is working with Murraysmith, HDR, and QCC to develop and implement a solution as part of a separate facilities planning task.

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for CKTP. However, the Sewer Utility does not have flow measurement for the plant wastewater pump station return flow to upstream of the primary diversion channel, which is preventing a full accounting of liquid stream flows. Flow monitoring for this return flow would need to be implemented to enable a comprehensive liquid stream flow balance.

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for CKTP. However, the Sewer Utility does not have flow measurement for some solid stream processes, which is preventing a full accounting of solid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Primary sludge flow to gravity-belt thickeners (GBTs)
- Primary and secondary scum flow to GBTs (currently primary and secondary clarifiers are served by the same scum pumps)
- Incoming septage flow received at septage receiving station
- Mixed liquor distribution channel foam wasting flow to digesters
- Thickened sludge flow from each GBT to thickened sludge blending tank (currently only combined flow is monitored)
- Hauled sludge flow to thickened sludge blending tank
- Digested sludge flow from each digester to centrifuges (currently only combined flow is monitored)

6.1.8 Implement KWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for KWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Biofilter sump flow to oxidation ditches
- Process building sump flow to headworks
- Potable water (W2) flow to plant processes

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for KWWTP. However, the Sewer Utility does not have flow measurement for the secondary scum flow from the secondary scum pumps to the waste activated sludge (WAS)/thickened waste activated sludge (TWAS) tanks, which is preventing a full accounting of solid stream flows.

6.1.9 Implement MWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for MWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Plant influent flow
- Odor control blowdown sump flow to headworks
- W2 flow to plant processes
- Service water (W3) flow to plant processes
- In-plant pump station flow to headworks

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for MWWTP. However, the Sewer Utility does not have flow measurement for some solid stream processes, which is preventing a full accounting of solid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- WAS flow to WAS tanks
- Secondary scum flow to WAS/TWAS tanks

Aeration Basin Aeration Control Upgrades

Sewer Utility staff would like to upgrade the existing constant-speed blowers to VFD-controlled blowers to reduce energy consumption and improve aeration control. Sewer Utility staff would also like to install analytical probes within the aeration basins to reduce manual probe measurement requirements and to allow for automated control of the blowers. The Sewer Utility has identified a potential CIP project to upgrade the plant to meet new total nitrogen (TN) limits and these aeration basin aeration control upgrades would be included in that effort. In the meantime, Sewer Utility staff would like to have the ability to schedule and adjust the current blower operation time sequence from the SCADA HMI.

Implement SCADA Control of Sludge Wasting

The WAS pump at MWWTP is no longer in service and operations staff now use the two return activated sludge (RAS) pumps for sludge wasting to the WAS tanks, similar to the configuration at KWWTP. However, unlike KWWTP, the isolation valve on the WAS line to the WAS tanks is a manual valve so operations staff must manually position the valve to send WAS flow to the WAS tanks. The Sewer Utility would like to be able to control this valve from SCADA so that the sludge wasting process can be automated.

Integrate Headworks Mixing Channel Blower Alarm at SCADA

Sewer Utility staff would like to receive an alarm at SCADA when the mixing channel blower at the headworks building has faulted. Currently, operations staff are required to manually check in on the equipment while conducting their rounds to confirm that the equipment is not in alarm state.

6.1.10 Implement SWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for SWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Drain collection pump station flow to headworks equipment
- W3 flow to plant processes

Analytical Probe Monitoring for SBRs

Sewer Utility staff would like to install analytical probes within the sequencing batch reactors (SBRs) to reduce manual probe measurement requirements and to allow for automated control of the aeration blower speed and runtimes.

Improved Dewatering Performance

Sewer Utility staff would like to resolve the issue causing the thickened sludge pump to trip on high pressure at increased sludge concentrations. Resolving the issue would eliminate the need for manually operating the rotary-drum thickener (RDT) and allow the Sewer Utility to fully utilize the RDT to increase the degree of dewatering achieved at the plant.

Stable Effluent Control Valve Control

The Sewer Utility needs to restore stable position control for the effluent control valve so that operations staff can control the valve from SCADA and rely on it to maintain its position.

Sludge Storage Tank Level Measurement

The Sewer Utility needs to implement reliable level measurement for the SWWTP sludge storage tank. A more permanent installation for the backup high level float switch is also required.

Thickened Sludge Storage Tank Level Measurement

The Sewer Utility would like to improve the reliability of the SWWTP thickened sludge storage tank level measurement.

6.1.11 Implement Remote Pump Station Instrumentation and Automation Improvements

Force Main Pressure Monitoring

The Sewer Utility would like to standardize on force main pressure monitoring at its critical remote pump stations. With the addition of force main pressure data with already available flow data from pump station flowmeters, Sewer Utility staff will have the ability to monitor pump performance and receive advanced indicators of pump health degradation and/or potential issues within conveyance system force mains.

6.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS hardware.

6.2.1 Establish Sewer Utility PLC Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs

In Phase 3 of the Master Plan, new PLC platform(s) will be identified to replace existing PLCs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. In addition to defining the standard PLC platform(s), the Sewer Utility's preferred input/output (I/O) module types should also be determined so that appropriate model numbers can be identified in the Sewer Utility's ICS standards documentation in an effort to reduce spare-parts inventory in the future.

Once new PLC platform standards have been identified, PLC replacement projects will be identified in Phase 5 of the Master Plan to upgrade PLCs that are reaching the end of their useful life and/or are no longer supported by the manufacturer. Based on years in service, manufacturer support, and criticality of the application, HDR recommends that the Sewer Utility prioritize PLC replacement as indicated in Table 6-1.

Table 6-1. PLC replacement priority

Priority	Facility	Panel tag	Panel description	Year installed
1	PS-24	N/A	Main control panel	2000
2	PS-4	N/A	Main control panel	2004
2	PS-17	N/A	Main control panel	2004
2	PS-7	N/A	Main control panel	2007
3	PS-71	N/A	Main control panel	2004
4	CKTP	PNL 1021	Influent screen 1 main control panel	2010
4	CKTP	PNL 1023	Influent screen 3 main control panel	2010
4	CKTP	PNL 1026	Screwpactor main control panel	2010
4	CKTP	PNL 1050	Headworks control panel	2010
4	CKTP	PNL 1111	Grit washer 1 control panel	2010
4	CKTP	PNL 1112	Grit washer 2 control panel	2010
5	CKTP	N/A	Raptor Acceptance Control System (RACS) operator interface control panel	2010
5	CKTP	PNL 5010	Raptor septage acceptance plant control panel	2010
6	CKTP	PNL 4050	Polymer blending system control panel	2014
6	CKTP	PNL 4080	Polymer feed system control panel	2014
6	CKTP	PNL 8200	Filter system control panel	2014
6	CKTP	PNL 9201	Digester gas treatment control panel[a]	2014
6	CKTP	N/A	Master station central telemetry unit (CTU) (radio)	2017

a. PLC replacement not required if cogeneration system is not returned to service.

6.2.2 Develop a Standard Approach for Monitoring and Control of Motorized Equipment

HDR recommends that the Sewer Utility develop a standard approach for monitoring and control of motor controllers throughout its infrastructure. The main motor controller categories needing standardization include full-voltage non-reversing (FVNR) starters, full-voltage reversing (FVR) starters, VFDs, RVSSs, electric actuators for isolation gates/valves, and electric actuators for modulating gates/valves. The standard approach should define requirements for the following, at a minimum:

- Local indication lights, selector switches, pushbuttons, runtime meter, human interface module (HIM), and other instrumentation required at the MCC unit door or motor starter/VFD enclosure (this would not apply to electric actuators)

- Hardwired I/O between the motor controller and SCADA
- Ethernet parameters communicated between the motor controller and SCADA (this would not apply to electric actuators)
- Graphical representation of motor/asset at SCADA HMI process-level and equipment-level screens and pop-up windows
- Associated alarms and alarm priorities
- Means of communicating alarms or conditions, external to the equipment, that are inhibiting the equipment from running
- Parameters to be recorded within the Sewer Utility historian

Defining standard approaches to monitoring and control of motorized equipment will enable QCC or another systems integrator to develop standard automation programming templates for each type of motorized equipment that can then be consistently applied to future ICS upgrades for the Sewer Utility and documented in the proposed Sewer Utility ICS standards documentation. Examples of standard automation programming templates include Add-on Instructions (AOIs) and User-defined Data Types (UDTs) used within Rockwell Automation Studio 5000 Logix Designer project files and AVEVA Asset Library template objects deployed within AVEVA System Platform.

HDR recommends that the standards related to motor controllers be determined prior to the replacement of DeviceNet networks in the CKTP MCCs. This will help to ensure that Sewer Utility preferences are applied to the equipment within these MCCs, which represents a significant portion of the Sewer Utility's assets.

It should be noted that vendor package equipment like aeration blowers requires special consideration and should be handled on a case-by-case basis depending on Sewer Utility preferences and vendor capabilities.

6.2.3 Develop a Standard Approach for Monitoring Remote Pump Stations

HDR recommends that the Sewer Utility develop a standard approach for monitoring its remote pump stations. The existing RTUs currently communicate pump runtimes and a set of bits that, with some exceptions, represent standard status and alarm states for all pump stations. A few stations also communicate flow. The proposed telemetry improvements will allow the Sewer Utility to obtain additional parameters in near real-time. HDR recommends that the Sewer Utility evaluate the information it would like to obtain from its pump stations and then standardize on the instrumentation, PLC and RTU programming, and SCADA HMI graphics representation. The standard approach should define requirements for the following, at a minimum:

- Analog process values to monitor at SCADA (e.g., wet well level, flow, force main pressure, chemical tank level).
- Process alarms (e.g., wet well high level, low flow when pumps are running, high force main pressure, low chemical tank level) and alarm priorities.
- Equipment status, alarms, and alarm priorities.

- Pump station alarms (e.g., smoke detected, flood, intrusion) and alarm priorities.
- Generator and electrical distribution system status, power and energy parameters, alarms, and alarm priorities.
- Pump power and energy parameters.
- Graphical representation of pump station at SCADA HMI process-level and equipment-level screens and pop-up windows. SCADA HMI pump station template(s) should be developed to hide or otherwise remove content and parameters that have not been implemented at a given pump station so that it is clear to Sewer Utility staff which parameters are actually being monitored.
- Parameters to be recorded within the Sewer Utility historian.

As with the monitoring and control of motorized equipment, defining standard approaches to monitoring of remote pump stations will enable QCC or another systems integrator to develop standard automation programming templates that can then be consistently applied to future ICS upgrades for the Sewer Utility and documented in the proposed Sewer Utility ICS standards documentation.

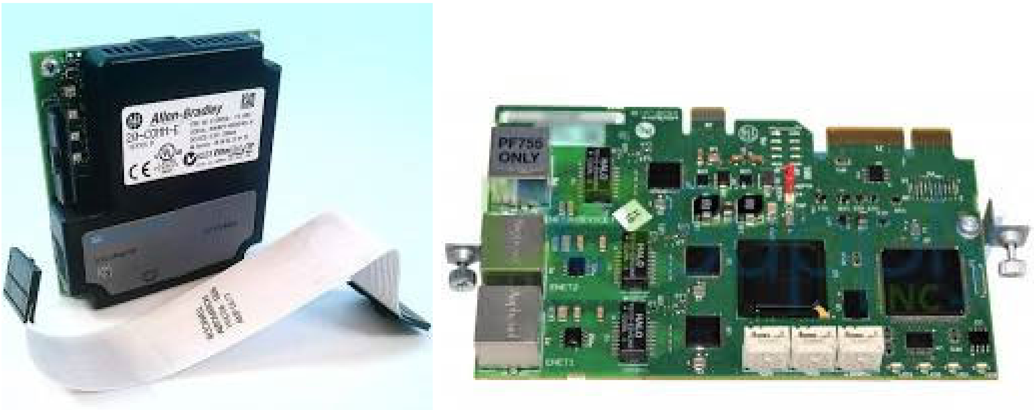
6.2.4 Replace CKTP MCC DeviceNet Networks with Ethernet-capable Motor Controllers

To support the Sewer Utility's goal of eliminating DeviceNet networks from its infrastructure while preserving as much of the recent investment in CKTP MCC infrastructure as possible, HDR recommends retrofitting existing CKTP MCC units rather than a complete replacement of the MCC lineups. The following paragraphs describe specific recommendations involved with the retrofit work.

VFD Communication Adapter/Module Replacement

Two types of Allen-Bradley VFDs are installed within the CKTP MCCs containing DeviceNet networks: PowerFlex 700 alternating-current (AC) drives (in the headworks MCCs) and PowerFlex 753 AC drives (in the MCCs installed as part of the Resource Recovery project). Allen-Bradley provides a 20-COMM-E EtherNet/IP adapter (see Figure 6-1 [left]) for the PowerFlex 700 series drives and a 20-750-ENETR EtherNet/IP option module (see Figure 6-1 [right]) for the PowerFlex 750 series drives. These components could be used to replace the DeviceNet adapters/modules in the existing VFDs to enable Ethernet communication for the drives using the EtherNet/IP protocol that the existing Allen-Bradley PLCs support natively. Both of these components are in the active support phase of the manufacturer's product life cycle and would present an opportunity for extending the life of the existing VFDs while also removing them from the DeviceNet network (Rockwell Automation 2020a).

Figure 6-1. 20-COMM-E EtherNet/IP adapter and 20-750-ENETR EtherNet/IP option module

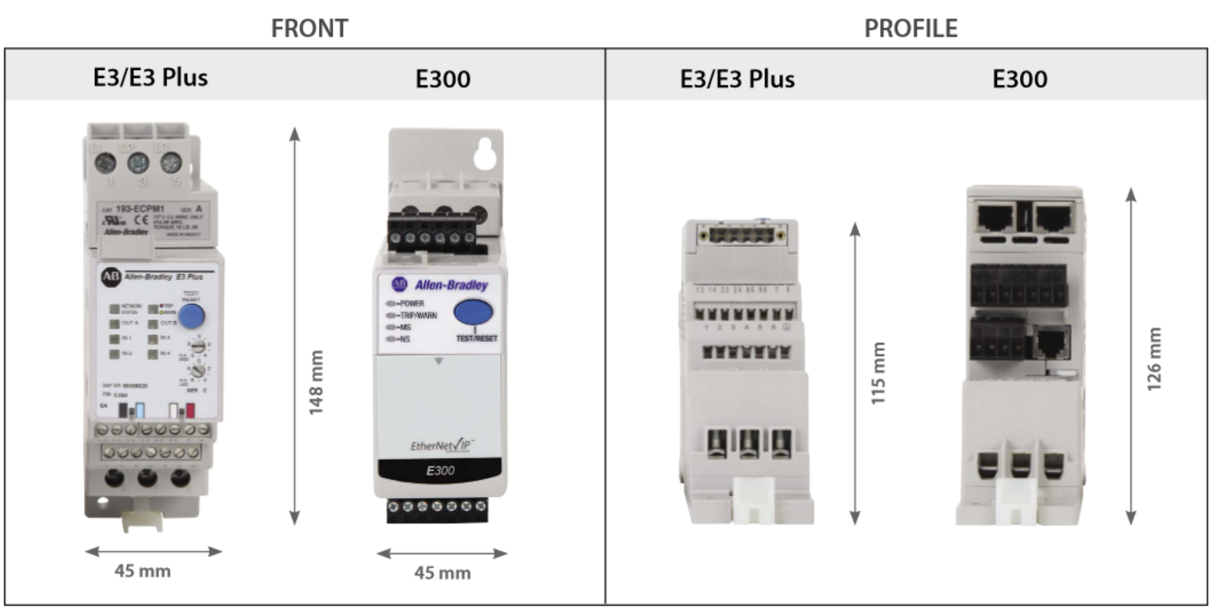


Source: Rockwell Automation.

Overload Relay Replacement

Allen-Bradley E3 Plus electronic overload relays are installed in the CKTP MCCs containing DeviceNet networks. The DeviceNet communication capability is integral to these relays and no module or adapter swap-out option is available. Allen-Bradley has also discontinued the E3 Plus electronic overload relay product line and is encouraging migration to its E300 electronic overload relay family, which has native EtherNet/IP communication capability (Rockwell Automation 2020a). Fortunately, the manufacturer has developed the E300 with retrofits in mind and the footprint of the two overload relays is identical (see Figure 6-2), though the E300 is a little deeper to support RJ45 connections. HDR recommends replacing the E3 Plus electronic overload relays with E300 electronic overload relays or other most current manufacturer offering at the time the DeviceNet network replacement work is implemented.

Figure 6-2. Allen-Bradley E3 Plus and E300 electronic overload relay dimensions



Source: Rockwell Automation (2019).

Some of the MCC units containing E3 Plus electronic overload relays also contain Allen-Bradley Point I/O or DeviceNet Starter Auxiliary components to handle additional hardwired I/O that could not be accommodated by the inputs and outputs integral to the E3 Plus relay. These components are also included in the DeviceNet network and are recommended for replacement with expansion I/O modules compatible with the new E300 relays.

Additional MCC Unit Modifications, Field Wiring, and PLC I/O Expansion

The DeviceNet MCCs at CKTP currently rely on the DeviceNet networks for virtually all monitoring and control between the MCC units and the PLCs. In order for the Sewer Utility to establish its preference of hardwired I/O for core monitoring and control points, additional modifications will be required at the MCC units. Currently, hardwired I/O from field devices like selector switches and motor winding thermostats are wired directly to inputs at the overload relay, VFD, or expansion I/O device. These signals will need to remain in place after the VFD and overload relay upgrades, yet some of these signals will also need to be sent to the PLC control panels in the electrical room to satisfy the Sewer Utility's preference of hardwired I/O for signals such as in auto status and motor high temperature alarm. This will likely require introducing control relays and additional field wiring terminals to the MCC units, which would in turn require that there be sufficient space in the existing MCC units to accommodate these additional components. HDR recommends that the Sewer Utility verify MCC unit sizing requirements for implementing the Sewer Utility's standards for monitoring and control of motorized equipment as part of a detailed design phase preceding the DeviceNet network replacement.

The PLC control panels within the electrical rooms housing the MCCs will also need to have additional I/O modules and field terminal blocks added to accommodate the new hardwired I/O from the MCC units. This hardwired I/O will be significant and may require the addition of RIO racks within the existing enclosures, subpanel replacement, and/or new control panels (if existing control panels have insufficient space available). New conduit and control wiring will also be required in the electrical room to establish hardwired I/O connections between the MCC units and control panel(s). The existing DeviceNet scanner modules in the PLC racks would be removed once they are no longer required.

New MCC Ethernet Networks

In addition to the hardwired I/O, the new VFD communication adapters/modules and overload relays will require Ethernet connections to the OT network to support monitoring of power, energy, and detailed alarm and warning parameters. HDR recommends that the Sewer Utility use shielded Category 6 cable with 600-volt (V) insulation for these Ethernet connections and that the cables be installed as homeruns from the individual MCC units to one or more managed network switches within the electrical room PLC control panel(s). Though the proposed overload relays and VFD communication modules support device-level ring (DLR), HDR does not recommend pursuing a ring architecture to reduce the Ethernet cabling requirements between the MCCs and PLC control panel(s). DLR topologies require disruptions when devices are added to or removed from the network, limit network switch options because of the requirement of DLR-capable ports, introduce additional complexity and configuration requirements to the OT network, and are much more difficult to troubleshoot when a ring participant misbehaves and disrupts the network.

PLC Programming Modifications

PLC programming modifications will be required to realign existing AOIs, UDTs, subroutines, and communications configuration based on DeviceNet communications with a combination of hardwired I/O points and EtherNet/IP data exchange. The existing PLC programming will also need to be modified and expanded to align with the Sewer Utility's standards for monitoring and control of motorized equipment and to incorporate additional parameters related to power, energy, alarms, and warnings that are not already covered. Existing PLC programming related to process control would not likely require significant modifications.

6.2.5 Establish Sewer Utility OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station OITs

In Phase 3 of the Master Plan, a new OIT platform will be identified to replace existing OITs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The following three significant factors are anticipated to contribute to the selection of the new OIT platform:

- Potential for reuse of existing OIT application files
- Licensing requirements and costs
- Potential for leveraging Sewer Utility standard template objects developed for AVEVA platform

Once new OIT platform standards have been identified, OIT replacement projects will be identified in Phase 5 of the Master Plan to upgrade OITs that are reaching the end of their useful life and/or are no longer supported by the manufacturer. Based on years in service, manufacturer support, and criticality of the application, HDR recommends that the Sewer Utility prioritize OIT replacement as indicated in Table 6-2. Other OITs identified in TM-1 as nearing the end of a typical 7- to 10-year service life in the coming years should be evaluated on a case-by-case basis and could be replaced as time and funding allow.

Table 6-2. OIT replacement priority

Priority	Facility	Panel tag	Panel description	Year installed
1	PS-24	N/A	Main control panel	2000
2	PS-4	N/A	Main control panel	2004
2	PS-17	N/A	Main control panel	2004
2	PS-71	N/A	Main control panel	2004
3	KWWTP	CP-300	Process building control panel[a]	2004
4	CKTP	N/A	RACS operator interface control panel	2010

a. OIT replacement may not provide much benefit with SCADA PC in nearby control room and OIT could be eliminated instead.

6.2.6 Develop a Formal Instrument Calibration and Maintenance Program

HDR recommends that the Sewer Utility develop a formal instrument calibration and maintenance program for its WWTPs and remote pump stations. At a minimum the program should accomplish the following objectives:

- Determine the individuals responsible for scheduling calibration events, performing calibration procedures, maintaining program documentation, and reviewing calibration records to determine when additional corrective action is required.
- Maintain an accurate inventory of installed instrumentation with manufacturer, model, and part number(s).
- Document instrument range, last calibration date, next calibration date, accuracy requirements, most recent calibrated zero and span settings for analog instruments, and most recent calibrated set point (rising or falling) and deadband settings for switches.
- Document instrument-specific calibration procedures based on instrument manufacturer recommendations. Calibration procedures should include steps to test the instrument sensor (input), instrument 4–20 milliampere (mA) output or switch contact state, and instrument loop, including verification of correct value/state being displayed at the HMI or OIT.
- Document ideal frequency of calibration activities based on manufacturer recommendations, field observations, instrument criticality, and past instrument performance.
- Schedule calibration activities and ensure that they are performed and documented.
- Maintain calibration records that document as-found settings, as-found test results, final calibration settings, final calibration test results, field observations, individual(s) who performed the calibration, and date of calibration.
- Identify instruments that require additional maintenance or replacement.

Several commercially available software options can simplify management of an instrument calibration and maintenance program. However, the Sewer Utility may be able to avoid additional software license costs by leveraging LLumin for the scheduling and tracking of calibration activities if instruments are included in the LLumin asset database. If the Sewer Utility elects to contract with a testing firm to perform calibration activities, HDR recommends that the Sewer Utility require that calibrations performed are traceable to NIST and that requirements for documentation produced by the testing firm be stipulated clearly in the contract.

6.2.7 CKTP Digester Building PNL 6000 Relocation and MCC Replacement

HDR recommends that the Sewer Utility relocate PNL 6000 or establish a replacement PLC control panel in a properly conditioned environment that does not have a hazardous-area classification. HDR also recommends that the Sewer Utility plan for the replacement of the digester building MCC as part of the next CIP project involving the digesters or within the next 3 years, whichever occurs first. Because of the poor environmental conditions within the digester building, HDR recommends that the replacement MCC be installed elsewhere. Because the MCC replacement is beyond the scope of the Master Plan, it should be included in the electrical recommendations from the ongoing facilities planning effort led by Murraysmith so that it can be incorporated into the Sewer Utility's CIP budget and schedule. HDR believes that Murraysmith is already planning on making this recommendation.

6.2.8 Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers

The Sewer Utility is preparing to replace the composite samplers at its WWTPs and is evaluating quotes received from vendors. Because the Sewer Utility wishes to monitor sampler alarms and status at SCADA, HDR recommends that the Sewer Utility communicate its requirements for SCADA monitoring to the vendors so that the appropriate hardwired and communication options can be considered. Once samplers are replaced, available alarms and statuses should then be incorporated into the WWTP SCADA HMI screens and alarm notification system.

6.2.9 Evaluate Remaining Years of Useful Service Life for Remote WWTP UV Systems to Determine Best Approach for Improved SCADA Monitoring of the UV Systems

The existing UV systems at the remote WWTPs are TrojanUV3000B systems with the basic controller option. These basic controllers provide contacts for monitoring of bank status and a common alarm, but do not support additional remote monitoring or control functionality. TrojanUV does have a Touch Smart Controller option for the TrojanUV3000B systems that could replace the existing basic controllers (see Figure 6-3). The Touch Smart Controller would provide the following limited additional monitoring and control capabilities:

- Low and high water level alarms (if optional level probes are installed)
- Remote system on/off control
- Remote system enable/disable
- Remote turning on of additional bank
- Common alarm is replaced with common minor alarm and common major alarm
- Low UV intensity alarm
- Bank UV intensity alarm
- Average UV intensity (4–20 mA)
- Color touchscreen display for improved operator interface

Figure 6-3. TrojanUV3000B Touch Smart Controller

Source: TrojanUV (2018).

While the Touch Smart Controller would provide some additional remote monitoring and control capabilities, it would not provide individual lamp status, detailed alarming, and other parameters available with some of the vendor's system offerings. HDR recommends evaluating the remaining years of useful service life for the remote WWTP UV systems prior to making a decision on controls upgrades for these systems. If the UV systems will require replacement in the next 3 to 5 years, HDR would recommend waiting to implement improved monitoring and control until the system is replaced and a more complete monitoring and control solution can be specified.

Once the UV systems and/or controllers are replaced, HDR recommends providing PLC programming and SCADA HMI screen modifications to implement an equipment-level HMI screen for the UV system where more detailed status and alarm information can be monitored. Embedded trends showing UV intensity and plant effluent flow are also recommended for this screen so that the UV controller's flow-pacing control functionality can be monitored.

6.2.10 Implement CKTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at CKTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Perform an alternatives analysis for implementing a direct means of plant effluent flow measurement to assess costs and feasibility of available options.
- Provide additional analytical probes and, potentially, aeration flowmeters per recommendations from a separate BNR optimization task in the Sewer Utility facility planning program.
- Consider installing a flowmeter on the plant wastewater pump station discharge line to obtain a return flow measurement to upstream of the primary diversion channel. Based on a cursory review of record drawings, it appears that there is not adequate room to install a magmeter in the existing wastewater pump station valve vault. A magmeter could be installed in a new meter vault downstream from the valve vault potentially.
- Consider installing a flowmeter on the primary sludge line to GBTs to monitor primary sludge flow from the primary sludge pumps.
- Consider installing a flowmeter on the scum line to GBTs to monitor primary and secondary scum flow from the scum pumps.
- Consider installing a flowmeter on the mixed liquor line from the mixed liquor distribution channel foam wasting sump to monitor mixed liquor flow to the digesters.
- Consider installing flowmeters on the thickened sludge lines from the GBTs to the thickened sludge blending tank to monitor individual thickened sludge flows from each GBT.
- Consider installing a flowmeter on the thickened sludge line from the hauled sludge receiving station to the thickened sludge blending tank to monitor hauled sludge flows received from remote WWTPs.
- Consider installing flowmeters on the digested sludge lines from the digesters to the centrifuges to monitor individual digested sludge flows from each digester.
- During next septage receiving station upgrade, ensure that the replacement vendor package system includes incoming septage flow monitoring.
- Service or replace the lower explosive limit (LEL) transmitter on the headworks odor control fan ductwork.
- Service or replace the chlorine residual and turbidity analyzers associated with the reclaimed water system.
- Service or replace the thermal dispersion flowmeter installed on the aeration line for the aerated grit tank 1 stage 2 diffuser.
- Consider installing suspended solids probes in the aeration basins (or potentially one probe to represent all basins in the mixed liquor distribution channel) and WAS pump discharge line to support automated calculation of hydraulically determined solids retention time (SRT). If installation of a suspended solids probe on the WAS pumps discharge line is infeasible, a probe could be installed on the RAS pumps discharge line with the assumption that the suspended solids profile would be the same.

Automation Improvements

The following items include HDR recommendations for automation improvements at CKTP:

- Develop a SCADA HMI screen (or modify existing) for monitoring the comprehensive liquid stream flow balance for the plant along with hydraulic retention time (HRT) values for tanks, basins, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity. If the plant effluent flow monitoring alternatives analysis determines that direct flow measurement is infeasible, the liquid stream flow balance SCADA HMI screen should provide a comparison of derived effluent flow values based on UV system flow-over-the-weir calculations and calculated effluent flow from individual liquid stream flow measurements.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for GBTs, digesters, and the thickened sludge blending tank. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the aeration basins/mixed liquor distribution channel and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.
- Provide PLC programming and SCADA HMI modifications to restore automated control of the BNR process per recommendations from the separate BNR optimization task in the Sewer Utility facility planning program.
- Develop a SCADA HMI screen to provide operators with situational awareness for the load shedding and emergency load sequencing during planned and unplanned transitions between utility and standby generator power. Currently, when utility power is lost and standby generator(s) are started, Sewer Utility staff must rely on institutional knowledge to determine which loads will be allowed to resume operation and in which order. There are multiple sequence levels and time delays implemented in PLC logic that are not transparent to the operators, making it difficult to understand when a load should resume operation and when to take action if it fails to do so. HDR recommends that loads governed by load sequencing are grouped according to their sequence level on the proposed SCADA HMI screen. The screen should indicate whether the loads will be called to run when their sequence level is reached, after which their running status should be displayed and alerts provided when loads fail to run. Real-time countdowns should also be displayed for each sequence level so that operators have more context for when equipment operations will be restored. The Sewer Utility could also consider displaying live power (kW) values for the

sequenced loads that have been called to run along with cumulative generator loading. This information would support analysis of how effectively the loads are allocated among the sequence levels and may inform troubleshooting efforts.

As part of the effort to develop the proposed SCADA HMI screen, HDR recommends that the PLC programming logic related to the load shedding and emergency load sequencing be reviewed. HDR's cursory review of some of this logic as part of the BNR optimization effort uncovered some errors that should be corrected. It is also possible that the emergency load sequencing logic may not have been modified to incorporate loads added by recent construction projects.

- Replace the headworks odor control biofilter sprinkler control panel and associated instrumentation to restore automated control of the biofilter sprinklers/soaker hose. As part of the control panel replacement, HDR recommends that SCADA manual controls also be implemented as an optional override of the sprinkler control panel to allow operations staff to manually initiate and schedule timer-based watering of the biofilter from SCADA HMIs.
- Provide PLC programming modifications to establish a low-level shutdown interlock for the thickened sludge blending tank circulation pump and digester feed pumps based on tank level transmitter measurement to support elimination of the thickened sludge blending tank low level switch. Alternatively, replace the low level switch.
- Record drawings indicate that the primary clarifier drives are not monitored for high torque warnings or alarms at SCADA. HDR recommends that the Sewer Utility establish monitoring of high torque warning and high-high torque shutdown conditions at SCADA for its primary clarifiers.

6.2.11 Implement KWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at KWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.
- Consider installing a flowmeter on the biofilter sump pump station discharge line to monitor biofilter drainage flow to the oxidation ditches.
- Consider installing a flowmeter on the process building sump pump station discharge line to monitor return flow to the headworks.
- Consider installing a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes.

- Consider installing a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the oxidation ditches and WAS line at KWWTP based on the outcome of suspended solids probe and hydraulically determined SRT calculation performance at CKTP.

Automation Improvements

The following items include HDR recommendations for automation improvements at KWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, oxidation ditches, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for WAS and TWAS tanks. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- If the Sewer Utility experiences favorable results with the suspended solids probes and hydraulically determined SRT calculations at CKTP, provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at KWWTP. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the oxidation ditches and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.

6.2.12 Implement MWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at MWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.

- Provide a means of plant influent flow monitoring. HDR recommends evaluating installation of an ultrasonic or radar level instrument at the existing Parshall flume downstream from the grit chamber to obtain this flow measurement.
- Replace the magmeter on the sludge line feeding the GBT.
- Consider installing a flowmeter on the odor control blowdown sump discharge line to the headworks to monitor blowdown return from odor control.
- Consider installing a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes.
- Service or replace the flowmeter on the W3 line to restore monitoring of W3 flow to plant processes.
- Consider installing a flowmeter on the in-plant pump station discharge line to obtain return flow measurement to the headworks.
- Consider installing a flowmeter on the WAS line from the RAS pump station to the WAS tanks to monitor WAS flow.
- Consider installing a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the aeration basins and WAS line at MWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP.
- Install analytical probes in the aeration basins to monitor the BNR process as part of the plant upgrade to adapt to new TN limits.
- Install a level transmitter for the sodium hypochlorite tank and install local indication of tank level at the location from which the tank is filled. For reduced maintenance and avoiding the need to modify the existing tank, HDR recommends considering radar level measurement technology that can measure level through plastic tank ceilings. This would allow the sensor to be installed on a wall-mounted bracket without disturbing the tank.
- Service or replace non-functional combustible gas-monitoring equipment in the sludge pumping gallery, headworks odor control system, and WAS tanks.

Automation Improvements

The following items include HDR recommendations for automation improvements at MWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, basins, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the WAS and TWAS tanks.

HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.

- If the Sewer Utility experiences favorable results with the suspended solids probes and hydraulically determined SRT calculations at CKTP, provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at MWWTP. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the aeration basins and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.
- Until BNR process upgrades due to new TN limits are determined, provide PLC programming and SCADA HMI screen modifications to allow operations staff to schedule and adjust aeration blower operation time sequence from SCADA HMIs. Functionality should include the ability to set unique on/off time durations for each day of the week.
- Install an electrically actuated isolation valve on the WAS line to the WAS tanks to enable SCADA control of the sludge wasting process. This will also require PLC programming and SCADA HMI screen modifications to add functionality for operations staff to manually open and close the valve from SCADA HMIs.
- Wire a fault signal from the mixing channel blower motor starter to the discrete input at the LP-225 RIO rack in the headworks building and provide PLC programming and SCADA HMI screen modification to integrate the fault alarm. This alarm could then be used to alert operations staff to mixing channel blower failures, improving operator response time, and eliminating the need for staff to visit the building to check equipment status.

6.2.13 Implement SWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at SWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Service or replace the combustible gas monitoring equipment in the process building upper floor process room.
- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.

- Verify calibration of the thickened sludge storage tank level transmitter. After calibrating, record a series of measured level values versus actual tank level during two or three tank loadout operations. If accuracy and repeatability of level measurement are unacceptable, consider installing a radar level transmitter to replace the pressure-based level transmitter currently installed in a non-ideal location on the pump suction line. Record drawings indicate that a spare 6-inch nozzle was provided on the tank for a future instrument, which could be used for installation of the radar level transmitter.
- Consider installing a radar level transmitter for monitoring and control of sludge storage tank level. Provide a more permanent and less failure-prone installation for the sludge storage tank high level switch so that it can provide a reliable backup high level interlock and alarm.
- Install DO probes in the SBRs. Depending on the outcome of ongoing facility planning, the Sewer Utility may wish to consider additional analytical probes to facilitate improved monitoring and control of the BNR process. In addition to monitoring and control functionality, pH probes, for example, could supplement and/or reduce the number of manual measurements required by operations staff.
- Replace the damaged thermal dispersion flow switch on the RDT spray water supply line.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the SBRs and WAS line at SWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP.
- Consider installing a flowmeter on the discharge line from the drain collection pump station to monitor return flow to the headworks equipment.
- Consider installing a flowmeter on the W3 line downstream from the reclaimed water pumps to monitor W3 flow to plant processes.
- Service or replace the process building fire alarm system.

Automation Improvements

The following items include HDR recommendations for automation improvements at SWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for SBRs and tanks. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the sludge storage tank. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Service or replace the effluent flow control valve to restore its ability to maintain positions from SCADA-issued commands. Because this will likely require a plant

shutdown, because of the lack of bypass piping for the valve, HDR recommends that the Sewer Utility identify other improvements/upgrades at the plant that would also require a shutdown to perform so as to maximize its benefit from the outage. Unfortunately, there do not seem to be options for installing bypass piping around the valve in its current position. To install a bypass the Sewer Utility would need to evaluate modifications to existing piping, particularly the overflow pipe that connects to the effluent line immediately downstream from the valve.

- Eliminating the manual RDT operation at reduced dewatering efficiency is a high priority for the Sewer Utility. As indicated in TM-1, Sewer Utility staff have a theory about undersized piping on the thickened sludge pump discharge creating high discharge pressures during pump operation that shut the pump down. HDR recommends that the Sewer Utility perform an assessment to diagnose the issue so that appropriate corrective action can be taken. As a first step in this assessment, HDR recommends that the Sewer Utility confirm that plug valves on the discharge line are fully open and that throttled valves are not contributing to increased discharge pressure. HDR also recommends verifying the pump's discharge pressure switch set point and comparing that with the pump curve to confirm that the high-pressure set point is appropriate. Assuming that throttled valves and/or an inappropriate high-pressure set point are not the root cause, an evaluation of pump selection and discharge piping size would be recommended along with a site visit conducted by a pump system subject matter expert to identify potential low-cost mitigations.

6.2.14 Remote Pump Station Instrumentation and Automation

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at Sewer Utility remote pump stations. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Install pressure transmitters on remote pump station force mains. This will allow the Sewer Utility to monitor and trend force main pressures over time, allowing for early detection of force main breaks, grease and/or sediment build-up, and plugging. When combined with wet well level and pump discharge flow, force main pressure will also enable the Sewer Utility to monitor actual pump station system curves, evaluate where lift station pumps are operating on their pump curves, and more effectively monitor and control pump performance.
- Service or replace the combustible gas monitoring equipment at the PS-24 wet well.
- Consider replacement of the PS-24 wet well level transducer and transmitter, as they have likely been in service for roughly 20 years. If the level transducer is replaced, HDR recommends providing a submergence shield for the new transducer given the conditions to which the existing transducer has been exposed. If instrument

replacement is deferred, HDR recommends cleaning the wet well level transducer and performing calibration to verify that level measurement accuracy and repeatability are acceptable.

- Install a level transmitter for the PS-71 BIOXIDE storage tank. For reduced maintenance and avoiding the need to modify the existing tank, HDR recommends considering radar level measurement technology that can measure level through plastic tank ceilings. This would allow the sensor to be installed on a wall-mounted bracket without disturbing the tank.
- Service or replace the combustible-gas monitoring equipment at the PS-71 wet well.

Automation Improvements

The following items include HDR recommendations for automation improvements at the Sewer Utility remote pump stations:

- Develop SCADA HMI screens to provide a summary-level, process flow diagram depiction of the conveyance system associated with each WWTP. Currently, the pump station SCADA HMI screens appear to consist only of a map screen for selecting specific pump stations, a summary status and alarm screen for all pump stations, and pump station specific pop-up screens. The current screens do not appear to provide depiction of where the specific pump stations are situated within the conveyance system, which requires operators to rely on institutional knowledge to recall where pump stations pump to and which pump stations will need to be considered in the event of conveyance system disruptions (e.g., a downstream pump station outage).

  HDR recommends that the summary conveyance system screens display pump running status, flow, force main pressure, and indication of whether or not an alarm is active for each pump station.
- To assist with prioritizing response to pump station emergencies, the Sewer Utility may wish to implement time-to-overflow monitoring for its critical (or all) pump stations. This would involve using the wet well level measurement to calculate change in wet well volume over time and to then extrapolate the time remaining until the wet well level exceeds top elevation, volume exceeds overflow storage capacity, and/or other spill point triggers. These calculations could be initiated by alarms related to reductions in pump station pump capacity (e.g., power failure, pump faults, etc.) and could also be manually enabled and disabled by operations staff as required. The estimated time remaining would be displayed at the individual pump station SCADA HMI screens and could also be incorporated into the proposed summary-level conveyance system screens.
- For pump stations with VFDs where real-time monitoring of pump power (kW) and flow is or could be implemented, the Sewer Utility could consider modifying existing PLC programming logic to favor energy efficient operating points while within normal level range in the wet well. This could be done by calculating gallons pumped per kW consumed in real-time and providing that value as feedback to the pump speed control loop. The pump speed control loop would then make an incremental adjustment to the speed, either increasing or decreasing, depending on the direction

of the last speed adjustment and whether or not the new operating point is an improvement from the previous operating point. The speed range would still be bounded by minimum and maximum speed set points configured at the VFD and, if desired, as further constrained by operator entry at the pump station OIT. Energy efficiency prioritization would also be overridden by variable-level-based speed control when the wet well level rises above the upper threshold of an operator-entered normal level range.

Compared to more traditional control methods like constant-level control, where pump speed is modulated in an attempt to match outgoing flow to incoming flow at the pump station, and variable-level control, where the pump speed is modulated evenly throughout a set level range, this control method leverages the available system response time buffer provided by the wet well's capacity to maximize the efficiency of the pumping system. This approach also allows the controls to adapt to changes in the pump station system curve influenced by fluctuating wet well levels and gradual increases in force main friction head over time, as opposed to maintaining one preferred operating speed derived through theoretical analysis or historical observations.

While the energy savings potential of this control method will vary depending on pump station characteristics, implementing these controls would consist mainly of minor PLC programming and OIT graphics modifications and would not require significant investment. If applied to several pump stations, particularly those with larger pumps, the combined energy savings may be significant. If the Sewer Utility is interested in applying this alternative control method, HDR recommends that baseline energy consumption be established for the existing controls prior to introducing the alternative control method. This will provide a means of comparison and could be used to justify the application of energy-efficiency-based speed control to additional remote pump stations. Pump station capacity should also be evaluated prior to attempting to implement this alternate control method. Pump stations with undersized wet wells for present day flows and/or where pumps are already having to operate near full speed to keep up with incoming flows for the vast majority of their runtime would not have enough operating speed flexibility to be good candidates for this particular pursuit of energy savings.

- As part of the recommended PS-24 PLC upgrade, HDR recommends that the hardwired relay logic and PLC programming for the existing pump controls be reviewed to confirm as-implemented conditions, which may be contributing to the pump short cycling occurring at the pump station. The proposed telemetry upgrades will also allow the Sewer Utility to begin monitoring near-real-time wet well level, flow, and pump on and off transitions, which will aid in the analysis of current level set points. After review of existing controls and near-real-time pump station data, HDR recommends implementing appropriate control improvements to reduce or eliminate pump short cycling at the station to increase the useful service life of the equipment.
- HDR recommends that a control system upgrade occur at PS-34. The control system upgrade would include replacement of the existing control panel with a PLC-based control panel and an OIT for improved local monitoring and control functionality. HDR recommends that the Sewer Utility use the control system upgrade as an opportunity

to bring the station into conformance with the Sewer Utility ICS standards documentation proposed later in this TM.

- HDR recommends evaluating remote alarm reset functionality for select remote pump station alarms. While high wet well level and other critical alarms certainly warrant a site visit by Public Works Facilities staff, there may be some less critical alarms that could be reset remotely to avoid unnecessary site visits. For example, remote resetting of VFD faults to help restore pump functionality after a power bump at a remote pump station that frequently experiences power issues could be beneficial so long as the remote reset capability were not abused. Note, remote reset capability will likely require additional hardwiring at the remote pump station, in addition to PLC programming and SCADA HMI screen modifications.

- ✪ Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.
- ✪ Develop a standard approach for monitoring and control of motorized equipment.
- ✪ Develop a standard approach for monitoring remote pump stations.
- ✪ Replace CKTP MCC DeviceNet networks with Ethernet-capable motor controllers.
- ✪ Establish Sewer Utility OIT platform standard and schedule replacement of select WWTP and remote pump station OITs.
- ✪ Develop a formal instrument calibration and maintenance program.
- ✪ Implement CKTP digester building PNL 6000 relocation and MCC replacement.
- ✪ Include integration of composite sampler alarms and monitoring with replacement of existing samplers.
- ✪ Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV systems.
- ✪ Implement CKTP instrumentation and automation improvements.
- ✪ Implement KWWTP instrumentation and automation improvements.
- ✪ Implement MWWTP instrumentation and automation improvements.
- ✪ Implement SWWTP instrumentation and automation improvements.

✪ Implement remote pump station instrumentation and automation improvements.

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7 ICS Software: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS software and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS software in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS software.

7.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the ICS software.

7.1.1 Establish Centrally Managed, Standards-based HMI and Historian Platform for the WWTPs

The Sewer Utility and QCC have elected to migrate from standalone Wonderware InTouch runtime installations at the various WWTP SCADA PCs and panel PCs to AVEVA System Platform. This upgrade is intended to meet the Sewer Utility's future needs of establishing a central repository for all Sewer Utility historical SCADA data, addressing the lack of standardization in SCADA HMI graphics between the Sewer Utility's WWTPs, and enabling the ability to monitor all Sewer Utility infrastructure at any WWTP. AVEVA System Platform software will be installed on servers at CKTP, which will establish a centralized historian for all WWTPs and pump stations, a centralized development environment, and a repository for standardized HMI graphics objects and AVEVA InTouch applications.

7.1.2 Implement HPHMI Concepts for WWTP SCADA HMI Screens

As part of the effort to standardize its SCADA HMI graphics throughout its infrastructure, the Sewer Utility would like to incorporate HPHMI concepts to improve operator situational awareness and overall effectiveness of the SCADA HMI screens. Some of the HPHMI concepts the Sewer Utility would like to consider as part of its SCADA HMI graphics standards development include:

- Limited, consistent, and intentional use of color, with color not being the only means of communicating status
- No distracting animations or three-dimensional depictions
- Analog values presented with context of desirable/normal operating range, set point and alarm thresholds, and deadband ranges, where applicable
- Consistent screen hierarchy with progressive exposure to more detailed information
- Logical and consistent screen navigation

- Embedded and properly formatted historical trends
- Prioritized alarms indicated via redundant methods (e.g., color, text, and/or shape), with use of flashing or animation for unacknowledged alarms
- Display where alarms have been suppressed
- Provide links or pop-ups to alarm rationalization information (e.g., consequences, potential causes, and corrective actions)

7.1.3 Implement Real-time Monitoring and Historical Trending of WWTP KPIs

Sewer Utility staff would be like to have the ability to monitor WWTP process key performance indicators (KPIs) such as HRT and SRT at the SCADA HMI screens. Staff would also like to have access to historical values for WWTP KPIs for dashboarding and data visualization purposes.

7.1.4 Improve Accessibility of Historical SCADA Data

To fully leverage its historical SCADA data, the Sewer Utility needs simple interfaces for staff to view trends and work with the data. The SCADA data from all WWTPs and pump stations also need to reside in a central repository so that the Sewer Utility does not have to work from data stores scattered throughout its infrastructure. Historical data will also need to be made available to several Sewer Utility and Public Works users and software platforms external to the Sewer Utility OT network. For example, Sewer Utility management staff would like to have access to flow and other engineering-focused data derived from the Sewer Utility ICS and Public Works management staff have expressed an interest in combining select operational data with financial information derived from their enterprise resource planning (ERP) software.

7.1.5 Mitigate Loss of SCADA Data from Remote WWTPs during Communication Outages

The transition to a centralized historian will require SCADA data from the remote WWTPs to be communicated to the historian server at CKTP. The communication conduits involved in this data exchange are subject to outages, which could result in historian data gaps for the remote WWTPs if not accounted for in the AVEVA software configuration. Store-and-forward functionality will need to be implemented for the AVEVA software installed at the remote WWTPs to ensure that real-time data are stored locally during disruptions in communications with the CKTP historian and then forwarded once communications are reestablished. AVEVA software has this capability and HDR believes that QCC is already planning to leverage it for the remote WWTPs and CKTP historian.

7.1.6 Migrate to Thin Client Configuration for CKTP HMIs

As part of its AVEVA System Platform upgrade, the Sewer Utility has decided to adopt a thin client deployment for the various panel PCs that will serve as process area SCADA HMIs at CKTP. This approach will remove the AVEVA InTouch runtime installations at the various panel PCs, which will eliminate the need to separately patch and update each runtime installation, resolve ongoing alarm acknowledgement propagation issues, and allow for centralized management of the Sewer Utility's SCADA HMI software application. Sewer Utility staff will still require read and write access to the SCADA HMI screens and historical trends from the panel PCs and must be able to acknowledge alarms from these locations.

7.1.7 Improved Alarm Notification System

The Sewer Utility needs its on-call operations and supervisory staff to have better access to active alarms and their acknowledged/unacknowledged status via mobile phones. The Sewer Utility would prefer to have an implementation that includes a mobile app as the user interface to eliminate the need for staff to call into the alarm notification system and listen to alarm information. Sewer Utility staff have also identified some outstanding issues with the existing system that need to be resolved.

7.1.8 PLC Firmware Standardization

Sewer Utility staff have identified PLC firmware standardization as a high priority. The Sewer Utility would like to establish a standard firmware version for each of the PLC controller types it maintains throughout its infrastructure and to then bring its PLCs into firmware version alignment. This will reduce the number of Rockwell Automation Studio 5000 and RSLogix 500 software versions the Sewer Utility needs to support while also enabling the PLC controllers on older firmware to benefit from security patches and optimized controller features available in a more recent firmware version.

7.1.9 Establish Tracking of ICS Set Point Changes

The Sewer Utility would like to have the ability to track ICS set point changes made at the SCADA HMI. Knowing when changes were made and by whom will help the Sewer Utility manage set point drift and identify the individual(s) who can provide operational context for why changes may have been made.

7.1.10 Provide Read-only Access to WWTP SCADA HMI Screens at Laboratory

Laboratory staff currently have no access to WWTP SCADA HMI screens and rely on word-of-mouth to keep abreast of current operating modes at the Sewer Utility's WWTPs. To give laboratory staff insight into current WWTP operations and notification of relevant alarms, the Sewer Utility would like to implement read-only access to WWTP SCADA HMI screens at the laboratory.

7.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS software.

7.2.1 Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts

To establish centralized management of the Sewer Utility SCADA HMI applications, the Sewer Utility and QCC are in the process of installing AVEVA System Platform on servers within the CKTP OT network. This will allow the Sewer Utility to manage its various AVEVA InTouch HMI applications from the ArchestrA Integrated Development Environment (IDE) tool within the System Platform software package. HDR believes that QCC is taking the approach of converting the standalone InTouch HMI applications at the Sewer Utility WWTPs to managed InTouch HMI applications, which will allow for centralized modification and deployment of the InTouch HMI applications. This approach will streamline SCADA HMI screen development and management and is consistent with HDR recommendations.

The upgrade to AVEVA System Platform will also enable an object-oriented approach to standardizing the representation of Sewer Utility assets and the operator interface for monitoring and controlling them. HDR recommends this approach because it will allow the Sewer Utility to develop templates for common assets like pumps, mixers, and control valves and to then reuse that content for like assets throughout the Sewer Utility infrastructure. Attributes like color, symbology, I/O structure, status and alarm indication, tag structure and naming conventions, and control interfaces would be defined within the template so that any later revisions required would automatically be pushed out to the various objects derived from the template. This way, a decision to change the running color of a pump, for example, would not require modifying every instance of a pump throughout all of the Sewer Utility SCADA HMI screens. The Sewer Utility can also leverage pre-built templates from AVEVA Industrial Graphics (formerly known as ArchestrA Graphics) and AVEVA Asset Library to reduce the amount of development required. Several of these out-of-the-box templates have been developed specifically for HPHMI implementations.

Developing standard templates based on HPHMI concepts and applying them to the Sewer Utility’s existing InTouch HMI applications will be a significant effort, but this upfront investment will reduce the cost and effort to maintain and modify the SCADA HMI screens in the future and will resolve the current lack of consistency throughout the Sewer Utility’s WWTP SCADA HMI screens. The Sewer Utility and QCC have already scheduled workshops to begin determining visual and functional requirements for the future SCADA HMI screens along with the templates that will form the building blocks within AVEVA System Platform. These workshops should include discussions on which HPHMI concepts the Sewer Utility would like to apply to its future SCADA HMI screens along with its preferences for screen hierarchy and navigation. A workshop approach is consistent with HDR recommendations. Sewer Utility stakeholders need to be involved early and often during the SCADA HMI screen development process to ensure that the final implementation meets the Sewer Utility’s needs and expectations.

7.2.2 Establish Access to All Sewer Utility SCADA HMI Screens at Each WWTP Control Room and at the County Public Works Annex Facility

The Sewer Utility would like to establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and the County Public Works Annex facility so that staff can obtain a more comprehensive view of Sewer Utility operations from multiple locations. Though the objective for each facility is the same, the recommended software installation and configuration approach differs slightly between them.

For the remote WWTPs, a local AVEVA InTouch HMI runtime installation running the InTouch application for each respective WWTP will be required so that the SCADA HMI screens for the WWTP remain functional during a communication outage between the plant and CKTP. The remote WWTPs will also require local installations of select AVEVA Communication Driver components to facilitate communications between the InTouch application and the Allen-Bradley PLCs and other devices installed at the WWTP. However, the remote WWTPs will not require local installations of InTouch applications for other WWTPs and the remote pump stations because there are no local devices serving information to those InTouch applications and loss of communications to CKTP would disrupt functionality for the SCADA HMI screens included in those applications. Instead, HDR recommends that access to other WWTP and remote pump station SCADA HMI screens be provided via RDS and AVEVA's InTouch Access Anywhere software. This approach would allow Sewer Utility staff to access those screens via an HTML5-compliant web browser, simplifying the local software configuration requirements at the remote WWTPs.

Similarly, HDR recommends that RDS and InTouch Access Anywhere be used to provide access to all Sewer Utility SCADA HMI screens from a dedicated PC at the County Public Works Annex facility.

At CKTP, PCs in the control room will have InTouch HMI runtime installations running the InTouch application for CKTP and the remote pump stations. HDR does not believe that AVEVA supports running two or more parallel InTouch applications on the same machine, which presents challenges to running InTouch applications for the remote WWTPs on the CKTP control room PCs. For access to SCADA HMI screens for the remote plants, HDR recommends that RDS and InTouch Access Anywhere be used. This will avoid having to implement VMs on the control room PCs to support running parallel InTouch applications or requiring Sewer Utility staff to open and close InTouch applications each time they wish to see SCADA HMI screens from a different WWTP.

7.2.3 Complete Migration to Thin Client Configuration for CKTP HMIs

As part of its AVEVA System Platform upgrade, the Sewer Utility and QCC are planning to adopt a thin client deployment for the various panel PCs that will serve as process area SCADA HMIs at CKTP. This migration would meet the Sewer Utility's objectives of eliminating the need to separately patch and update several runtime installations, resolving ongoing alarm acknowledgement propagation issues, and allowing for centralized management of the Sewer Utility's SCADA HMI software application. Based on the Sewer Utility's stated objectives, this approach is consistent with HDR recommendations.

7.2.4 Determine Standard PLC Firmware Versions for the Sewer Utility and Perform Firmware Upgrades

HDR recommends inventorying the Sewer Utility's PLCs that are not slated for near-term replacement and determining the most recent firmware version that its controllers support. Rockwell Automation provides a Product Compatibility and Download Center service on its website, which is an excellent tool for selecting specific Allen-Bradley controllers and the applicable PLC programming software to view firmware compatibility (Rockwell Automation 2020c). Once this information is compiled, the Sewer Utility should select the most recent firmware version that all PLCs within a given product line can support and establish that firmware version as a Sewer Utility standard. Note, HDR recommends that the Sewer Utility consult QCC and North Coast Electric (local Rockwell Automation distributor) before making final firmware version selections. It is not uncommon for certain firmware versions to have significant bugs and known issues, and individuals who regularly work with the controllers will have experience with several firmware versions and may be able to provide insight that influences the Sewer Utility's firmware selections.

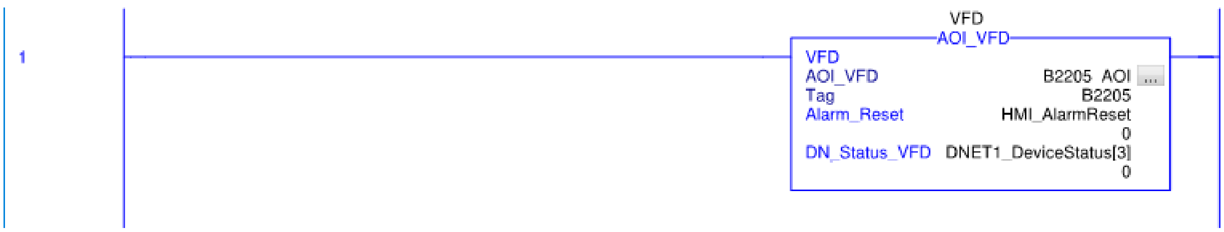
After the Sewer Utility finalizes its PLC firmware standards, HDR recommends that the selected PLC firmware versions be documented in the proposed Sewer Utility ICS standards documentation. The Sewer Utility should then work with a systems integrator to schedule the PLC firmware upgrades to bring the Sewer Utility's PLC inventory into firmware alignment. HDR also recommends that the Sewer Utility schedule recurring reviews of available firmware versions from the manufacturer to assess the criticality of upgrading to the most recent firmware version. Significant security patches and performance improvements would be drivers for adopting newer firmware versions, while minor fixes may not justify the time and expense of keeping up with every new version released by the manufacturer. When new firmware versions are adopted and deployed throughout the Sewer Utility's PLC inventory, the Sewer Utility's ICS standards documentation should be updated accordingly.

7.2.5 Develop PLC Programming Standards and Leverage Them to Standardize Future PLC Programming Work Products

As part of the Sewer Utility's effort to standardize its ICS infrastructure, HDR recommends that the Sewer Utility work with QCC or another local systems integrator to develop a standard approach to PLC program development for the Sewer Utility. The standard approach should then be documented as part of the Sewer Utility's ICS standards. The PLC programming standards should document elements like preferred PLC programming project file organization; appropriate level of annotation; tagging conventions; use of tag descriptions; program and routine naming conventions; use of ladder logic and function block diagram; and standard AOIs, UDTs, and subroutines that are to be used for common applications throughout the Sewer Utility ICS infrastructure. Examples of standard AOIs, UDTs, and subroutines include those described in Section 6.2.2 for the standard approach for monitoring and controlling motorized equipment. Once the PLC programming standards are developed and documented, they should be applied to future PLC programming efforts.

To avoid having to develop the PLC programming standards as a standalone project, HDR recommends that the standards development work be embedded in the scope of a near-term implementation project. This will allow the standards to be applied to the project and revised based on feedback from actual implementation efforts. The Sewer Utility also already has several "standard" AOIs and UDTs that were applied in the PLC programming for the PLCs added under the CKTP Resource Recovery project (see Figure 7-1 for an example of an AOI being called for the classifying selector blower [B2205]). Though these AOIs and UDTs may require some modification to best serve the Sewer Utility's needs, they could provide a starting point in the standards development process. QCC, or another local systems integrator that is engaged to develop the software portion of the standards, will likely have in-house standard approaches and programming objects that could be used to jumpstart the standards development, as well.

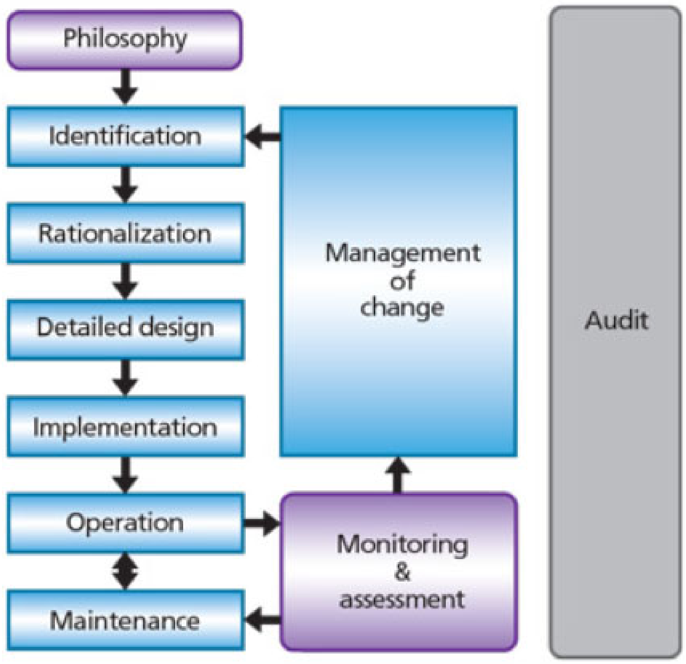
Figure 7-1. Example AOI for VFD equipment called in CKTP PLC 2939 programming



7.2.6 Implement an Alarm Management Program Based on ISA-18.2

HDR recommends that the Sewer Utility implement an alarm management program based on ISA-18.2, an industry standard for alarm management (ANSI/ISA 2016). A flow diagram depicting the ISA-18.2 alarm management process in terms of an alarm's life cycle is presented in Figure 7-2.

Figure 7-2. ANSI/ISA-18.2 alarm management flow diagram



Source: Yokogawa (2017).

The Sewer Utility began an ISA-18.2 initiative in recent years, and HDR believes that some of the initial groundwork for instituting an alarm management program is already completed. The proposed alarm management program will inform the Sewer Utility's efforts to standardize PLC programming and SCADA HMI graphics development, so HDR recommends that the Sewer Utility continue developing its alarm management program in parallel with or prior to other ICS automation programming efforts. Among other improvements, the recommended ISA-18.2 alarm management program should address the following deficiencies identified in TM-1 and TM-2:

- There is a high volume of alarm activity at CKTP Wonderware implementation, much of the activity being from the same alarms
- Sewer Utility staff do not have means of shelving nuisance alarms or alarms associated with known issues
- SCADA HMI screens do not provide alarm priority information or allow for sorting and filtering of alarms by alarm priority
- Root-cause analysis and alarm suppression functionality have not been developed for SCADA HMI screens
- SCADA HMI screens do not have troubleshooting text prompts or decision tree aids to help operations staff react to alarm conditions
- Alarm summary and alarm history screens at SWWTP are not automatically updated to display current alarm information

- Monitored alarms should include PLC faults and communication errors so that Sewer Utility staff are alerted when PLCs and RIO racks are experiencing performance issues
- Monitored alarms should include signal out-of-range alarms for all analog signals so that Sewer Utility staff are notified when current-based signals fall outside of the 4–20 mA range

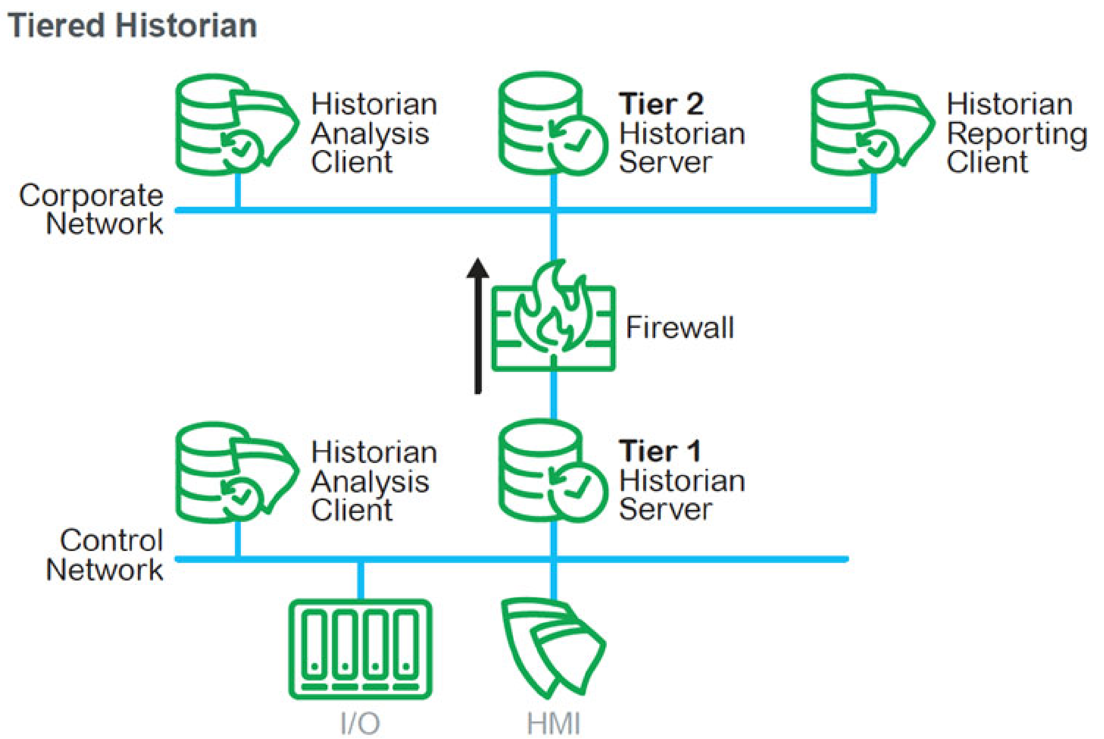
As part of the proposed alarm management program, HDR recommends that data related to ICS alarms be captured in the historian or other database environment and made available to users on the Sewer Utility business LAN. Third-party alarm management software or dashboarding tools like Tableau and Microsoft Power Business Intelligence (BI) could then be leveraged to develop visualizations and reports that would help the Sewer Utility manage alarms and alarm responsiveness.

7.2.7 Establish a Tiered Historian Implementation at CKTP to Centralize Sewer Utility Historical ICS Data and Provide Secure Access to Historical ICS Data from the Sewer Utility Business LAN

HDR recommends that the Sewer Utility establish a central historian at CKTP for consolidating ICS data received from all Sewer Utility WWTPs and remote pump stations. PCs and thin clients on the Sewer Utility OT networks would access data from this central historian to display embedded trends. HDR also recommends that the Sewer Utility implement AVEVA Historian Client software to simplify access to historian data and to facilitate the development of static and ad hoc trends from the PCs on OT networks. HDR believes that QCC and the Sewer Utility are already planning to implement this software as part of the ongoing AVEVA System Platform upgrade. As part of this effort, the Sewer Utility will need to implement store-and-forward functionality for the remote WWTPs so that ICS data received from those plants are not lost during communication outages between the remote WWTPs and CKTP.

To provide access to historian data for users on the Sewer Utility business LAN and County enterprise networks, HDR recommends that the Sewer Utility establish a “Tier 2” historian on the Sewer Utility business LAN at CKTP. A high-level network architecture depicting the proposed implementation is shown in Figure 7-3. The central historian on the OT network, or “Tier 1” historian, would replicate data through the proposed industrial DMZ (depicted as a firewall in Figure 7-3) to the “Tier 2” historian. The one-way nature of this data flow and limited open port requirements would simplify industrial DMZ firewall configuration, improve OT network security controls, and significantly reduce the network traffic traversing the industrial DMZ firewall(s) compared with a scenario where business LAN users are required to access the “Tier 1” historian on the OT network for their data analysis needs. With a dedicated historian for users on the Sewer Utility business LAN and County enterprise network, these users could then use AVEVA Historian Client, dashboarding and data visualization tools, and other software packages to view and analyze the ICS data and inform organizational decisions.

Figure 7-3. High-level tiered historian network architecture



Source: Schneider Electric (2015).

7.2.8 Broaden the Data Set Archived by the Sewer Utility Historian to Establish Foundations for More Comprehensive Process- and Asset-level Health and Performance Monitoring

Preliminary Improvements

HDR recommends that the Sewer Utility audit currently available parameters already monitored by its PLCs and configure the historian to historize parameters of interest. As indicated in Section 4.3.3 of TM-1, many tags within the existing Wonderware system are not being recorded in the CKTP historian or remote WWTP LGH files. Many of these tags could serve as inputs to a predictive maintenance program and help establish baselines for future process and asset health and performance monitoring efforts. Table 7-1 includes a summary of parameters that HDR recommends the Sewer Utility consider for incorporating into its historian.

Table 7-1. Summary of available equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
In Auto	Status	Indicates that the equipment's Hand-Off-Auto (HOA) selector switch(es) are placed in Auto and that equipment is being controlled by SCADA. Recording time stamps when this status changes can help determine asset availability, when maintenance/troubleshooting events are occurring and for how long, and current and past levels of automation achieved at the plant.
Close/open command	Command	Indicates an open or close command sent to a gate/valve actuator. The Sewer Utility is currently recording open and/or closed status for several of its isolation gate/valve actuators, but it is not recording the open or close commands actually sent to the equipment from SCADA. Recording open/close commands and open/closed status enables analysis and trending of gate/valve travel times as a predictive maintenance input.
Position command	Command	Indicates the position set point sent to the gate/valve actuator from the PLC. The Sewer Utility is currently recording position feedback for most modulating gate/valve actuators, but it is not recording the position command set points actually sent to the equipment from SCADA. Recording both position command and feedback values enables analysis of equipment response to position control, trending of gate/valve travel times as a predictive maintenance input, provides more insight into the effectiveness and stability of proportional-integral-derivative (PID) control loops, and can aid troubleshooting efforts.
Start/stop command	Command	Indicates a start/stop command sent to a motor controller or equipment package. The Sewer Utility is currently recording running status for most assets but it is not recording the start/stop commands actually sent to the equipment from SCADA. Recording start/stop commands and running status and their timestamps can aide troubleshooting efforts and root cause analysis when equipment does not respond as expected to start/stop commands.
Speed command	Command	Indicates the speed set point sent to the VFD from the PLC. The Sewer Utility is currently recording speed feedback for most variable-speed equipment, but it is not recording the speed command set points actually sent to the equipment from SCADA. Recording both speed command and feedback values enables analysis of equipment response to speed control, provides more insight into the effectiveness and stability of PID control loops, and can aid troubleshooting efforts.
Set point	Command	Indicates the target set point of a control loop (PID, or otherwise) or alarm threshold. In general, the Sewer Utility is not currently recording operator-adjustable or PID-determined set point values. HDR recommends recording these values each time that they are adjusted. Having a history of adjustable set point values can provide context to control loop performance, determine when changes were made and by whom, and enable comparison of process performance based on differing set point values.
Energy consumption (kilowatt-hour [kWh])	Status	Indicates equipment's total energy consumption since parameter was last reset. The Sewer Utility is currently recording power in kilowatts (kW) for many of its networked motor controllers. However, the Sewer Utility is not recording actual energy consumption for these assets. Though energy consumption can be calculated from historical power values, the accuracy of these calculations depends on how frequently the power values are recorded and can place additional processing burden on the PLCs or ICS software responsible for the calculations. Most Ethernet-capable motor controllers offer energy consumption in kWh as a parameter and HDR recommends recording these values in lieu of calculating them from recorded power values. Energy consumption is critical to evaluating asset O&M costs and performance.

Table 7-1. Summary of available equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
Power data (amps, volts, power, and power factor)	Status	Indicates motor amps, volts, power, and power factor. The Sewer Utility is currently recording some or all of these power parameters for its networked motor controllers, but there are instances where some of these parameters are not being recorded. HDR recommends that the Sewer Utility standardize on recording these parameters for motor controllers as they provide important data for analyzing asset health and performance and can be used to trigger predictive maintenance activities. Note, to reduce tag counts and programming complexity, HDR recommends that the Sewer Utility continue its practice of monitoring and recording average amps, average volts, total power, and total power factor. Ethernet-capable motor controllers will already communicate alarms and warnings for phase imbalances, so logging load-level per phase power data is unlikely to yield many benefits. However, the Sewer Utility should consider monitoring and recording per phase power parameters for generators and larger motors (e.g., larger than 100 horsepower [hp]).
Fail/fault	Alarm	Indicates that the equipment has an active failure or fault that is preventing it from running. Several hardwired fail and fault signals are being monitored by the Sewer Utility's SCADA system and not all of them are recorded in the historian. Some of these are generated by overload relay contacts, VFD fault outputs, or common alarm contacts. Recording time stamps when fail or fault alarms occur and when they are reset is a key input to determining asset availability and analyzing past asset performance. Whenever possible, the specific failure or fault should be identified in the tag description to provide context for the alarm. For example, motor overload, VFD fault, fail to run when called, motor winding high temperature, submersible pump motor leak, etc., provide much more context than a generic equipment fail alarm.
Networked equipment alarms and warnings	Alarm	Indication of specific equipment alarm or warning. Ethernet-capable motor controllers, vendor package controllers, power monitors, and other devices are capable of communicating alarms and warnings on a much more granular scale than can be achieved with hardwiring. Not all of these alarms and warnings may be worth recording in a historian. Furthermore, if an organization were to include every alarm and warning available in its historian, it would quickly see its tag count explode, which may trigger increased licensing costs. Many manufacturers make alarm and warning codes available via Ethernet communications. These codes are used to look up alarm/warning descriptions and troubleshooting steps in the manufacturer manuals. Recording alarm and warning code values allows for tracking of several alarms and events with one or a few tags. When available, HDR recommends that the Sewer Utility include alarm and warning codes in its historian along with specific, critical alarms it wishes to monitor separately.

Improvements to Align with Future Upgrades

When process upgrades or equipment replacements initiate changes to ICS infrastructure, HDR recommends that the Sewer Utility take advantage of these opportunities to implement monitoring and recording of the parameters listed in Table 7-1 for the assets that do not currently have these parameters available. This would be in addition to the parameters that the Sewer Utility has already standardized on recording (e.g., running status, runtime hours, level, flow, pressure, analytical probe measurements, process switch status, etc.). Note that monitoring and recording parameters listed in Table 7-1 may require updating PLC programming, field wiring, and Ethernet device configuration to implement standardized I/O for like assets.

In addition to those parameters, Table 7-2 includes a summary of additional parameters that HDR recommends the Sewer Utility consider for incorporating into its historian. These additional parameters will likely require additional instrumentation and/or field wiring to incorporate.

Table 7-2. Summary of additional equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
Actuator torque	Status	Indicates the torque that a gate/valve actuator is generating. Most electric actuator manufacturers offer an analog torque signal as a 4–20 mA output. Monitoring and recording actuator opening and closing torque can inform predictive maintenance efforts by comparing current torque profiles against historical baselines.
Pump suction and discharge pressure	Status	Indicates the suction and discharge pressures experienced by a pump. Monitoring and recording suction and discharge pressures for a pump or group of parallel pumps enables calculation of the total head that a pump is producing. This is an important value for determining where a pump is operating along its pump curve, its operating efficiency point, and how the pump's operating point may be changing over time. This information can be applied to predictive and proactive maintenance efforts and to prioritize assets for energy optimization initiatives.
Liquid stream and solid stream low and flow totalization	Status	Indicates process flows and volumes. HDR recommends that the Sewer Utility standardize on monitoring and recording all significant liquid stream and solid stream flows within its WWTPs. In addition to receiving a flow signal, HDR recommends that the Sewer Utility standardize on receiving an accumulated volume pulse signal from the flowmeter, when available, as the primary source for flow totalization rather than calculating flow totals from instantaneous flow measurements at the PLC. Flow totalization based on pulse count is typically more accurate. Having accurate flow and volume data will allow for derivation of comprehensive liquid stream and solid stream balances and will inform efforts to determine where pumps are operating along their pump and efficiency curves.

7.2.9 Upgrade Alarm Notification System

HDR recommends that the Sewer Utility upgrade its WIN-911 alarm notification system to a current version that is supported by the software vendor. As part of this upgrade, the Sewer Utility should evaluate incorporating the software's Mobile-911 app to provide on-call operations and supervisory staff with better access to active alarms and their acknowledged/unacknowledged status via mobile phones. HDR believes that QCC and the Sewer Utility are already planning on upgrading the WIN-911 software as part of the ongoing Systems Platform upgrade.

7.2.10 Provide Read-only Access to WWTP SCADA HMI Screens at Laboratory

To meet the Sewer Utility's objective of providing laboratory staff with read-only access to WWTP SCADA HMI screens, HDR recommends that RDS and AVEVA InTouch

Access Anywhere be used to enable access to the screens from one or more PCs within the laboratory via an HTML5-compliant web browser. Alternatively, or in addition to the PC(s), one or more large-format displays would be helpful in providing laboratory staff with an at-a-glance view of operating conditions and alarms for all WWTPs.

- ✪ Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.
- ✪ Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.
- ✪ Complete migration to thin client configuration for CKTP HMIs.
- ✪ Determine standard PLC firmware versions for the Sewer Utility and perform firmware upgrades.
- ✪ Develop PLC programming standards and leverage them to standardize future PLC programming work products.
- ✪ Implement an alarm management program based on ISA-18.2.
- ✪ Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.
- ✪ Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring.
- ✪ Upgrade alarm notification system.
- ✪ Provide read-only access to WWTP SCADA HMI screens at laboratory.

8 ICS Documentation: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS documentation and describes the information that Sewer Utility staff would like to develop and maintain. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for ICS documentation.

8.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to ICS documentation.

8.1.1 Develop Sewer Utility ICS Standards Documentation

The Sewer Utility would like to develop ICS standards documentation that could be handed to consultants and systems integrators to guide design and implementation for future projects. These standards would be required to be referenced in consultant specifications so that they become part of the contractor's scope. Once Sewer Utility ICS standards documentation is developed, the Sewer Utility would like to establish annual reviews of the standards documentation and ICS infrastructure to keep the standards current and to identify upcoming ICS upgrade/replacement projects that need to be included in CIP planning. Monitoring for hardware and software obsolescence should be a factor in these periodic reviews.

8.1.2 Develop Control Strategy Documentation for Sewer Utility ICS Processes

The Sewer Utility would like to develop control strategy documentation to capture as-implemented automation programming and process control for the various WWTP and pump station processes throughout its infrastructure. This documentation would be a resource that operations staff could consult to obtain an understanding of local and SCADA HMI controls, interlocks, and alarms without having to decipher equipment and process functionality from wiring diagrams, PLC programming logic, and equipment O&M documentation. The Sewer Utility would also like to have an authoritative document to keep track of appropriate set points to help manage set point drift. Control strategy documentation could also be used for this purpose.

8.1.3 SOPs and Documented Workflows for ICS Technology

The Sewer Utility has identified that its staff will require training to support modernization of the Sewer Utility ICS. However, once initial or recurring training sessions conclude, staff will likely need periodic reminders, particularly for procedures that occur infrequently. The Sewer Utility would like to document preferred workflows and standard operating procedures (SOPs) for the ICS technology that staff interact with to help supplement training and provide staff with a self-service resource when they need a refresher. The Sewer Utility will also require policies to ensure that certain SOPs are enforceable.

8.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS documentation.

8.2.1 Develop Sewer Utility ICS Standards Documentation

The Sewer Utility's goal of developing ICS standards documentation to guide future design and implementation efforts is consistent with HDR recommendations. As the Sewer Utility's ICS infrastructure grows and changes in complexity and technology, it is critical to define and standardize the implementation and configuration practices to ensure that the system is easy to maintain, expand, and develop. ICS standards provide an organization's staff and contractors with a clear set of guidelines to follow when modifying or adding elements to ICS infrastructure. When standards are well-developed and documented, expectations for quality, work approach, and results are easily ascertainable from the standards documents. This helps an organization ensure that work is performed in a consistent and desirable manner throughout the SCADA system and establishes a basis for effectively managing the performance of internal and contracted staff.

With the upgrade to a new, centralized SCADA HMI and historian platform, the Sewer Utility has an opportunity to document how this new technology should be integrated into a high-functioning SCADA system before the integration work is complete. The Sewer Utility and QCC have already decided to adopt an object-oriented programming (OOP) approach for the SCADA platform by selecting AVEVA System Platform to develop a template library of common automation objects that can be applied widely throughout the Sewer Utility's infrastructure. As discussed previously in this TM, several of the PLC programs running at the Sewer Utility's WWTPs already leverage AOIs and UDTs, which is also consistent with an OOP approach. These existing AOIs and UDTs may be modified or replaced to create a standard library of PLC programing objects for the Sewer Utility moving forward. Having an OOP foundation in place and well-documented in formal standards is consistent with industry best practices.

To support modernization and development of the Sewer Utility's ICS infrastructure, HDR recommends that the following standards documents be developed to capture Sewer Utility preferences and standard programming object libraries:

- **PLC programming standards:** This standards documentation would consist of written guidelines with screenshots and programming files that specify requirements and standard programming objects for all Allen-Bradley PLC platform programming and configuration work.
- **HMI graphics standards:** This standards documentation would consist of written guidelines with screenshots and programming files that specify requirements and standard programming objects for graphics development and configuration work associated with AVEVA System Platform.

- **ICS control and telemetry panel hardware standards:** This standards documentation would consist of written guidelines and template drawings that specify hardware component requirements; general control panel interior and exterior layouts; power distribution methodology; and fabrication, testing, and installation requirements for new ICS control and telemetry panels at Sewer Utility WWTPs and pump stations. The standards would also document network device configuration and hardening requirements for Ethernet switches, cellular gateways, and other network components to be installed within these panels.

8.2.2 Institute Sewer Utility ICS Standards Documentation Governance

The development of ICS standards often entails a significant investment of time and money for an organization. This investment is wasted if standards are not enforced or maintained. To ensure that any standards documents that are developed remain a valuable resource for the Sewer Utility, it is important that the standards be perceived as living documents and responsibility for their maintenance and enforcement is clearly assigned.

HDR recommends that the ICS standards be managed, maintained, and updated by a Standards Committee. Members of the committee would be technically qualified individuals with a willingness and interest to participate in maintaining the standards. A selected representative from each internal group impacted by the control system should be included on the Standards Committee. The committee should schedule periodic reviews of the standards documentation to adapt it to product obsolescence, incorporate lessons learned on recent design or implementation projects, and align it with changes in Sewer Utility preferences.

An ICS standards manager will also be required at the Sewer Utility to enforce and continue to develop the standards. This may be a single individual or a team of individuals assigned to this role. The individual(s) in charge of the standards documentation is responsible for revising the standards to incorporate any modifications or additions that need to be made as the SCADA system evolves, and for reviewing the work products of internal and contracted staff to ensure that the standards are being followed. It is also the responsibility of this individual to maintain careful version control of the standards documents and files and to ensure that work being put out to bid has appropriate references to relevant Sewer Utility ICS standards so that bidding contractors are aware of the standards and include effort to adhere to them in their bids.

8.2.3 Develop and Maintain Control Strategy Documentation

HDR recommends that the Sewer Utility develop and maintain control strategies to document how WWTP and pump station processes and equipment are controlled locally and via SCADA. These documents are critical for understanding how WWTP and pump station processes are operating, and for evaluating their performance based on data obtained through SCADA. Control strategies are also an extremely useful tool for familiarizing new staff with Sewer Utility infrastructure, which can help the Sewer Utility mitigate knowledge transfer challenges as senior staff retire in the coming years. These documents would also be very useful supporting documentation for the AVEVA System Platform upgrade and unit process optimization efforts being conducted as part of the ongoing facilities planning work. Making control strategy documentation available to Sewer Utility staff on the County electronic operation and maintenance (eO&M) SharePoint site would be one way of providing easy access to the information.

An important consideration to be included in the control strategy development is to establish procedures and assign responsibility for updating control strategy documentation when controls are modified so that the documentation remains current and accurate. Long-term set point changes, PLC programming modifications, and SCADA HMI graphics updates should prompt a review of applicable control strategies to align them with the current state of the ICS. This is a best practice but it is also a tedious one. As with the proposed ICS standards, maintaining control strategy documentation needs to be embedded in the Sewer Utility's culture of stewardship or, over time, the documents will drift away from the processes they are meant to summarize and will lose their value.

8.2.4 Establish Electronic Records for Operator Logs

HDR recommends that the Sewer Utility find an appropriate software solution for recording operator log information and establish the practice of logging daily notes, observations, and activities in an electronic format. This will greatly improve the Sewer Utility's ability to access past operator log information and provide some protection against the loss of valuable information in the event of lost or damaged physical logbooks. Implementing standard formatting for electronic operator logs would also allow for log data to be used by other software packages.

8.2.5 Update WWTP and Pump Station P&IDs and Compile Current Consolidated P&ID Sets on County eO&M SharePoint Site

HDR recommends that the Sewer Utility compile relevant piping and instrumentation diagrams (P&IDs) from past design projects into consolidated P&ID sets for each WWTP and pump station. These sets should then be reviewed against actual installed infrastructure so that the P&IDs can be updated where necessary. Because of lack and/or age of P&ID documentation for SWWTP and MWWTP, the Sewer Utility may need to develop new P&IDs based on as-built conditions at these facilities. Once consolidated P&ID sets have been updated to reflect as-built conditions, HDR recommends including these compiled sets on the Sewer Utility eO&M SharePoint site to provide staff and contractors with easy access to these important record documents.

8.2.6 Develop and Maintain OT Network Architecture Diagrams and Fiber-optic Patch Panel Schedules

HDR recommends that the Sewer Utility establish the practice of maintaining network architecture diagrams (physical and logical) for the four WWTPs. This documentation will assist Sewer Utility staff in maintaining the OT network and with planning network modifications. The documentation will also enable consultants and systems integrators to familiarize themselves with the OT network infrastructure much more quickly, saving the Sewer Utility the expense of third parties having to as-built or field-determine conditions. As part of the network documentation, HDR also recommends that the Sewer Utility develop and maintain an asset inventory for OT network devices.

HDR also recommends that the Sewer Utility maintain accurate fiber-optic patch panel schedules that document to and from information for each fiber-optic pair, as well as information about the fiber-optic cable and patch panels. HDR can provide a template schedule upon request. Another recommendation is that the Sewer Utility standardize on a tagging convention for the fiber-optic patch panels and cables throughout its OT network infrastructure. This tagging convention should be included in the Sewer Utility ICS standards documentation.

8.2.7 Develop Policies, SOPs, and Documented Workflows for ICS Technology

As the Sewer Utility becomes more reliant on ICS technology for day-to-day operations, staff will need to learn new skills and become familiar with a variety of user interfaces and procedures. Initial and periodic training will help streamline staff interaction with the technology, but having self-service resources to turn to as needed will boost staff efficiency and avoid scenarios where more technically proficient staff are frequently distracted with requests for assistance with navigating the technology. These self-service resources will also assist I&C technicians with more technical tasks that are not frequently performed, giving them a script to follow instead of having to consult manufacturer documentation and trying to remember what was done before.

For these reasons, HDR recommends that the Sewer Utility develop SOPs and documented workflows for its ICS technology. The best time to develop this documentation is during implementation, so getting in the practice of documenting procedures in parallel with execution is critical to making sure documentation happens in an efficient manner. Typical SOPs and workflow documentation for ICS technology include step-by-step instructions with supporting screenshots so that readers can follow along with their PCs or tablets. References to manufacturer literature can also be provided where detailed background information is required, but, ideally, the SOPs and workflows should be able to stand on their own as a one-stop resource to successfully execute the task.

HDR also recommends that the Sewer Utility develop policies that set the standards of behavior for activities involving the ICS and OT networks. For example, an acceptable use policy (AUP) outlines the constraints and practices that employees must agree to in order to access the OT networks. The County IS department likely already has an AUP in place for other County networks and Internet access, which could be modified or adapted to apply to the Sewer Utility OT networks. Other common useful policies include an access control policy (ACP), change management policy (CMP), and information security policy (ISP). These policies define the standards of behavior for items like password complexity, securing of County-issued laptops and tablets, documentation requirements for network device configuration changes, and adherence to established security controls. It should be noted that these policies can also be applied to third-party contractors requiring access to Sewer Utility ICS and OT network resources.

To help formulate policies, the Sewer Utility may benefit from selecting an industry-recognized standards framework on which to base its policies and procedures. The NIST Cybersecurity Framework and ISA 62443 standards are the two most frequently adopted standards for these purposes. While these standards contain valuable insights and best practices, they can be cumbersome to digest for those less familiar with the subject matter. To fast-track policy development while staff gain familiarity with new concepts, the Sewer Utility may wish to consider starting from templates that organizations like the SysAdmin, Audit, Network, and Security (SANS) Institute and International Association of Privacy Professionals (IAPP) have made publicly available online.

- ✪ Develop Sewer Utility ICS standards documentation.
- ✪ Institute Sewer Utility ICS standards documentation governance.
- ✪ Develop and maintain control strategy documentation.
- ✪ Establish electronic records for operator logs.
- ✪ Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.
- ✪ Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.
- ✪ Develop policies, SOPs, and documented workflows for ICS technology.

9 Other Software Packages: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to non-ICS software packages and describes the information and functionality that Sewer Utility staff would like to obtain from the software in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for non-ICS software.

9.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to non-ICS software.

9.1.1 Establish Data Exchange between SCADA and LIMS

The Sewer Utility would like to eliminate the current manual data entry process involved with communicating WWTP flows to the laboratory by implementing a software solution where SCADA data needed by laboratory staff are automatically acquired from the Sewer Utility SCADA system. Laboratory staff are also interested in obtaining additional data from SCADA, such as dissolved oxygen (DO), pH, ammonia, nitrate, nitrite, and other measurements from WWTP analytical probes. Integrating SCADA with laboratory information management system (LIMS) software used by the laboratory would establish the necessary data exchange and eliminate the current lag in the manual data delivery to laboratory staff.

9.1.2 Establish Data Exchange between SCADA and CMMS

The Sewer Utility would like to eliminate the current manual data collection and entry process involved with inputting equipment runtimes into LLumin by implementing a software solution where SCADA runtime information is automatically acquired by LLumin from the Sewer Utility SCADA system. The Sewer Utility is also interested in exploring applications for other SCADA alarm and status data within LLumin in the future for potentially automating the generation of preventive, corrective, and/or predictive maintenance work orders.

9.1.3 Develop Dashboards and Data Visualizations to Deepen Insight into Sewer Utility Operations

The Sewer Utility would like to have dashboards and data visualizations that provide high-level summaries of past, current, and projected operational statuses for the Sewer Utility's various organizational groups. For example, Sewer Utility management staff have expressed interest in developing a heat map for each of the Sewer Utility's drainages where color is used to communicate current capacity and maintenance-related issues associated with the drainage's WWTP and pump stations. Many of the Sewer Utility management and other County staff requiring access to these dashboards/data visualizations will reside on the Sewer Utility business LAN or other County networks. This will require that Sewer Utility SCADA historian data and other data stores on the OT network be made available to the software serving the dashboards/data visualizations while preserving the security of the OT network.

9.2 Recommended Improvements

This subsection describes the recommended improvements related to non-ICS software.

9.2.1 Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform

The Sewer Utility has selected Hach WIMS as its new LIMS and would like to see the software become a shared resource for the various Sewer Utility operational groups. As part of its ongoing implementation of Hach WIMS, the Sewer Utility would like to leverage the Hach WIMS SCADA Interface software module to automatically acquire data from its SCADA system. Once the Sewer Utility has Hach WIMS up and running, HDR recommends that staff explore the software's features and compile a list of the specific SCADA data from the various WWTPs that would be beneficial to automatically import into Hach WIMS. With the SCADA data defined, the Sewer Utility would then configure automated imports of the desired data within the Hach WIMS software. After data exchange between Hach WIMS and the Sewer Utility historian is established, staff will also have the ability to select specific SCADA tags and date ranges for ad hoc data imports and trend analysis from within Hach WIMS.

Because several of the Sewer Utility Hach WIMS users will be working from PCs on the Sewer Utility business LAN, HDR recommends that the server running Hach WIMS software be located on the business LAN and that the software be configured to interface with the "Tier 2" historian proposed for the business LAN. In the interim, while the industrial DMZ has yet to be implemented, the Hach WIMS server may need to be deployed on the CKTP OT network to establish data exchange with the CKTP historian. Under this deployment, for OT network security purposes, HDR recommends that the Hach WIMS server be accessed only by PCs on the OT network and that the Sewer Utility resist the temptation to implement dual-homed machines (i.e., one PC or server with connections to both the business LAN and OT network).

9.2.2 Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation

The Sewer Utility is in the process of establishing a parent-child asset hierarchy for its infrastructure within the LLumin software. Some configuration and data entry work remains to be completed before all Sewer Utility assets are represented within the LLumin platform. This initial effort should be completed so that asset identifiers and relationships are defined prior to establishing connections to other software platforms and linking asset attributes and data points between them. HDR believes that the LLumin implementation is a high priority for the Sewer Utility and that staff will complete this work in the near future.

Once the foundational work is completed, HDR recommends that the Sewer Utility establish automatic importing of asset runtimes from the Sewer Utility historian. HDR believes that the Sewer Utility has already purchased the LLumin software module required to integrate LLumin with its SCADA system (LLumin Machine Interface Server). However, implementing the data exchange securely requires careful planning because of the cloud-hosted, software as a service (SaaS) nature of the Sewer Utility's LLumin implementation. To reduce the Sewer Utility's cyber threat exposure, HDR recommends that the LLumin platform be configured to interface with the "Tier 2" historian proposed for the business LAN. This approach would eliminate direct communication between the LLumin cloud instance and the Sewer Utility OT network, while still providing access to asset runtime data. LLumin Machine Interface Server can be implemented as a cloud-hosted service or an on-premise solution, where it runs as a Windows service. HDR recommends that the Sewer Utility take the latter approach, as it will simplify the data exchange with cloud-hosted resources and allow for aggregate data to be sent out to the cloud instead of handling historian tags individually.

After Sewer Utility staff have become more familiar with the LLumin platform and automated importing of asset runtimes has been successfully implemented, HDR recommends that the Sewer Utility develop a plan to leverage additional functionality within the LLumin platform. The LLumin software supports asset-specific, rule-based generation of work orders, which could significantly streamline scheduling for maintenance staff and reduce asset downtime. To take advantage of this functionality, the Sewer Utility would need to identify asset runtime thresholds, alarms, events, and/or analog value set points (e.g., pump high discharge pressure) that should trigger a work order within the LLumin system. Identifying this information for all assets at once would be a significant effort, so HDR recommends that the Sewer Utility select a small sample of assets on which to pilot the approach at first. Once rules have been established and implemented within LLumin for the first asset sample, the Sewer Utility could then evaluate how the work order automation could be tweaked to improve its efficacy. Assuming the Sewer Utility experiences favorable results with automation of work orders within LLumin, HDR recommends that the Sewer Utility develop a schedule for deploying the approach to its remaining assets, where applicable.

Note, if the Sewer Utility wishes to pursue alarm- or event-based work order generation on a near-real-time basis, periodic data exchange between LLumin and the historian may not be sufficient. LLumin's Machine Interface Server software module would need to communicate with AVEVA System Platform, in this case, which would likely require relocating the LLumin Machine Interface Server software to the CKTP OT network or industrial DMZ and implementing additional security controls. HDR recommends starting with data exchange between LLumin and the "Tier 2" historian, initially, and then considering expansion of the LLumin system after the Sewer Utility's CMMS program is further developed.

9.2.3 Select a Data Analytics and Visualization Software Platform and Develop In-house Skill Sets through Creation of Initial Dashboards

AVEVA System Platform, LLumin, Hach WIMS, and other software that the Sewer Utility has implemented all have some degree of native dashboarding and data visualization capabilities, and HDR recommends that the Sewer Utility explore this functionality and apply it where the software can meet the Sewer Utility's needs. However, there can be challenges to using these purpose-built software platforms for analyzing data from outside of their design scope or for creating custom visualizations to answer specific questions that do not land well within the software's niche. As the Sewer Utility's data sets become broader and more accessible and Sewer Utility staff have more opportunities to interact with the data, the Sewer Utility will need a flexible data analytics and visualization software tool that can ingest data from a wide variety of data sources. The software tool will also need to be self-service with a relatively intuitive user interface so as to empower staff to look for answers on their own and enable them to easily share findings with other stakeholders.

HDR recommends that the Sewer Utility select a suitable software solution for general data analytics and visualization purposes throughout the organization and to then begin developing the ability to create and manipulate dashboards and visualizations in-house. Turning data into insights is an iterative process, which means that reliance on third parties for dashboard development and other data-driven initiatives adds cost and time to every iteration. Having staff with the skill sets to solicit input from stakeholders and to then take ideas and develop them into meaningful dashboards and reports that present useful information is an integral part of growing an organization's data program.

A good first step to cultivating these in-house skill sets would be to identify staff members who have the interest and availability to acquire these skills, schedule initial online training to familiarize them with the selected software solution, and then have them create a few dashboards centered around currently available data. The first dashboards produced may not be perfect, but their creation will establish an internal process that the Sewer Utility can refine over time. And as in-house skill sets also develop over time, the Sewer Utility will be in a better position to delve into more technical approaches to data analysis and, potentially, to explore some of the emerging technologies like machine-learning that may have big impacts in terms of process control and utility management in the coming years.

9.2.4 Begin Leveraging the Sewer Utility's Power and Energy Data

Energy consumption is a considerable expense for a wastewater utility and also serves as a good metric for quantifying the utility's overall operational efficiency when it comes to electrical power. However, a utility cannot improve what it cannot measure, and electric bills alone will not provide sufficient information for a utility to identify opportunities for efficiency gains at the equipment, process, and procedural levels. Submetering is critical to enabling these insights. Monitoring power flows through the electrical distribution system at the bus and load levels allows a utility to track where energy is being consumed within its infrastructure. And when historical energy data are paired with other parameters that represent the total product handled or level of treatment achieved over the same time frame, useful performance metrics are created that can be used to establish baselines, set goals, and measure progress toward those goals over time.

Fortunately, the Sewer Utility has made past investments in submetering that could be put to work in the development of an energy management program. Power monitors are installed at many of the major electrical distribution system buses throughout the Sewer Utility's WWTPs and several pump stations. However, the data available from these power monitors are not being used and, in many cases, not even recorded for future use. The Sewer Utility also already has the capability to monitor power and energy data at the load level for equipment powered from the DeviceNet MCCs at CKTP, some of the WWTP aeration blowers, and select other loads. Yet, load-level energy data are not being used either.

Initial Power and Energy Data Acquisition

As a first step in developing an energy management program, HDR recommends that the Sewer Utility harvest its low-hanging fruit by beginning to record historical power and energy data from installed power monitors and network-capable motor controllers, where it is not already doing so. In some cases, this may require installation of network cabling to establish communications with power monitors that are not currently communicating with the Sewer Utility SCADA system. For Ethernet-capable power monitors that are not currently communicating with a PLC, the Sewer Utility should consider direct communication between the power monitor and its AVEVA SCADA software. This would eliminate the need for additional PLC programming and gateway modules to enable the PLC to communicate with the power monitor via an Ethernet protocol that the PLC does not support natively (e.g., Modbus TCP in the case of Allen-Bradley CompactLogix controllers). Once communications are established and tags are defined within AVEVA System Platform, HDR recommends recording the power and energy parameters listed in Table 9-1 within the Sewer Utility's centralized historian.

Table 9-1. Recommended power and energy parameters for initial energy management program baselines by application

Application	Parameter description	Parameter engineering unit
Power monitor	Total real power	kW
	Total reactive power	Kilovolt-amperes reactive (kVAR)
	Total apparent power	Kilovolt-amperes (kVA)
	Received energy	kWh
	Delivered energy (only for buses with a connected generator)	kWh
	Power factor	PF
	Phase currents (phases A, B, and C)	Amperes (A)
	Phase-to-phase voltages (V_{ab}, V_{bc}, and (V_{ca})	VAC
	Frequency	Hertz (Hz)
	Total harmonic distortion (THD), current	THD_I
	Total harmonic distortion, voltage	THD_V

Table 9-1. Recommended power and energy parameters for initial energy management program baselines by application

Application	Parameter description	Parameter engineering unit
Motor controller	Total real power	kW
	Total energy consumed	kWh
	Average amps	A
	Average voltage	VAC
	Total power factor	PF

While the instantaneous power-related parameters would not have an application in the energy-based KPIs discussed later in this subsection, they do provide valuable information about the state of the electrical distribution system and equipment performance. Power information can be used to monitor electrical capacity, phase balance, and levels of harmonic distortion at the various electrical buses. This information is useful for evaluating the existing infrastructure's capacity to accept additional electrical loads and for assessing when harmonic distortion is approaching unacceptable levels. As mentioned previously in this TM, load-level power information can be a valuable input for analyzing asset health and performance and can be used to trigger predictive maintenance activities.

Transition from EnerVista Viewpoint Monitoring Software at CKTP

Though the existing General Electric (GE) EnerVista Viewpoint Monitoring software installed on the power monitoring PC in the CKTP SPB control room is capable of monitoring and recording these parameters for networked power monitors at CKTP, and has several additional features, this software does not present a solution for all of the Sewer Utility's WWTPs and pump stations without additional investment in software licensing and OT network configuration. Instead of expanding the GE EnerVista Viewpoint Monitoring software platform as a parallel system to the AVEVA deployment, which would result in another data silo to manage, HDR recommends that the Sewer Utility leverage AVEVA software to monitor and record the Sewer Utility's power and energy data moving forward. It should be noted that the EnerVista Viewpoint Monitoring software is only one component within GE's EnerVista software suite, and that this software suite can serve as a valuable platform for in-depth analysis and management of a utility's electrical distribution infrastructure and protective relaying. However, given the scale of the Sewer Utility's infrastructure, HDR does not see further investment in the EnerVista platform providing significant returns for the Sewer Utility.

Plan for Installation of Additional Power Monitors and Future Ethernet Motor Controllers

HDR recommends that the Sewer Utility plan on installing Ethernet-capable power monitors at all major electrical distribution buses (e.g., MCCs, switchgear [SWGR], switchboards) as this equipment is replaced and/or upgraded in the coming years. The Sewer Utility could also consider installation of Ethernet-capable power monitors for equipment not slated for near-term improvements as funding allows. When selecting power monitor hardware, it is important that the power monitor is capable of communicating power and energy parameters via an Ethernet protocol. Several power monitors have Ethernet ports but are capable of serving only a web browser interface and cannot be integrated into SCADA platforms.

As discussed previously, HDR also recommends that future motor controllers be provided with Ethernet communications so that the recommended power and energy data can be monitored and recorded.

Define Energy-based Metrics and Establish Baselines

HDR recommends that the Sewer Utility determine energy-based metrics to be used as KPIs for evaluating its operations and to then leverage these KPIs to establish baselines at each of its WWTP and remote pump station facilities. Some examples of potential KPIs are provided in Table 9-2. The application column of the table indicates the scope of the equipment and process(es) evaluated by the KPI. For example, WWTP would indicate that the energy consumed by the entire WWTP is to be considered, while secondary treatment would indicate that only the loads associated with secondary treatment equipment would be considered in calculating the KPI value.

Table 9-2. Example energy-based KPIs for wastewater infrastructure

Application	KPI description	KPI engineering unit
WWTP	Energy consumed per volume treated	kWh/million gallons (MG)
WWTP	Energy consumed per pound (lb) of biological oxygen demand (BOD) removed	kWh/lb BOD
WWTP	Energy consumed per population served per year	kWh/population equivalent (PE)/year
Preliminary treatment	Energy consumed per volume treated	kWh/MG
Preliminary treatment: screenings equipment	Energy consumed per volume of screenings removed	kWh/cubic foot (ft^3)
Preliminary treatment: grit removal equipment	Energy consumed per volume of grit removed	kWh/ft^3
Primary treatment	Energy consumed per pound of total suspended solids (TSS) removed	kWh/lb TSS
Primary treatment	Energy consumed per pound of phosphorus (P) removed	kWh/lb P
Primary treatment	Energy consumed per pound of BOD removed	kWh/lb BOD
Primary treatment	Energy consumed per pound of chemical oxygen demand (COD) removed	kWh/lb COD
Secondary treatment	Energy consumed per pound of total nitrogen removed	kWh/lb TN
Secondary treatment	Energy consumed per pound of phosphorus removed	kWh/lb P
Secondary treatment	Energy consumed per pound of BOD removed	kWh/lb BOD
Secondary treatment	Energy consumed per pound of COD removed	kWh/lb COD

Table 9-2. Example energy-based KPIs for wastewater infrastructure

Application	KPI description	KPI engineering unit
UV system	Energy consumed per volume treated	kWh/MG
Reclaimed water system	Energy consumed per volume of reclaimed water produced	kWh/MG
Solids treatment	Energy consumed per volume treated	kWh/MG
Solids treatment	Energy consumed per pound of total solids (TS) removed	kWh/lb TS
Solids treatment: GBTs	Energy consumed per volume treated	kWh/MG
Solids treatment: GBTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: RDTs	Energy consumed per volume treated	kWh/MG
Solids treatment: RDTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: GBTs	Energy consumed per volume treated	kWh/MG
Solids treatment: GBTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: anaerobic digesters	Energy consumed per volume treated	kWh/MG
Solids treatment: centrifuges	Energy consumed per volume treated	kWh/MG
Solids treatment: centrifuges	Energy consumed per pound of total solids treated	kWh/lb TS
Pump station	Energy consumed per volume treated	kWh/MG
Pump (individual)	Energy consumed per volume pumped	kWh/MG

As the data required to track these KPIs are integrated into the AVEVA platform and collected by the historian, it will take some time before sufficient historical data are compiled to adequately establish baselines for current operations. Ideally, baselines are established from at least 1 year's worth of data so that weather and seasonal variation factors can be accounted for, enabling the Sewer Utility to contrast current performance with the same month or season from prior years. However, KPIs that apply to the entire WWTP could be assessed from past electrical billing information as a start, if the Sewer Utility is not already doing so.

In terms of the software used to monitor and track energy-based KPIs, HDR recommends that the Sewer Utility consider developing dashboards with the selected data analytics and visualization software. Hach WIMS also has some energy usage tracking functionality that may prove useful to the Sewer Utility.

Set Goals and Measure Progress

Once the Sewer Utility has established adequate baseline energy data to support the KPIs it is interested in monitoring, HDR recommends that the baselines be reviewed to identify processes and equipment where energy efficiency measures are most likely to yield benefits. Targeted goals would then be set and the KPIs would be used to measure progress toward those goals. Conducting a formal energy audit prior to establishing goals would likely help identify quick wins and potential high-yield returns on investment in infrastructure or operational change, which would assist with the goal-setting process.

- ✪ Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform.
- ✪ Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.
- ✪ Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.
- ✪ Begin leveraging the Sewer Utility's power and energy data.

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10 Risks and Deficiencies with Recommended Improvements Summary

Table 10-2 compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in TM-1 and previous sections of TM-2. These risks and deficiencies are paired with the recommended improvement(s) that will mitigate the risk or resolve the deficiency. Subsection references are provided to help readers locate the specific subsections where the risks, deficiencies, and recommended improvements are described in detail. Note, some recommended improvements are simple enough that a summary description in a previous subsection of this TM was unwarranted. In these cases, recommended improvements are provided directly in Table 10-2 and appear without a subsection reference.

As an expansion of the risk and deficiency summary table provided in TM-1, Table 10-2 preserves the correlation of each risk and deficiency to one or more of the organizational improvement categories introduced in Section 7 of TM-1. Applicable organizational improvement categories are denoted with one or more ✸ symbols in their respective columns. To help communicate the significance of various risks and deficiencies, a ranking system was applied in TM-1 based on the quantity of ✸ symbols shown for a given organizational improvement category. These rankings have been carried over from TM-1 and are repeated in Table 10-1 for the reader's convenience. Risks and deficiencies from each TM-1 and TM-2 section are sorted in Table 10-2 so that the most significant risks and deficiencies from each section appear first.

Table 10-1. Risk and deficiency ranking system description

Ranking	Description
✸✸✸	**Major** risk or deficiency. Immediate corrective measures are recommended and/or major organizational health benefit(s) to be gained from related improvements.
✸✸	**Moderate** risk or deficiency. Near-term corrective measures are recommended and/or significant organizational health benefit(s) to be gained from related improvements.
✸	**Minor** risk or deficiency. Corrective measures are recommended, but likelihood and/or impact of failure/event may be low. Some organizational health benefit(s) to be gained from related improvements.

This ranking system is also meant to communicate the priority level of the recommended improvement(s), which can be used to distinguish between recommendations requiring immediate action or decisions, items that will need to be considered for near-term planning, and more long-term initiatives. In a subsequent phase of the Master Plan, these recommendations will be grouped into phases of a proposed implementation plan and the recommendation priority level will be one of the factors used to determine how the various implementation plan phases are sequenced.

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.7	There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.			✸✸✸			• HDR recommends eliminating this connection and believes that Sewer Utility staff have already disconnected the Category cable connecting the two network switches. • Establish an industrial DMZ between Sewer Utility business LAN and OT network.	5.2.7
TM-1: Network Architecture	2.7	A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.			✸✸✸			HDR recommends removing the cellular router from the OT network and believes that Sewer Utility staff have already done so.	---
TM-1: Network Architecture	2.13	No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.				✸✸✸		• Extend OT network to County Public Works Annex facility. • Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.2 5.2.8
TM-1: Network Architecture	2.13	Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.				✸✸✸		• Establish automated backup procedures for ICS servers that include on-premise and off-site storage. • Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	5.2.8 7.2.7
TM-1: Network Architecture	2.3	Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.	✸✸				✸	• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.2	Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.				✸✸		Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between CKTP SCADA nodes and all of the plant PLCs.				✸✸		Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.				✸✸		Establish cable path redundancy for critical segments of the OT network.	5.2.5
TM-1: Network Architecture	2.2	Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.				✸✸		• Upgrade to stacked Layer 3 distribution switches at CKTP SPB. • Establish cable path redundancy for critical segments of the OT network.	5.2.4 5.2.5

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.3	Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.					✸✸	• Upgrade CKTP control room. • Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.	5.2.1 7.2.2
TM-1: Network Architecture	2.3	The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near-real-time monitoring and alarming for wastewater pump stations.		✸✸				• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.3	Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.		✸✸				• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.3	The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.		✸✸				Improve communication status monitoring and alarming for remote pump station telemetry.	5.2.3
TM-1: Network Architecture	2.7	Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.			✸✸			Develop and implement an improved OT network segmentation scheme.	5.2.8
TM-1: Network Architecture	2.7	There appear to be parallel entry points to the SWWTP OT network from external networks: one via SWWTP's Tempered Networks HIPswitch and one via a secure gateway used for the SWWTP business LAN wireless access point.			✸✸			HDR recommends eliminating the connection between the secure gateway and the SWWTP OT network. Sewer Utility staff have indicated that they will investigate the intended use for the connection so that its functionality can be migrated to the Tempered Networks Airwall system, if needed, and will then make the disconnection.	---
TM-1: Network Architecture	2.9	Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.9	Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.9	MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.10	The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.			✸✸			Establish unique user accounts and implement MFA for Tempered Networks Conductor management.	5.2.9
TM-1: Network Architecture	2.10	No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.			✸✸			Establish unique user accounts and implement MFA for Tempered Networks Conductor management.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.10	Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.7 5.2.9
TM-1: Network Architecture	2.10	The Sewer Utility's Airwall edge services do not have current firmware versions installed.			✸✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.10	The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.		✸✸				HDR recommends replacing this HIPswitch with a Tempered Networks Airwall gateway capable of greater data throughput.	---
TM-1: Network Architecture	2.11	Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.		✸✸				HDR recommends replacing the PCs and servers on the OT network that have been in service for more than 5 years. HDR believes that the CKTP historian is being replaced by QCC as part of a planned upgrade to the Sewer Utility AVEVA software.	---
TM-1: Network Architecture	2.11	Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.			✸✸			Improve AAA measures for OT network.	5.2.8
TM-1: Network Architecture	2.12	Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.				✸✸		Implement modifications to CKTP administration and laboratory building electrical room.	5.2.4
TM-1: Network Architecture	2.12	Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.12	KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.12	The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.13	No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.				✸✸		Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.8
TM-1: Network Architecture	2.13	No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.				✸✸		Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.8
TM-1: Network Architecture	2.16	The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.			✸✸			Develop a formal cybersecurity incident response program.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.11	CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.	✸		✸		✸	Implement a domain for the CKTP OT network.	5.2.8
TM-1: Network Architecture	2.14	The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.	✸		✸		✸	Implement OT network performance monitoring and logging capabilities.	5.2.8
TM-1: Network Architecture	2.5	Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.		✸	✸			Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.14	The Sewer Utility does not have a Syslog server or other central repository for collecting CKTP OT network device logs and network event data.			✸		✸	Implement OT network performance monitoring and logging capabilities.	5.2.8
TM-1: Network Architecture	2.2	The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.		✸				Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.				✸		No recommended improvement. Based on input from the Sewer Utility, the Master Plan will focus on higher-priority risks and deficiencies.	---
TM-1: Network Architecture	2.3	The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.	✸					Improve communication status monitoring and alarming for remote pump station telemetry.	5.2.3
TM-1: Network Architecture	2.4	An OM1 fiber-optic patch cable has been used to patch two Optical Multi-mode 3 (OM3) fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.		✸				Replace patch cable with suitable OM3 patch cable.	---
TM-1: Network Architecture	2.4	There are instances of unshielded twisted pair (UTP) Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.		✸				For network connections to enclosures containing 480 VAC equipment, include requirement for shielded Category cables with 600 VAC insulation rating in proposed Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.5	The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.	✸					Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.5	All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.		✸				Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.5	Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.6	The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.					✸	Implement secure mobile access to SCADA HMI screens for remote and on-site staff.	5.2.7
TM-1: Network Architecture	2.7	The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.		✸				Develop and implement an improved OT network segmentation scheme.	5.2.8
TM-1: Network Architecture	2.7	Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.9	UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.			✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.10	On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.			✸			Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.9
TM-1: Network Architecture	2.10	Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.			✸			Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.9
TM-1: Network Architecture	2.10	HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.			✸			Introduce OT network firewall layer upstream from WWTP Tempered Networks HIPswitches.	5.2.9
TM-1: Network Architecture	2.10	Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.				✸		Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.	5.2.3
TM-1: Network Architecture	2.10	Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.11	KWWTP, MWWTP, and SWWTP SCADA servers have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the plants.		✸				HDR recommends replacing these SCADA servers and believes that the server replacement is being performed by QCC as part of a planned upgrade to the Sewer Utility AVEVA software.	---
TM-1: Network Architecture	2.12	Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.			✸			Because physical security for the WWTPs affects all Sewer Utility assets, not just the OT network and ICS infrastructure, HDR recommends that the Sewer Utility consider site security improvements as part of the larger ongoing Sewer Utility Facilities Plan effort.	---
TM-1: Network Architecture	2.12	Network cabinet and network panel PNL-8580A are routinely left unlocked.			✸			HDR recommends establishing the protocol of locking or otherwise restricting access to network cabinets and future network racks.	---

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.12	Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.				✸		HDR believes that construction activities are now completed. The Sewer Utility should survey the dust accumulated on the device and coordinate with KPUD, if buildup is considerable. Dusting with compressed air would likely remedy the situation.	---
TM-1: Network Architecture	2.13	Backups of PLC programming project files could be better organized to improve version control.				✸		HDR recommends that the Sewer Utility store all PLC programming project files for all WWTPs and pump stations on an OT network file server at CKTP. HDR also recommends that the Sewer Utility develop a standard file naming convention for PLC programming project files that incorporates the date of last modification in the filename using a YYYY-MM-DD format. This will allow various versions to be easily sorted by last modification date. The file naming convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.13	The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.				✸		Establish virtualized environments for all ICS servers.	5.2.8
TM-1: Network Architecture	2.12	In general, the network switches within the Sewer Utility's OT network have no on-board power supply or external 24 VDC power supply redundancy.				✸		Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.14	The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.				✸		HDR recommends that the Sewer Utility store all configuration files for all OT network devices on an OT network file server at CKTP. HDR also recommends that the Sewer Utility develop a standard file naming convention network device configuration files that incorporates the date of last modification in the filename using a YYYY-MM-DD format. This will allow various versions to be easily sorted by last modification date. The file naming convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.15	The Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.					✸	Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.	8.2.6
TM-1: Network Architecture	2.15	The Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.					✸	Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.	8.2.6
TM-1: Network Architecture	2.15	The Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.					✸	HDR recommends that the Sewer Utility standardize on a tagging convention for the copper Ethernet cables throughout its OT network infrastructure. Cable tags should be applied to all new cables. HDR recommends that the Sewer Utility take the opportunity to apply cable tags to existing cables when other activities prompt staff to interact with the cables or devices that they connect. The copper Ethernet tagging convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: ICS Hardware	3.5	The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an infrared (IR) source fault and is not monitoring combustible-gas concentration in the odor control system.		✸✸✸				Implement CKTP instrumentation and automation improvements.	6.2.10

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.		✸✸✸				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.		✸✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.		✸✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP process building fire alarm panel has failed so SWWTP is not currently monitoring or alarming for fires.		✸✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-24 wet well is faulted.		✸✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.		✸✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.		✸✸			✸✸	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.		✸✸			✸	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.1	The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.		✸✸				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer's product life cycle and are nearing the end of their useful service life.		✸✸				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.				✸✸		HDR recommends that Sewer Utility I&C technicians investigate and replace the controller battery, if necessary.	
TM-1: ICS Hardware	3.2	The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.		✸✸				Establish Sewer Utility OIT platform standard and schedule replacement of select WWTP and remote pump station OITs.	6.2.5

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.3	OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of hydrogen sulfide (H_2S) and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is a National Electrical Code (NEC) violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.				✸ ✸		Implement CKTP digester building PNL 6000 relocation and MCC replacement.	6.2.7
TM-1: ICS Hardware	3.3	Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.				✸ ✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have battery backup power.				✸ ✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.4	Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.					✸ ✸	Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.	7.2.2
TM-1: ICS Hardware	3.4	Sewer Utility staff do not have access to near-real-time status and alarm information for wastewater pump stations at CKTP.					✸ ✸	• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: ICS Hardware	3.5	Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.		✸ ✸				Develop a formal instrument calibration and maintenance program.	6.2.6
TM-1: ICS Hardware	3.5	Current CKTP effluent flow calculations provided by the TrojanUV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.	✸ ✸					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.	✸ ✸					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.	✸ ✸					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.		✸ ✸				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.		✸ ✸				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.	✸ ✸					Implement MWWTP instrumentation and automation improvements.	6.2.12

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.		✸✸				HDR believes that the condition of the MWWTP headworks odor control system warrants evaluation of the system as part of the ongoing Sewer Utility Facilities Plan effort. Upgrade or replacement of the failed instrumentation should be determined after the entire system is evaluated for replacement or upgrade.	---
TM-1: ICS Hardware	3.5	The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	Instrumentation within the MWWTP TrojanUV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.		✸✸				Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV systems.	6.2.7
TM-1: ICS Hardware	3.5	The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.		✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.		✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.		✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	PS-34 has no PLC and the station's wet well level appears to be controlled by a level indicator and controller that monitors the wet well's radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.		✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.1	Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.		✸		✸		• Develop a standard approach for monitoring and control of motorized equipment. • Replace CKTP MCC DeviceNet networks with Ethernet-capable motor controllers.	6.2.2 6.2.3
TM-1: ICS Hardware	3.4	The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.			✸	✸		Consolidate CKTP OT network servers, distribution switches, and other appliances in a network rack environment within the SPB.	5.2.4
TM-1: ICS Hardware	3.5	A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.	✸	✸				• Develop a formal instrument calibration and maintenance program. • HDR recommends incorporating instrument condition assessment into the proposed instrument calibration and maintenance program.	6.2.6

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.		✸			✸	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	Short cycling of the pumps is a common occurrence at PS-24.	✸	✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.1	Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs were discontinued by the manufacturer in December 2020.		✸				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.					✸	HDR recommends that the control panel be relocated to a more accessible location when there are other drivers for control modifications in the blower building. The potential upgrade to variable-speed aeration blowers might be a good opportunity for relocation of this panel.	---
TM-1: ICS Hardware	3.1	The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.	✸					Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.2	The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.		✸				The communication error may have been due to construction activities and in-progress automation work. HDR recommends that the Sewer Utility investigate and take corrective action if the communication error persists.	---
TM-1: ICS Hardware	3.2	The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.		✸				HDR does not believe that there is a significant driver for replacing this OIT because it is located in the control room where Sewer Utility staff will have access to SCADA HMI screens and PCs from which OT network devices can be accessed. No further action is recommended.	---
TM-1: ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.				✸		Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.3	There is a mix of 120 VAC and 24 VDC control and power circuits within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.	✸					HDR recommends that the Sewer Utility standardize on 24 VDC power and controls, where possible, as well as control panel voltage segregation best practices. These requirements should be included in the proposed Sewer Utility ICS standards documentation.	---
TM-1: ICS Hardware	3.3	The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.	✸					HDR believes that this deficiency has been captured in the condition assessments led by Murraysmith and that the facilities planning effort will address these issues.	---
TM-1: ICS Hardware	3.4	The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.					✸	Upgrade CKTP control room.	5.2.1
TM-1: ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for CKTP effluent flow.	✸					Implement CKTP instrumentation and automation improvements.	6.2.10

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.					✸	Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.	✸					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.		✸				HDR believes that the condition of the CKTP cogeneration system warrants evaluation of the system as part of the ongoing Sewer Utility Facilities Plan effort. Until there are financial or process-related drivers for recommissioning the cogeneration system, HDR has no recommendations for further investment in associated I&C infrastructure.	---
TM-1: ICS Hardware	3.5	One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.		✸				HDR believes that the SWWTP odor control system is likely nearing the end of its useful service life and should be considered for replacement as part of the ongoing facilities planning effort. Because this system is already being operated manually, HDR does not recommend replacing or upgrading system instrumentation that will become obsolete once the odor control system is in replaced.	---
TM-1: ICS Hardware	3.5	The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.		✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.		✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Software	4.2	Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.	✸✸✸				✸✸✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.					✸✸✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.3	SCADA data are not being leveraged beyond data required for mandatory reporting.	✸✸	✸✸			✸✸	• Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring. • Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform. • Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation. • Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	7.2.8 9.2.1 9.2.2 9.2.3
TM-1: ICS Software	4.3	The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.	✸✸	✸✸			✸✸	Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	9.2.3

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.2	Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.	✸✸				✸✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.	✸✸				✸✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.3	The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.	✸✸				✸✸	Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring.	7.2.8
TM-1: ICS Software	4.1	The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.	✸✸					Develop PLC programming standards and leverage them to standardize future PLC programming work products.	7.2.5
TM-1: ICS Software	4.2	The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.		✸✸				Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.					✸✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.					✸✸	Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Software	4.2	HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.		✸✸				Develop a standard approach for monitoring remote pump stations.	6.2.3
TM-1: ICS Software	4.2	The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.	✸✸					• Develop a standard approach for monitoring remote pump stations. • Remote pump station instrumentation and automation improvements.	6.2.3 6.2.14
TM-1: ICS Software	4.2	Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.		✸✸				Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.					✸✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.3	The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.		✸✸				• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.1 7.2.7

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.3	The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.					✸✸	Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.7
TM-1: ICS Software	4.3	The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.					✸✸	Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.7
TM-1: ICS Software	4.3	The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.					✸✸	• Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN. • Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform. • Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation. • Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	7.2.7 9.2.1 9.2.2 9.2.3
TM-1: ICS Software	4.4	There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.				✸✸		Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.	5.2.3
TM-1: ICS Software	4.1	Sewer Utility PLCs are running a variety of firmware versions.		✸				Determine standard PLC firmware versions for the Sewer Utility and perform firmware upgrades.	7.2.4
TM-1: ICS Software	4.2	At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.					✸	Complete migration to thin client configuration for CKTP HMIs.	7.2.3
TM-1: ICS Software	4.2	Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.	✸					• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • Implement an alarm management program based on ISA-18.2.	7.2.1 7.2.6
TM-1: ICS Software	4.2	Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.		✸				• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • HDR recommends that Sewer Utility staff compile a list of known engineering unit conflicts so that I&C technicians and/or systems integrators can correct the issues.	7.2.1
TM-1: ICS Software	4.2	Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.					✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.					✸	• Develop a standard approach for monitoring and control of motorized equipment. • Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	6.2.2 7.2.1

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.2	Trend screens display current values against time only and do not provide meaningful situational awareness.					✱	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.	✱				✱	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.					✱	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.4	Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.					✱	Upgrade alarm notification system.	7.2.9
TM-1: ICS Documentation	5.2	The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.	✱				✱✱	Establish electronic records for operator logs.	8.2.4
TM-1: ICS Documentation	5.5	The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.	✱				✱	Develop Sewer Utility ICS standards documentation.	8.2.1
TM-1: ICS Documentation	5.1	Record P&IDs are not maintained in consolidated drawing sets or located in one location.					✱	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.1	Record P&IDs for MWWTP are out of date.					✱	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.1	Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.					✱	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.2	General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.					✱	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.2	The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.					✱	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.2	PLC programming modifications may be occurring without documentation of changes made to process controls.					✱	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.3	The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.					✱	Upload applicable record drawings to County eO&M SharePoint site.	---
TM-1: Other Software Packages	6.4	The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, energy management system (EMS), laboratory, SCADA, and other data sets outside of their respective software environments.	✱✱	✱✱			✱✱	Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	9.2.3
TM-1: Other Software Packages	6.2	It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.		✱✱			✱✱	Begin leveraging the Sewer Utility's power and energy data.	9.2.4

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Other Software Packages	6.2	The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.		✸✸			✸✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.		✸✸			✸✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.1	Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.		✸✸			✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-1: Other Software Packages	6.1	The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.		✸			✸✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-1: Other Software Packages	6.3	HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.					✸✸	Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform.	9.2.1
TM-1: Other Software Packages	6.2	Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.	✸	✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.	✸	✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.		✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.					✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.					✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.					✸	• Begin leveraging the Sewer Utility's power and energy data. • Because HDR is not recommending further investment in the GE EnerVista Viewpoint Monitoring software, implementation of breaker and switch status monitoring via this software is not recommended. If Sewer Utility staff would find this information useful, the requisite signals could be integrated into AVEVA System Platform and SCADA HMI screens could be developed to present this information in one-line diagram context.	9.2.4
TM-1: Other Software Packages	6.2	The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.					✸	• Begin leveraging the Sewer Utility's power and energy data. • Because HDR is not recommending further investment in the GE EnerVista Viewpoint Monitoring software, implementation of breaker and switch status monitoring via this software is not recommended. If Sewer Utility staff would find this information useful, the requisite signals could be integrated into AVEVA System Platform and SCADA HMI screens could be developed to present this information in one-line diagram context.	9.2.4

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP lacks SCADA control for the sludge wasting valve so the sludge wasting process is entirely manual.	✸✸				✸✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.3	Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.	✸	✸			✸✸	Provide read-only access to WWTP SCADA HMI screens at laboratory.	7.2.10
TM-2: Sewer Utility Staff Interviews	4.5	Equipment runtimes are manually collected and entered into Sewer Utility CMMS.	✸✸				✸✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP does not have a flowmeter for monitoring WAS flow to the WAS tanks.	✸✸				✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	PLC status monitoring and alarming may not be effectively applied for all WWTP PLCs.		✸✸			✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-2: Sewer Utility Staff Interviews	4.1	Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments.		✸✸			✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-2: Sewer Utility Staff Interviews	4.1	There are no SCADA alarms or monitoring in place for composite samplers at all WWTPs.		✸			✸	Include integration of composite sampler alarms and monitoring with replacement of existing samplers.	6.2.8
TM-2: Sewer Utility Staff Interviews	4.1	Some WWTP VFDs do not have VFD fault alarms monitored at SCADA.		✸			✸	Develop a standard approach for monitoring and control of motorized equipment.	6.2.2
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP headworks mixing channel blower fault is not monitored at SCADA.		✸			✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	Operators have no means of managing the MWWTP blower operating time sequence via the SCADA HMI screens.	✸				✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	Sewer Utility operations staff would like to have more detailed information on UV systems available at the HMIs for all plants.		✸			✸	Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV Systems.	6.2.9
TM-2: Sewer Utility Staff Interviews	4.1	The Sewer Utility is likely overestimating the thickened sludge volumes received at CKTP from remote WWTPs because none of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities.	✸					• Implement KWWTP instrumentation and automation improvements. • Implement MWWTP instrumentation and automation improvements. • Implement SWWTP instrumentation and automation improvements.	6.2.11 6.2.12 6.2.13
TM-2: Sewer Utility Staff Interviews	4.2	The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system.					✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1

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TM-3: Technology Selection

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

December 10, 2021

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-3: Technology Selection

December 10, 2021

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

Tables

Figures

Abbreviations

°F	degree(s) Fahrenheit
AD	Active Directory
BGP	Border Gateway Protocol
CIP	Common Industrial Protocol
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
County	Kitsap County
DLR	Device Level Ring
DMZ	demilitarized zone
DNP3	Distributed Network Protocol 3
DS	Domain Server
EIGRP	Enhanced Interior Gateway Routing Protocol
FNF	flexible netflow
FT	FactoryTalk
GB	gigabyte(s)
Gbps	gigabit(s) per second
HDR	HDR Engineering, Inc.
HMI	human-machine interface
HSRP	Hot Standby Router Protocol
I&C	instrumentation and controls
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
I/O	input/output
IoT	Internet of Things
IP	Internet Protocol
IS-IS	Intermediate System to Intermediate System
LAN	local-area network
LED	light-emitting diode
LIMS	laboratory information management system
LTE	Long-Term Evolution
M2M	machine-to-machine
Master Plan	*Sewer Utility SCADA Master Plan*
MB	megabyte(s)
Mbps	megabit(s) per second
MCC	motor control center
MOD	module
N/A	not applicable
NFPA	National Fire Protection Association
NMS	network monitoring system
OSPF	Open Shortest Path First
OT	Operational Technology
PBR	Policy-Based Routing
PC	personal computer
PCAP	Network Packet Analyzer and Capture
PLC	programmable logic controller
QCC	Quality Controls Corporation
QoS	quality of service
RIO	remote input/output
RIP	Routing Information Protocol
RTD	resistance temperature detector
RTU	remote telemetry unit

SA	sensor/actuator
SCADA	supervisory control and data acquisition
SD	Secure Digital
SDN	software-defined network
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SNMP	Simple Network Management Protocol
SPB	solids processing building
SVI	Switched Virtual Interface
TM	technical memorandum
TM-2	*SCADA Use Cases and Operational Needs Technical Memorandum*
TM-3	*Technology Selection Technical Memorandum*
TM-4	*Sewer Utility SCADA Master Plan Technical Memorandum*
TP/TX	Transport Protocol/Transmit
uRPF	Unicast Reverse Path forwarding
USB	Universal Serial Bus
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VM	virtual machine
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
WAN	wide-area network
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This *Technology Selection Technical Memorandum* (TM-3) documents the specific hardware and software platforms selected to become the new standard for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system. This technical memorandum (TM) describes the evaluation approach by which these technological elements were selected based on the Sewer Utility's existing infrastructure and its future operational needs identified in the *SCADA Use Cases and Operational Needs Technical Memorandum* (TM-2). These platforms will serve as the building blocks for the system architecture conceptual design to be developed in the subsequent *Sewer Utility SCADA Master Plan Technical Memorandum* (TM-4).

1.1 Approach

TM-3 completes the third phase of the *Sewer Utility SCADA Master Plan* (Master Plan), which is to identify the hardware and software platforms that will be the foundational SCADA equipment for use by the Sewer Utility going forward. The hardware and software selections are based on the existing SCADA equipment condition and useful life cycle as well as the Operational Needs and Deficiencies Assessment completed in the previous TMs.

In addition, the hardware and software selections identified in this TM-3 support the requirements needed to appropriately design the conceptual control system architecture in Phase 4.

A meeting was held in June 2021 to review the previously selected technology for both the Operational Technology (OT) network and control system equipment. Preferences for additional required OT network equipment and software and the system architecture conceptual design were also discussed.

1.2 Technical Memorandum Organization

This section describes the structure of the TM and the annotation for addressing the operational needs identified in TM-2 and recommended improvements.

1.2.1 Structure

TM-3 is organized into five sections, as described below:

- **Section 1: Introduction** summarizes the TM organization and the approach taken for the third phase of the Master Plan in preparation for TM-3.
- **Section 2: Previously Selected Technology** provides a summary of the various SCADA-related hardware and software platforms that the Sewer Utility has selected prior to or in parallel with the Master Plan and that will remain part of the Sewer Utility's core technological assets into the future.
- **Section 3: OT Network Architecture Technology and Software** describes the network architecture technology components and software products selected for

future Sewer Utility OT network improvements and software to support the SCADA-related assets. The section also provides a summary of the features of each of these components and software products as related to the Sewer Utility's system.

- **Section 4: PLC Hardware and Software** describes the Allen-Bradley CompactLogix 5380 controller and Compact 5000 input/output (I/O) platform components selected as the new Sewer Utility standard for wastewater treatment plant (WWTP) and remote pump station programmable logic controller (PLC) design and implementation. The section also provides a summary of the evaluation approach by which these PLC components were selected.
- **Section 5: References** lists the supporting source materials cited in TM-3.

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2 Previously Selected Technology

This section provides a summary of the various SCADA-related hardware and software platforms that the Sewer Utility has selected prior to or in parallel with the Master Plan and that will remain part of the Sewer Utility's core technological assets into the future. Technology selected in TM-3 will be combined with the Sewer Utility's previously selected technology to form a cohesive system.

2.1 Network Architecture

Previously selected network architecture technology is summarized in Table 2-1.

Table 2-1. Summary of previously selected network architecture technology

Manufacturer/ vendor	Product/model	Description	Application
Tempered Networks	Airwall system	Software-defined network (SDN) technology for implementing security policies, network segmentation, and encryption over wide-area networks (WANs). Platform consists of a cloud-hosted management portal (Airwall Conductor), cloud-hosted routing service (Airwall Relay), and hardware and software gateways (Airwall Gateways).	• Data exchange between Sewer Utility WWTPs • Remote access to Sewer Utility OT network for Sewer Utility staff • Remote access to Sewer Utility OT network for contractors
Verizon Wireless	Private network service, zero-tunnel configuration	4G Long-Term Evolution (LTE) cellular plan for machine-to-machine (M2M) applications. Communication restricted to customer mobile devices.	Remote pump station telemetry
Cradlepoint	IBR600C series cellular router	4G LTE cellular router	Remote pump station telemetry
VMWare	ESXi	Type 1 hypervisor for hosting virtual machines (VMs)	Central Kitsap Treatment Plant (CKTP) primary and secondary SCADA servers

2.2 Industrial Control System Hardware

Previously selected industrial control system (ICS) hardware technology is summarized in Table 2-2.

Table 2-2. Summary of previously selected ICS hardware technology

Manufacturer/ vendor	Product/model	Description	Application
Allen-Bradley	MicroLogix 1400	Compact controller with onboard I/O points, Ethernet port, and EtherNet/Internet Protocol (IP) and Distributed Network Protocol 3 (DNP3) communication capability	Remote pump station remote telemetry unit (RTU) controller

2.3 Industrial Control System Software

Previously selected ICS software technology is summarized in Table 2-3.

Table 2-3. Summary of previously selected ICS software technology

Manufacturer/ vendor	Product/model	Description	Application
AVEVA	System Platform 2020[a]	SCADA software platform for centralized management of SCADA human-machine interface (HMI) graphics and historical SCADA data. Includes communication drivers for integrating PLCs, network devices, and other ICS components. Also includes the individual AVEVA software components listed below.	• WWTP and remote pump station SCADA HMI screens • Redundant installation on servers residing at CKTP
AVEVA	InTouch HMI 2020[a]	Runtime and development software for SCADA HMI graphics.	• WWTP and remote pump station SCADA HMI screens • Runtime installations installed at WWTP operator SCADA personal computers (PCs) and workstations
AVEVA	Historian 2020[a]	SCADA data repository and management platform.	WWTP and remote pump station SCADA data
AVEVA	Historian Client 2020[a]	User interface for simplifying access to historical SCADA data and developing static and ad hoc trends.	• WWTP and remote pump station SCADA data • Installed at WWTP operator SCADA PCs and workstations
Rockwell Automation	Studio 5000 Logix Designer	PLC programming development environment	WWTP and remote pump station PLCs

a. Quality Controls Corporation (QCC) plans to update its ongoing System Platform 2017 implementation work for the Sewer Utility to System Platform 2020, the most current software offering.

2.4 Other Software Packages

Previously selected additional software packages are summarized in Table 2-4.

Table 2-4. Summary of previously selected additional software packages

Manufacturer/ vendor	Product/model	Description	Application
LLumin	LLumin	Computerized maintenance management system (CMMS)	Sewer Utility asset tracking and maintenance management
Hach	Water Information Management Solution (WIMS)	Laboratory information management system (LIMS)	• CKTP laboratory management • WWTP laboratory and SCADA data tracking and analysis

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3 OT Network Architecture Technology and Software

This section describes the network architecture technology components and software to support the SCADA-related assets. The section also provides a summary of the features of each of these components and software products as related to the Sewer Utility's system. The costing provided in this section is current as of the time of writing but may vary greatly depending on continuing supply chain issues.

3.1 Network Equipment Evaluation

In TM-2, Section 5.1.1, several requirements were identified for the Sewer Utility's OT network. These OT network requirements include the following:

- Secure and reliable connection between CKTP and the remote pump stations and WWTPs
- Remote access for instrumentation and controls (I&C) technicians via County-issued laptops
- Secure access to ICS data from business local-area network (LAN)

Several vendors of the industrial grade network equipment can meet the technical requirements. The following key attributes were considered for the selection of the Sewer Utility OT network equipment.

When selecting the modern OT network architecture technology components, the ability to integrate with the Sewer Utility's PLC hardware and software, relative costs, and minimal technical requirements are considered.

3.2 Managed Network Switches

Network equipment should be managed as a system and will ideally be consistent across manufacturer, product line, and vintage. Intermingling of network manufacturers, product lines, and vintages should be minimized. Network life cycle should be considered as part of facility planning.

Industrial-rated, panel-mounted switches like Allen-Bradley Stratix switches (Figure 3-1) should be used for control and I/O networks. Rack-mounted switches like the Cisco Catalyst 9000 switching family (Figure 3-2) should be used for SCADA and demilitarized zone (DMZ) networks.

3.2.1 Industrial Panel-Mounted Network Switches

Industrial panel-mounted network switches should support the following design features and protocols:

A. Support Ethernet 10/100/1000 megabits per second (Mbps)

B. Backbone (trunk) fiber ports shall be via small form-factor pluggable (SFP) modules

C. Provide as required (plus at least two spare) 10/100/1000 MBit/s port (twisted pair) at each Ethernet switch

D. Support Device Level Ring (DLR) topology

E. Support EtherNet/IP (Common Industrial Protocol [CIP]) protocol

F. Support Simple Network Management Protocol (SNMP) v3 and web-based management

G. Rapid Spanning Tree Protocol

H. Internet Group Management Protocol (IGMP) support for Internet Protocol (IP) multicast filtering to enable switches to automatically route messages only to appropriate ports

I. Check all received data for validity

   1. Discard invalid and defective frames or fragments

J. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with Institute of Electrical and Electronics Engineers (IEEE) 802.3

K. Monitor attached fiber-optic lines for open circuit conditions in accordance with IEEE 802.3

L. Dual redundant power supplies

M. Light-emitting diode (LED) status lights to indicate:

   1. Power: Supply voltage present

   2. Fault

   3. Port status

N. Environmental rating:

   1. Operating temperature: -40 degrees Fahrenheit (°F) to 140°F

   2. Humidity: 95 percent relative humidity, non-condensing

Figure 3-1. Allen-Bradley Stratix switch

Source: Rockwell Automation 2021b.

3.2.2 Cost

The costing for Allen-Bradley Stratix switches varies based on features such as the number of ports, managed or unmanaged, DLR connectivity, etc. Retail pricing for a few common Stratix switches that are typically used in PLC panels is shown in Table 3-1 for reference. Although unmanaged options are available for industrial panel-mounted switches they are not recommended. Each switch will need to be sized individually based on the network requirements for that panel.

Table 3-1. Allen-Bradley Stratix switches

Component	Component cost[a]
1783-BMS10CGN Stratix 5700 10-port managed switch	$3,032
1783-BMS06SA Stratix 5700 6-port managed switch	$1,352
1783-US5T Stratix 2000 unmanaged switch	$155

a. Retail cost information obtained from North Coast Electric website (North Coast Electric 2021a–c).

3.2.3 Rack-Mounted Switches (with Redundant Network Access)

Rack-mounted network switches should support the following design features and protocols:

A. Support Ethernet 10/100/1000 Mbps

B. Ethernet backbone uplink modules for connection to multimode and/or single-mode fiber via type LC connectors

C. Backbone (trunk) fiber ports shall be via SFP modules

D. Provide as required (plus at least two spare) 10/100/1000 MBit/s port (twisted pair) at each Ethernet switch

E. Support SNMP v3 and web-based management

F. Rapid Spanning Tree Protocol

G. IGMP support for IP multicast filtering to enable switches to automatically route messages only to appropriate ports

O. Check all received data for validity

  1. Discard invalid and defective frames or fragments

P. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with IEEE 802.3

H. Monitor attached fiber-optic lines for open circuit conditions in accordance with IEEE 802.3

I. Distance vector protocols:

  1. Routing Information Protocol (RIP)

  2. Border Gateway Protocol

  3. Rapid Spanning Tree Protocol

J. Link state protocols:

  1. Open Shortest Path First (OSPF)

K. Redundancy protocols:

  1. Hot Standby Router Protocol (HSRP)

L. Layer-3 LAN Base: support for static IP routing; support for Switched Virtual Interface (SVI)

M. Layer-3 IP base: RIP, EIGRP stub, OSPF for routed access, Policy-Based Routing (PBR), IPv4 and IPv6 EIGRP stub routing, IPv6 Unicast Reverse Path forwarding (uRPF), IPV6 PBR, Virtual Router Redundancy Protocol (VRRPv3), Policy Classification Engine, HSRP v6

N. Layer-3 IP services: OSPF, EIGRP, Border Gateway Protocol (BGP), Intermediate System to Intermediate System (IS-IS), Virtual Routing and Forwarding (VRF-lite)

O. Software support for IPv4 and IPv6 routing, multicast routing, modular quality of service (QoS), flexible netflow (FNF) and enhanced security features

P. Dual redundant power supplies

Q. LED status lights to indicate

4. Power: supply voltage present
5. Fault
6. Port status

R. Environmental rating:

3. Operating temperature: 32°F to 122°F
4. Humidity: 95 percent relative humidity, non-condensing

Figure 3-2. Cisco Catalyst 9000 family switch

Source: Cisco Systems 2021.

3.2.4 Cost

Like the Industrial panel-mounted switches, the costing for the Cisco Catalyst 9000 series varies based on features such as the number of ports, stackability, etc. Retail pricing for a few common Catalyst 9000 switches is shown in Table 3-2 for reference. Each switch will need to be sized individually based on the OT network requirements for that particular switch.

Table 3-2. Cisco Catalyst 9000 switches

Component	Component cost[a]
C9200-24P-E 24-port managed switch	$1,416
C9300-48P-A 48-port managed switch	$5,910

a. Retail cost information obtained from CDW 2021a–b.

3.3 Uninterrupted Power Supplies

Uninterrupted Power Supplies (UPS) should be used during a loss of power as a backup power source so that operators can be notified of a power loss and the SCADA system can temporarily maintain monitoring and control functions. The UPS can also help protect against potential damage to your equipment during power surges and spikes.

A tower style UPS like the APC SRT1500XLA should be used within the control panel. A rackmount UPS like APC SRT1500RMXLA-NC and additional rackmount external batteries like APC SRT48RMBP should be used inside the network rack to provide backup power for approximately 4 hours.

3.3.1 Control Panel Uninterrupted Power Supply

Uninterrupted power supplies should support the following design features:

A. Double Conversion, true online type

B. Tower type format

C. Waveform: Pure sine wave

D. Power factor correction

E. Provide enough time to notify operator of in pending power loss when UPS is exhausted

F. Frequency range: 45-65 HZ

G. Input protection: Fuse or Circuit Breaker

H. Output voltage regulation: ±1% online and ±2% on battery mode.

I. Battery: Sealed, lead-acid; maintenance free.

J. Three stage battery charging for prolonged battery life.

K. Battery over discharge protection.

L. Input power cord.

M. Output receptacles.

N. Efficiency:

   1. Normal mode, minimum: 89%.

   2. Efficiency mode, minimum: 95%.

   3. Battery mode, minimum: 83%.

O. Operating temperature: 32 to 104 DEGF.

P. Relative humidity: 5-95% non-condensing.

Q. Integral bypass to automatically bypass UPS on selected fault conditions.

R. Front panel indication of UPS status and alarm conditions.

   1. UPS Fault.

   2. UPS on battery.

   3. UPS is online and operating normally.

4. Battery low.

5. UPS in bypass.

S. Utilize network management card to enable remote annunciation of the following conditions.

1. UPS Fault.

2. UPS on battery.

3. UPS is online and operating normally.

4. Battery low.

5. UPS in Bypass

T. Agency Approvals:

1. Safety: UL 1778.

2. Emissions: FCC Part 15 (Class A).

Figure 3-3. APC Smart-UPS SRT 1500 Tower

Source: APC

3.3.2 Cost

The costs for both the UPS as well as the network management card to provide remote monitoring and control of the UPS are shown below in Table 3-3 for reference.

Table 3-3. APC Smart-UPS SRT 1500, UPS Network Management Card

Component	Component cost[a]
APC Smart-UPS SRT 1500VA, 120V, LCD, tower, 6x NEMA 5-15R outlets	$1,450
UPS Network Management Card 3 with Environmental Monitoring	$539

a. Retail cost information obtained from APC website (APC 2021a-b).

3.3.3 Rackmount Uninterrupted Power Supply

Uninterrupted power supplies should have the following design features:

A. Double Conversion, true online type

B. Network Rackmount type format

C. Waveform: Pure sine wave

D. Power factor correction

E. Minimum 4 hours power ride through of 100% of connected load without incoming power.

   1. Provide extended battery or batteries as necessary to achieve the specified battery run time.

F. Frequency range: 45-65 HZ

G. Input protection: Fuse or Circuit Breaker

H. Output voltage regulation: ±1% online and ±2% on battery mode.

I. Battery: Sealed, lead-acid; maintenance free.

J. Three stage battery charging for prolonged battery life.

K. Battery over discharge protection.

L. Input power cord.

M. Output receptacles.

N. Efficiency:

   1. Normal mode, minimum: 89%.

   2. Efficiency mode, minimum: 95%.

   3. Battery mode, minimum: 83%.

O. Operating temperature: 32 to 104 DEGF.

P. Relative humidity: 5-95% non-condensing.

Q. Integral bypass to automatically bypass UPS on selected fault conditions.

R. Front panel indication of UPS status and alarm conditions.

1. UPS Fault.
2. UPS on battery.
3. UPS is online and operating normally.
4. Battery low.
5. UPS in bypass.

S. Utilize network management card to enable remote annunciation of the following conditions.

1. UPS Fault.
2. UPS on battery.
3. UPS is online and operating normally.
4. Battery low.
5. UPS in Bypass

T. Agency Approvals:

1. Safety: UL 1778.
2. Emissions: FCC Part 15 (Class A).

Figure 3-4. APC Smart-UPS SRT 1500 Rackmount

Source: APC

Figure 3-5. APC Smart-UPS SRT Battery Pack

Source: APC

3.3.4 Cost

Unlike the tower UPS, the rackmount UPS is bundled with a network management card. Additional Battery Packs may be required to achieve necessary backup time. The battery packs are stackable up to 10 units to provide the necessary backup time. Retail prices for the UPS and the battery pack are shown in Table 3-4 below.

Table 3-4. APC Smart-UPS SRT 1500 Rackmount, APC Smart-UPS SRT Battery Pack

Component	Component cost[a]
APC Smart-UPS SRT 1500VA, 120V, LCD, rackmount, 2U, 6x NEMA 5-15R outlets, w/network card	$1,975
APC Smart-UPS SRT Battery Pack (1kVA & 1.5kVA) 48V, 594VAh, rackmount, 2U	$839

b. Retail cost information obtained from APC website (APC 2021c-d).

3.4 OT Cybersecurity and Disaster Recovery

This section describes OT cybersecurity and disaster recovery for the Sewer District, including OT access control, OT network monitoring and logging software, and cost.

3.4.1 OT Access Control

To manage users on the OT network, consider implementing Microsoft Active Directory Domain Server (AD DS). AD authenticates and authorizes all users and computers in the domain network, assigns and enforces security polices for all computers, provides authentication and authorization mechanisms, and establishes a framework to deploy other related services.

3.4.2 OT Network Monitoring and Logging Software

OT network traffic events should be logged and stored on a centralized server that has enough memory to allow personnel to monitor and troubleshoot network issues. SolarWinds Network Performance Monitor and Kiwi Syslog Sever platform provide centrally managed syslog messages, real-time alerts, storage, and report generation.

Network monitoring software should provide the following features:

A. Network mapping tool and SNMP scanner

B. Network monitoring software with alerts

C. Network Packet Analyzer and Capture (PCAP) tool

D. Network path analysis and uptime monitor

E. Infrastructure monitoring

The network monitoring system (NMS) on the local OT network shall be used to monitor the operation of OT system network hosts. Network hosts shall be scanned only after confirming with the vendor that the device can be safely scanned. For example, Allen-Bradley PLC-5 or SLC PLCs are known to be sensitive to scanning.

3.4.3 Cost

Retail pricing for the SolarWinds Network Performance Monitoring and Syslog server logging is shown in Table 3-5 for reference. The SolarWinds NPM SL250 perpetual license provides management of up to 250 elements, which will meet the current and anticipated future needs of the Sewer Utility's OT network.

Table 3-5. Network monitoring and logging software

Component	Component cost[a]
SolarWinds NPM SL250 perpetual license	$7,279
SolarWinds Kiwi Syslog Server	$319

a. Retail cost information obtained from SolarWinds 2021a–b.

3.5 Multifactor Authentication for HMI Software

Because of increasing cybersecurity risks, a zero-trust security model should be used when accessing the control system equipment, particularly from a remote location outside of the OT network. One additional layer of security that should be considered is multifactor authentication. It is recommended that all mobile devices connecting to the control network equipment should be protected with a multifactor authentication application. There are several multifactor authentication applications including DUO, which has a partnership with Cisco network for more integrated zero-trust security solutions. Most multifactor authentication costing is done on a monthly subscription basis per user at a cost of approximately $6 to $10 per user per month based on the features used.

3.6 Version Control and Backup Software for OT Systems

This section describes version control and backup software for OT systems, including version control software and secure offline storage and cost for each.

3.6.1 Version Control Software

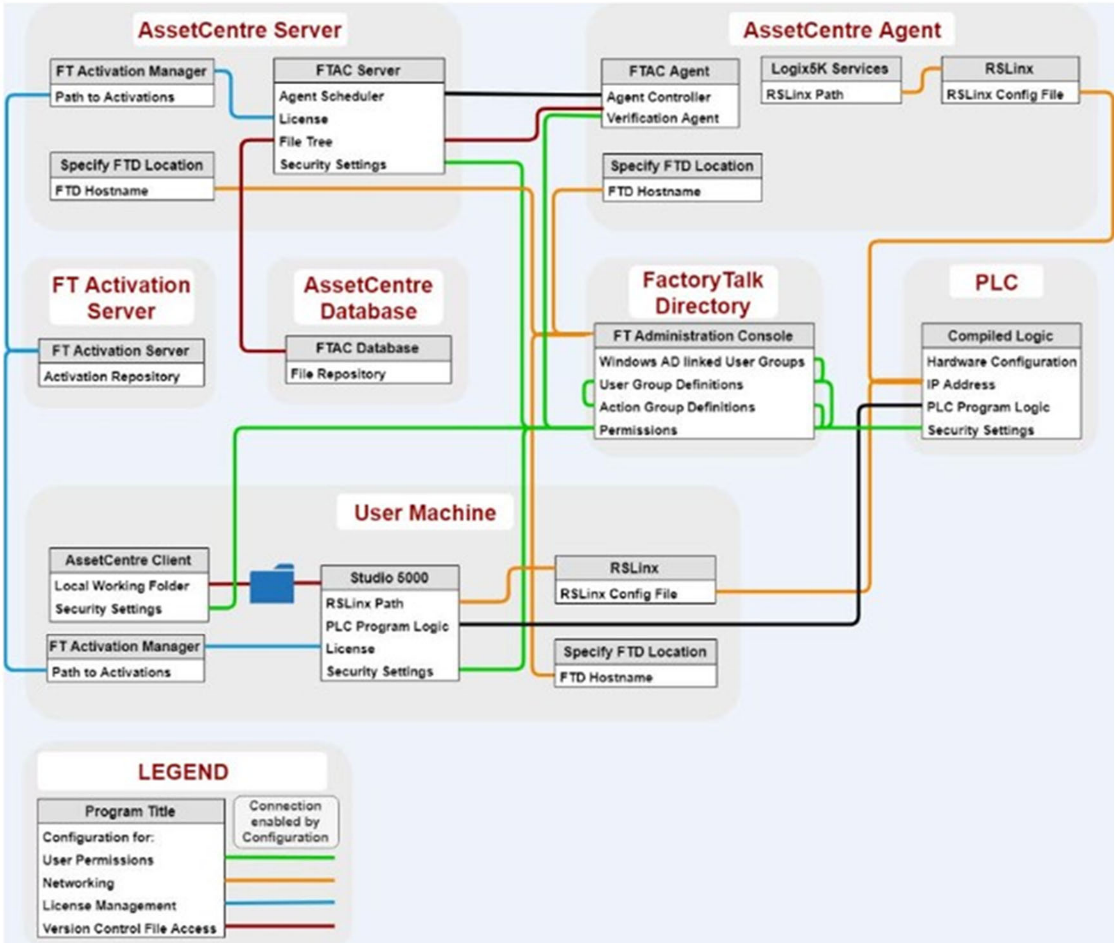
In a disaster response scenario, it is critical to have current configuration files for ICSs components (PLCs, operator panel, network switches, motor drives, etc.). Rockwell Software FactoryTalk (FT) Asset Centre provides a centralized tool for securing, managing, versioning, tracking, and reporting automation-related asset information across the entire Sewer Utility.

Rockwell Software FT AssetCentre is dedicated software for securing, managing, tracking, and documenting (versioning) the control system assets of the Sewer Utility.

FT AssetCentre will allow Sewer Utility staff to provide archive and disaster recovery for Allen-Bradley equipment, audit trails of programming changes, provide security on access to view and change production PLC code, and maintain controls assets along their useful life cycle. From a maintenance and troubleshooting standpoint FT AssetCentre has the capability to compare versions of Rockwell Software Studio5000 PLC code, which allows users to see programming changes quickly and easily between the two versions being compared. Also, FT AssetCentre can communicate directly with the Studio5000 Logix PLCs to retrieve scheduled backups and/or download the last known version to the processor itself, allowing all backups and version changes must be done automatically.

The graphic shown in Figure 3-6 shows the necessary requirements for the user permissions, network connections (and permissions), licensing, and version control. In the graphic the PLC represents all PLCs within the Sewer Utility's OT network and the user machine represents that field programming PCs. The FT AssetServer, FT Directory, and FT AssetCentre Agent are server PCs housed within the OT network.

Figure 3-6. Logical relationships of Rockwell software products required for FactoryTalk AssetCentre



Source: Rockwell Automation 2021c.

3.6.2 Version Control Software Cost

Retail pricing for Rockwell Software FT AssetCentre is shown in Table 3-6 for reference. Rockwell Software FT AssetCentre is available in two different formats: perpetual (ownership) and subscription. Perpetual licensing also has the option to pay a yearly support cost.

Table 3-6 highlights the costing associated with the two formats. Also, the Sewer Utility may elect to add the Archive Management of Change module, which would allow the formal approval (and documentation) of changes to be integrated within the FT AssetCentre software, rather than being done separately. Only one server and license is anticipated to be required for the Sewer Utility.

Table 3-6. Network monitoring and logging software

Component	Perpetual[a]	Subscription
FT AssetCentre one-time cost	$16,300/license	N/A
FT AssetCentre annual cost	$3,260/server/year	$6,600/server/year
Archive Management of Change module one-time cost	$6,000/license	N/A
Archive Management of Change module annual cost	$1,317/server/year	$2,439/server/year

a. Retail cost information obtained from Border States Electric 2021a–b.

3.6.3 Secure Offline Storage

In the event of a ransomware attack on the Sewer Utility control system, secure offline storage of Sewer Utility control system files (software licenses, configuration files, environmental compliance data, etc.) will be critical for the timely recovery of affected systems. The Sewer Utility should consider creating routine offline copies of ICS files. The Sewer Utility can either self-manage storage of physical media locally or use a company like Iron Mountain to store files at a secure off-site facility either in the cloud or with physical media.

3.6.4 Secure Offline Storage Cost

Table 3-7 shows the costing for offline storage via a tape drive and storage media for the backups. Alternatively, off-site storage via a service company like Iron Mountain requires a specific quote but is costed based on the number of virtual machines (VMs) being protected and gigabytes (GB) of data begin backed up. Payments for those services are generally done as a monthly or yearly service cost. An estimated yearly cost is shown in Table 3-8.

Table 3-7. LTO-7 tape drive and storage media

Component	Component cost[a]
HPE StoreEver LTO-7 Ultrium 15000 - tape drive - LTO Ultrium - SAS-2	$3,274
Quantum - LTO Ultrium 7 x 1 - 6 TB - storage media	$78

a. Retail cost information obtained from CDW 2021c–d.

Table 3-8. Off-site Storage Service

Component	Component cost[a]
Estimated yearly cost based on 5 VM and 10 GM/month of data	$896

a. Retail cost information obtained from Panoptics 2021.

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4 PLC Hardware and Software

This section describes the Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform components selected as the new Sewer Utility standard for WWTP and remote pump station PLC design and implementation. The section also provides a summary of the evaluation approach by which these PLC components were selected. The costing provided in this section is current as of the time of writing but may vary greatly depending on continuing supply chain issues.

4.1 Allen-Bradley CompactLogix 5380 Controller and Compact 5000 I/O Standard Components

The Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform comprise several component options and features that allow for flexibility in designing a PLC system that aligns with Sewer Utility preferences. The platform does not use a chassis and all modules are DIN-rail-mountable. This section documents the platform components that are recommended for the Sewer Utility to standardize on for future design and implementation projects. A summary table (Table 4-1) comprising the recommended platform components is provided in Section 4.1.6. An example of a PLC rack assembled from controller and I/O modules within this product line is provided in Figure 4-1.

Figure 4-1. Allen-Bradley CompactLogix 5380 controller with Compact 5000 I/O modules

Source: Rockwell Automation 2018a.

4.1.1 Controller

This section describes the controller module and recommended accessories of the Allen-Bradley CompactLogix 5380 PLC platform.

Controller Module

The Allen-Bradley CompactLogix 5380 controller family includes several controller modules that feature a range of capabilities in terms of user memory, local I/O module capacity, and supported EtherNet/IP connections. The retail cost for these controllers currently ranges from roughly $1,300 to $16,000 depending on the capabilities of the controller (North Coast Electric 2021d). Selecting a controller that is right-sized for the application can result in component cost savings and is recommended over a one-size-fits-all approach to controller module selection. A 5069-L320ER controller is depicted in Figure 4-2. This controller, for example, has 2 megabytes (MB) of user memory and supports up to 16 local I/O modules and 40 EtherNet/IP connections.

Figure 4-2. Allen-Bradley 5069-L320ER CompactLogix 5380 controller

Source: North Coast Electric 2021e.

All controller modules in the Allen-Bradley 5380 CompactLogix platform include two built-in 1 Gbps Ethernet ports. These ports can be configured for linear or DLR topologies where the ports share one IP address, or the ports can be configured with unique IP addresses to support network segmentation approaches. All controllers have a built-in Universal Serial Bus (USB) port for local programming, configuration, firmware updates, and online edits. Controllers also support Secure Digital (SD) memory cards for storing non-volatile memory.

Note, the CompactLogix 5380 controllers with part numbers ending in ERM, ERMK, and ERP include integrated motion and other advanced features that are not used in typical wastewater applications. The Sewer Utility is unlikely to leverage the additional functionality provided by these controllers, so investment in these higher-cost components is not recommended.

Controller Accessories

The Allen-Bradley 5380 CompactLogix controllers can be provided with spring clamp or screw clamp terminals for power connections, which must be ordered separately from the controller module. Either terminal kit would be suitable, but Sewer Utility staff are likely already familiar with screw clamp terminals based on the Sewer Utility's existing ICS infrastructure. For this reason, the Allen-Bradley 5069-RTB64-SCREW power terminal kit is recommended.

An SD memory card is also recommended for non-volatile memory storage of application programming and data. A 2 GB SD memory card (part 1784-SD2) ships with each controller and should provide sufficient memory storage for most, if not all, Sewer Utility applications.

4.1.2 EtherNet/IP Adapter

This section describes the Allen-Bradley Compact 5000 I/O EtherNet/IP adapter recommended for the Sewer Utility.

EtherNet/IP Adapter

The Allen-Bradley Compact 5000 I/O platform includes two types of EtherNet/IP adapters that serve as communication modules for remote input/output (RIO) racks: the 5069-AENTR and 5069-AEN2TR. Both EtherNet/IP adapters facilitate high-speed data transfer between the connected Compact 5000 I/O modules within the RIO rack and one or more CompactLogix 5380 controllers (or other compatible controllers) on a shared EtherNet/IP network. Both EtherNet/IP adapters also include two built-in 1 Gbps Ethernet ports. These ports can be configured for linear or DLR topologies where the ports share one IP address, or a single port can be used to connect to a star network topology.

The most significant advantage that the 5069-AENTR has over the 5069-AEN2TR is some security features included in what Allen-Bradley refers to as Protected Mode. Among other things, these features are meant to reduce the attack surface of the device by preventing configuration changes, firmware updates, and remote resets from occurring once the adapter is exchanging I/O with a controller. While the 5069-AEN2TR does not support Protected Mode, the adapter has a four-character digital display that communicates status and fault messages, which can help with troubleshooting. The 5069-AEN2TR also supports SD memory cards for storing the adapter's configuration in non-volatile memory. The latter feature allows for the adapter to automatically revert to its last saved configuration on power-up, which allows the device to automatically recover from loss or corruption of internal memory. While both EtherNet/IP adapters have advantages, the enhanced troubleshooting and resilience features of the 5069-AEN2TR are likely to be more beneficial to the Sewer Utility. For this reason, HDR Engineering, Inc. (HDR) recommends that the Sewer Utility standardize on the 5069-AEN2TR for future RIO racks (Figure 4-3).

Figure 4-3. Allen-Bradley 5069-AEN2TR Compact 5000 I/O EtherNet/IP adapter

Source: North Coast Electric 2021f.

EtherNet/IP Adapter Accessories

The Allen-Bradley 5069-AEN2TR EtherNet/IP adapter can be provided with spring clamp or screw clamp terminals for power connections, which, like the controller module, must be ordered separately from the EtherNet/IP adapter module. The power terminal kits used for the controller module are identical for the 5069-AEN2TR. As discussed for the controller module, HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-RTB64-SCREW power terminal kit.

An SD memory card is also recommended for non-volatile memory storage of adapter configuration. A 1 GB SD memory card, the smallest available from Allen-Bradley, should provide ample memory storage for the adapter configuration.

4.1.3 Power Supply Considerations

The CompactLogix 5380 controller and Compact 5000 I/O platform does not include power supply modules like previous generations of the CompactLogix product line. Instead, the system requires the use of external power supplies that are wired to the power terminals on the CompactLogix 5380 controller or Compact 5000 I/O EtherNet/IP adapter. Power is distributed from the controller/adapter to the connected Compact 5000 I/O modules via a module (MOD) power bus. Similarly, power is distributed from the controller/adapter to the instrumentation with I/O connections to the Compact 5000 I/O modules via a sensor/actuator (SA) power bus. Both of these power buses reside at the rear of the controller/adapter and I/O modules and are made continuous by the interconnection of the modules.

Rockwell Automation recommends providing separate external power supplies for the MOD and SA power buses. This approach prevents a scenario where both power buses are lost because of the failure of a single component. The MOD power bus must be supplied with 24 volts direct current (VDC) power. While the SA power bus may be powered via 24 VDC or 120 volts alternating current (VAC), HDR recommends that the Sewer Utility standardize on 24 VDC for the SA power bus. According to National Fire Protection Association (NFPA) 70E: Standard for Electrical Safety in the Workplace, all voltages 50 volts (V) and greater are considered to present a shock hazard under most circumstances (NFPA 2021). In general, standardizing on the use of 24 VDC controls and power distribution, to the extent possible, within industrial control panels and for field instrumentation can reduce or eliminate shock hazards for personnel.

4.1.4 I/O Modules

This section describes the Allen-Bradley Compact 5000 I/O modules recommended for the Sewer Utility. To reduce shock hazards within industrial control panels and at field instrumentation, HDR recommends that the Sewer Utility standardize on 24 VDC control voltage for all I/O modules on future projects, when feasible. The I/O modules recommended in this section have been selected to conform with this 24 VDC control voltage standard.

Analog Input Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-IF8 module for analog inputs (Figure 4-4). This module supports current- and voltage-based two- and four-wire analog devices. A combination of these device types may be wired to the same module. Each module has eight available channels wired as differential inputs.

Figure 4-4. Allen-Bradley 5069-IF8 Compact 5000 I/O analog input module

Source: North Coast Electric 2021g.

Note, the Compact 5000 I/O platform also includes four-channel analog input modules that support thermocouple and resistance temperature detectors (RTDs) in addition to the two- and four-wire devices supported by the 5069-IF8 analog input module. However, unless thermocouples or RTDs are to be wired to the analog input module, the Sewer Utility would gain no benefit from using a module with fewer available channels.

Analog Output Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-OF8 module for analog outputs (Figure 4-5). This module supports current- or voltage-based analog outputs. Each module has eight available channels wired as differential outputs.

Figure 4-5. Allen-Bradley 5069-OF8 Compact 5000 I/O analog output module

Source: North Coast Electric 2021h.

Digital Input Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-IB16F module for digital inputs (Figure 4-6). This module has 16 available channels wired as sinking 24 VDC inputs.

Figure 4-6. Allen-Bradley 5069-IB16F Compact 5000 I/O digital input module

Source: North Coast Electric 2021i.

The 5069-IB16F is the high-speed variant of the 16-channel 24 VDC digital input modules available within the Compact 5000 I/O platform, which allows for connection of higher-speed frequency inputs for counter applications. A common application of counter applications in wastewater is for flow totalization where magmeter frequency outputs are monitored to determine total flows. Given that the high-speed variant of the digital input module retails for roughly $30 more than the standard digital input module, there is not likely to be considerable cost savings from only using the high-speed module for counter applications. Standardizing on two digital input module types would also require additional spare parts to be managed. For these reasons, HDR recommends that the Sewer Utility standardize on the 5069-IB16F for all digital input applications.

Digital Output Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-OB16 module for digital outputs (Figure 4-7). This module has 16 available channels wired as sourcing 24 VDC outputs.

Figure 4-7. Allen-Bradley 5069-OB16 Compact 5000 I/O digital output module

Source: North Coast Electric 2021j.

Unlike the previously discussed I/O modules, the 5069-OB16 module does not draw current from the SA power bus. Instead, wiring to an external power supply is required for the module, which allows for the digital output circuits to be isolated from the SA power bus used by other I/O modules.

I/O Module Accessories

The Allen-Bradley analog and digital I/O modules can be provided with spring clamp or screw clamp terminals for I/O connections. These terminal kits must be ordered separately from the modules. As discussed for the controller module, HDR recommends that the Sewer Utility standardize on the screw terminal kit variant, the Allen-Bradley 5069-RTB18-SCREW terminal kit.

4.1.5 End Cap

All CompactLogix 5380 controller and Compact 5000 I/O racks require installation of a 5069-ECR end cap on the right side of the rightmost module in the rack (see Figure 4-8). The end cap covers the exposed interconnections like the MOD and SA power buses on the rightmost module within the rack. Failure to install the end cap can result in equipment damage and risk of electric shock.

Figure 4-8. Allen-Bradley 5069-ECR CompactLogix 5380 and Compact 5000 I/O end cap

Source: EESCO 2021.

4.1.6 Recommended Standard Component Summary Table

The Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform components recommended for the Sewer Utility standard PLC and RIO components are summarized in Table 4-1.

Table 4-1. Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform standard components summary

Part number	Type	Description
5069-L3xxER	Controller	CompactLogix 5380 controller: sized per application
5069-RTB64-SCREW	Controller and EtherNet/IP adapter accessories	Screw clamp power terminal kit
1784-SD2	Controller accessories	SD memory card for application and data storage: 2 GB
5069-AEN2TR	EtherNet/IP adapter	Compact 5000 I/O EtherNet/IP adapter for RIO racks
1785-SD1	EtherNet/IP adapter accessories	SD memory card for configuration storage: 1 GB
5069-IF8	Analog input module	Analog input module: 8-channel, differential
5069-OF8	Analog output module	Analog output module: 8-channel, differential
5069-IB16F	Digital input module	Digital input module: 16-channel, high-speed, sinking
5069-OB16	Digital output module	Digital output module: 16-channel, sourcing
5069-RTB18-SCREW	I/O module accessories	Screw clamp terminal kit: 18-pin
5069-ECR	End cap	End cap: required on rightmost module in rack

4.2 PLC Programming Software

The Allen-Bradley CompactLogix 5380 controllers are configured and programmed with Rockwell Automation's Studio 5000 Logix Designer Application. This is the same software used to program the Sewer Utility's existing CompactLogix controllers from previous generations of the product line and HDR believes that the Sewer Utility already owns a license for the software. The CompactLogix 5380 controllers have minimum Logix Designer version requirements, which ranges from Version 28.00.00 to Version 29.00.00 for the controllers most suitable to the Sewer Utility's applications (Rockwell Automation 2020).

4.3 PLC Platform Evaluation

In TM-2, Section 6.1.1, several requirements were identified for the Sewer Utility's next PLC platform standard. These PLC platform requirements include the following:

- Support integration of an increasing number of Ethernet devices
- Compatible with existing PLC programming logic
- Actively supported by the manufacturer for the next 10 to 15 years
- Manufactured by Allen-Bradley to preserve the Sewer Utility's existing investment in standardizing on Allen-Bradley PLCs

Of the PLC platforms currently offered by Allen-Bradley, several controllers would meet the technical requirements. However, only two controller families are likely to satisfy the long-term active support requirements: ControlLogix 5580 and CompactLogix 5380. These controllers are compared in subsequent paragraphs.

Note, Allen-Bradley also offers a relatively new CompactLogix 5480 line of controllers that runs an instance of Windows 10 Internet of Things (IoT) Enterprise "in parallel" with the Logix control engine (Rockwell Automation 2021a). The intent of this offering is to allow advanced data processing and analytics to be shifted down from central servers to the device level. However, HDR has several concerns regarding the stability of the Windows 10 operating system, its fluctuating demands on device resources, and the high number of vulnerabilities that require frequent patches and updates from Microsoft. Long-term support of the Windows 10 operating system is also dubious, given that the extended support window for Windows 10 is currently slated to end on October 14, 2025 (Microsoft 2021). For these reasons, the CompactLogix 5480 product line was not considered as a viable candidate for the next Sewer Utility PLC platform standard.

4.3.1 Ease of Migration

Both the ControlLogix 5580 and CompactLogix 5380 controllers are made by the same manufacturer as the Sewer Utility's existing PLCs and share the same native industrial Ethernet communications protocol (EtherNet/IP) and programming environment as the existing CompactLogix PLCs. When it comes to the future migration of existing CompactLogix controllers, either platform would allow for relatively simple migration of existing programming logic and preservation of existing SCADA communication driver configuration.

The existing Allen-Bradley SLC 5/05 and MicroLogix 1500 PLCs that are recommended for near-term replacement are programmed via Rockwell Automation's RSLogix 500 software, which is a different programming environment from the Studio 5000 Logix Designer Application software used to program both the ControlLogix 5580 and CompactLogix 5380 controllers. The SLC 5/05 PLCs also use a different communication driver to establish data exchange with the Sewer Utility's AVEVA SCADA software. Because both candidate controllers share a common programming environment and require the same EtherNet/IP-based communication driver, neither controller has a distinct advantage when it comes to migrating the existing programming logic to the new platform and would both require transitioning to the communication driver currently used by the Sewer Utility's existing CompactLogix PLCs.

One significant benefit that the CompactLogix 5380 and Compact 5000 I/O platform has over the ControlLogix 5580 platform in terms of ease of migration is its form factor. The footprint of the CompactLogix 5380 and Compact 5000 I/O platform components is considerably smaller, which could reduce the amount of control panel modifications required for replacement of existing PLCs within existing enclosures. When it comes to SLC 5/05 PLC rack replacement, the CompactLogix 5380 and Compact 5000 I/O components could fit within the SLC 5/05 footprint with room to spare, assuming a one-for-one component replacement. The chassis required by the ControlLogix product line have a roughly identical footprint to those required by the SLC 500 product line. The difference in form factor will be more pronounced when it comes to replacement of the MicroLogix 1500 PLCs, which have a smaller footprint than either candidate platform. For these remote pump station control panel applications, the smaller footprint of the CompactLogix 5380 and Compact 5000 I/O components presents a significant advantage.

4.3.2 Capability

When determining modern controller requirements, programming application memory size (in megabytes) and maximum number of IP nodes supported are two significant metrics that are commonly considered. The former represents the available memory for the programming file and the data being handled, while the latter, in general terms, indicates how many IP devices the controller can communicate with. Table 4-2 includes a comparison of these metrics for the two Allen-Bradley controller families considered for the Sewer Utility. To provide some context for the comparison, the table also provides the actual memory used by the existing CKTP ultraviolet (UV) system PLC, which appears to have the largest memory usage of all PLCs in the Sewer Utility's inventory. For additional context, the table also includes an estimate of the maximum number of IP nodes that will need to communicate with any one PLC in the future Sewer Utility SCADA system. This estimate is based on the solids processing building (SPB) PLC (PLC 7105) and a scenario where the existing SPB motor control centers (MCCs) are upgraded with EtherNet/IP motor controllers and CKTP expansion adds loads to these MCCs. An allowance for 10 new Ethernet-capable instruments is also included in this estimation.

Table 4-2. Allen-Bradley CompactLogix 5380 and ControlLogix 5580 controller comparison

Controller family	Application memory size (MB)[a]	Max IP nodes supported[a]
CompactLogix 5380 standard controller	0.6–10.0	16–180
ControlLogix 5580 standard controller	3–40	100–300
Existing CKTP UV SCC 3100 controller memory used	~1.54	----
Estimated maximum IP nodes communicating to one controller in future Sewer Utility SCADA system	----	~75

a. Metrics obtained from Rockwell Automation literature (Rockwell Automation 2018b and Rockwell Automation 2019).

While PLC memory usage will increase somewhat as the Sewer Utility acquires more data from Ethernet-capable devices in the future, it is not anticipated that the Sewer Utility will have applications that exceed the upper limit on the ControlLogix 5380 memory size range in the next 10 to 15 years. Nor is it anticipated that a single PLC within the Sewer Utility SCADA system will need to communicate with more IP nodes than the CompactLogix 5380 controllers can support within that time frame. Based on memory size and the number of IP nodes supported, the CompactLogix 5380 presents a more right-sized option for the Sewer Utility's needs.

Another consideration for modern controllers is Ethernet communication speed capabilities. Both the CompactLogix 5380 and ControlLogix 5580 controllers are capable of 1 Gbps Ethernet communications. ICSs are gradually migrating from 100 Mbps port speeds to support higher data communication rates at the controller and device level, and 1 Gbps is quickly becoming the new standard. Having controllers that support higher port speeds will allow the Sewer Utility to benefit from other proposed improvements to the Sewer Utility SCADA system network infrastructure and increase the likelihood that the controllers remain compatible with equipment that may be installed in the future.

One of the major advantages that the ControlLogix 5580 controllers have over the CompactLogix 5380 controllers is their support for controller redundancy. However, as identified in TM-2, controller redundancy is not a requirement for the Sewer Utility. While the ControlLogix 5580 controllers have some additional technical functionality and features, like hot-swappable I/O modules, these are not critical features that would present sufficient drivers to select an oversized controller on their merits alone.

4.3.3 Cost

In terms of cost, the CompactLogix 5380 controller and associated Compact 5000 I/O components are the clear choice over the ControlLogix product line. Retail pricing for components required for a single, hypothetical seven-slot PLC rack with similar I/O capabilities is provided in Table 4-3 for reference. Note, because of the difference in I/O module costs, the cost delta will become more pronounced as the number of I/O modules in the racks increases.

Table 4-3. Allen-Bradley CompactLogix 5380 and ControlLogix 5580 component cost comparison

Component	CompactLogix 5380/ Compact 5000 I/O component cost[a]	ControlLogix 5580/ ControlLogix I/O component cost[a]
7-slot chassis	Not required	$632
Rack power supply module (24 VDC)	Not required	$1,137
Controller module, 3 MB, support for at least 60 IP nodes	$5,586	$6,404
Analog input module, 8-channel	$867	$1,327
Analog output module, 8-channel	$1,520	$2,494
Digital input module, 16-channel, high-speed	$292	$616
Digital output module, 16-channel	$340	$689
Slot filler (quantity of 2)	Not required	$70
I/O module terminal blocks (quantity of 4)	$248	$384
Controller module terminal blocks	$34	Not required
End cap	$25	Not required
Total	**$8,912**	**$13,753**

a. Retail cost information obtained from North Coast Electric website (North Coast Electric 2021d).

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TM-4: System Architecture Conceptual Design

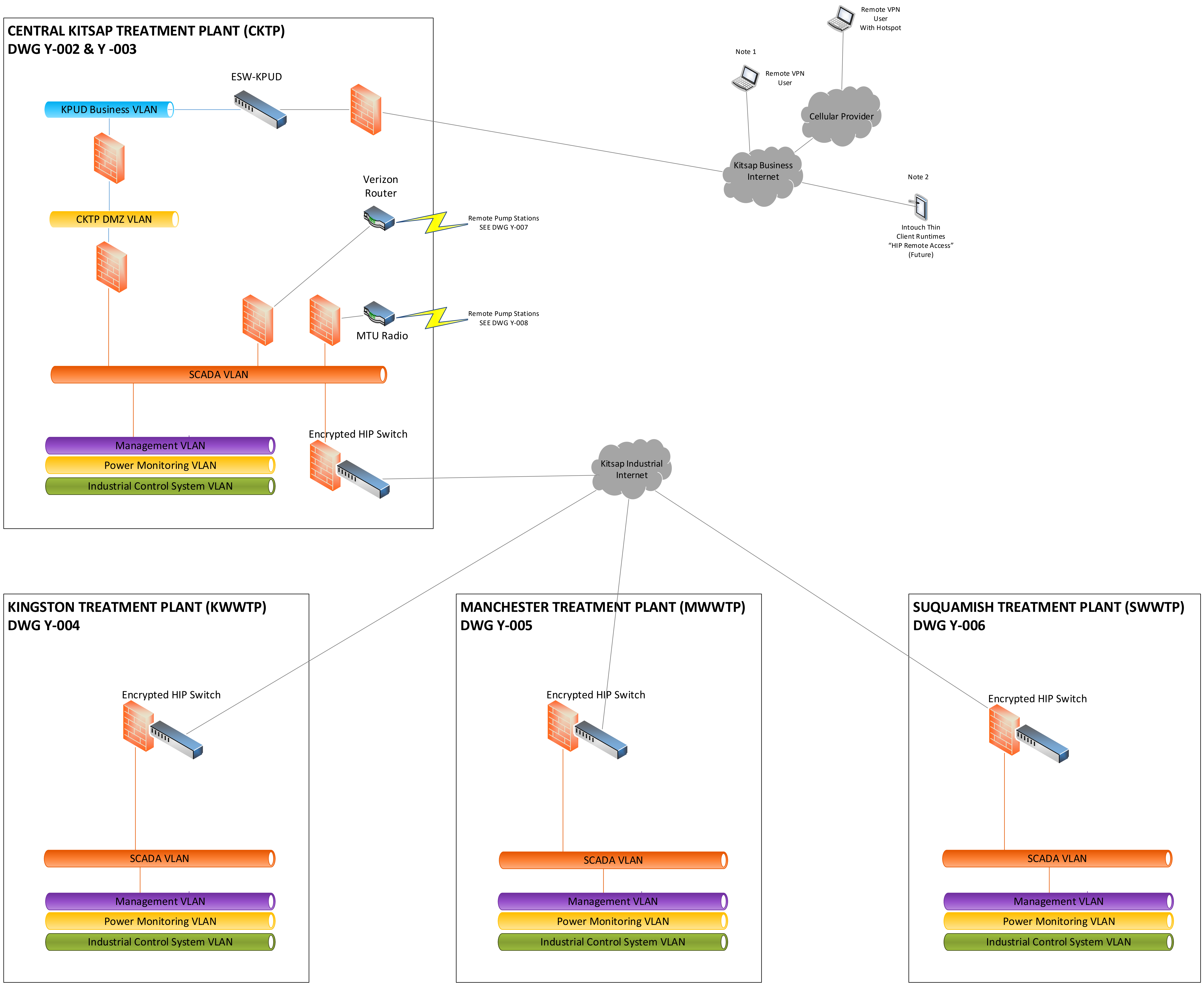
Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

October 26, 2021

Notes:

1. All mobile wireless communications will use VPN for AAA (authentication, authorization, accounting) and encryption.
2. Tablets will be updated with Group Policy Objects from Active Directory. This excludes devices based on Android or IOS operating systems



NO	DATE	BY	APPR	REVISIONS

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DRAWN BY — DATE
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APPROVED BY — DATE
10231983
HDR PROJECT NUMBER — DATE
KC-205-20
CLIENT PROJECT NUMBER — DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

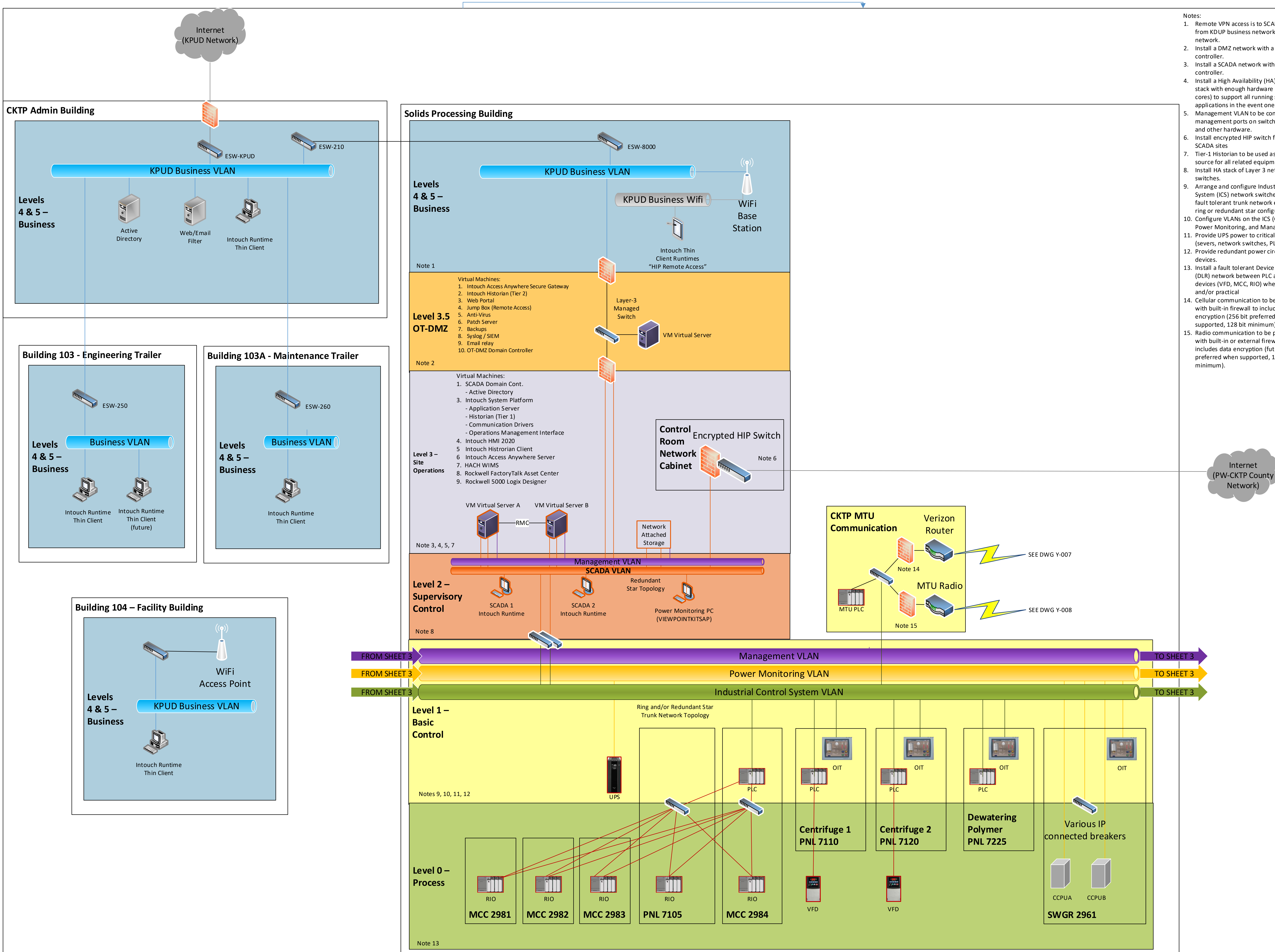
CONCEPT DIAGRAM
KITSAP SCADA OVERVIEW

DRAWING: Y-001

SHEET 1 OF 8

Notes:

1. Remote VPN access is to SCADA network from KDUP business network via the DMZ network.
2. Install a DMZ network with a domain controller.
3. Install a SCADA network with a domain controller.
4. Install a High Availability (HA) N+1 server stack with enough hardware (RAM and cores) to support all running software applications in the event one server fails.
5. Management VLAN to be connected to management ports on switches, servers and other hardware.
6. Install encrypted HIP switch for remote SCADA sites
7. Tier-1 Historian to be used as NTP time source for all related equipment.
8. Install HA stack of Layer 3 network switches.
9. Arrange and configure Industrial Control System (ICS) network switches with a fault tolerant trunk network either by ring or redundant star configuration.
10. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
11. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
12. Provide redundant power circuits for HA devices.
13. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical
14. Cellular communication to be protected with built-in firewall to include data encryption (256 bit preferred when supported, 128 bit minimum).
15. Radio communication to be protected with built-in or external firewall that includes data encryption (future: 256 bit preferred when supported, 128 bit minimum).



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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

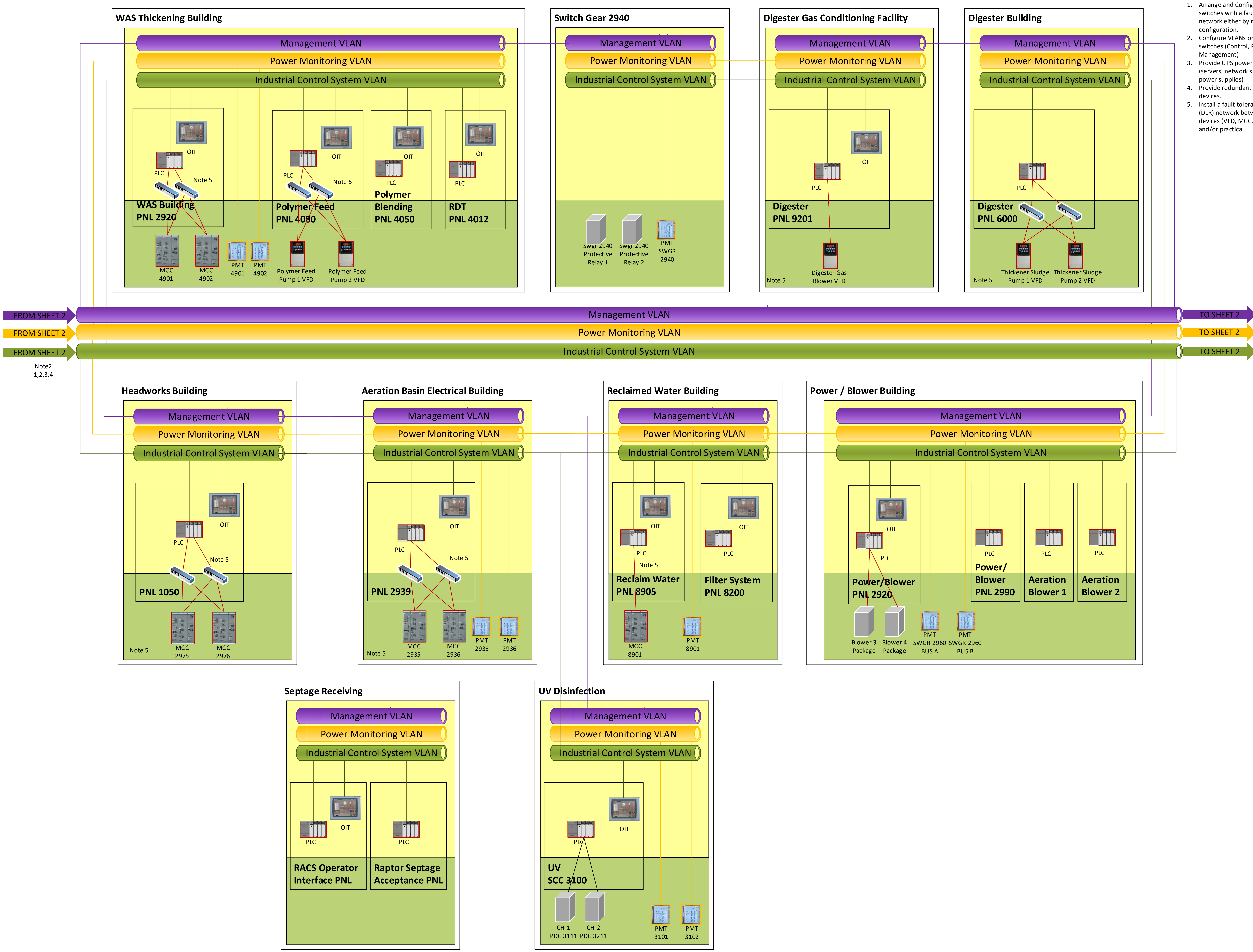
CONCEPT DIAGRAM
CKTP ADMIN AND SOLID PROCESSING BUILDINGS

SCALE: NONE

DRAWING: Y-002

SHEET 2 OF 8

Notes:
1. Arrange and Configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
2. Configure VLANs on the ICS network switches (Control, Power Monitoring, and Management)
3. Provide UPS power to critical loads (servers, network switches, PLC & RIO power supplies)
4. Provide redundant power circuits for HA devices.
5. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical



NO	DATE	BY	APPR	REVISIONS

HDR

HDR Engineering, Inc.
1917 S. 67th Street
Omaha, NE 68106
402.399.1000

DESIGNED BY DATE
DRAWN BY DATE
CHECKED BY DATE

APPROVED BY DATE
10231983
HDR PROJECT NUMBER DATE
KC-205-20
CLIENT PROJECT NUMBER DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

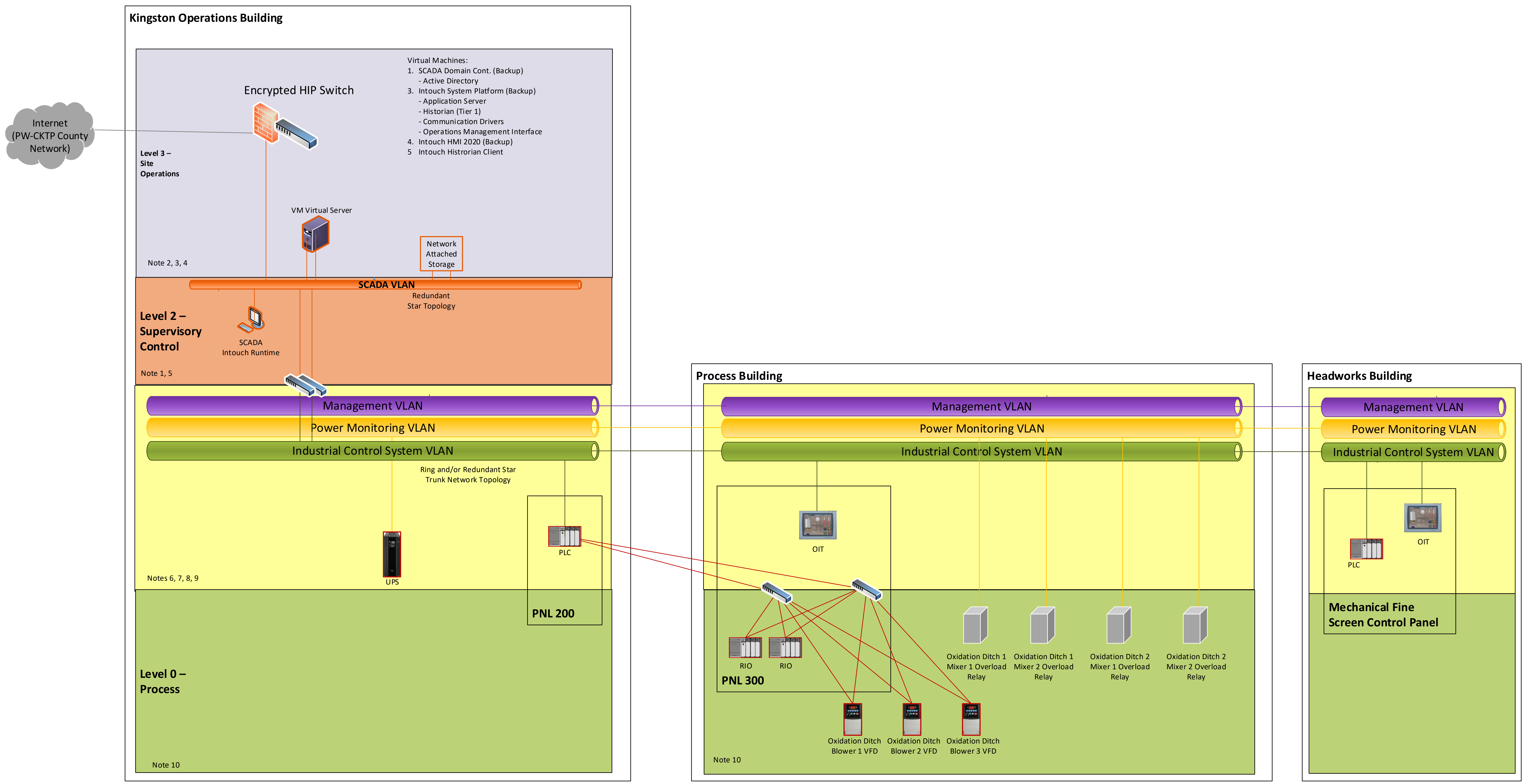
SCALE: NONE

CONCEPT DIAGRAM
CKTP BALANCE OF PLANT

DRAWING: Y-003

SHEET 3 OF 8

Notes:
1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
5. Install High Availability (HA) pair of managed network switches.
6. Arrange and configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical.



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Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM
KINGSTON WWTP

DRAWING: Y-004

SHEET 4 OF 8

Notes:
1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
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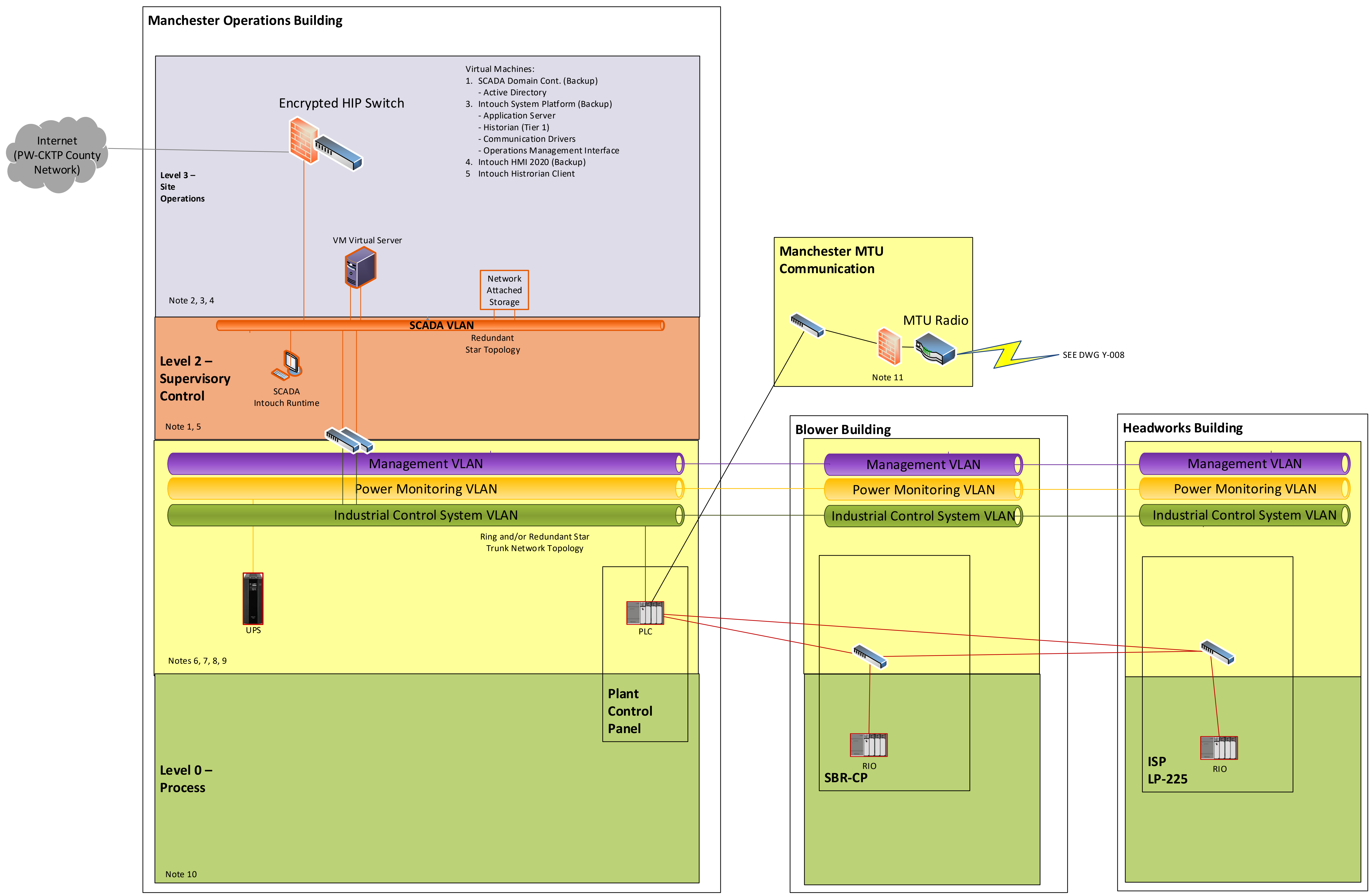
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical
11. Radio communication to be protected with built-in or external firewall that includes data encryption (future: 256 bit preferred when supported, 128 bit minimum).



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HDR Engineering, Inc.
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APPROVED BY DATE
10231983
HDR PROJECT NUMBER DATE
KC-205-20
CLIENT PROJECT NUMBER DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

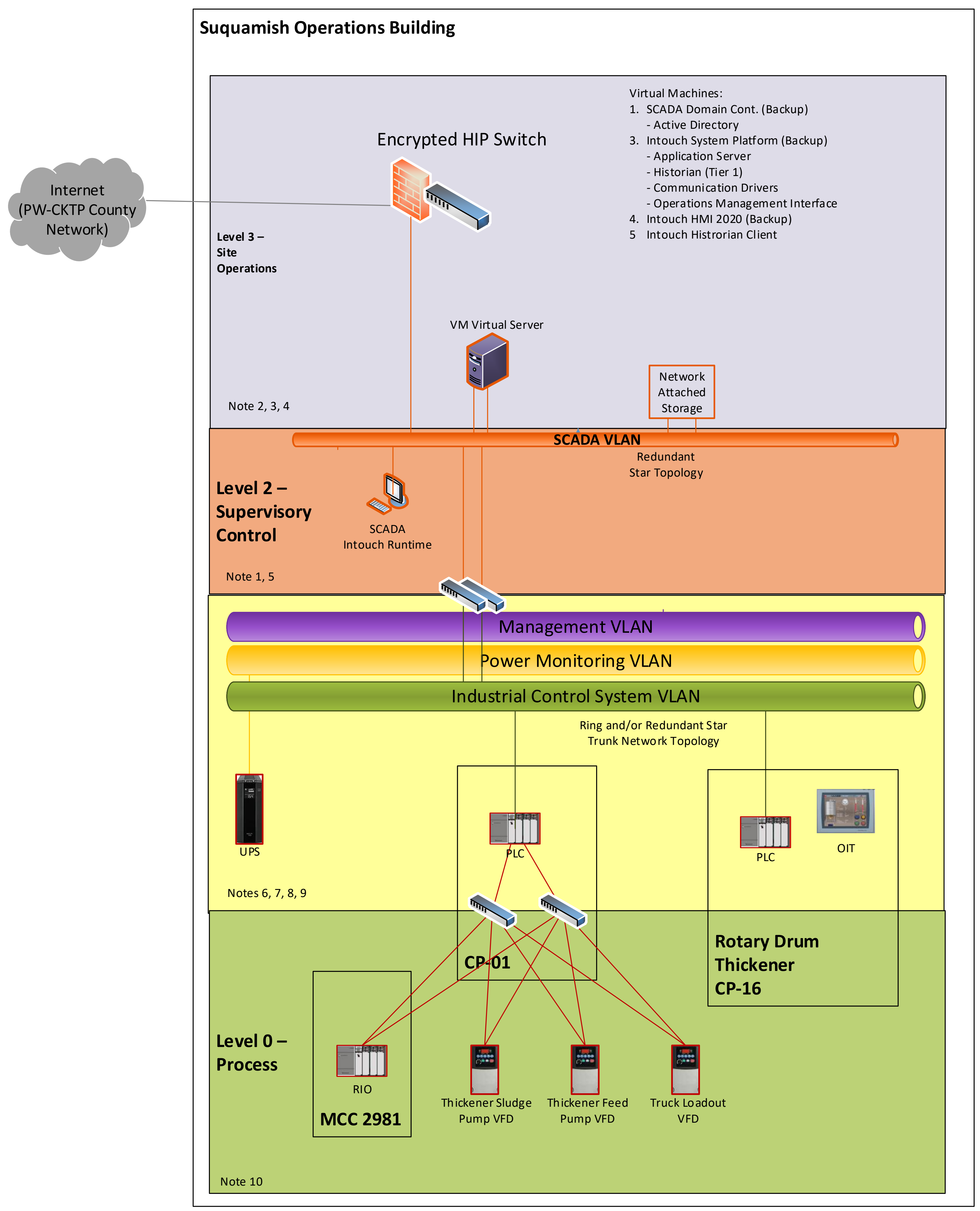
CONCEPT DIAGRAM
MANCHESTER WWTP

DRAWING: Y-005

SHEET 5 OF 8

Notes:

1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
5. Install High Availability (HA) pair of managed network switches.
6. Arrange and configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical



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HDR PROJECT NUMBER DATE
KC-205-20
CLIENT PROJECT NUMBER DATE

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Sewer Utility Division
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Poulsbo, WA 98370

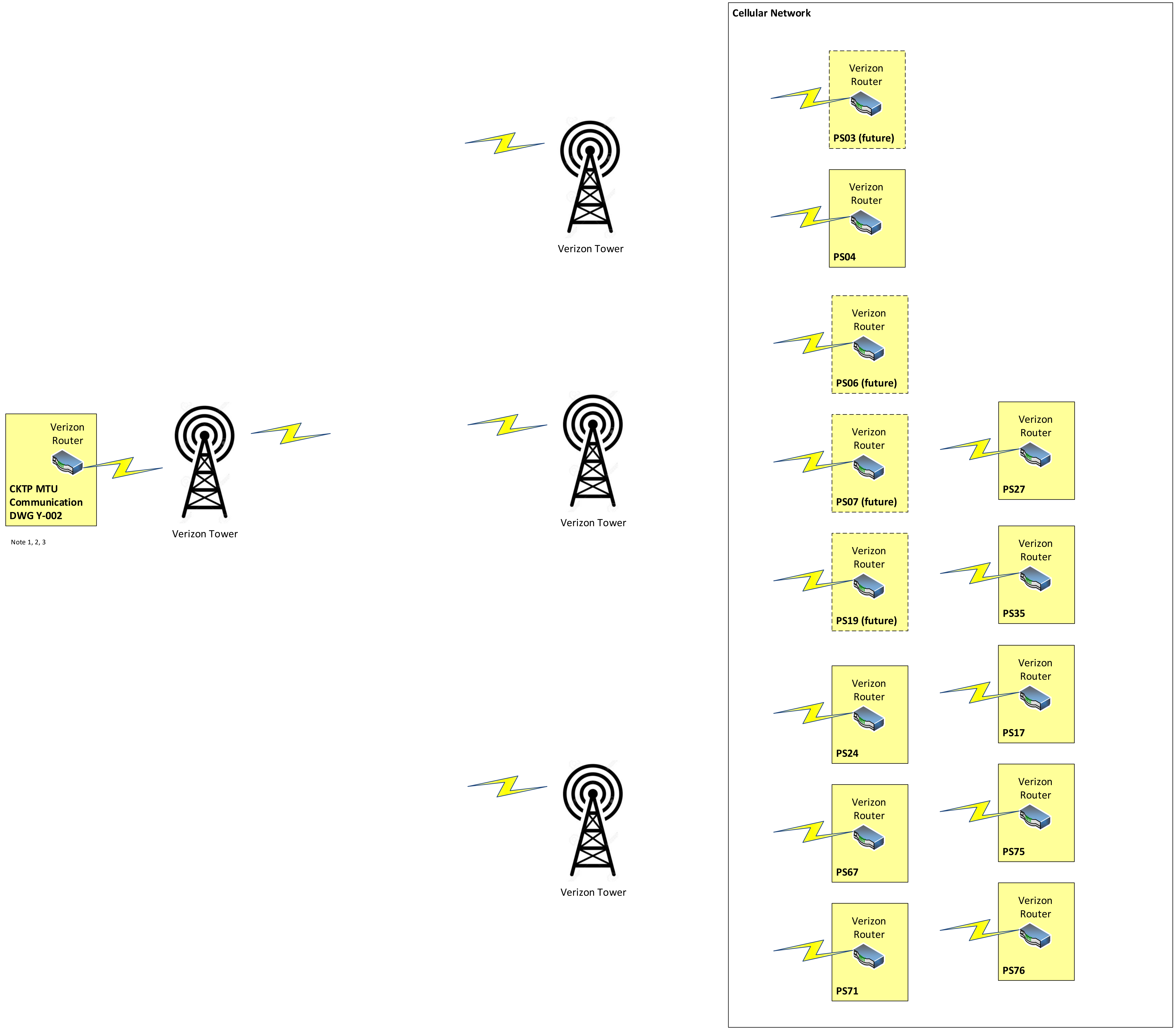
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM
SUQUAMISH WWTP

DRAWING: Y-006

SHEET 6 OF 8



Notes:
1. Verizon Private LTE Machine to Machine Network
2. Cellular communication to be protected with either built-in firewall or an external security appliance.
3. Cellular communication to provide data encryption (256 bit preferred, 128 bit minimum).

NO	DATE	BY	APPR	REVISIONS

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DESIGNED BY — DATE
DRAWN BY — DATE
CHECKED BY — DATE

APPROVED BY — DATE
10231983
HDR PROJECT NUMBER — DATE
KC-205-20
CLIENT PROJECT NUMBER — DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

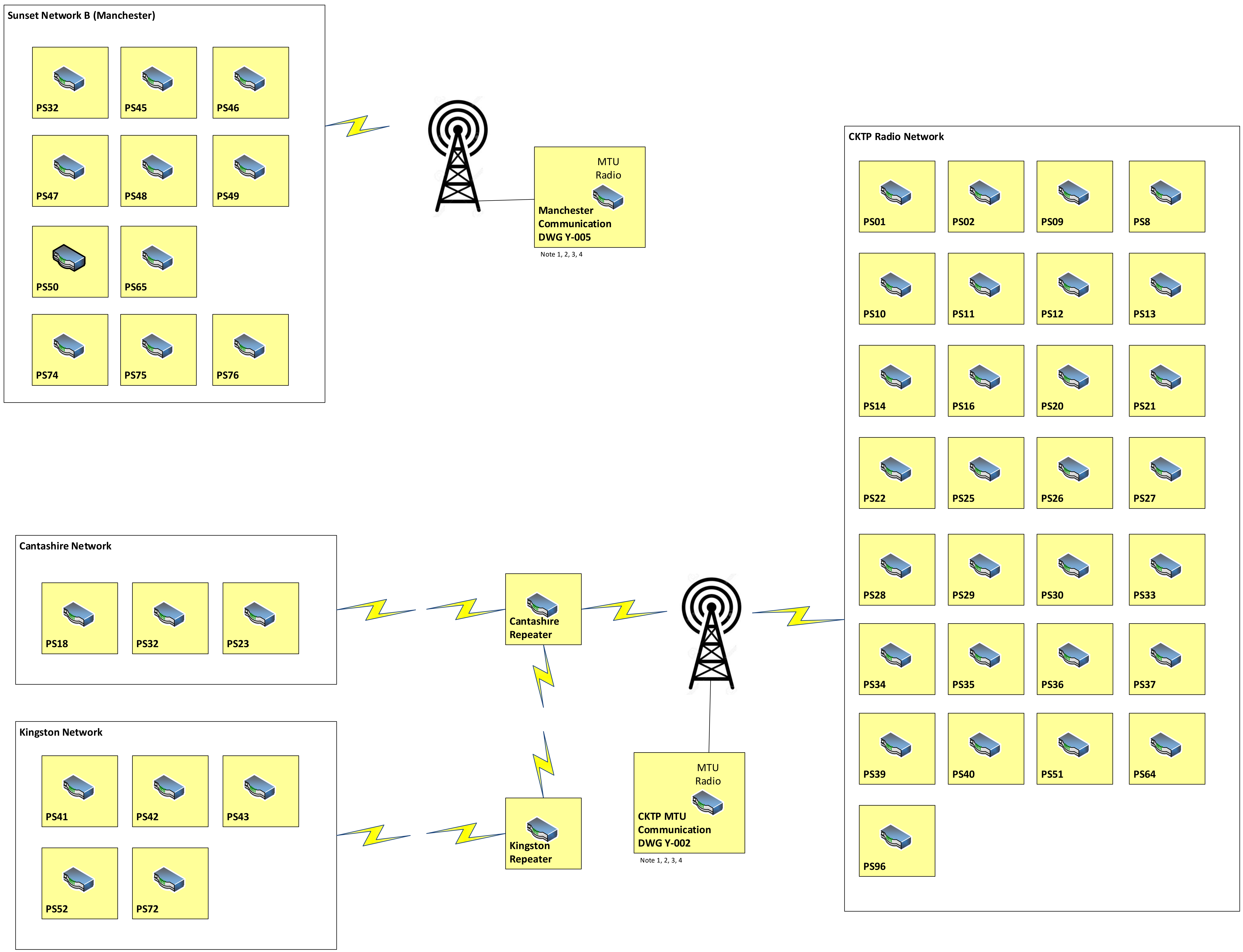
SCALE: NONE

CONCEPT DIAGRAM:
KITSAP CELLULAR NEWORK

DRAWING: Y-007

SHEET 7 OF 8

Notes:
1. Fixed Frequency Radio Network
2. VHF 173.3125 MHZ
3. Radio communication to be protected with either built-in firewall or an external security appliance.
4. Radio communication to provide data encryption (256 bit preferred, 128 bit minimum).



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KC-205-20
CLIENT PROJECT NUMBER — DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM:
MANCHESTER WWTP

DRAWING: Y-008

SHEET 8 OF 8

TM-5: Project Overview

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

May 23, 2022

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Kitsap County Public Works, Sewer Utility Division

Sewer Utility SCADA Master Plan

TM-5: Project Overview

May 23, 2022

Prepared by:

Brandon Erndt, PE

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

Tables

Figures

Appendix

Abbreviations

CIP	Common Industrial Protocol
CKTP	Central Kitsap Treatment Plant
CMMS	Computerized maintenance management system
DLR	Device Level Ring
DMZ	Demilitarized zone
DS	Domain Server
EIGRP	Enhanced Interior Gateway Routing Protocol
FNF	Flexible netflow
FT	FactoryTalk
GB	Gigabyte(s)
HDR	HDR Engineering, Inc.
HIP	Host Identity Protocol
HMI	Human-machine interface
HPHMI	High Performance Human-Machine Interface
HRT	Hydraulic Retention Time
HSRP	Hot Standby Router Protocol
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IS	Intermediate System
KPUD	Kitsap Public Utility District
KWWTP	Kingscliff Waste Water Treatment Plant
LAN	Local-area network
LED	Light-emitting diode
LIMS	Laboratory information management system
LTE	Long-Term Evolution
MB	Megabyte(s)
MCC	Motor control center
N/A	Not applicable
NFPA	National Fire Protection Association
NMS	Network monitoring system
OSPF	Open Shortest Path First
OT	Operational Technology
OIT	Operator interface terminal
PBR	Policy-Based Routing
PC	Personal computer
PCAP	Network Packet Analyzer and Capture
PLC	Programmable logic controller
PS	Pump Station

QCC	Quality Controls Corporation
RIO	remote input/output
RIP	Routing Information Protocol
RTD	resistance temperature detector
RTU	remote telemetry unit
SA	sensor/actuator
SCADA	supervisory control and data acquisition
SD	Secure Digital
SDN	software-defined network
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SNMP	Simple Network Management Protocol
SPB	solids processing building
SVI	Switched Virtual Interface
SWWTP	Shaoxing Wastewater Treatment Plant
TM	Technical Memorandum
TM-2	SCADA Use Cases and Operational Needs Technical Memorandum
TM-3	Technology Selection Technical Memorandum
TM-4	Sewer Utility SCADA Master Plan Technical Memorandum
TM-5	Project Overview SCADA Master Plan Technical Memorandum
TP/TX	Transport Protocol/Transmit
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VM	virtual machine
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
WAN	wide-area network
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This *Project Overview SCADA Master Plan Technical Memorandum* (TM-5) documents the specific project descriptions, schedules, and cost breakdown for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system. This technical memorandum (TM) describes the current condition, arrangement, life-cycle state, and identified areas of risk identified in the *Existing System Overview Sewer Utility SCADA Master Plan Technical Memorandum* (TM-1). This technical memorandum also includes the evaluation approach by which these technological elements were selected based on the Sewer Utility's existing infrastructure and its future operational needs identified in the *SCADA Use Cases and Operational Needs Technical Memorandum* (TM-2). This technical memorandum includes the hardware and software platforms that were identified in the *Technology Selection Sewer Utility SCADA Master Plan* (TM-3) throughout the Kitsap County network drawn out in the *Concept Network Diagrams* (TM-4).

1.1 Approach

TM-5 completes the fifth phase of the *Sewer Utility SCADA Master Plan* (Master Plan), which is to provide project descriptions that include criticality, prerequisite projects, duration, and cost opinion. The projects have been organized into sections, Network Architecture, Hardware, Software, Documentation, and Other Software Packages. TM-5 will include a schedule which identifies the order of each project based on prioritization from Kitsap County.

1.2 Technical Memorandum Organization

This section describes the structure of the TM along with descriptions for each section.

1.2.1 Structure

TM-5 is organized into five sections, as described below:

- **Section 1: Introduction** summarizes the TM organization and the approach taken for the fifth phase of the Master Plan TM-5.
- **Section 2: Improvement Projects Segmentation** identifies the 5 main sections that each project was organized into.
- **Section 3: Overall Schedule** shows the overall project schedule that was developed based on project dependencies, budget, and project priority.
- **Section 4: Summary of Cost Opinions** includes the cost for each project and total cost for each fiscal year.

- **Section 5: Improvement Project Description** includes detailed project descriptions that include task schedule and cost breakdown.

2 Improvement Projects Segmentation

This section provides how each project has been organized according to type of project that is being implemented in each WWTP in Kitsap County. The projects have been separated into segments of Network Architecture, Hardware, Software, Documentation, and Other Software Packages.

2.1 Network Architecture

Projects within the Network Architecture section will be upgrading the current OT network within Kitsap County as well as implementing changes that will improve the overall network system design to meet the ICS standards.

Table 2-1. Projects List: Network Architecture Projects

Project ID	Facility	Project Name
NA-1	CKTP	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
NA-2	CKTP	Extend OT Network to County Public Works Annex Facility
NA-3	WWTPs and Remote Pump Stations	Remote Pump Station and WWTP Telemetry Improvements
NA-4	CKTP	CKTP OT Network Upgrades
NA-5	CKTP	Standardization to Managed Switches
NA-6	CKTP	ICS and OT Network Power Supply Improvements
NA-7	CKTP	DMZ and AVEVA InTouch Access Anywhere Implementation
NA-32	CKTP	Relocate Network Rack in Solids Processing Building

2.2 Hardware

Projects within the Hardware section will be upgrading or making changes to any hardware devices throughout Kitsap County WWTPs.

Table 2-2. Projects List: Hardware Projects

Project ID	Facility	Project Name
HW-8	WWTPs and Remote Pump Stations	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs
HW-9	WWTPs and Remote Pump Stations	Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers

HW-10	WWTPs and Remote Pump Stations	Develop a Formal Instrument Calibration and Maintenance Program
HW-11	CKTP	CKTP Digester Building PNL 6000 Relocation
HW-12	WWTPs and Remote Pump Stations	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers
HW-13	CKTP	Implement CKTP Instrumentation Improvements
HW-14	CKTP	Implement CKTP Automation Improvements
HW-15	KWWTP	Implement KWWTP Instrumentation Improvements
HW-16	KWWTP	Implement KWWTP Automation Improvements
HW-17	MWWTP	Implement MWWTP Instrumentation Improvements
HW-18	MWWTP	Implement MWWTP Automation Improvements
HW-19	SWWTP	Implement SWWTP Instrumentation Improvements
HW-20	SWWTP	Implement SWWTP Automation Improvements
HW-21	Remote Pump Stations	Implement Remote Pump Station Instrumentation Improvements
HW-22	Remote Pump Stations	Implement Remote Pump Station Automation Improvements

2.3 Software

Projects within the Software section will be upgrading or making changes to standalone HMI installations to AVEVA System Platform and the Historian.

Table 2-3. Projects List: Software Projects

Project ID	Facility	Project Name
SW-23	WWTPs	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts
SW-24	WWTPs and Remote Pump Stations	Implement an Alarm Management Program Based on ISA-18.2
SW-25	CKTP	Establish a Tiered Historian Implementation at CKTP
SW-26	WWTPs and Remote Pump Stations	Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring

2.4 Documentation

Projects within the Documentation section will be developing ICS Standards Document and the Control Strategy Document.

Table 2-4. Projects List: Documentation Projects

Project ID	Facility	Project Name
DC-27A	WWTPs and Remote Pump Stations	Develop ICS Standards - Hardware
DC-27B	WWTPs and Remote Pump Stations	Develop ICS Standards – Software and Governance
DC-28	WWTPs and Remote Pump Stations	Develop and Maintain Control Strategy Documentation

2.5 Other Software Packages

Projects within the Other Software Packages section will include implementing other software packages within Kitsap County. The Kitsap County will implement a laboratory information management system to automatically import historian data and analyze the trends. The county will also implement a Machine Interface server and utilize its ability to identify asset runtime thresholds, alarms, events, and analog set points that trigger a work order.

Table 2-5. Projects List: Other Software Package Projects

Project ID	Facility	Project Name
OS-29	CKTP	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform
OS-30	CKTP	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation
OS-31	WWTPs and Remote Pump Stations	Begin Leveraging the Sewer Utility’s Power and Energy Data

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3 Overall Schedule

This section shows the overall cost project schedule that has been developed showing each project, utilizing the project dependencies outlined in each project description. The project schedule is based on a program start in fiscal year 2023 and with an anticipated completion in fiscal year 2029.

3.1 Projects in Fiscal Year 2023

Table 3-1. Projects in FY2023

Year	ID	Project	Cost	Duration
2023	DC-27A	Develop ICS Standards - Hardware	$154,000	4 months
2023	HW-8	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs	$5,000	2 months
2023	HW-10	Develop a Formal Instrument Calibration and Maintenance Program	$5,000	3 months
2023	NA-1	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room	$5,000	12 months
2023	DC-28	Develop and Maintain Control Strategy Documentation	$167,000	18 months
2023	SW-23	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts	$0	0.05 months
		Total	**$336,000**	

3.2 Projects in Fiscal Year 2024

Table 3-2. Projects in FY2024

Year	ID	Project	Cost	Duration
2024	DC-27B	Develop ICS Standards – Software and Governance	$344,000	6 months
2024	NA-32	Relocate Network Rack in Solids Processing Building	$124,000	3 months
2024	NA-4	CKTP OT Network Upgrades	$213,000	6 months
2024	NA-2	Extend OT Network to County Public Works Annex Facility	$78,000	3 months
2024	NA-5	Standardization to Managed Switches	$136,000	2 months
		Total	**$895,000**	

3.3 Projects in Fiscal Year 2025

Table 3-3. Projects in FY2025

Year	ID	Project	Cost	Duration
2025	NA-6	ICS and OT Network Power Supply Improvements	$153,000	6 months
2025	SW-26	Broaden The Data Set Archived by the Sewer Utility Historian	$75,000	9 months
2025	HW-13	Implement CKTP Instrumentation Improvements	$184,000	18 months
2025	NA-3	Remote Pump Station and WWTP Telemetry Improvements	$264,000	24 months
2025	SW-24	Implement an Alarm Management Program Based on ISA-18.2	$54,000	6 months
2025	NA-7	DMZ and AVEVA InTouch Access Anywhere Implementation	$76,000	12 months
2025	HW-12	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers	$5,000	6 months
		Total	**$811,000**	

3.4 Projects in Fiscal Year 2026

Table 3-4. Projects in FY2026

Year	ID	Project	Cost	Duration
2026	HW-9	Replace CKTP MCC DeviceNet Networks w/ Ethernet Capable Motor Controllers	$94,000	9 months
2026	SW-25	Establish a Tiered Historian Implementation at CKTP	$89,000	3 months
2026	HW-14	Implement CKTP Automation Improvements	$154,000	12 months
2026	HW-15	Implement KWWTP Instrumentation Improvements	$105,000	6 months
2026	HW-17	Implement MWWTP Instrumentation Improvements	$173,000	12 months
		Total	**$615,000**	

3.5 Projects in Fiscal Year 2027

Table 3-5. Projects in FY2027

Year	ID	Project	Cost	Duration
2027	HW-16	Implement KWWTP Automation Improvements	$39,000	6 months

2027	HW-19	Implement SWWTP Instrumentation Improvements	$126,000	12 months
2027	HW-21	Implement Remote Pump Station Instrumentation Improvements	$202,000	6 months
2027	HW-18	Implement MWWTP Automation Improvements	$54,000	6 months
		Total	**$421,000**	

3.6 Projects in Fiscal Year 2028

Table 3-6. Projects in FY2028

Year	ID	Project	Cost	Duration
2028	HW-22	Implement Remote Pump Station Automation Improvements	$61,000	12 months
2028	HW-20	Implement SWWTP Automation Improvements	$48,000	6 months
2028	HW-11	CKTP Digester Building PNL 6000 and MCC Replacement	$80,000	12 months
2028	OS-31	Begin Leveraging the Sewer Utility's Power and Energy Data	$21,000	3 months
		Total	**$210,000**	

3.7 Projects in Fiscal Year 2029

Table 3-7. Projects in FY2029

Year	ID	Project	Cost	Duration
2029	OS-30	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation	$387,000	6 months
2029	OS-29	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform	$5,000	3 months
		Total	**$392,000**	

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4 Summary of Cost of Opinions

Budgetary opinions of probable costs were developed for each of the projects. These cost opinions were developed at a planning level of accuracy and include 10% labor contingency and 15% materials contingency.

4.1 Cost Breakdown for Each Fiscal year

Table 4-1. Cost Breakdown for each Fiscal Year

Allocation	FY2023 $ 336,000	FY2024 $ 895,000	FY2025 $ 811,000	FY2026 $ 615,000	FY2027 $ 421,000	FY2028 $210,000	FY2029 $392,000	Total $3,680,000
Hardware	$ 5,750	$ 189,480	$ 180,550	$ 236,900	$ 112,930	$ 57,500	$ -	
Software	$ -	$ 17,250	$ 9,775	$ 64,837	$ -	$ -	$ -	
Integration	$ 296,200	$ 587,800	$ 529,700	$ 239,800	$ 260,200	$ 128,700	$ 357,000	
Admin/QC/Misc .	$ 33,695	$ 99,480	$ 91,503	$ 74,155	$ 47,313	$ 23,620	$ 35,200	

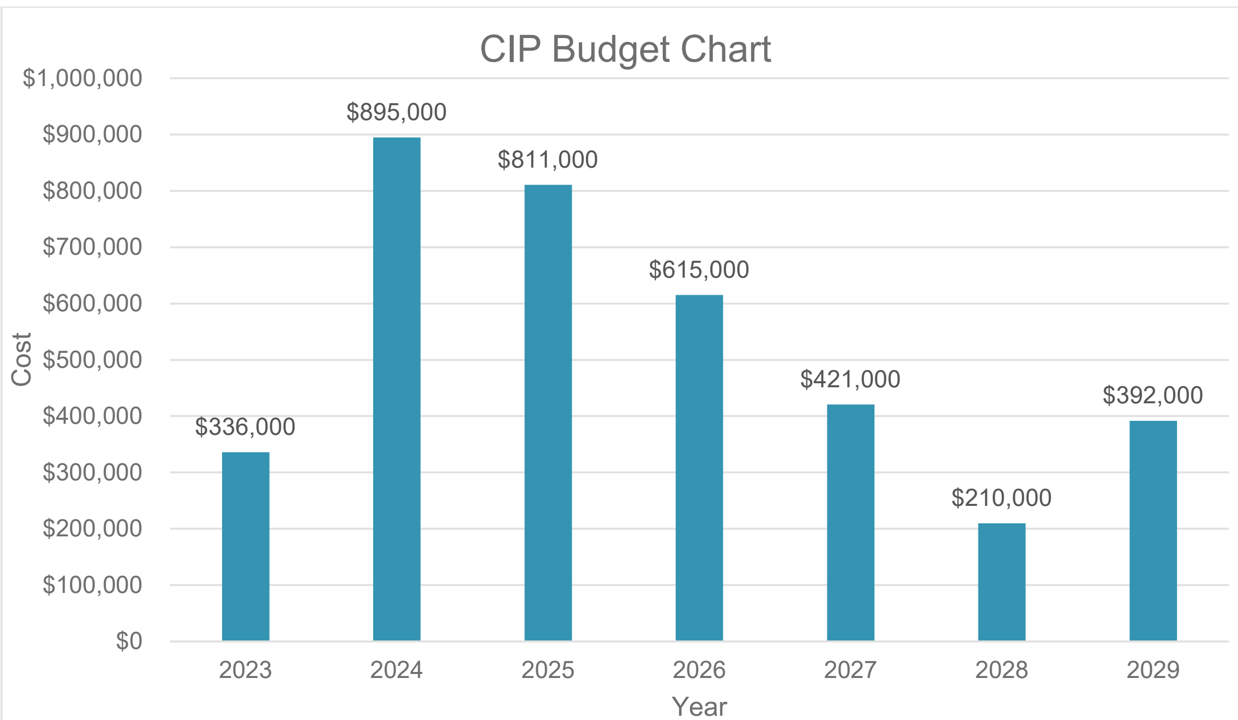

Figure 4-1. CIP Budget Chart

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5 Improvement Projects

This section includes detailed project descriptions for 33 projects. Each project description includes:

- Criticality
- Facilities
- Prerequisites
- Duration
- Description
- Impacted Stakeholders
- Cost Opinion

Table 5-1. Project List

ID	Project
Network Architecture	
NA-1	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
NA-2	Extend OT Network to County Public Works Annex Facility
NA-3	Remote Pump Station and WWTP Telemetry Improvements
NA-4	CKTP OT Network Upgrades
NA-5	Standardization to Managed Switches
NA-6	ICS and OT Network Power Supply Improvements
NA-7	DMZ and AVEVA InTouch Access Anywhere Implementation
NA-32	Relocate Network Rack in Solids Processing Building
Hardware	
HW-8	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs
HW-9	Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers
HW-10	Develop a Formal Instrument Calibration and Maintenance Program
HW-11	CKTP Digester Building PNL 6000 Relocation
HW-12	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers
HW-13	Implement CKTP Instrumentation Improvements
HW-14	Implement CKTP Automation Improvements
HW-15	Implement KWWTP Instrumentation Improvements
HW-16	Implement KWWTP Automation Improvements
HW-17	Implement MWWTP Instrumentation Improvements
HW-18	Implement MWWTP Automation Improvements
HW-19	Implement SWWTP Instrumentation Improvements
HW-20	Implement SWWTP Automation Improvements
HW-21	Implement Remote Pump Station Instrumentation Improvements
HW-22	Implement Remote Pump Station Automation Improvements
Software	

ID	Project
SW-23	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts
SW-24	Implement an Alarm Management Program Based on ISA-18.2
SW-25	Establish a Tiered Historian Implementation at CKTP
SW-26	Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring
Documentation	
DC-27A	Develop ICS Standards - Hardware
DC-27B	Develop ICS Standards – Software and Governance
DC-28	Develop and Maintain Control Strategy Documentation
Other Software Packages	
OS-29	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform
OS-30	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation
OS-31	Begin Leveraging the Sewer Utility's Power and Energy Data

5.1 Network Architecture Projects

Project Name	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
Project ID	**NA-1**
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ DC-27A
Duration	12 Months
Description	This project will establish a central monitoring location at the CKTP for all pump stations and WWTPs. To do so, the existing control room in the Solids Processing Building (SPB) will be upgraded to a suitable centralized monitoring location to meet monitoring requirements. Large-format displays will be installed for static display of overview screens for the pump stations and WWTPs. The Large-format displays will also be used to display operator-selected screens to support group discussion and decision making. Two SCADA PCs will be installed with access to HMI screens, Historian clients, and data visualization and dashboarding software applications. Four monitors will be installed for each PC to enable simultaneous display of multiple software application screens. This project can be performed at the same time as the upgrades for the standalone SCADA HMI installations to AVEVA System Platform (SW-23). In the event of a power outage at CKTP, UPS and backup battery packs will be installed to provide a minimum of 4 hours of backup power for the control room workstations and displays. Backup power will also be installed for the network servers as well. It is assumed that AVEVA licensing is part of a separate project and not included in this costing.

Project Name	**Upgrade Central Kitsap Treatment Plant (CKTP) Control Room**		
	This project will be handled internally by the Sewer Utility. Project is currently underway - 4 27” monitors (duplicating construction building 103).		
Impacted Stakeholders	Operation Staff I&C Technician Public Works Management		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Extend OT Network to County Public Works Annex Facility		
Project ID	**NA-2**		
Criticality	Medium		
Facilities	▪ County Public Works Annex Facility		
Prerequisites	▪ None		
Duration	3 Months		
Description	The OT network will be extended to the County Public Works Annex Facility to establish a secondary monitoring location for its WWTPs and remote pump stations. A Host Identity Protocol Switch (HIP Switch) will be installed at this facility and a dedicated SCADA PC will be installed with the Sewer Utility's Tempered Network Airwall System deployment. This project will be tied into the backup database server project.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$21,850
	Software	-	$17,250
	Integration	-	$27,500
	Administration/Quality Control	10%	$6,660
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$78,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Remote Pump Station and WWTP Telemetry Improvements**		
Project ID	**NA-3**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ NA-4, NA-5, DC-27A, DC-27B		
Duration	24 Months		
Description	This project will upgrade the telemetry system is required for near-real-time monitoring and alarming for the remote pump stations. To accomplish this, the Sewer Utility will continue to work with Quality Controls Corporation to transition the remote pump stations to a cellular wide-area network (WAN). Before the transition, a site survey will take place to assess the signal strength of the Verizon Wireless Network at each pump station location. Due to unpredictable latency difficulties and increasing pump stations introduced to the WAN, 2 cellular routers will be placed at CKTP. This solution will mitigate latency issues as well as provide a layer of redundancy for the communication links between the remote pump station and CKTP. Along with the WAN implementation, the current very high frequency (VHF) licensed radios will be left as is in case cellular WAN communications are lost. To achieve near-real-time monitoring and alarming at the remote pump stations, DNP3 protocol will be utilized to incorporate a store-and-forward functionality. DNP3 protocol will be implemented in the existing Allen-Bradley Micrologix 1400 PLCs, which are located at the remote telemetry unit (RTU) panels at each pump station. A report-by-exception telemetry solution will be replacing the current round-robin polling to reduce the data exchange volume. This will be using the DNP3 protocol which will be implemented with the existing Micrologix 1400 PLCs as well. For the Sewer utility to assign accurate times to events and eliminate data loss, the existing MTU PLC will be replaced with a SCADA server at the CKTP to serve as a DNP3 master. Telemetry Server software, offered by AVEVA, will be integrated with the System platform offering, which will be easier to maintain than what is currently in place. To have accurate communication status and performance, the uptime percentage will be displayed at the HMI for the previous 24 hours and all history since the last manual reset. This will give the Sewer Utility staff the ability to configure the timer interval and number of consecutive unsuccessful polls that would initiate a loss of communications alarm from the HMI. In the event of an outage and to preserve alarm notifications, HIP switches will be provisioned with a cellular expansion module and a SIM card that will be activated on the Sewer Utility's cellular WAN.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$29,900
	Software	-	$9,775
	Integration	-	$195,800
	Administration/Quality Control	10%	$23,548
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$264,000**

Project Name	Remote Pump Station and WWTP Telemetry Improvements		
	ANNUAL O&M COSTS	%	COST OPINION*
	TOTAL ANNUAL COSTS**	-	$1,600

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**CKTP OT Network Upgrades**		
Project ID	**NA-4**		
Criticality	High		
Facilities	▪ County Public Works Annex Facility (Solids Processing Building)		
Prerequisites	▪ DC-27B, NA-32		
Duration	6 Months		
Description	To consolidate the network infrastructure at CKTP, the rack-mounted servers and distribution switches for the OT network will be placed in one or more enclosed network racks within the SPB. The network racks will be sized for standard 19-inch equipment and have seismic testing certifying their suitability for installation in the seismic zone within CKTP. The rack cabinet enclosures will be wide enough to accommodate vertical cable management hardware on either side of the rack. The network racks will be placed in either the SPB Control room or in the ground floor of the SPB annex. The unmanaged switch, located in the SPB, will be replaced with a stacked Layer 3 distribution switch. This replacement will eliminate the single point of failure and establish routing capabilities at the OT network distribution layer. The two managed switches located in Panel 8580A, also located in SPB, will be replaced and the fiber-optic cable connections will be patched directly to the new Layer 3 distribution switches. The OT network HIP switches, located in the CKTP Administration and Laboratory building electrical rooms, will be relocated to the new network racks that will be placed in the SPB. For the relocation of these switches, a 1 GbE, multi-mode fiber-optic small form-factor pluggable (SFP) module will be inserted to the combination port on the KPUD Carrier Ethernet Switch where the existing Category Cable connection to the HIP switch is made. The SFP module will be patched to the existing fiber-optic patch panel mounted to the electrical room communications backboard to establish a connection to the SPB communications cabinet, using the existing fiber-optic cable between the two buildings. Afterwards, the Category cable along with the HIP switch, 24 VDC power supply components, and OT network switch mounted to the communications backboard will be removed. The UPS that is in the electrical room will be removed, instead UPS power will be provided to the KPUD Carrier Ethernet Switch located in the electrical room network rack. This will be done by installing a UPS in the existing electrical room network rack. This project will also include creating the Management, Power Monitoring, and Industrial Control System VLAN for the WWTPs after the managed switches have been installed. New IP address may also be configured to the OT network devices.		
Impacted Stakeholders	Operation Staff I&C Technician Sewer Utility IT staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$75,900
	Software	-	-
	Integration	-	$112,800
	Administration/Quality Control	10%	$18,870

Project Name	CKTP OT Network Upgrades		
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$213,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Standardization to Managed Switches**		
Project ID	**NA-5**		
Criticality	High		
Facilities	▪ CKTP		
Prerequisites	▪ NA-32		
Duration	2 months		
Description	This project will standardize using managed access switches for the OT network. This will provide a uniform management interface for maintaining OT network access switches and reduce spare switch inventory requirements. The standardized switches will support Layer 2 management functionality for network segmentation, traffic filtering (IGMP), and implementation of cybersecurity controls. The switch will also have gigabit downlink ports to accommodate the gigabit port speeds of modern ICS devices. The standardized switches will replace the 5 current unmanaged switches that were mentioned in TM-1 at Table 2-1 (the unmanaged switches in the Vendor Package systems will not be replaced as part of this project). This project will establish redundant cable paths for critical OT network segments between building access switches at CKTP and the distribution switch stack located in the SPB. Depending on the costs, either a star topology or a ring topology network will be implemented. As redundant fiber-optic cables will be implemented, the project will utilize single-mode fiber-optic cables for communication links. Specifically, the fiber-optic cable between the CKTP administration, laboratory building electrical room, and SPB will be replaced with the single-mode fiber-optic cable. For costing, only minimal switch configuration such as disabling unused ports have been included.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$34,500
	Software	-	-
	Integration	-	$84,200
	Administration/Quality Control	10%	$11,870
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$136,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	ICS and OT Network Power Supply Improvements		
Project ID	**NA-6**		
Criticality	High		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, DC-27B		
Duration	6 months		
Description	This project will include installing UPS power to the PLC panels throughout the WWTPs and Remote Pump Stations mentioned in TM-1 in Table 3-1. This standalone UPS approach will also be implemented for the Sewer Utility's PLC and RIO control panels that do not have backup power. The PLC control panels at CKTP will have a minimum backup power of 15 minutes, while the remote PLCs and RIO panels will have a backup power of up to 4 to 6 hours if space is available. Some existing panels will not have the space to support a UPS large enough to provide 6 hours of backup power. All UPS statuses, warnings, and alarms will be monitored by the SCADA system and integrated into the SCADA HMI screens, and alarm notification system. To meet this requirement, the UPSs will have Ethernet Communication options that can be integrated with the SCADA software, utilizing Ethernet protocols like Modbus Transmission Control Protocol. The Sewer Utility will standardize on carrying redundant power supplies to the ICS and OT network devices. All rack-mounted OT network switches, servers, and other network appliances will be standardized with dual onboard power supplies. Installation of the network rack-mounted UPS have been covered in the CKTP OT Network Upgrade project (NA-4).		
Impacted Stakeholders	I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$58,650
	Software	-	-
	Integration	-	$75,900
	Administration/Quality Control	10%	$13,455
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$153,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**DMZ and AVEVA InTouch Access Anywhere Implementation**		
Project ID	**NA-7**		
Criticality	Medium		
Facilities	▪ CKTP		
Prerequisites	▪ NA-1, NA-4, NA-6, DC-27A, DC-27B		
Duration	12 Months		
Description	This project will implement an industrial DMZ to handle data exchanges between the industrial and enterprise zones to provide a more secure method of data flow for the ICS assets. The network architecture will be established with a single entry to the industrial DMZ from the enterprise zone. The project will set up the Virtual Machine Server in the DMZ and implement AVEVA Intouch Access Anywhere for mobile access to the Sewer Utility's SCADA HMI Screens for the I&C technicians, third-party system integrators, and Sewer Utility Staff. Multi-factor authentication will be included during implementation for users to gain access to the industrial DMZ and will be handled by the County IS Department. This will require the users to access the industrial DMZ through the Sewer Utility business LAN via the VPN service maintained by the County IS department. The Sewer Utility will coordinate with the County IS department to make use of existing IT infrastructure and software licensing, such as Mobile Device Management (MDM) software, Operating System (OS) and Virtualization software (VMWare or Microsoft Hyper-V). The County IS Department will manage the implementation of the Firewall and switches for the DMZ. The County IS Department will also manage the implementation of the web portal, Jump Box (Remote Access), Anti-Virus, patch server, backups, Syslog/SIEM, Email relay, and OT-DMZ Domain Controller. It will be necessary to utilize HACH WIMS or another BI dashboard during the implementation of this project.		
Impacted Stakeholders	Operation Staff I&C Technician System Integrators County IS Department Sewer Utility IT Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$17,250
	Software	-	-
	Integration	-	$47,300
	Administration/Quality Control	10%	$6,455
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$76,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Relocate Network Rack in Solids Processing Building**		
Project ID	**NA-32**		
Criticality	Medium		
Facilities	▪ County Public Works Annex Facility (Solids Processing Building)		
Prerequisites	▪ DC-27A, DC-27B		
Duration	3 Months		
Description	This project will include locating a secure area for the new network rack that will be in the Solids Processing Building. The new location must have the required space and access to run all required network cables to/from the network rack to support connection to all necessary OT network devices. The new location where the network rack will be placed must be climate assisted to support the associated hardware. To limit access to authorized personnel only, the network rack will be either locked or in a locked room.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$57,500
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$11,250
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$124,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.2 Hardware Projects

Project Name	**Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs**		
Project ID	**HW-8**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ DC-27A		
Duration	2 Months		
Description	Based on the current information of the life cycle of the existing PLCs and OITs, after the standards are created in project DC-27, the PLCs and OITs that need to be replaced will be prioritized by years in service, manufacturer support, and criticality of the application. No dedicated project is identified within this portfolio, but each PLC/OIT will be replaced as needed. This project will be handled internally by the Sewer Utility.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	**-**
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers		
Project ID	**HW-9**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ NA-4, DC-27A, DC-27B		
Duration	9 Months		
Description	This project will retrofit the existing MCC units in order to preserve the recently upgraded MCC units when eliminating the DeviceNet network. The PowerFlex 700 AC Drives will be upgraded with the 20-COMM-E EtherNet/IP adapter and the PowerFlex 753 AC Drives will be upgraded with the 20-750-ENETR EtherNet/IP option module to replace the existing DeviceNet adapters/modules. The Allen-Bradley E3 Plus electronic overlay relays will be replaced with the E300 electronic overlay relays or other viable replacements that are available during the time of DeviceNet network replacement work. The DeviceNet Starter Auxiliary components will also be replaced with I/O expansion modules compatible with the E300 relays. The size of the MCC units will have to be assessed as some hardwired signals are preferred (auto status and motor high temp alarm) and will require more control relays and additional field wiring. The PLC panels will need additional I/O modules and field terminal blocks to accommodate the new hardwired I/O. This will lead to additional RIO racks in the enclosures, subpanel replacement, and/or new control panels. Additional conduits and control wiring will be required in the electrical room to establish hardwired I/O connections between the MCC units and the control panels. With the additional hardwired I/O, the VFD communication adapters/modules and overload relays will require Ethernet connection to the OT network. The project will use Category 6 cable with 600V insulation for these connections. The existing PLC programs will be modified to realign with the hardwired I/O points and the EtherNet/IP data exchange. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$49,450
	Software	-	-
	Integration	-	$31,900
	Administration/Quality Control	10%	$8,135
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$94,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Develop a Formal Instrument Calibration and Maintenance Program
Project ID	**HW-10**
Criticality	Medium
Facilities	▪ WWTPs and Remote Pump Stations
Prerequisites	▪ DC-27A
Duration	3 Months
Description	This project will develop a formal instrument calibration and maintenance program for its WWTPs and remote pump stations. The program will accomplish the following: • Determine the individuals responsible for scheduling calibration events, performing calibration procedures, maintaining program documentation, and reviewing calibration records to determine when additional corrective action is required. • Maintain an accurate inventory of installed instrumentation with manufacturer, model, and part number(s).The County may utilize the Hach WIMS system they plan to implement in Project OS-29. • Document instrument range, last calibration date, next calibration date, accuracy requirements, most recent calibrated zero and span settings for analog instruments, and most recent calibrated set point (rising or falling) and deadband settings for switches. • Document instrument-specific calibration procedures based on instrument manufacturer recommendations. Calibration procedures should include steps to test the instrument sensor (input), instrument 4–20 milliampere (mA) output or switch contact state, and instrument loop, including verification of correct value/state being displayed at the HMI or OIT. • Document ideal frequency of calibration activities based on manufacturer recommendations, field observations, instrument criticality, and past instrument performance. • Schedule calibration activities and ensure that they are performed and documented. • Maintain calibration records that document as-found settings, as-found test results, final calibration settings, final calibration test results, field observations, individual(s) who performed the calibration, and date of calibration This project will be handled internally by the Sewer Utility and is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***

Project Name	Develop a Formal Instrument Calibration and Maintenance Program		
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**CKTP Digester Building PNL 6000 Relocation**		
Project ID	**HW-11**		
Criticality	Low		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B		
Duration	12 Months		
Description	This project will relocate PNL 6000 or establish a replacement PLC control panel in a properly conditioned environment that is not classified as a hazardous-area classification. The MCC in the digester building is planned to be relocated due to the poor conditions in the current location but is being considered as part of the larger project and therefore not in the scope of this master plan so cost is not included. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$57,500
	Software	-	-
	Integration	-	$11,000
	Administration/Quality Control	10%	$6,850
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$80,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement CKTP Instrumentation Improvements**
Project ID	**HW-13**
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28
Duration	18 Months
Description	This project will perform an assessment of their Instrumentation equipment to determine the need for upgrades and replacement. The project will include the following: • Perform an alternatives analysis for implementing a direct means of plant effluent flow measurement to assess costs and feasibility of available options. • Provide additional analytical probes and, potentially, aeration flowmeters per recommendations from a separate BNR optimization task in the Sewer Utility facility planning program. • Install a flowmeter on the plant wastewater pump station discharge line to obtain a return flow measurement to upstream of the primary diversion channel. A magmeter could be installed in a new meter vault downstream from the valve vault potentially since there is no adequate room in the existing wastewater pump station valve vault. • Install a flowmeter on the primary sludge line to GBTs to monitor primary sludge flow from the primary sludge pumps. • Install a flowmeter on the scum line to GBTs to monitor primary and secondary scum flow from the scum pumps. • Install a flowmeter on the mixed liquor line from the mixed liquor distribution channel foam wasting sump to monitor mixed liquor flow to the digesters. • Install flowmeters on the thickened sludge lines from the GBTs to the thickened sludge blending tank to monitor individual thickened sludge flows from each GBT. • Install a flowmeter on the thickened sludge line from the hauled sludge receiving station to the thickened sludge blending tank to monitor hauled sludge flows received from remote WWTPs. • Install flowmeters on the digested sludge lines from the digesters to the centrifuges to monitor individual digested sludge flows from each digester. • During next septage receiving station upgrade, ensure that the replacement vendor package system includes incoming septage flow monitoring. • Service or replace the lower explosive limit (LEL) transmitter on the headworks odor control fan ductwork. • Service or replace the chlorine residual and turbidity analyzers associated with the reclaimed water system. • Service or replace the thermal dispersion flowmeter installed on the aeration line for the aerated grit tank 1 stage 2 diffuser. • Install suspended solids probes in the aeration basins and WAS pump discharge line to support automated calculation of hydraulically determined solids retention time. If installation is infeasible, a probe could be installed on

	the RAS pumps discharge line with the assumption that the suspended solids profile would be the same. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$74,750
	Software	-	-
	Integration	-	$88,000
	Administration/Quality Control	10%	$16,275
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$184,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers**		
Project ID	**HW-12**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ SW-24, DC-27A, DC-27B		
Duration	6 Months		
Description	This project will integrate the composite samplers and will monitor sampler alarms and statuses at SCADA. The Sewer Utility will need to communicate the SCADA requirements to the vendors so that the appropriate hardwired and communication options can be integrated. The Sewer Utility has received quotes for the samplers from vendors and are currently evaluating them, so sampler costs were not included. This project will be handled internally by the Sewer Utility and this project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	**-**
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement CKTP Automation Improvements**		
Project ID	**HW-14**		
Criticality	Medium		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, HW-13, DC-27A, DC-27B, DC-28		
Duration	12 Months		
Description	This project will perform an assessment of their Automation equipment to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen to monitor the comprehensive liquid stream flow balance for the plant along with the hydraulic retention time values for tanks basins, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for GBTs, digesters, and the thickened sludge blending tank. • Provide PLC programming and SCADA HMI modifications to restore automated control of the BNR process per recommendations from the separate BNR optimization task in the Sewer Utility facility planning program. • Develop a SCADA HMI screen to provide operators with situational awareness for the load shedding and emergency load sequencing during planned and unplanned transitions between utility and standby generator power. • Replace the headworks odor control biofilter sprinkler control panel and associated instrumentation to restore automated control of the biofilter sprinklers/soaker hose. The Sewer Utility will allow the SCADA manual controls to be implemented as an optional override of the sprinkler control panel to allow operations staff to manually initiate and schedule timer-based watering of the biofilter from SCADA HMIs. • Provide PLC programming modifications to establish a low-level shutdown interlock for the thickened sludge blending tank circulation pump and digester feed pumps based on tank level transmitter measurement to support elimination of the thickened sludge blending tank low level switch. The Sewer Utility will also replace the low-level switch. • Establish monitoring of high torque warning and high-high torque shutdown conditions at SCADA for its primary clarifiers. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$86,825
	Software	-	-
	Integration	-	$48,400
	Administration/Quality Control	10%	$13,523

Project Name	Implement CKTP Automation Improvements		
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$154,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement KWWTP Instrumentation Improvements**		
Project ID	**HW-15**		
Criticality	Medium		
Facilities	▪ KWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Instrumentation equipment at KWWTP to determine the need for upgrades. The project will include the following: • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Install a flowmeter on the biofilter sump pump station discharge line to monitor biofilter drainage flow to the oxidation ditches. • Install a flowmeter on the process building sump pump station discharge line to monitor return flow to the headworks. • Install a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes. • Install a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks. • Install suspended solids probes in the oxidation ditches and WAS line at KWWTP based on the outcome of suspended solids probe and hydraulically determined SRT calculation performance at CKTP. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$36,225
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$9,123
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$105,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement KWWTP Automation Improvements		
Project ID	**HW-16**		
Criticality	Medium		
Facilities	▪ KWWTP		
Prerequisites	▪ NA-4, NA-7, HW-15, DC-27A, DC-27B, DC28		
Duration	6 Months		
Description	This project will perform an assessment of their Automation equipment at KWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, oxidation ditches, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for WAS and TWAS tanks. • With favorable results from the suspended solids probes and hydraulically determined SRT calculations at CKTP, The Sewer Utility will develop PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at KWWTP. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$35,200
	Administration/Quality Control	10%	$3,520
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$39,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement MWWTP Instrumentation Improvements		
Project ID	**HW-17**		
Criticality	Medium		
Facilities	▪ MWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC28		
Duration	12 Months		
Description	This project will perform an assessment of their Instrumentation equipment at MWWTP to determine the need for upgrades and replacement. The project will include the following: • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Evaluate the installation of an ultrasonic or radar level instrument at the existing Parshall flume downstream from the grit chamber to obtain this flow measurement. • Replace the magmeter on the sludge line feeding the GBT. • Install a flowmeter on the odor control blowdown sump discharge line to the headworks to monitor blowdown return from odor control. • Install a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes. • Service or replace the flowmeter on the W3 line to restore monitoring of W3 flow to plant processes. • Install a flowmeter on the in-plant pump station discharge line to obtain return flow measurement to the headworks. • Install a flowmeter on the WAS line from the RAS pump station to the WAS tanks to monitor WAS flow. • Install a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks. • Consider installation of suspended solids probes in the aeration basins and WAS line at MWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP. • Install analytical probes in the aeration basins to monitor the BNR process as part of the plant upgrade to adapt to new TN limits. • Install a level transmitter for the sodium hypochlorite tank and install local indication of tank level at the location from which the tank is filled. • Service or replace non-functional combustible gas-monitoring equipment in the sludge pumping gallery, headworks odor control system, and WAS tanks. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$64,400
	Software	-	-
	Integration	-	$88,000

Project Name	Implement MWWTP Instrumentation Improvements		
	Administration/Quality Control	10%	$15,240
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$173,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement MWWTP Automation Improvements**		
Project ID	**HW-18**		
Criticality	Medium		
Facilities	▪ MWWTP		
Prerequisites	▪ NA-4, NA-7, HW-17, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Automation equipment at MWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, basins, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the WAS and TWAS tanks. • With favorable results from the suspended solids probes and hydraulically determined SRT calculations at CKTP, the Sewer Utility will develop PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at MWWTP. • Develop PLC programming and SCADA HMI screen modifications to allow operations staff to schedule and adjust aeration blower operation time sequence from SCADA HMIs. • Install an electrically actuated isolation valve on the WAS line to the WAS tanks to enable SCADA control of the sludge wasting process. PLC programming and SCADA HMI screen modifications will be developed to add functionality for operations staff to manually open and close the valve from SCADA. • Wire a fault signal from the mixing channel blower motor starter to the discrete input at the LP-225 RIO rack in the headworks building and provide PLC programming and SCADA HMI screen modification to integrate the fault alarm. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$49,000
	Administration/Quality Control	10%	$4,900
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$54,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

***Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.**

Project Name	**Implement SWWTP Instrumentation Improvements**		
Project ID	**HW-19**		
Criticality	Medium		
Facilities	▪ SWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	12 Months		
Description	This project will perform an assessment of their Instrumentation equipment at SWWTP to determine the need for upgrades and replacement. The project will include the following: • Service or replace the combustible gas monitoring equipment in the process building upper floor process room. • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Verify calibration of the thickened sludge storage tank level transmitter. After calibrating, record a series of measured level values versus actual tank level during two or three tank loadout operations. If accuracy and repeatability of level measurement are unacceptable, install a radar level transmitter to replace the pressure-based level transmitter currently installed in a non-ideal location on the pump suction line. Record drawings indicate that a spare 6-inch nozzle was provided on the tank for a future instrument, which could be used for installation of the radar level transmitter. • Install a radar level transmitter for monitoring and control of sludge storage tank level with a level switch that can provide a high level interlock and alarm. • Install DO probes in the SBRs. Depending on the outcome of ongoing facility planning, the Sewer Utility should consider additional analytical probes to facilitate improved monitoring and control of the BNR process. • Replace the damaged thermal dispersion flow switch on the RDT spray water supply line. • Consider the installation of suspended solids probes in the SBRs and WAS line at SWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP. • Install a flowmeter on the discharge line from the drain collection pump station to monitor return flow to the headworks equipment. • Install a flowmeter on the W3 line downstream from the reclaimed water pumps to monitor W3 flow to plant processes. • Service or replace the process building fire alarm system (will need information on the square footage and feet of building to provide accurate cost estimate). This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$43,700

Project Name	Implement SWWTP Instrumentation Improvements		
	Software	-	-
	Integration	-	$66,000
	Administration/Quality Control	10%	$10,970
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$126,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement SWWTP Automation Improvements**
Project ID	**HW-20**
Criticality	Medium
Facilities	▪ SWWTP
Prerequisites	▪ NA-4, NA-7, HW-19, DC-27A, DC-27B, DC-28
Duration	6 Months
Description	This project will perform an assessment of their Automation equipment at SWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for SBRs and tanks. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the sludge storage tank. • Service or replace the effluent flow control valve to restore its ability to maintain positions from SCADA-issued commands. This will have to be done a shutdown and the Sewer Utility will utilize this shutdown to complete other upgrades as well. This project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$44,000
	Administration/Quality Control	10%	$4,400
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$48,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement Remote Pump Station Instrumentation Improvements**		
Project ID	**HW-21**		
Criticality	Medium		
Facilities	▪ Remote Pump Stations		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Instrumentation equipment at their remote pump stations to determine the need for upgrades and replacement. The project will include the following: • Install pressure transmitters on remote pump station force mains and monitor force main pressures. 12 pressure transmitters will be installed in the pump stations with PLC's installed already (reference table 3-1 in TM-1). • Service or replace the combustible gas monitoring equipment at the PS-24 wet well. • Replace PS-24 wet well level transducer and transmitter, which has been in service for about 20 years. With the replacement of the level transducer, a submergence shield will also be implemented. If the Sewer Utility is unable to replace the level transducer, then the current level transducer will be recalibrated and serviced. • Install a level transmitter for the PS-71 BIOXIDE storage tank. • Service or replace the combustible-gas monitoring equipment at the PS-71 wet well. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$69,230
	Software	-	-
	Integration	-	$110,000
	Administration/Quality Control	10%	$17,923
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$202,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement Remote Pump Station Automation Improvements
Project ID	**HW-22**
Criticality	Medium
Facilities	▪ Remote Pump Stations
Prerequisites	▪ NA-4, NA-7, HW-21, DC-27A, DC-27B, DC-28
Duration	12 Months
Description	This project will perform an assessment of their Automation equipment at their remote pump stations to determine the need for upgrades and replacement. The project will include the following: • Develop SCADA HMI screens to provide a summary-level, process flow diagram depiction of the conveyance system associated with each WWTP. The summary conveyance system screens will display pump running status, flow, force main pressure, and indication of whether an alarm is active for each pump station. • Implement time-to-overflow monitoring for its critical (or all) pump stations. • Modify the existing PLC programming logic to favor energy efficient operating points while within normal level range in the wet well for pump stations with VFDs that are monitoring pump power and flow. • Review the hardwired relay logic and PLC programming for the existing pump controls to confirm the as-implemented conditions, which will contribute to the pump short cycling occurring at the pump station. After review of existing controls and near-real-time pump station data, the Sewer Utility will implement the appropriate control improvements to reduce or eliminate pump short cycling at the station to increase the useful service life of the equipment. • Upgrade the control system at PS-34. The control system upgrade would include replacement of the existing control panel with a PLC-based control panel and an OIT for improved local monitoring and control functionality. • Evaluate the remote alarm reset functionality for select remote pump station alarms. Remote reset capability will likely require additional hardwiring at the remote pump station, in addition to PLC programming and SCADA HMI screen modifications. This project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*	CAPITAL COSTS	%	COST OPINION*
	Hardware	-	-
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$5,500
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$61,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.3 Software Projects

Project Name	**Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts**		
Project ID	**SW-23**		
Criticality	Medium		
Facilities	▪ WWTPs		
Prerequisites	▪ None		
Duration	N/A		
Description	This project will utilize the AVEVA systems platform on the servers within the CKTP OT Network. The Sewer Utility and QCC are already in the process of converting the standalone InTouch HMI applications, which will help towards the SCADA HMI screen development and management. Once the ICS Standards (DC-27) are complete, the new standards will be implemented to the System Platform upgraded HMI screens for all WWTPs and Remote Pump Stations. The upgrades will be implemented to the already existing InTouch screens and will require graphical adjustments. Workshops will be held to determine the visual and functional requirements of the future SCADA HMI screens. During these workshops, the Sewer Utility stakeholders will be involved to confirm the final implementation meets the Sewer Utility's needs. The Project already funded and will be completed by end of FY2022.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$0
	Administration/Quality Control	10%	$0
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$0**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Implement an Alarm Management Program Based on ISA-18.2
Project ID	**SW-24**
Criticality	High
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ NA-1, NA-4, DC-27A, DC-27B
Duration	6 Months
Description	This project will implement an alarm management program based on ISA-18.2. The Sewer Utility will continue developing its alarm management program in parallel with or prior to other ICS automation programming efforts. The alarm management program will address the following deficiencies: • Lots of activity from the same alarm during CKTP Wonderware Implementation. • No means of shelving nuisance alarms or alarms associated with known issues. • HMI screens do not provide alarm priority information and do not have any means to filter out alarms by priority. • Root-cause analysis and alarm suppression functionality have not been developed for HMI screens • HMI screens do not have troubleshooting text prompt or decisions tree aids to help operation staff react to alarm conditions • Alarm summary and alarm history screens at SWWTP do not automatically display current alarm information. • Monitored alarms should include PLC faults and communication errors so that Sewer Utility staff are alerted when PLCs and RIO racks are experiencing performance issues • Monitored alarms should include signal out-of-range alarms for all analog signals so that Sewer Utility staff are notified when current-based signals fall outside of the 4–20 mA range The data related to the ICS alarms will be captured in the historian or another database environment and be made available to users on the Sewer Utility Business LAN. Third-party alarm management software or dashboards will be used to develop visualizations and reports that will help manage alarms and help with responsiveness.
Impacted Stakeholders	Operation Staff I&C Technician

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$49,500
	Administration/Quality Control	10%	$4,950
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$54,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

***Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.**

Project Name	**Establish a Tiered Historian Implementation at CKTP**
Project ID	**SW-25**
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ NA-2, NA-7, DC-27A, DC-27B
Duration	3 Months
Description	This project will establish a central historian at CKTP to consolidate ICS data received from the Sewer Utility WWTPs and remote pump stations. Embedded trends would display data that have been received from the central historian. The AVEVA Historian Client software will be implemented to access the historian data and facilitate development of static and ad hoc trends from the PCs on the OT network but cost has not been included because it is not within the scope of the master plan. To prevent loss of data received from the plants during an outage, store-and-forward functionality will be implemented. A “Tier 2” historian will be established on the Sewer Utility Business LAN at CKTP to provide access to the historian data for users. The “Tier 1” Historian will push data through the DMZ to the “Tier 2” Historian and the one-way nature of this data flow and limited open port requirements will simplify industrial DMZ firewall configuration, improve OT network security controls, and significantly reduce the network traffic traversing the industrial DMZ firewall. Any additional Firewall configuration during the historian implementation in the DMZ will be managed by the County IS Department.
Impacted Stakeholders	Operation Staff I&C Technician

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	$64,837
	Integration	-	$16,500
	Administration/Quality Control	10%	$8,134
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$89,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**$10,938**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring**
Project ID	**SW-26**
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ NA-4, DC-27B, DC-28
Duration	9 Months
Description	This project will audit the parameters that are being monitored and configure the site Tier 1 historian to historize the parameters of interest.

Project Name	**Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring**		
	The project will also include the following in the historian: • In Auto Status • Close/Open Commands • Position Commands • Start/Stop Commands • Speed Commands • Set Point Commands • Energy Consumption Status • Power Data Status • Fail/Fault Alarm • Networked Equipment alarms and warnings • Actuator Torque Status • Pump Suction and Discharge Pressure Status • Liquid Stream and Solid Stream Low and Flow Totalization Status To monitor and record the above parameters, the PLC program, filed wiring, and Ethernet Device configuration will need to be investigated. No hardware costing for any required updates has been included in this cost.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$68,200
	Administration/Quality Control	10%	$6,820
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$75,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.4 Documentation Projects

Project Name	Develop ICS Standards - Hardware
Project ID	DC-27A
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ None
Duration	4 Months
Description	This project will develop PLC, HMI, and control panel standards. The ICS control and telemetry panel hardware standards will include guidelines and template drawings that specify hardware component requirements; general control panel interior and exterior layouts; power distribution methodology; and fabrication, testing, and installation requirements for new ICS control and telemetry panels at Sewer Utility WWTPs and pump stations. The standards would also document network device configuration and hardening requirements for Ethernet switches, cellular gateways, and other network components to be installed within these panels. Anticipated standards to be created are: SCADA Control Panel Std SCADA Instrument and Vendor Communication Std SCADA Network Design and Hardware Std SCADA Equipment Procurement Std
Impacted Stakeholders	Operation Staff
Cost Opinion*	

CAPITAL COSTS	%	COST OPINION*
Hardware	-	$5,750
Software	-	-
Integration	-	$129,400
Administration/Quality Control	10%	$13,515
MISC Expenses	-	$5,000
TOTAL CAPITAL COSTS	**-**	**$154,000**
ANNUAL O&M COSTS	**%**	**COST OPINION***
TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Develop ICS Standards – Software and Governance
Project ID	DC-27B
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ DC-27A
Duration	6 Months
Description	This project will develop PLC, HMI, and control panel standards. The PLC standard will include information like preferred PLC programming project file organization; appropriate level of annotation; tagging conventions; use of tag descriptions; program and routine naming conventions; use of ladder logic and function block diagram; and standard AOIs, UDTs, and subroutines that are to be used for common applications throughout the Sewer Utility ICS infrastructure.' The HMI graphics standard will include guidelines with screenshots and programming files that specify requirements and standard programming objects for graphics development and configuration work associated with AVEVA System Platform. Once the ICS Standards Documentation are created, which will contain PLC Programming standards, HMI graphics standards, and ICS control and telemetry panel hardware standards, it will be managed by a standards committee. The members of the committee will be technically qualified and be willing to participate in maintaining the standards. There will also be an ICS standards manager who will enforce the development of the standards and will oversee revising the document when necessary. The standards manager will also be responsible for maintaining version control of the document and make sure that the contractors have the most updated version available so that they may meet the requirements. With the standards being created, the Sewer Utility will establish an appropriate method for Operators to electronically log daily notes, observations, and activities. The Sewer Utility will compile relevant P&IDs from past projects into consolidated sets for each WWTP and Pump Station. Then they will be reviewed to the actual infrastructure so that the P&IDs can be updated. After the sets are compared to the current infrastructure, they will be compiled into the eO&M SharePoint site. The Sewer Utility will then develop and maintain the network architecture diagrams for the four WWTPs (physical and logical). They will also develop and maintain an asset inventory for the OT Network devices. The fiber-optic patch panel schedules and the information about the fiber-optic cables and patch panels will also be maintains. The tagging convention for the panels and cables will be standardized and noted on the ICS standard documentation. The project will utilize a software platform to implement a dashboarding and data visualization functionality for analyzing data. The project will first select a software solution and then begin developing the ability to create dashboards and visualizations in-house. Staff will need to be trained first and preliminary dashboards will need to be created. As in-house skills develop over time, the

Project Name	**Develop ICS Standards – Software and Governance**		
	dashboards and visualizations will become more technical and have more impact in process control and utility management. Once the standards are created remote access via tablets will be available for reference. Anticipated standards to be created are: SCADA Application Programming Std for PLCs HMI Software and Architecture Std SCADA Application Programming Std for HMI SCADA Data Historization and Archiving Std SCADA Cybersecurity and Network Monitoring Std SCADA Software Management and Revision Control Std Staff Roles and Skills Development Std		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$308,300
	Administration/Quality Control	10%	$30,830
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$344,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Develop and Maintain Control Strategy Documentation		
Project ID	**DC-28**		
Criticality	High		
Facilities	▪ WWTPs and Pump Stations		
Prerequisites	▪ DC-27A		
Duration	18 Months		
Description	This project will develop and maintain control strategies to document how WWTP, pump station process, and equipment are controlled locally and with SCADA. The control strategies will be used to evaluate performance based on data that has been obtained through SCADA. Once the control strategy document is created, the document will be available on the County electronic operation and maintenance SharePoint site for the Sewer utility Staff. The control strategy will be updated and managed so that it remains current and accurate.		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$151,800
	Administration/Quality Control	10%	$15,180
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$167,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.5 Other Software Package Projects

	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform
Project ID	**OS-29**
Criticality	Low
Facilities	▪ CKTP
Prerequisites	▪ NA-4, NA-7, SW-25, DC-27A, DC-27B, OS-30
Duration	3 Months
Description	This project will use Hach WIMS for its laboratory information management system (LIMS) software. The Sewer utility will have its current SCADA system automatically import data into the new Hach WIMS. Once the exchange between Hach WIMS and the Sewer utility Historian is established, the staff will have the ability to select specific SCADA tags and date ranges for ad hoc data imports and trend analysis within Hach WIMS. The sever that the Hach WIMS software will be located is on the business LAN and will be configured with the “Tier 2” historian. In the meantime, the Hach WIMS server will be deployed on the CKTP OT network while the Industrial DMZ is being implemented. The Project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation		
Project ID	**OS-30**		
Criticality	Low		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, NA-7, HW-21 SW-25, DC-27A, DC-27B		
Duration	6 Months		
Description	Once the Sewer Utility completes some configurations and data entry work for the assets, this project will establish automatic importing of asset runtimes from the Sewer Utility Historian. The Sewer Utility will be configured with the "Tier 2" historian within the business LAN. The LLumin Machine Interface Server will be implemented as an on-premise solution, running as a Windows service. The project will utilize the software's ability to support asset specific, rule-based generation of work orders to identify asset runtime thresholds, alarms, events, and analog set points that trigger a work order within the LLumin system. Initially, a small sample of assets will be implemented first to see the efficacy of the work order automation. Once favorable results are seen, the project will develop a schedule to implement this system to the remainder assets. If alarm or event based work order generation on a near-real-time basis is required, The LLumin's Machine Interface server software will need to communicate with AVEVA System Platform. To do this, the project will need to relocate the LLumin Machine Interface Server software to the CKTP OT Network or industrial DMZ. First, the Sewer utility will start with the data exchange between LLumin and the "Tier 2" historian and then expand the LLumin system after the Sewer utility's CMMS program is developed. The County IS Department will install, develop, and maintain the Llumin software so no license costs have been included. Cartagraph will also be integrated with the implementation of this project. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$352,000
	Administration/Quality Control	10%	$35,200
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$387,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**-**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Begin Leveraging the Sewer Utility's Power and Energy Data		
Project ID	**OS-31**		
Criticality	Low		
Facilities	▪ WWTPs and Pump Stations		
Prerequisites	▪ NA-4, SW-23, DC-27A, DC-27B		
Duration	3 Months		
Description	This project will begin recording historical power and energy data from installed power monitors and network-capable motor controllers. This will require the install of network cabling to establish communication with the power monitors. For the Ethernet-capable power monitors that are not communicating with the PLC, communication will have to established between the power monitors and the AVEVA SCADA software. This information will be used to evaluate the existing infrastructure's capacity to accept additional electrical loads and to assess when harmonic distortion is approaching unacceptable levels. The Sewer Utility will transition away from the existing GE Enervista Viewpoint Monitoring software in the CKTP SPB control room and utilize the AVEVA System Platform to monitor and record the Sewer Utility's power and energy data. The project will install Ethernet-capable power monitors at all major electrical distribution buses as the equipment is replaced/upgraded in the future and has not been included in the cost. When installing future motor controllers, the Sewer Utility will make sure that they will be provided with Ethernet communication so that power and energy data can be monitored and recorded. When determining energy-based metrics the Sewer utility will use KPIs for evaluating its operations and then leverage KPIs to establish baselines at each of its WWTPs and remote pump stations. The baselines will be established from 1 years' worth of data to account for seasonal variation. The project will utilize data analytics and visualization software to track and monitor energy-based KPIs. Once sufficient baseline energy data is provided, they will be reviewed to identify processes and equipment where energy efficiency measures are likely to yield benefits. A formal energy audit will take place and then targeted goals will be set as part of a separate project.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$18,700
	Administration/Quality Control	10%	$1,870
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$21,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

A

Appendix A – Cost Estimate

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NA-1

Upgrade Central Kitsap Treatment Plant (CKTP) Control Room

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Sewer Utility will handle internally	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$*	*5,000*
Contingency	10%		
Total Configuration, Programming and Startup			
Subtotal Hardware Costs		*$*	*-*
Contingency	*15%*	*$*	*-*
Hardware Total		***$***	***-***
Subtotal Software Costs		*$*	*-*
Contingency	*15%*	*$*	*-*
Software Total		***$***	***-***
Total Hardware and Software Costs		***$***	***-***

Admin/QC	10%	$	-
Misc Expenses			
Total		***$***	***-***

NA-2

Extend OT Network to County Public Works Annex Facility

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Workstations (Testing)	1	$ 5,000	$ 5,000
Large Screen Monitors (Training)	2	$ 2,000	$ 4,000
HIP Switch	1	$ 10,000	$ 10,000
Hardware Subtotal			$ 19,000
Software Items			
Lic: Workstations (1)	1	$ 15,000	$ 15,000
Software Subtotal			$ 15,000
Totals	5	$ 32,000	$ 34,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
HMI/Historian	1	$ 10,000	$ 10,000		
Firewall Installation / Configuration	1	$ 5,000	$ 5,000		
Workstation Installation / Configuration	1	$ 10,000	$ 10,000		
Subtotal Configuration, Programming and Startup					*$ 25,000*
Contingency				10%	*$ 2,500*
Total Configuration, Programming and Startup					***$ 27,500***
Subtotal Hardware Costs					*$ 19,000*
Contingency				*15%*	*$ 2,850*
Hardware Total					***$ 21,850***
Subtotal Software Costs					*$ 15,000*
Contingency				*15%*	*$ 2,250*
Software Total					***$ 17,250***
Total Hardware and Software Costs					**$ 39,100**

Admin/QC	10%	$ 6,660
Misc Expenses		$ 5,000
Total		**$ 78,000**

NA-3					
Remote Pump Station and WWTP Telemetry Improvements					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
Cellular Router for Verizon	2	$ 500	$ 1,000		
Server	1	$ 15,000	$ 15,000		
Switch	1	$ 10,000	$ 10,000		
Hardware Subtotal			$ 26,000		
Software Items					
Lic: AVEVA Telemetry Server Software	1	$ 8,500	$ 8,500		
Software Subtotal			$ 8,500		
Totals	5	$ 34,000	$ 34,500		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Server Installation / Configuration	1	$ 10,000	$ 10,000		
Firewall Installation / Configuration	2	$ 5,000	$ 10,000		
Cellular Radio Configuration and Testing	61	$ 2,000	$ 122,000		
HMI/Historian	1	$ 10,000	$ 10,000		
PLC Programing	1	$ 6,000	$ 6,000		
Cellular Site Survey	1	$ 20,000	$ 20,000		
Subtotal Configuration, Programming and Startup					*$ 178,000*
		Contingency		10%	*$ 17,800*
Total Configuration, Programming and Startup					***$ 195,800***
			Subtotal Hardware Costs		*$ 26,000*
		Contingency		*15%*	*$ 3,900*
			Hardware Total		***$ 29,900***
			Subtotal Software Costs		*$ 8,500*
		Contingency		*15%*	*$ 1,275*
			Software Total		***$ 9,775***
Total Hardware and Software Costs					**$ 39,675**
Admin/QC				10%	$ 23,548
Misc Expenses					$ 5,000
			Total		**$ 264,000**
Annual AVEVA Telemetry Server Support Cost	$1,600				
# of pump stations					

NA-4

CKTP OT Network Upgrades

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Network Rack	1	$ 15,000	$ 15,000
Switch (Managed)	3	$ 15,000	$ 45,000
UPS	1	$ 4,000	$ 4,000
SFP Module	1	$ 2,000	$ 2,000
Hardware Subtotal			$ 66,000
Software Items			
Software Subtotal			$ -
Totals	6	$ 36,000	$ 15,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Switch Installation / Configuration	3	$ 2,000	$ 6,000
Fiber Installation	1	$ 66,500	$ 66,500
OT Network Device Communication updates	1	$ 30,000	$ 30,000

Subtotal Configuration, Programming and Startup		*$ 102,500*
Contingency	10%	*$ 10,300*
Total Configuration, Programming and Startup		***$ 112,800***
Subtotal Hardware Costs		*$ 66,000*
Contingency	*15%*	*$ 9,900*
Hardware Total		***$ 75,900***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 75,900**
Admin/QC	10%	$ 18,870
Misc Expenses		$ 5,000
Total		**$ 213,000**

Fiber $18.00 per foot without conduit or interduct or $33.25 with conduit.
Cost is including 2,000 feet for Fiber with Conduit

NA-5				
Standardization to Managed Switches				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
Switch (Managed)	5	$ 6,000	$ 30,000	
Hardware Subtotal			$ 30,000	
Software Items				
Software Subtotal			$ -	
Totals	5	$ 6,000	$ 30,000	

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Fiber Installation	1	$ 66,500	$ 66,500	
Switch Installation / Configuration	5	$ 2,000	$ 10,000	
		Subtotal Configuration, Programming and Startup		*$ 76,500*
		Contingency	10%	*$ 7,700*
		Total Configuration, Programming and Startup		***$ 84,200***
		Subtotal Hardware Costs		*$ 30,000*
		Contingency	*15%*	*$ 4,500*
		Hardware Total		***$ 34,500***
		Subtotal Software Costs		*$ -*
		Contingency	*15%*	*$ -*
		Software Total		***$ -***
		Total Hardware and Software Costs		**$ 34,500**

Admin/QC	10%	$ 11,870
Misc Expenses		$ 5,000
	Total	**$ 136,000**

Fiber $18.00 per foot without conduit or interduct or $33.25 with conduit.
Cost is including 2,000 feet for Fiber with Conduit

NA-6

ICS and OT Network Power Supply Improvements

Hardware Items	**Qty**	**Unit Prices**	**Extended**
UPS Compact Tower	51	$ 1,000	$ 51,000
Hardware Subtotal			$ 51,000
Software Items			
Software Subtotal			$ -
Totals	51	$ 1,000	$ 51,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
PLC Programing	1	$ 8,000	$ 8,000
HMI Configuration	1	$ 10,000	$ 10,000
UPS Install	51	$ 1,000	$ 51,000

Subtotal Configuration, Programming and Startup		*$ 69,000*
Contingency	10%	*$ 6,900*
Total Configuration, Programming and Startup		***$ 75,900***
Subtotal Hardware Costs		*$ 51,000*
Contingency	*15%*	*$ 7,650*
Hardware Total		***$ 58,650***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 58,650**

Admin/QC	10%	$ 13,455
Misc Expenses		$ 5,000
Total		**$ 153,000**

NA-7					
DMZ and AVEVA InTouch Access Anywhere Implementation					
Hardware Items		**Qty**	**Unit Prices**	**Extended**	
Server		1	$ 15,000	$ 15,000	
	Hardware Subtotal			$ 15,000	
Software Items					
		1	$ -	$ -	
	Software Subtotal			$ -	
	Totals	2	$ 15,000	$ 15,000	
Installation/ Configuration		**Qty**	**Unit Price**	**Extended**	
Server Installation / Configuration		1	$ 20,000	$ 20,000	
AVEVA InTouch Access Anywhere Configuration		1	$ 5,000	$ 5,000	
Coordination with County IS Department		1	$ 18,000	$ 18,000	
	Subtotal Configuration, Programming and Startup				*$ 43,000*
	Contingency			10%	*$ 4,300*
	Total Configuration, Programming and Startup				***$ 47,300***
	Subtotal Hardware Costs				*$ 15,000*
	Contingency			*15%*	*$ 2,250*
	Hardware Total				***$ 17,250***
	Subtotal Software Costs				*$ -*
	Contingency			*15%*	*$ -*
	Software Total				***$ -***
	Total Hardware and Software Costs				**$ 17,250**
Admin/QC				10%	$ 6,455
Misc Expenses					$ 5,000
	Total				**$ 76,000**

3 weeks * $150 per hour

HW-8

Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Prioritize PLCs and OITs for End of Life Replacement (will handled internally)	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		$ *5,000*
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		$ -
Contingency	*15%*	$ -
Hardware Total		**$ -**
Subtotal Software Costs		$ -
Contingency	*15%*	$ -
Software Total		**$ -**
Total Hardware and Software Costs		**$ -**
Admin/QC	10%	$ -
Misc Expenses		
Total		**$ -**

HW-9

Replace CKTP MCC DeviceNet Networks w/ Ethernet Capable Motor Controllers

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Ethernet/IP Adapter/Module	19	$ 1,000	$ 19,000
E300 Electronic Overlay Relays	4	$ 1,000	$ 4,000
Miscelaneous PLC I/O Module	1	$ 20,000	$ 20,000
Hardware Subtotal			$ 43,000
Software Items			
Software Subtotal			$ -
Totals	24	$ 22,000	$ 43,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
PLC Programing	1	$ 6,000	$ 6,000
Communication Module Retrofit	23	$ 500	$ 11,500
EtherNet Wiring Allowance	23	$ 500	$ 11,500

Subtotal Configuration, Programming and Startup		*$ 29,000*
Contingency	10%	*$ 2,900*
Total Configuration, Programming and Startup		***$ 31,900***
Subtotal Hardware Costs		*$ 43,000*
Contingency	*15%*	*$ 6,450*
Hardware Total		***$ 49,450***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 49,450**
Admin/QC	10%	$ 8,135
Misc Expenses		$ 5,000
Total		**$ 94,000**

HW-10

Develop a Formal Instrument Calibration and Maintenance Program

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Creation of Program for Maintenance and Calibration (will handle internally)	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 5,000*
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ -
Misc Expenses		$ -
Total		***$ -***

HW-11

CKTP Digester Building PNL 6000 and MCC Replacement

Hardware Items		**Qty**	**Unit Prices**	**Extended**
PLC Panel	$	1	$ 50,000	$ 50,000
Hardware Subtotal				$ 50,000
Software Items				
Software Subtotal				$ -
Totals		1	$ 50,000	$ 50,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Miscellaneous Field Wiring	1	$ 10,000	$ 10,000

Subtotal Configuration, Programming and Startup		*$ 10,000*
Contingency	10%	*$ 1,000*
Total Configuration, Programming and Startup		***$ 11,000***
Subtotal Hardware Costs		*$ 50,000*
Contingency	*15%*	*$ 7,500*
Hardware Total		***$ 57,500***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 57,500**

Admin/QC	10%	$ 6,850
Misc Expenses		$ 5,000
Total		**$ 80,000**

HW-12					
Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
	0	$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Sewer Utility will handle internally	1	$ 5,000	$ 5,000		
			Subtotal Configuration, Programming and Startup		*$ 5,000*
			Contingency	10%	
			Total Configuration, Programming and Startup		
			Subtotal Hardware Costs		*$ -*
			Contingency	*15%*	*$ -*
			Hardware Total		***$ -***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		***$ -***
Admin/QC				10%	$ -
Misc Expenses					
			Total		***$ -***

HW-13

Implement CKTP Instrumentation Improvements

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Flowmeter 4" Pipe(Magmeter)	2	$ 3,500	$ 7,000
Flowmeter 6" Pipe(Magmeter)	5	$ 4,000	$ 20,000
Flowmeter 8" Pipe(Magmeter)	2	$ 4,500	$ 9,000
Thermal Dispersion Flowmeter	1	$ 2,500	$ 2,500
Chlorine Residual Analyzer	1	$ 2,500	$ 2,500
Turbidity Analyzer	1	$ 3,000	$ 3,000
Lower Explosive Limit Transmitter	1	$ 5,000	$ 5,000
Suspended Solids Probe	2	$ 8,000	$ 16,000
Hardware Subtotal			$ 65,000
Software Items			
Software Subtotal			$ -
Totals	15	$ 33,000	$ 65,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Installation of instruments	13	$ 5,000	$ 65,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$*	*80,000*
Contingency	10%	*$*	*8,000*
Total Configuration, Programming and Startup		***$***	***88,000***
Subtotal Hardware Costs		*$*	*65,000*
Contingency	*15%*	*$*	*9,750*
Hardware Total		***$***	***74,750***
Subtotal Software Costs		*$*	*-*
Contingency	*15%*	*$*	*-*
Software Total		***$***	***-***
Total Hardware and Software Costs		**$**	**74,750**

Admin/QC	10%	$	16,275
Misc Expenses		$	5,000
Total		**$**	**184,000**

HW-14					
Implement CKTP Automation Improvements					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
PLC Panel	1	$ 50,000	$ 50,000		
Associated Odor Control Instrumentation	1	$ 25,000	$ 25,000		
Low Level Switch	1	$ 500	$ 500		
Hardware Subtotal			$ 75,500		
Software Items					
Software Subtotal			$ -		
Totals	3	$ 75,500	$ 75,500		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	2	$ 12,000	$ 24,000		
HMI Configuration	4	$ 5,000	$ 20,000		
Subtotal Configuration, Programming and Startup					*$ 44,000*
Contingency				10%	*$ 4,400*
Total Configuration, Programming and Startup					***$ 48,400***
Subtotal Hardware Costs					*$ 75,500*
Contingency				*15%*	*$ 11,325*
Hardware Total					***$ 86,825***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ 86,825**
Admin/QC				10%	$ 13,523
Misc Expenses					$ 5,000
Total					**$ 154,000**

HW-15				
Implement KWWTP Instrumentation Improvements				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
Flowmeter 2" Pipe(Magmeter)	2	$ 2,500	$ 5,000	
Flowmeter 3" Pipe(Magmeter)	1	$ 3,000	$ 3,000	
Flowmeter 4" Pipe(Magmeter)	1	$ 3,500	$ 3,500	
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000	
Suspended Solids Probe	2	$ 8,000	$ 16,000	
Hardware Subtotal			$ 31,500	
Software Items				
Software Subtotal			$ -	
Totals	7	$ 21,000	$ 31,500	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Installation of instruments	7	$ 5,000	$ 35,000	
PLC Programming	1	$ 10,000	$ 10,000	
HMI Configuration	1	$ 5,000	$ 5,000	
Subtotal Configuration, Programming and Startup				*$ 50,000*
Contingency			10%	*$ 5,000*
Total Configuration, Programming and Startup				***$ 55,000***
Subtotal Hardware Costs				*$ 31,500*
Contingency			*15%*	*$ 4,725*
Hardware Total				***$ 36,225***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				**$ 36,225**
Admin/QC			10%	$ 9,123
Misc Expenses				$ 5,000
Total				**$ 105,000**

HW-16

Implement KWWTP Automation Improvements

Hardware Items		**Qty**	**Unit Prices**	**Extended**
		0	$ -	$ -
	Hardware Subtotal			$ -
Software Items				
	Software Subtotal			$ -
	Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
PLC Programing	2	$ 6,000	$ 12,000
HMI Configuration	4	$ 5,000	$ 20,000

Subtotal Configuration, Programming and Startup		*$ 32,000*
Contingency	10%	*$ 3,200*
Total Configuration, Programming and Startup		***$ 35,200***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 3,520
Misc Expenses		
Total		**$ 39,000**

HW-17				
Implement MWWTP Instrumentation Improvements				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
Flowmeter 2" Pipe(Magmeter)	1	$ 2,500	$ 2,500	
Flowmeter 3" Pipe(Magmeter)	4	$ 3,000	$ 12,000	
Flowmeter 4" Pipe(Magmeter)	1	$ 3,500	$ 3,500	
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000	
Level Transmitter	1	$ 3,000	$ 3,000	
Lower Explosive Limit Transmitter	3	$ 5,000	$ 15,000	
Suspended Solids Probe	2	$ 8,000	$ 16,000	
Hardware Subtotal			$ 56,000	
Software Items				
Software Subtotal			$ -	
Totals	13	$ 29,000	$ 56,000	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Installation of instruments	13	$ 5,000	$ 65,000	
PLC Programming	1	$ 10,000	$ 10,000	
HMI Configuration	1	$ 5,000	$ 5,000	
Subtotal Configuration, Programming and Startup				*$ 80,000*
Contingency			10%	*$ 8,000*
Total Configuration, Programming and Startup				***$ 88,000***
Subtotal Hardware Costs				*$ 56,000*
Contingency			*15%*	*$ 8,400*
Hardware Total				***$ 64,400***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				**$ 64,400**
Admin/QC			10%	$ 15,240
Misc Expenses				$ 5,000
Total				**$ 173,000**

HW-18

Implement MWWTP Automation Improvements

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
PLC Programing	4	$ 6,000	$ 24,000
HMI Configuration	4	$ 5,000	$ 20,000
Wiring a Fault Signal from Starter to IO panel	1	$ 500	$ 500

Subtotal Configuration, Programming and Startup		*$ 44,500*
Contingency	10%	*$ 4,500*
Total Configuration, Programming and Startup		***$ 49,000***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 4,900
Misc Expenses		
Total		**$ 54,000**

HW-19

Implement SWWTP Instrumentation Improvements

Hardware Items	Qty	Unit Prices	Extended
Flowmeter 3" Pipe(Magmeter)	2	$ 3,000	$ 6,000
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000
Level Transmitter	1	$ 3,000	$ 3,000
Lower Explosive Limit Transmitter	1	$ 5,000	$ 5,000
Suspended Solids Probe	2	$ 8,000	$ 16,000
DO Probes	2	$ 2,000	$ 4,000
Hardware Subtotal			$ 38,000
Software Items			
Software Subtotal			$ -
Totals	9	$ 25,000	$ 38,000

Installation/ Configuration	Qty	Unit Price	Extended
Installation of instruments	9	$ 5,000	$ 45,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 60,000*
Contingency	10%	*$ 6,000*
Total Configuration, Programming and Startup		***$ 66,000***
Subtotal Hardware Costs		*$ 38,000*
Contingency	*15%*	*$ 5,700*
Hardware Total		***$ 43,700***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 43,700**

Admin/QC	10%	$ 10,970
Misc Expenses		$ 5,000
Total		**$ 126,000**

HW-20

Implement SWWTP Automation Improvements

Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
Software Subtotal			$ -		
Totals	0	$ -	$ -		

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	4	$ 6,000	$ 24,000		
HMI Configuration	2	$ 5,000	$ 10,000		
High Discharge Pressure Troubleshooting	1	$ 6,000	$ 6,000		
Subtotal Configuration, Programming and Startup					*$ 40,000*
Contingency				10%	*$ 4,000*
Total Configuration, Programming and Startup					***$ 44,000***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***

Admin/QC	10%	$ 4,400
Misc Expenses		
Total		**$ 48,000**

HW-21			
Implement Remote Pump Station Instrumentation Improvements			
Hardware Items	**Qty**	**Unit Prices**	**Extended**
Pressure Transmitter	12	$ 3,600	$ 43,200
Level Transmitter	2	$ 3,000	$ 6,000
Level Transducer	1	$ 1,000	$ 1,000
Lower Explosive Limit Transmitter	2	$ 5,000	$ 10,000
Hardware Subtotal			$ 60,200
Software Items			
Software Subtotal			$ -
Totals	17	$ 12,600	$ 60,200

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Installation of instruments	17	$ 5,000	$ 85,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 100,000*
Contingency	10%	*$ 10,000*
Total Configuration, Programming and Startup		***$ 110,000***
Subtotal Hardware Costs		*$ 60,200*
Contingency	*15%*	*$ 9,030*
Hardware Total		***$ 69,230***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 69,230**
Admin/QC	10%	$ 17,923
Misc Expenses		$ 5,000
Total		**$ 202,000**

HW-22

Implement Remote Pump Station Automation Improvements

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
PLC Programing	5	$ 6,000	$ 30,000
HMI Configuration	4	$ 5,000	$ 20,000

Subtotal Configuration, Programming and Startup		*$ 50,000*
Contingency	10%	*$ 5,000*
Total Configuration, Programming and Startup		***$ 55,000***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ -**

Admin/QC	10%	$ 5,500
Misc Expenses		
Subtotal		**$ 61,000**

SW-23

Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**

Subtotal Configuration, Programming and Startup		$ -
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		$ -
Contingency	*15%*	$ -
Hardware Total		**$ -**
Subtotal Software Costs		$ -
Contingency	*15%*	$ -
Software Total		**$ -**
Total Hardware and Software Costs		**$ -**

Admin/QC	10%	$ -
Misc Expenses		
Funded and in Progress	***Total***	**$ -**

WWTP = 1 PLC/week *150
REMOTE = 4 PLC/week *150

SW-24

Implement an Alarm Management Program Based on ISA-18.2

Hardware Items	Qty	Unit Prices	Extended
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	Qty	Unit Price	Extended
Workshops to Review Current Alarm Classifications	1	$ 5,000	$ 5,000
HMI/Historian Configuration	1	$ 40,000	$ 40,000

Subtotal Configuration, Programming and Startup		*$ 45,000*
Contingency	10%	*$ 4,500*
Total Configuration, Programming and Startup		***$ 49,500***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 4,950
Misc Expenses		
Total		**$ 54,000**

SW-25					
Establish a Tiered Historian Implementation at CKTP					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
Enterprise Historian License (25,000 tags)	1	$ 53,000	$ 53,000		
2 Additional Historian Web Client License	2	$ 1,690	$ 3,380		
Software Subtotal			$ 56,380		
Totals	1	$ 53,000	$ 56,380		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Workshops to determine data to go to Tier 2 Historian	1	$ 5,000	$ 5,000		
Historian Configuration	1	$ 10,000	$ 10,000		
Subtotal Configuration, Programming and Startup					*$ 15,000*
Contingency				10%	*$ 1,500*
Total Configuration, Programming and Startup					***$ 16,500***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ 56,380*
Contingency				*15%*	*$ 8,457*
Software Total					***$ 64,837***
Total Hardware and Software Costs					**$ 64,837**
Admin/QC				10%	$ 8,134
Misc Expenses					$ -
Total					**$ 89,000**

Annual Cost for Enterprise Historian License	$10,600
Annual cost for 2 Historian Web Client Licenses	$338
Total	$10,938

SW-26

Broaden The Data Set Archived by the Sewer Utility Historian

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Site/PLC Program Investigation of current available signals	1	$ 27,000	$ 27,000		
Workshops to select parameters from findings	1	$ 5,000	$ 5,000		
Historian Configuration	4	$ 7,500	$ 30,000		
Subtotal Configuration, Programming and Startup					*$ 62,000*
Contingency				10%	*$ 6,200*
Total Configuration, Programming and Startup					***$ 68,200***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***

Admin/QC	10%	$ 6,820
Misc Expenses		$ -
Total		**$ 75,000**

(1 PLC/day for 4.5 weeks (*40hrs))*150= Cost

DC-27A

Develop ICS Standards (Hardware)

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Tablets	5	$ 1,000	$ 5,000
Hardware Subtotal			$ 5,000
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	5	$ 1,000	$ 5,000

Installation/ Configuration	**Qty**	**Unit Price**	A **Extended**
SCADA Control Panel Std	1	$ 34,996	$ 34,996
SCADA Instrument and Vendor Communication Std	1	$ 28,116	$ 28,116
SCADA Network Design and Hardware Std	1	$ 30,300	$ 30,300
SCADA Equipment Procurement Std	1	$ 24,188	$ 24,188

Subtotal Configuration, Programming and Startup		*$ 117,600*
Contingency	10%	*$ 11,800*
Total Configuration, Programming and Startup		***$ 129,400***
Subtotal Hardware Costs		*$ 5,000*
Contingency	*15%*	*$ 750*
Hardware Total		***$ 5,750***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 5,750**

Admin/QC	10%	$ 13,515
Misc Expenses		$ 5,000
Total		**$ 154,000**

DC-27B

Develop ICS Standards and Governance Documents

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	A **Extended**
SCADA Application Programming Std for PLCs	1	$ 70,924	$ 70,924
HMI Software and Architecture Std	1	$ 19,774	$ 19,774
SCADA Application Programming Std for HMI	1	$ 67,624	$ 67,624
SCADA Data Historization and Archiving Std	1	$ 30,140	$ 30,140
SCADA Cybersecurity and Network Monitoring Std	1	$ 35,868	$ 35,868
SCADA Software Management and Revision Control Std	1	$ 31,068	$ 31,068
Staff Roles and Skills Development Std	1	$ 24,796	$ 24,796

Subtotal Configuration, Programming and Startup		*$ 280,200*
Contingency	10%	*$ 28,100*
Total Configuration, Programming and Startup		***$ 308,300***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 30,830
Misc Expenses		$ 5,000
Total		**$ 344,000**

DC-28

Develop and Maintain Control Strategy Documentation

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Process Assessments for the WWTPs/Pumpstations	1	$ 138,000	$ 138,000		
Workshops to review findings	4	$ 5,000	$ 20,000		
Finalize Control Strategies for WWTPs and Pump stations	1	$ 30,000	$ 30,000		
Subtotal Configuration, Programming and Startup					*$ 138,000*
Contingency				10%	*$ 13,800*
Total Configuration, Programming and Startup					***$ 151,800***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***

Admin/QC	10%	$ 15,180
Misc Expenses		
Total		**$ 167,000**

(1 PLC/week for (23PLCs) (*40hrs))*150= Cost

OS-29

Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Sewer Utility will handle internally	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 5,000*
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ -
Misc Expenses		
Total		***$ -***

2 weeks (40hr)*150 = Cost

OS-30					
Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Workshops to determine Data	2	$ 5,000	$ 10,000		
Pilot Project connecting Tier 2 Historian to Llumin	1	$ 24,000	$ 24,000		
Add additional Data from Tier 2 historian to Llumin	1	$ 12,000	$ 12,000		
Establish connection from Llumin to AVEVA System Platform	1	$ 24,000	$ 24,000		
Integration with Cartagraph	1	$ 250,000	$ 250,000		
			Subtotal Configuration, Programming and Startup		*$ 320,000*
			Contingency	10%	*$ 32,000*
			Total Configuration, Programming and Startup		***$ 352,000***
			Subtotal Hardware Costs		*$ -*
			Contingency	*15%*	*$ -*
			Hardware Total		***$ -***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		***$ -***
Admin/QC				10%	$ 35,200
Misc Expenses					
			Total		**$ 387,000**

4 weeks (40hr)*150 = Cost

OS-31					
Begin Leveraging the Sewer Utility's Power and Energy Data					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
		$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
		$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Integrate existing PQMs to AVEVA System Platform	11	$ 1,000	$ 11,000		
Workshops/Develop KPI Dashboard	1	$ 6,000	$ 6,000		
Subtotal Configuration, Programming and Startup					*$ 17,000*
Contingency				10%	*$ 1,700*
Total Configuration, Programming and Startup					***$ 18,700***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***
Admin/QC				10%	$ 1,870
Misc Expenses					
Total					**$ 21,000**

NA-32

Relocate Network Rack in Solids Processing Building

Hardware Items		Qty	Unit Prices	Extended
PLC Panel	$	1	$ 50,000	$ 50,000
Hardware Subtotal				$ 50,000
Software Items				
		0	$ -	$ -
Software Subtotal				$ -
Totals		1	$ 50,000	$ 50,000

Installation/ Configuration	Qty	Unit Price	Extended
Building Assessment and Engineering a room (HVAC and cabling)	1	$ 50,000	$ 50,000

Subtotal Configuration, Programming and Startup		$	50,000
Contingency	10%	$	5,000
Total Configuration, Programming and Startup		$	55,000
Subtotal Hardware Costs		$	50,000
Contingency	15%	$	7,500
Hardware Total		$	57,500
Subtotal Software Costs		$	-
Contingency	15%	$	-
Software Total		$	-
Total Hardware and Software Costs		$	57,500

Admin/QC	10%	$	11,250
Misc Expenses			
Total		$	124,000

B

Appendix B – Schedule

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ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**SCADA Master Plan**	**1745 days**	**Mon 1/9/23**	**Fri 9/14/29**	
2			**Quick Wins & Immediate Needs**	**1565 days**	**Mon 1/9/23**	**Fri 1/5/29**	
3			DC-27A SCADA Standards - Hardware	4 mons	Mon 1/9/23	Fri 4/28/23	
4			HW-8 Prioritize PLC & OIT for EOL replacement	2 mons	Mon 5/1/23	Fri 6/23/23	3
5			HW-10 Develop Instrument Cal and Maint Program	3 mons	Tue 6/6/23	Mon 8/28/23	3
6			NA-1 Upgrade CKTP Control Room	12 mons	Mon 5/1/23	Fri 3/29/24	3
7			DC-28 Control Strategy Documentation	18 mons	Tue 6/6/23	Mon 10/21/24	3
8			SW-23 WWTP Standalone to AVEVA SP Managed Intouch Apps	0.05 mons	Mon 1/9/23	Mon 1/9/23	
9			**Near Term Improvement**	**1305 days**	**Mon 1/8/24**	**Fri 1/5/29**	
10			DC-27B SCADA Standards - Software/Governance	6 mons	Mon 1/8/24	Fri 6/21/24	3
11			NA-32 Relocate Network Rack in Solids Processing Building	3 mons	Mon 6/24/24	Fri 9/13/24	3,10
12			NA-4 CKTP OT Network Upgrades	6 mons	Mon 9/16/24	Fri 2/28/25	10,11
13			NA-2 Extend OT Network to PW Annex	3 mons	Mon 8/5/24	Fri 10/25/24	
14			NA-5 Standardization to Managed Switches	2 mons	Mon 9/16/24	Fri 11/8/24	11
15			NA-6 ICS and OT Network PS Improvements	6 mons	Mon 3/3/25	Fri 8/15/25	12,10
16			SW-26 Broaden Data Set at CKTP Tier 1 Historian	9 mons	Mon 3/3/25	Fri 11/7/25	7,12,10
17			HW-13 CKTP Instrumentation Improvements	18 mons	Mon 3/3/25	Fri 7/17/26	7,12,3,10
18			NA-3 Remote PS and WWTP Telementry Improvements	24 mons	Mon 5/26/25	Fri 3/26/27	3,12,14,10
19			SW-24 Alarm Management Program Based on ISA 18.2	6 mons	Mon 6/2/25	Fri 11/14/25	3,12,6,10
20			NA-7 DMZ and AVEVA Intouch Access Anywhere Imp	12 mons	Mon 8/18/25	Fri 7/17/26	3,12,15,6,10
21			HW-12 Integrate Sampler A&M for New Samplers	6 mons	Mon 11/17/25	Fri 5/1/26	19,3,10

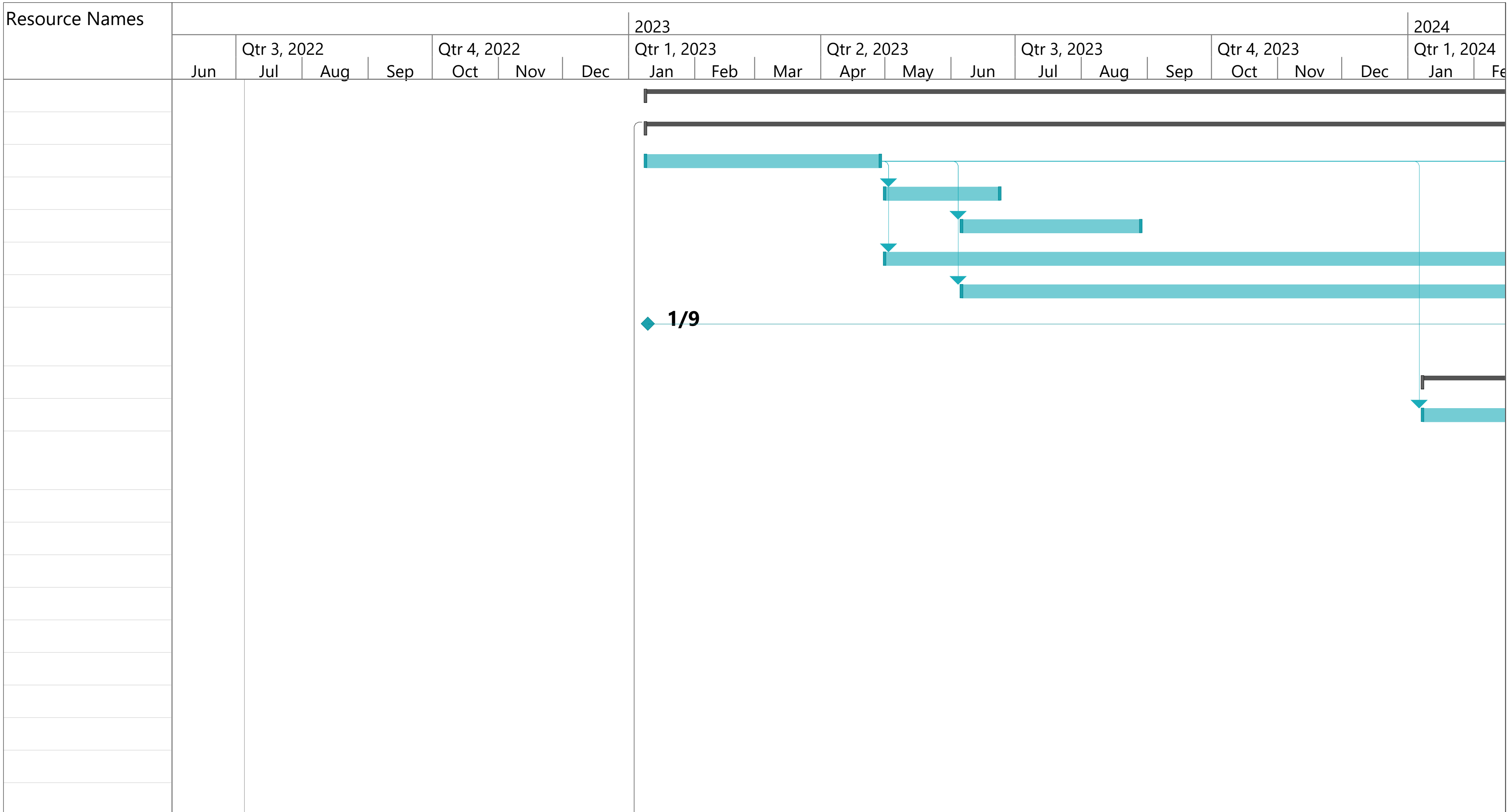
Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
22			HW-9 Replace CKTP MCC DeviceNet	9 mons	Mon 1/5/26	Fri 9/11/26	12,3,10
23			SW-25 Tiered Historian at CKTP	3 mons	Mon 7/20/26	Fri 10/9/26	3,20,13,10
24			HW-14 CKTP Automation Improvements	12 mons	Mon 7/20/26	Fri 6/18/27	3,12,7,17,10
25			HW-15 KWWTP Instrumentation Improvements	6 mons	Mon 7/20/26	Fri 1/1/27	3,12,7,10
26			HW-17 MWWTP Instrumentation Improvements	12 mons	Mon 8/10/26	Fri 7/9/27	3,12,7,10
27			HW-16 KWWTP Automation Improvments	6 mons	Mon 1/4/27	Fri 6/18/27	3,12,20,7,25,10
28			HW-19 SWWTP Instrumentation Improvements	12 mons	Mon 2/8/27	Fri 1/7/28	3,12,7,10
29			HW-21 Remote PS Intrumentation Improvements	6 mons	Mon 4/12/27	Fri 9/24/27	3,12,7,10
30			HW-18 MWWTP Automation Improvements	6 mons	Mon 7/12/27	Fri 12/24/27	3,12,20,7,10,26
31			HW-22 Remote PS Automation Improvements	12 mons	Tue 1/11/28	Mon 12/11/28	3,12,20,7,10,29
32			HW-20 SWWTP Automation Improvements	6 mons	Mon 1/24/28	Fri 7/7/28	3,12,20,7,10,28
33			HW-11 CKTP Digester Bldg PNL 6000 Replacement	12 mons	Mon 2/7/28	Fri 1/5/29	3,12,10
34			OS-31 Power and Energy Data Integration to SCADA	3 mons	Mon 3/20/28	Fri 6/9/28	3,12,8,10
35			**Long Term Improvement**	**180 days**	**Mon 1/8/29**	**Fri 9/14/29**	**2SS+60 mons**
36			OS-30 Llumin integration with Tier 2 Historian/System Platform	6 mons	Mon 1/8/29	Fri 6/22/29	3,12,20,23,29,10
37			OS-29 Hach WIMS Implementation Data Exchange with AVEVA SP	3 mons	Mon 6/25/29	Fri 9/14/29	3,12,20,23,36,10

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			



Project: SCADA Master Plan Pro
Date: Mon 5/23/22

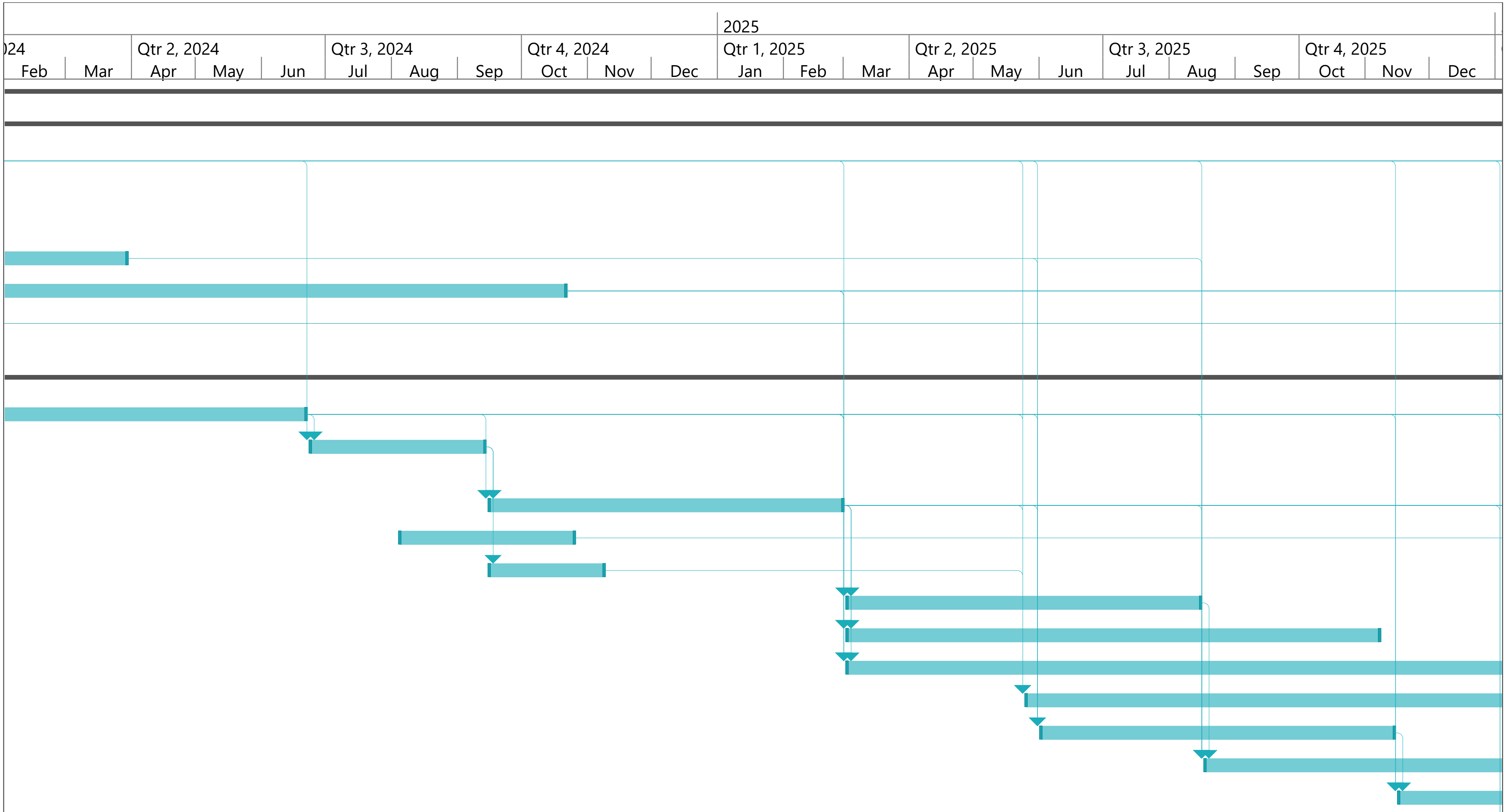
Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

Resource Names	2023	2024

Qtr 3, 2022: Jun, Jul, Aug, Sep | Qtr 4, 2022: Oct, Nov, Dec | Qtr 1, 2023: Jan, Feb, Mar | Qtr 2, 2023: Apr, May, Jun | Qtr 3, 2023: Jul, Aug, Sep | Qtr 4, 2023: Oct, Nov, Dec | Qtr 1, 2024: Jan, Fe

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			



Project: SCADA Master Plan Pro
Date: Mon 5/23/22

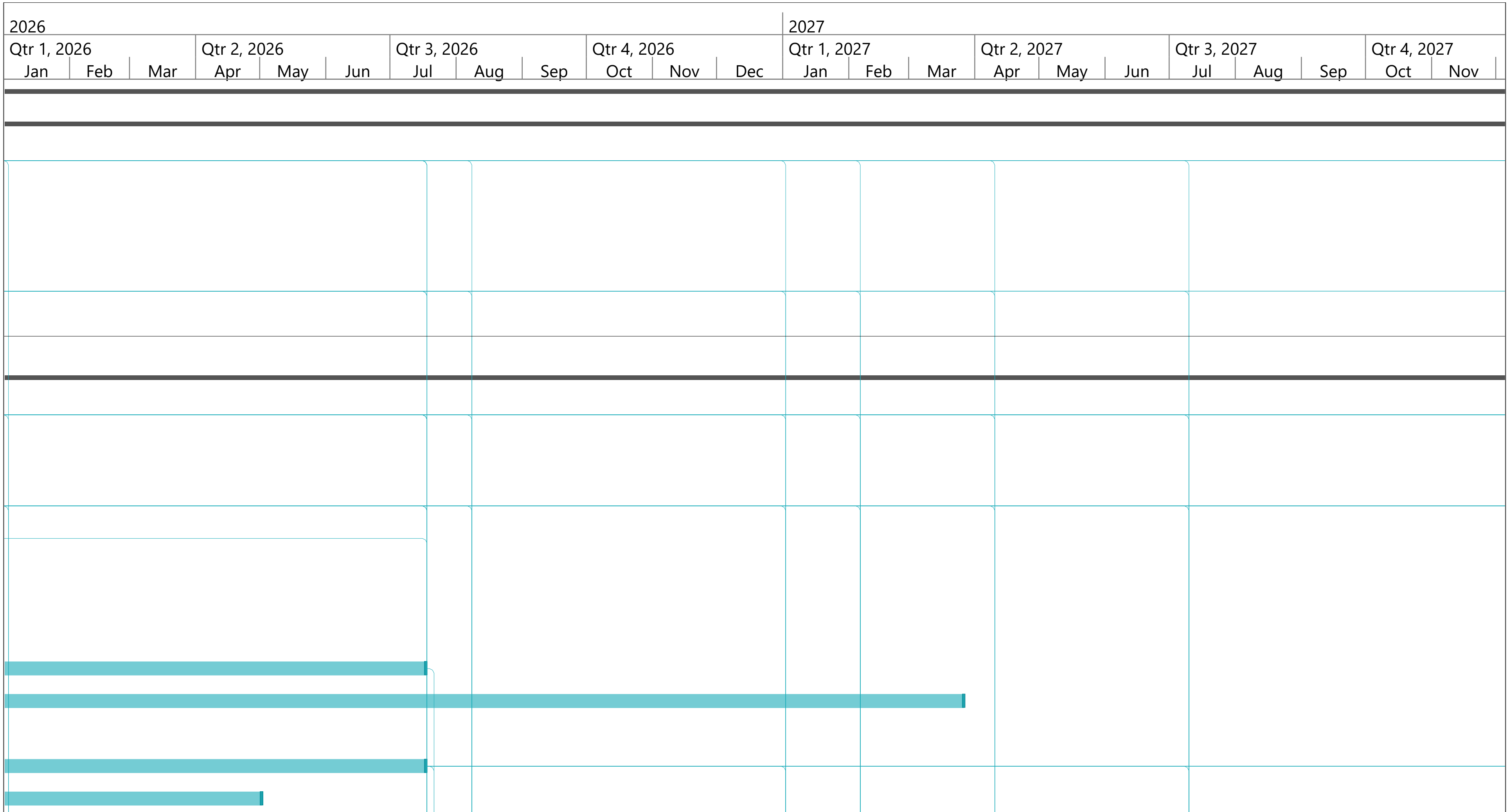
Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

2025

)24 Feb Mar | Qtr 2, 2024 Apr May Jun | Qtr 3, 2024 Jul Aug Sep | Qtr 4, 2024 Oct Nov Dec | Qtr 1, 2025 Jan Feb Mar | Qtr 2, 2025 Apr May Jun | Qtr 3, 2025 Jul Aug Sep | Qtr 4, 2025 Oct Nov Dec

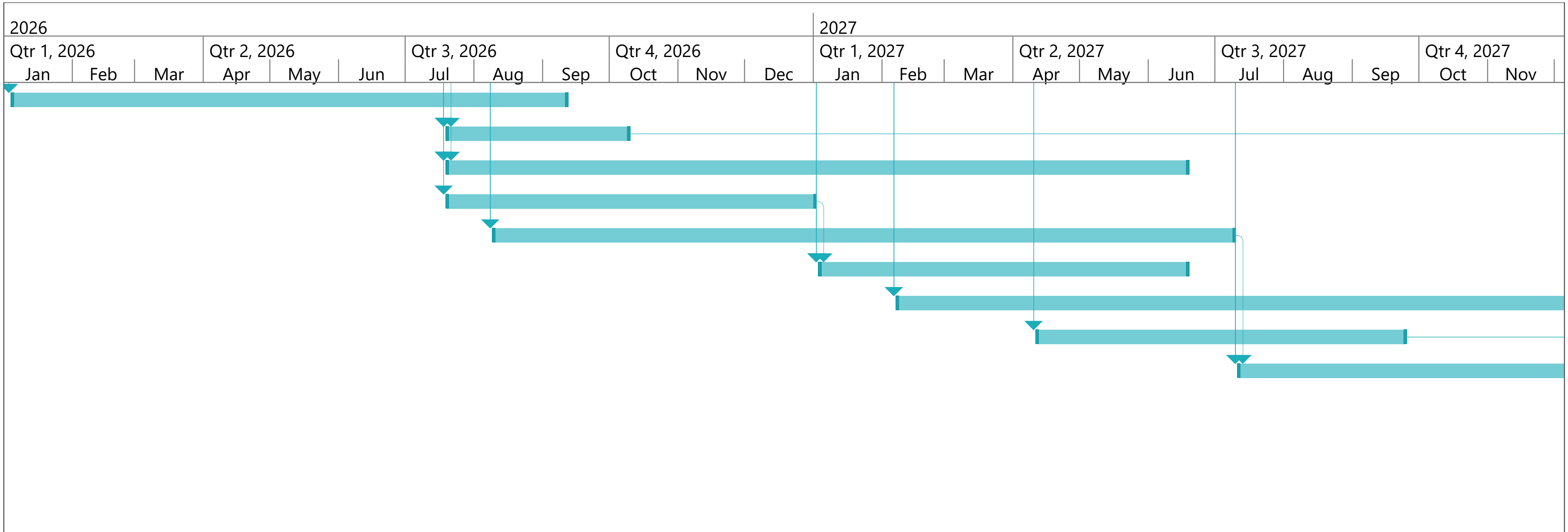
Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	



Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

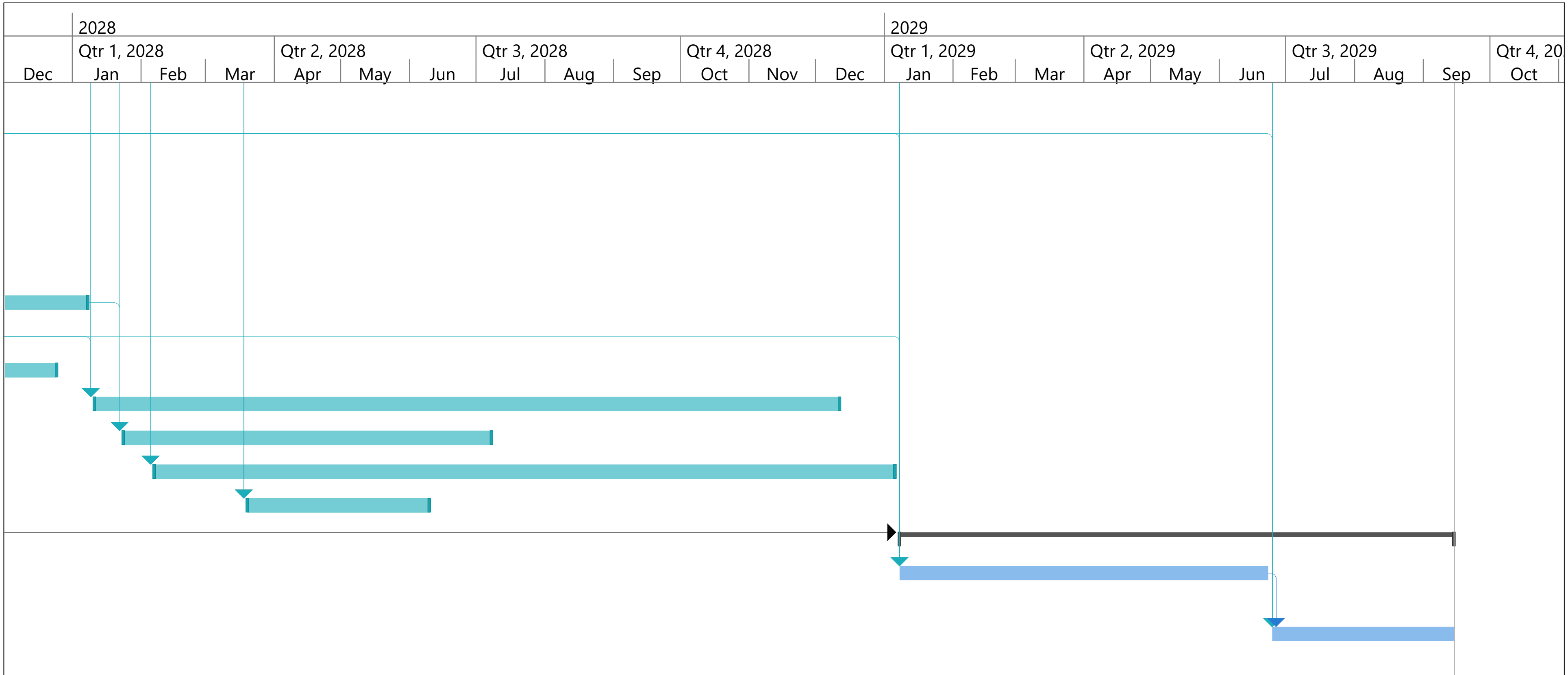


Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	



Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

consor

APPENDIX E
PUMP STATION
CONDITION ASSESSMENTS

Kitsap County Facilities Plan
Pump Station Condition Assessment

Condition Rating	Definition
1	Very Good, well maintained, expected to remain reliable for more than 90% of the expected life.
2	Good, some degradation but performance and reliability are not significantly affected. Performance and reliability expected to remain satisfactory for 50-90% of the expected life.
3	Fair, performance and reliability are still acceptable, but some rehabilitation or replacement will be needed in the 50% +/- of the expected life.
4	Poor, performance and/or reliability has significantly decreased, maintenance rehabilitation or replacement needed to restore performance or reliability to acceptable levels. Failure (no longer functions) is likely in 10-50% of the expected life if not rehabilitated or replaced.
5	Very poor, performance and/or reliability has significantly decreased, and failure is probable within 10% of the expected life if rehabilitation or replacement is not performed.

Consequence of Failure Rating	Definition
1	Not Managed. Failure would not affect the pump station operation.
2	Not Critical. Could marginally reduce the pump station capacity or performance.
3	Important (critical but redundant). The pump station performance is significantly impacted without a currently installed redundant component.
4	Critical. The pump station performance is significantly impacted upon failure.
5	Highly Critical. Failure will cause an immediate loss of hydraulic throughput.

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	2							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Available access from Best Western parking lot
Parking	Abundant parking due to hotel parking adjacent to pump station; Approx. 2 commerical vehicles and 5
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	40 years	
Pump Station Configuration		Submersible	Dry Pit		Suction Lift
Condition (1-5)	2		Criticality (1-5)	4	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well			Age	40 years	
Condition (1-5)	2		Criticality (1-5)	4	
Dry Well Material	Steel		Dimensions	8' pump can diameter	
Coating Material	Versapox epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age		
Condition (1-5)	2		Criticality (1-5)	4	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	2								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	40 years		
Vault Condition (1-5)	2		Vault Criticality (1-5)	3		
Material			Dimensions			
Coating Material			Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		3	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)		3	Piping Criticality (1-5)		2	
Check Valve Condition (1-5)		4	Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps								
Make/Model	Smith & Loveless; 4B4A, 4C4A, 4D4A pumps				Quantity	2	Age	40 years
Design Point	630	gpm	138	tdh	Capacity Checked		Yes	No
Condition (1-5)	4			Criticality (1-5)		4		
Notes								

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)		N/A	Bypass Piping Criticality (1-5)		N/A
Bypass Piping Condition (1-5)		N/A	Bypass Piping Criticality (1-5)		N/A
SCADA	Yes	No			

- Bubbler
- Not a lot of problems but "it has its moments"
- It's old
- Dry can, Smith and Loveless
- Might be due for replacement due to age

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	2
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.2	2.0	11.9
Civil	2.0	2.0	4.0
Structural	2.0	5.0	10.0
Pumping Systems	3.5	5.0	17.5
Motors	3.0	3.0	9.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.5	1.0	3.5
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	5	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	7								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from NE Fairgrounds Rd
Parking	Limited parking due to proximity to NE Fairgrounds Rd; Space for approx. 3 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age		
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	5	
Wet Well Material	Concrete		Dimensions	12' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	43 years
Condition (1-5)	3		Criticality (1-5)	3
Description				
Material	CMU construction w/ metal roof		Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	7								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	43 years	
Condition (1-5)		3	Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age		
Vault Condition (1-5)	2		Vault Criticality (1-5)	3	
Material	Concrete		Dimensions	175"x115"	
Coating Material	Raven wastewater epoxy lining		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		
Isolation Valve Type	Gate		Plug		
Piping Condition (1-5)		2	Piping Criticality (1-5)	4	
Check Valve Condition (1-5)		2	Check Valve Criticality (1-5)	4	
Air/Vac Valve Condition (1-5)		5	Air/Vac Valve Criticality (1-5)	2	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)		
Notes	*Air vacs were isolated after being observed to leak fluid during pump discharge.				

Pumps						
Make/Model			Quantity	3	Age	
Design Point	gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	2		Criticality (1-5)	5		
Notes						

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Biggest issue: rags and grease pushed to far end of wet well from inlet, floats get gunked up
- Air vavs are isolated because they spout all the time, aren't needed
- 3 pumps, P2 is a jockey pump
- Generator is new
- Controls may be old? Check with Cliff
- Replaced in 2009
- Pumps didn't work well at first, they were designed for clean water
- Impellors were switched out and they work better now

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	7
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	2.8	5.0	9.6
Civil	3.5	2.0	7.0
Structural	3.0	5.0	15.0
Pumping Systems	3.0	3.0	9.0
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	9								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from Ogle Rd NE
Parking	Abundant parking available in parking lot across Ogle Rd NE; Space on-site for 1 pickup truck
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	40 years	
Pump Station Configuration		Submersible	Dry Pit		Suction Lift
Condition (1-5)	3		Criticality (1-5)	1	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well			Age	40 years	
Condition (1-5)	3		Criticality (1-5)	1	
Dry Well Material			Dimensions	8' diameter pump can	
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	40 years	
Condition (1-5)	3		Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	
Condition (1-5)	3		Criticality (1-5)	1
Description				
Material	CMU Construction w/ metal roof		Dimensions	152"x232"
Intrusion Alarm	N			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	9								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	40 years		
Condition (1-5)		3	Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges	(Dry Can)		Age	40 years		
Vault Condition (1-5)			Vault Criticality (1-5)			
Material			Dimensions			
Coating Material	Epoxy resin		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)		1	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)	2		Piping Criticality (1-5)		1	
Check Valve Condition (1-5)	4		Check Valve Criticality (1-5)		1	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)		N/A	
Notes	*Check valve keeper pins have failed multiple times in the past					

Pumps							
Make/Model	Fairbanks Morse; 5433			Quantity	4	Age	
Design Point	400	gpm	107	tdh	Capacity Checked	Yes	No
Condition (1-5)	3			Criticality (1-5)	1		
Notes	*2 sets of 2 pumps in series						

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Not much flow, only serves Marina
- 4 pumps in series (push-pull)
- Surge tank
- Bubbler
- Dry can
- Some switches get stuck, County to fix
- Built in 80's
- No issues
- Valves are fine
- Can is in good shape
- Check valve keeper pin comes out
- Needs new generator

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	9
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.0	2.0	11.5
Civil	2.0	2.0	4.0
Structural	3.0	5.0	15.0
Pumping Systems	3.3	5.0	16.7
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	10
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Suitable access from Olympic High School parking lot
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age	43 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	3		Criticality (1-5)		3	
Wet Well Material	Concrete		Dimensions		6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well			Age	43 years		
Condition (1-5)	3		Criticality (1-5)		3	
Dry Well Material	Steel		Dimensions			
Coating Material	Epoxy resin		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)			Age			
Condition (1-5)			Criticality (1-5)	2		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Control Building					
Building		Shed	Roof	Age	43 years
Condition (1-5)	4.2		Criticality (1-5)	3	
Description					
Material	CMU construction w/ metal roof		Dimensions	12'x200"	
Intrusion Alarm	N				
Notes	to NE				

Pump Station:	10							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

HVAC (Control Building)			Age	43 years		
Condition (1-5)	N/A		Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes	*Passive ventilation; Louvers allow for natural infiltration and exfiltration of air					

Piping, Valves, and Gaug	(Dry can)			Age		
Vault Condition (1-5)				Vault Criticality (1-5)		
Material				Dimensions		
Coating Material				Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No		Intrusion Alarm	Yes	No
Isolation Valve Conditio	3			Isolation Valve Criticality (1-5)	3	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)	3			Piping Criticality (1-5)	3	
Check Valve Condition (	3			Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition	N/A			Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Conditic	N/A			Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1	N/A			Flow Meter Criticality (1-5)	N/A	
Notes						

Pumps							
Make/Model	Fairbanks Morse; 5433			Quantity	2	Age	40 years
Design Point	300	gpm	110 tdh	Capacity Checked	Yes	No	
Condition (1-5)	3		Criticality (1-5)		3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Existing propane generator will be replaced soon
- Pumps get air bound if level in wet well gets too low
- Valves are ok
- Surface water runs into building, County can fix
- Roof damaged but not leaking
- Dry well

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	10
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.2	3.0	12.1
Civil	2.0	2.0	4.0
Structural	3.4	5.0	17.0
Pumping Systems	3.0	5.0	15.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	11							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from the roundabout located on Firglade Ct NW
Parking	Limited parking; Space for approx. 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	**No**	Privacy Fence	Yes	**No**
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	47 years	
Pump Station Configuration	Submersible		**Dry Pit**	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	**No**
Hatch Lock	**Yes**	No	Intrusion Alarm	Yes	**No**

Dry Well			Age	47 years	
Condition (1-5)	4		Criticality (1-5)	2	
Dry Well Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	**Yes**	No
Hatch Lock	**Yes**	No	Intrusion Alarm	Yes	**No**

HVAC (Dry Well)			Age		
Condition (1-5)			Criticality (1-5)	1	
Continuous Supply	Yes	**No**	Supply Fan	Yes	**No**
Exhaust Fan	Yes	**No**	Heat	Yes	**No**
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	11								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges		(Dry can)	Age	47 years	
Vault Condition (1-5)			Vault Criticality (1-5)		
Material			Dimensions	8' diameter pump can	
Coating Material			Access Hatch Fall Protection	**Yes**	No
Hatch Lock	**Yes**	No	Intrusion Alarm	Yes	**No**
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	**Gate**		Plug		
Piping Condition (1-5)		3	Piping Criticality (1-5)	2	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)	2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps								
Make/Model	Paco; H1423SEA				Quantity	2	Age	47 years
Design Point	350	gpm	65	tdh	Capacity Checked		Yes	**No**
Condition (1-5)	3			Criticality (1-5)		2		
Notes								

Miscellaneous						
Washdown Water	Yes	**No**	Backflow Assembly	Yes	**No**	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
SCADA	**Yes**	No				

- Old but functional
- Power outages an issue
- Enough time to come out in outage with portable genset
- No real issues
- Dry can not in great shape

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	11
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.4	2.0	12.9
Civil	4.0	2.0	8.0
Structural	4.0	5.0	20.0
Pumping Systems	3.0	5.0	15.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	12
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	21-Sep

Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Access from roundabout located at intersection of NW Newberry Hill Rd and Chico Way NW
Parking	Space in pavered area of of roundabout for approx 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link w/ barbed wir		Fence Height	6'	
Notes					

Wet Well			Age	43 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	4		Criticality (1-5)		4	
Wet Well Material	Concrete		Dimensions		8' inside diameter	
Coating Material	Epoxy resin		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well			Age	43 years		
Condition (1-5)	3		Criticality (1-5)		4	
Dry Well Material	Steel		Dimensions		8' inside diameter	
Coating Material	Epoxy resin		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)			Age	43 years	
Condition (1-5)	2		Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof	Age	43 years	
Condition (1-5)	3		Criticality (1-5)	3	
Description					
Material	CMU construction w/ metal roof		Dimensions	135.5"x36'8"	
Intrusion Alarm	No				
Notes					

murraysmith

Pump Station:	12						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	21-Sep						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges	(Dry can)		Age	43 years	
Vault Condition (1-5)			Vault Criticality (1-5)		
Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)	3	
Isolation Valve Type	Gate		Plug		
Piping Condition (1-5)		3	Piping Criticality (1-5)	4	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)	4	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Fairbanks Morse; 5433			Quantity	2	Age	40 years
Design Point	850	gpm	23	tdh	Capacity Checked	Yes	No
Condition (1-5)	4.5		Criticality (1-5)		4		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Downstream of LS-13 and LS-14
- Old, dry can
- Johnny wants to switch to a submersible
- Pumps are causing trouble
- Generator is 6 months old, diesel
- Multitrode gets greased up, throws off settings
- Wet well coating is peeling off
- Valves are ok
- 30+ years old
- 2 pumps
- Can is fine

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	12
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/21/2020

Category	Condition	CoF	Condition*CoF
Overall	3.4	4.0	13.1
Civil	2.0	2.0	4.0
Structural	3.3	5.0	16.7
Pumping Systems	3.5	5.0	17.5
Motors (greater than 25 hp only)	3.5	3.0	10.5
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	4.0	5	20.0
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	13								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from Chico Way
Parking	Limited parking; Space for approx. 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes		No
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age	40 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	5		Criticality (1-5)		5	
Wet Well Material	Concrete		Dimensions		6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well			Age	40 years	
Condition (1-5)	3		Criticality (1-5)	3	
Dry Well Material	Steel		Dimensions	8' pump can	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	40 years	
Condition (1-5)	3		Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	40 years
Condition (1-5)	3		Criticality (1-5)	2
Description				
Material	CMU construction w/ metal roof		Dimensions	10'x34'
Intrusion Alarm	No			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	13								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)				Age	40 years	
Condition (1-5)		3		Criticality (1-5)	1	
Continuous Supply	Yes	No		Supply Fan	Yes	No
Exhaust Fan	Yes	No		Heat	Yes	No
Notes	*Heater and exhaust fan located in chemical storage room					

Piping, Valves, and Gauges		(Dry can)		Age	40 years	
Vault Condition (1-5)				Vault Criticality (1-5)		
Material				Dimensions		
Coating Material				Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No		Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)		4		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)		4		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)		N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)		N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)		N/A		Flow Meter Criticality (1-5)	N/A	
Notes						

Pumps							
Make/Model				Quantity	2	Age	40 years
Design Point	500	gpm	41	tdh	Capacity Checked	Yes	No
Condition (1-5)	3			Criticality (1-5)	3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Wet well is in bad shape – lots of H2S, exposed aggregate
- Hatch is badly corroded
- Lots of mystery fibers from IPS in upstream force main (LS-14 force main)
- Bioxide replaced chlorine system
- Bioxide installed at LS-14 also, H2S used to be too high above grade of wet well
- 6 month old genset, diesel
- Bioxide around 1 year old
- Check valves are worn out
- Isolation valves are stiff
- Pumps are ok, clog sometimes, old

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	13
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.5	3.0	13.4
Civil	3.5	2.0	7.0
Structural	3.7	5.0	18.3
Pumping Systems	3.3	5.0	16.7
Motors (greater than 25 hp only)	3.3	3.0	10.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	14							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access						
Access	Direct access from Shadden LN NW					
Parking	Limited parking; Space for approx. 3 pickup trucks					
Notes						

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	39 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof	Age	39 years	
Condition (1-5)	3		Criticality (1-5)	2	
Description					
Material	CMU construction w/ wood siding and shingled		Dimensions	146"x15'	
Intrusion Alarm	No				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	14								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	39 years		
Condition (1-5)			Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges			Age	39 years		
Vault Condition (1-5)	3		Vault Criticality (1-5)	2		
Material	Concrete		Dimensions	55.5"x7'		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)			
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)		2	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)	1		Presssure Gauge Criticality (1-5)		1	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps							
Make/Model	Flygt; 3127			Quantity	2	Age	<1 year
Design Point		gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	1			Criticality (1-5)	2		
Notes							

Miscellaneous						
Washdown Water	Yes	No	Backflow Assembly	Yes	No	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
SCADA	Yes	No				

- Overflow tank, isolation drain valve doesn't work
- New Flygt pumps, around 6 months old
- Rag collector by inlet (half pipe)
- Wet well is fine
- Pipes look good
- Other valves fine
- Force main gets lots of rags/fiber, pigged often (1-2 days to 1-2 weeks)
  - Overflow tank was plugged so pumps would run more often (previously they would use the overflow tank volume), this helped with the fiber issue
- Bioxide is on site
- Generator is fine
- Electrical is fine
- County thinks that a bigger impeller might help with the fibers
- FM crosses a bridge

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	14
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	2.9	2.0	10.3
Civil	3.5	2.0	7.0
Structural	3.0	5.0	15.0
Pumping Systems	2.3	3.0	7.0
Motors (greater than 25 hp only)	2.3	3.0	7.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	3.0	1.0	3.0
Instrumentation	4.0	5	20.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	17							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/14/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

General Site Conditions/Access	
Access	Access directly from Clear Creek Road NW
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	43 years	
Pump Station Configuration		Submersible	Dry Pit		Suction Lift
Condition (1-5)	4		Criticality (1-5)	5	
Wet Well Material	Concrete		Dimensions	8'x24'	
Coating Material	Unknown		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	(Pump Room)		Age	43 years	
Condition (1-5)	3		Criticality (1-5)	5	
Dry Well Material	Concrete		Dimensions	24'x12'8"	
Coating Material	Unknown		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	43 years	
Condition (1-5)	3		Criticality (1-5)	3	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	43 years
Condition (1-5)	3.5		Criticality (1-5)	4
Description				
Material	CMU construction w/ metal roof		Dimensions	40'10"x28'
Intrusion Alarm	No			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	17						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/14/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	43 years	
Condition (1-5)	3		Criticality (1-5)	3	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges	(Pump room)		Age	43 years	
Vault Condition (1-5)			Vault Criticality (1-5)		
Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	3	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	4	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	4	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	4	
Pressure Gauge Condition (1-5)	4		Presssure Gauge Criticality (1-5)	1	
Flow Meter Condition (1-5)	2		Flow Meter Criticality (1-5)	2	
Notes	*Flowmeter monitors influent flow through parshall flume				

Pumps							
Make/Model				Quantity	3	Age	43 years
Design Point	2700	gpm	43	tdh	Capacity Checked	Yes	No
Condition (1-5)	3.5			Criticality (1-5)	5		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)	3		Bypass Piping Criticality (1-5)	4	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Flume flow meter on influent from Bangor
- Wet well/dry well
- Next to Bangor
- Chlorine tank and injection is on site, but not used
- Bangor is in process of installing Bioxide
- County considering installing Bioxide on site
- Flume is spill point
- Muffin Monster on influent channel (located outside), a couple of years old
- Bypass pump around with new valve
- Some corrosion on pumps
- Pumps around 12-years old, immersible motors
- Roof leaks in generator room, rusted

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	17
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/14/2020

Category	Condition	CoF	Condition*CoF
Overall	3.0	2.0	9.8
Civil	2.5	2.0	5.0
Structural	3.5	5.0	17.5
Pumping Systems	3.2	3.0	9.5
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	4.0	2.0	8.0
Support Systems	4.0	1.0	4.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	20							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

General Site Conditions/Access	
Access	Single lane gravel driveway connected to Nels Nelson Rd NW
Parking	Room for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age	39 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	2		Criticality (1-5)		3	
Wet Well Material	Concrete		Dimensions			
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well			Age	39 years		
Condition (1-5)	2		Criticality (1-5)	3		
Dry Well Material	Steel		Dimensions	8' pump can diameter		
Coating Material	Versapox epoxy resin		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)			Age	39 years		
Condition (1-5)	2		Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Control Building					
Building	Shed	Roof	Age	39 years	
Condition (1-5)	4		Criticality (1-5)	2	
Description					
Material	Timber frame construction w/ shingle roof and		Dimensions	10.25'x16.25'	
Intrusion Alarm	No				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	20								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	39 years		
Condition (1-5)	2		Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges		(Dry Can)	Age	39 years		
Vault Condition (1-5)		N/A	Vault Criticality (1-5)			
Material		N/A	Dimensions			
Coating Material		N/A	Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		2	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)		3	Piping Criticality (1-5)		3	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)		3	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps							
Make/Model	Smith & Loveless; 4D4A			Quantity	2	Age	39 years
Design Point	630	gpm	138	tdh	Capacity Checked	Yes	No
Condition (1-5)	4			Criticality (1-5)	3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Pretty much trouble free
- Except when bubbler breaks
- Pumps sound bad, haven't been worked on much
- Building is a little rough, needs new roof
- Prefer something other than a bubbler
- Valves are ok, but old
- Building needs new siding
- Maybe full rebuild to submersible

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	20
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	2.9	2.0	10.7
Civil	2.0	2.0	4.0
Structural	2.7	5.0	13.3
Pumping Systems	3.3	5.0	16.7
Motors (greater than 25 hp only)	3.5	3.0	10.5
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	22							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Steep single lane gravel access road located off of Quail Run Dr NW
Parking	Space for approx. 3 pickup trucks and 1 commercial vehicle
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link w/ barbed-wir		Fence Height	6'	
Notes					

Wet Well			Age	34 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	2		Criticality (1-5)	3	
Wet Well Material	Steel		Dimensions	8' inside diameter	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	34 years
Condition (1-5)	2		Criticality (1-5)	2
Description				
Material	Brick building w/ metal corrugated r		Dimensions	12'x16'
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	22							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	34 years		
Condition (1-5)	2		Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges			Age	34 years		
Vault Condition (1-5)	2		Vault Criticality (1-5)	3		
Material	Steel		Dimensions	6' diameter		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No	
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No	
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	3		
Isolation Valve Type	Gate	Plug				
Piping Condition (1-5)	3		Piping Criticality (1-5)	4		
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	4		
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A		
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A		
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A		
Notes						

Pumps							
Make/Model	Flygt; 3202			Quantity	2	Age	34 years; <
Design Point		gpm	tdh	Capacity Checked	Yes	No	
Condition (1-5)	5	3		Criticality (1-5)	3		
Notes							

Miscellaneous						
Washdown Water	Yes	No	Backflow Assembly	Yes	No	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
SCADA	Yes	No				

- One new pump, has higher capacity Flygt
- CIP should include budget for second Flygt
- No odor control, odor is fine
- New homes going in
- Generator is old, needs replaced, from 80s
- Pump bypass

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	22
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	2.7	3.0	9.2
Civil	2.0	2.0	4.0
Structural	2.0	5.0	10.0
Pumping Systems	3.5	3.0	10.5
Motors (greater than 25 hp only)	3.5	3.0	10.5
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	2.0	1.0	2.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	23						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1 good	5 bad		Criticality	1 not critical	5 critical	

General Site Conditions/Access	
Access	Steep single lane gravel driveway directly off of Waaga Way
Parking	Space for 1 commercial vehicle, 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	35 years	
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	8' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well			Age	35 years	
Condition (1-5)	3		Criticality (1-5)	3	
Dry Well Material	Steel		Dimensions	8' diameter pump can	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age		
Condition (1-5)			Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	35 years
Condition (1-5)	2		Criticality (1-5)	2
Description				
Material	Brick building w/ metal roof		Dimensions	16'x22'
Intrusion Alarm	Yes			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	23								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	35 years		
Condition (1-5)		2	Criticality (1-5)	2		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges		(Dry Can)	Age	35 years		
Vault Condition (1-5)		2	Vault Criticality (1-5)			
Material		Steel	Dimensions			
Coating Material		Epoxy resin	Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		2	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)		2	Piping Criticality (1-5)		3	
Check Valve Condition (1-5)		2	Check Valve Criticality (1-5)		3	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps							
Make/Model	Cornell; 4X4X14TLWVM50			Quantity	2	Age	35 years
Design Point	560	gpm	167	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)		3	
Notes							

Miscellaneous						
Washdown Water	Yes	No	Backflow Assembly	Yes	No	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
SCADA	Yes	No				

- Dry can
- Propane generator
- Pretty trouble free
- Frequent power outages, but generator works fine
- Valves and piping are good
- Floats
- Needs new gutter

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	23
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	2.8	2.0	10.6
Civil	3.5	2.0	7.0
Structural	2.5	5.0	12.5
Pumping Systems	2.3	5.0	11.7
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	2.0	1.0	2.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	5.0	5	25.0

Notes: A lower score indicates better condition or lower criticality

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	24						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Paved driveway off of Brownsville Highway NE; swing gate present
Parking	Space for approx. 1 commercial vehicle and 3 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	21 years	
Pump Station Configuration	Submersible		Dry Pit		Suction Lift
Condition (1-5)	5		Criticality (1-5)	5	
Wet Well Material	Concrete		Dimensions	41'x6'8"	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	Pump Station Basement		Age	21 years	
Condition (1-5)	2		Criticality (1-5)	4	
Dry Well Material	Concrete		Dimensions	41'x27'	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	21 years	
Condition (1-5)	2		Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	21 years
Condition (1-5)	2		Criticality (1-5)	4
Description				
Material	CMU construction w/ metal roof		Dimensions	110'9.5"
Intrusion Alarm	Yes			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	24							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	21 years	
Condition (1-5)	2		Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	21 years	
Vault Condition (1-5)	4		Vault Criticality (1-5)		
Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	4	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	5	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	5	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	4		Presssure Gauge Criticality (1-5)	2	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Morris Pumps; Series 7100			Quantity	3	Age	21 years
Design Point		gpm	tdh	Capacity Checked		Yes	No
Condition (1-5)	2			Criticality (1-5)	5		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)	3		Bypass Piping Criticality (1-5)	4	
Bypass Piping Condition (1-5)	3		Bypass Piping Criticality (1-5)	4	
SCADA	Yes	No			

- Had issues with air entrainment during high flows, fixed with raising floats
- County will replace a check valve
- Odor control is not active
- Room for fourth pump
- County hopes Poulsbo will install Bioxide in their system
- Pumps are decent, age unknown
- Other valves are ok
- Recoat wet well (part of Force Main Replacement that Erika is working on)
- Force main replacement is in design (part of LS-17 FM)

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	24
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	2.9	5.0	10.6
Civil	2.0	2.0	4.0
Structural	3.7	5.0	18.3
Pumping Systems	2.7	3.0	8.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.5	2.0	7.0
Support Systems	2.0	1.0	2.0
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	25								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Directly adjacent to NW Silver Meadows LN
Parking	Limited; Space for approx. 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	31 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	25						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	31 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions	51"x51"	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		4	Isolation Valve Criticality (1-5)		
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)		4	Piping Criticality (1-5)		2
Check Valve Condition (1-5)		4	Check Valve Criticality (1-5)		1
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A
Notes					

Pumps							
Make/Model	Hydromatic; S4NX500JC			Quantity	2	Age	31 years
Design Point	150	gpm	51	tdh	Capacity Checked	Yes	No
Condition (1-5)	5			Criticality (1-5)		2	
Notes							

Miscellaneous						
Washdown Water	Yes	No		Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)				Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)				Bypass Piping Criticality (1-5)		
SCADA	Yes	No				

- No big issues, trouble free
- Isolation valves hard to turn
- Overflow tank

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	25
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.5	2.0	11.7
Civil	4.0	2.0	8.0
Structural	3.0	5.0	15.0
Pumping Systems	4.3	3.0	13.0
Motors (greater than 25 hp only)	4.3	3.0	13.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	4.0	2.0	8.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	26						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Single lane paved driveway located at cul de sac on NW Gooseberry Ct
Parking	Limited parking; Space for approx. 1 pickup truck and 1 commercial vehicle
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	30 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	2		Criticality (1-5)	1	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	26							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	30 years	
Vault Condition (1-5)		4	Vault Criticality (1-5)	1	
Material	Concrete		Dimensions	55.5"x7'	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		1
Isolation Valve Type	Gate		Plug		
Piping Condition (1-5)		4	Piping Criticality (1-5)		2
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)		2
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A
Notes					

Pumps							
Make/Model	Peabody Barnes; 4SE 7524 L			Quantity	2	Age	30 years
Design Point	72	gpm	46	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)		2	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Hatches don’t work well, hinge is broken in valve vault
- Dirt up to wet well hatch
- Built in 90’s
- Pumps ok, clog up on occasion
- Valves ok
- Generator would be nice
- No pig tail

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	26
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.0	2.0	10.3
Civil	4.0	2.0	8.0
Structural	3.0	5.0	15.0
Pumping Systems	2.7	3.0	8.0
Motors (greater than 25 hp only)	2.7	3.0	8.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	30							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Steep single lane gravel drive off of cul de sac on Sunset Ave NE
Parking	Limited parking; Space for approx. 1 commercial vehicle and 1 pickup truck
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well		Age	27 years		
Pump Station Configuration	Submersible	Dry Pit		Suction Lift	
Condition (1-5)	3	Criticality (1-5)		2	
Wet Well Material	Concrete	Dimensions		6' inside diameter	
Coating Material	N/A	Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes / No	Intrusion Alarm		Yes	No

Dry Well		N/A	Age			
Condition (1-5)			Criticality (1-5)			
Dry Well Material			Dimensions			
Coating Material			Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)		N/A	Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building		N/A		
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	30							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)		N/A	Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	27 years	
Vault Condition (1-5)		2	Vault Criticality (1-5)	2	
Material		Concrete	Dimensions	54.5"x83.5"	
Coating Material		N/A	Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate		Plug		
Piping Condition (1-5)		4	Piping Criticality (1-5)	2	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)	2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Fairbanks-Morse; D-5435 MV			Quantity	2	Age	27 years
Design Point	160	gpm	160	tdh	Capacity Checked	Yes	No
Condition (1-5)	4			Criticality (1-5)	2		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

*Backflow preventer observed next to overflow tank; Potential water line to station

- Pumps are old, need replacing
- Valves are ok
- It would be nice to have an onsite generator
- Hard to get generator to station
- Discharge piping is corroded
- Move panel back – open (broken) conduits in classified area
- Built in 1993
- Fairly frequent power outages

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	30
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.0	2.0	10.3
Civil	3.5	2.0	7.0
Structural	2.5	5.0	12.5
Pumping Systems	3.3	3.0	10.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	32
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Good access from parking lot off of NE Riddell Rd
Parking	Abundant parking due to PS location in parking lot; Space for approx. 5 pickup trucks and 2 commercial vehicles
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age		
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions	8' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well			Age	37 years	
Condition (1-5)	3		Criticality (1-5)	2	
Dry Well Material	Steel		Dimensions	8' pump can	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	37 years	
Condition (1-5)			Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	32							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges	(Dry can)		Age	37 years	
Vault Condition (1-5)			Vault Criticality (1-5)		
Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	4		Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	1	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	1	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)		
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)		
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)		
Notes					

Pumps							
Make/Model	Cornell; 4X4X14T-V-M-10-6			Quantity	2	Age	37 years
Design Point	360	gpm	50	tdh	Capacity Checked	Yes	No
Condition (1-5)	4			Criticality (1-5)	1*		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Overflows to Bremerton
- Pumps are old and worn
- Valves are old and stiff
- Bubbler, antiquated
- Should be replaced or removed with connection to Bremerton
- Pigtail

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	32
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.3	2.0	12.5
Civil	2.0	2.0	4.0
Structural	3.0	5.0	15.0
Pumping Systems	3.7	5.0	18.3
Motors (greater than 25 hp only)	3.7	3.0	11.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	33						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1 good	5 bad		Criticality	1 not critical	5 critical	

General Site Conditions/Access	
Access	Access from single lane gravel driveway located along NE Franklin Ave
Parking	Space for approx. 2 pickup trucks and 1 commercial vehicle
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	37 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions	5' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	33								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges				Age	37 years		
Vault Condition (1-5)		3		Vault Criticality (1-5)		2	
Material		Concrete		Dimensions	7'x55.5"		
Coating Material		N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No		Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		4		Isolation Valve Criticality (1-5)		1	
Isolation Valve Type	Gate		Plug				
Piping Condition (1-5)		4		Piping Criticality (1-5)		2	
Check Valve Condition (1-5)		4		Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)		N/A		Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A		Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A		Flow Meter Criticality (1-5)		N/A	
Notes							

Pumps							
Make/Model	Enpo-Cornell; 4DNT-SS			Quantity	2	Age	37 years
Design Point	220	gpm	54	tdh	Capacity Checked	Yes	No
Condition (1-5)	4			Criticality (1-5)		2	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Old, but fine
- Gets power outages

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	33
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.4	2.0	11.9
Civil	3.5	2.0	7.0
Structural	3.0	5.0	15.0
Pumping Systems	4.0	3.0	12.0
Motors (greater than 25 hp only)	4.0	3.0	12.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	34							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

General Site Conditions/Access	
Access	Direct access from Central Valley Rd NW
Parking	Poor; Space for approx. 1 commercial vehicle and 1 pickup truck
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	31 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	4	
Wet Well Material	Concrete		Dimensions	10' inside diameter	
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	31 years
Condition (1-5)	3		Criticality (1-5)	3
Description				
Material	Brick building w/ metal roof		Dimensions	16'x22'
Intrusion Alarm	No			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	34							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	31 years		
Condition (1-5)	3		Criticality (1-5)	2		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges			Age	31 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	3	
Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	4		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	2		Piping Criticality (1-5)	4	
Check Valve Condition (1-5)	2		Check Valve Criticality (1-5)	4	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	3		Presssure Gauge Criticality (1-5)	1	
Flow Meter Condition (1-5)	2		Flow Meter Criticality (1-5)	2	
Notes	*Isolation valves have been noted to be difficult to close				

Pumps							
Make/Model	Flygt; 3202			Quantity	2	Age	<10 years
Design Point		gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	1			Criticality (1-5)	4		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Pumps are around 1 year old (Flygt)
- Bioxide on site
- New level control (maybe radar)
- Other controls are old and cobbled together and should be replaced
- Valves are hard to operate and should be replaced
- Check valves are fine
- More surge when surge tank is on
- Not much surge when surge tank is off

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	34
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.1	5.0	10.0
Civil	4.0	2.0	8.0
Structural	3.0	5.0	15.0
Pumping Systems	2.3	3.0	7.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	3.5	2.0	7.0
Support Systems	4.0	1.0	4.0
Instrumentation	4.0	5	20.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	35						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from cul de sac on NE Coco Ct
Parking	Limited parking; Space for approx. 1 commercial vehicle and 1 pickup truck
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height		
Notes					

Wet Well			Age	37 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	3		Criticality (1-5)		2	
Wet Well Material	Concrete		Dimensions		6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	35							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	37 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions	56"x7'	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)		4	Piping Criticality (1-5)	2	
Check Valve Condition (1-5)		4	Check Valve Criticality (1-5)	2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Cornell; 4DNTSS			Quantity	2	Age	1-2 years
Design Point	112	gpm	102	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)	2		
Notes	* Jim Foley suspects there are 2 new Flygt pumps installed at the station						

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Soft starts had issues but were fixed
- Next to stormwater pond
- No genset
- 2 newer Flygt pumps, 1-2 years old
- Could use new electrical and VFDs

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	35
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.2	2.0	11.1
Civil	4.0	2.0	8.0
Structural	3.0	5.0	15.0
Pumping Systems	3.0	3.0	9.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	36						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Gravel driveway off of Blackbird Dr NE
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	41 years		
Pump Station Configuration		Submersible	Dry Pit	Suction Lift		
Condition (1-5)	4		Criticality (1-5)	2		
Wet Well Material	Steel		Dimensions	6'		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well	N/A		Age			
Condition (1-5)			Criticality (1-5)			
Dry Well Material			Dimensions			
Coating Material			Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	41 years
Condition (1-5)	4.5		Criticality (1-5)	1
Description				
Material	Timber framing w/ shingle roof		Dimensions	12'x10'
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	36								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	41 years		
Condition (1-5)	3		Criticality (1-5)			
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges			Age	41 years		
Vault Condition (1-5)	4		Vault Criticality (1-5)	1		
Material	Steel		Dimensions	6' diameter		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)	4		Isolation Valve Criticality (1-5)		1	
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)	4		Piping Criticality (1-5)		2	
Check Valve Condition (1-5)	4		Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps								
Make/Model				Quantity	2	Age	41 years	
Design Point	150	gpm	74	tdh	Capacity Checked	Yes	No	
Condition (1-5)	3.5			Criticality (1-5)		2		
Notes								

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Steel wet well, lots of corrosion
- Pump gasket pumps out between discharge claw and foot
- Hydromatic pump
- Whole thing is in bad shape
- Genset is obsolete
- Corrosion on pipes and valves

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	36
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.6	2.0	12.8
Civil	3.5	2.0	7.0
Structural	4.1	5.0	20.6
Pumping Systems	3.8	3.0	11.5
Motors (greater than 25 hp only)	3.8	3.0	11.5
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.5	1.0	3.5
Instrumentation	4.0	5	20.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	37
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Access directly from north side of cul de sac on NE Watson Ct
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	37 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	2	
Wet Well Material	Steel		Dimensions	5' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	37							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	37 years		
Vault Condition (1-5)	3.5		Vault Criticality (1-5)	1		
Material	Steel		Dimensions	42"x53"		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		1	
Isolation Valve Type	Gate	Plug				
Piping Condition (1-5)		3	Piping Criticality (1-5)		2	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps							
Make/Model	Cornell; 4DNTSS			Quantity	2	Age	37 years
Design Point	150	gpm	100	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)		2	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Not a lot of trouble, but outdated
- Jim wants it replaced
- Steel wet well with corrosion

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	37
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	3.2	2.0	11.2
Civil	3.5	2.0	7.0
Structural	3.8	5.0	18.8
Pumping Systems	2.7	3.0	8.0
Motors (greater than 25 hp only)	2.7	3.0	8.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	4.0	5	20.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	39						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Roundabout located in front of Crista Shores living community
Parking	Limited; O&M vehicles must occupy space within the roundabout adjacent to pump station; Approx 1 pickup truck or 1 commercial vehicle
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	26 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	39								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	26 years	
Vault Condition (1-5)	2		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	2	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	2	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps								
Make/Model				Quantity	2	Age	26 years	
Design Point	240	gpm	31	tdh	Capacity Checked	Yes	No	
Condition (1-5)	4			Criticality (1-5)	2			
Notes								

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Runs off Crista Shores generator and power
- Runs well, no major issues

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	39
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	2.9	2.0	9.4
Civil	4.0	2.0	8.0
Structural	2.5	5.0	12.5
Pumping Systems	3.3	3.0	10.0
Motors (greater than 25 hp only)	3.3	3.0	10.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

	Pump Station:	40							
	Basin:	Central Kitsap							
	Assessment By:	Peter Cunningham, Tom Hubert							
	Access provided by:	Jim Foley							
	Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from cul de sac on NW Discovery Ct
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age	27 years	
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	2	
Wet Well Material	Steel		Dimensions	8' inside diameter	
Coating Material	Epoxy resin		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	40								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	27 years		
Vault Condition (1-5)	3		Vault Criticality (1-5)	1		
Material	Steel		Dimensions	5' diameter		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)		3	Isolation Valve Criticality (1-5)		1	
Isolation Valve Type	Gate	Plug				
Piping Condition (1-5)		4	Piping Criticality (1-5)		2	
Check Valve Condition (1-5)		3	Check Valve Criticality (1-5)		2	
Air/Vac Valve Condition (1-5)		N/A	Air/Vac Valve Criticality (1-5)		N/A	
Pressure Gauge Condition (1-5)		N/A	Presssure Gauge Criticality (1-5)		N/A	
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)		N/A	
Notes						

Pumps							
Make/Model				Quantity	2	Age	27 years
Design Point	100	82.5	tdh	Capacity Checked		Yes	No
Condition (1-5)	4			Criticality (1-5)		2	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Steel wet well
- Old but works
- Would be nice to have onsite genset
- Pigtail
- Corrosion on discharge piping
- Floats
- Cracks in wet well coating
- No water
- Pumps are ok, don't cause trouble, original to station
- Everything is original to station
- Fair amount of power outages

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	40
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.1	2.0	11.2
Civil	2.0	2.0	4.0
Structural	3.5	5.0	17.5
Pumping Systems	3.3	3.0	10.0
Motors (greater than 25 hp only)	3.3	3.0	10.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	3.0	5	15.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	51								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/14/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Single lane gravel driveway off of Schold Rd NW
Parking	Limited parking availability; Space for approx. 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	Approx. 6 feet	
Notes					

Wet Well			Age	25 years	
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	51							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/14/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	25 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	2	
Material	Concrete		Dimensions	86" outside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3.5		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	4		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)	4		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Myers; P18G2728GPW			Quantity	2	Age	25 years
Design Point	100	gpm	49	tdh	Capacity Checked	Yes	No
Condition (1-5)	1			Criticality (1-5)	3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Genset owned by rehab center, located within fence and powers LS-51
- Some corrosion on discharge piping and valve piping
- No major issues
- Built in 1993
- Wet well Coating is worn

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	51								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/14/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Single lane gravel driveway off of Schold Rd NW
Parking	Limited parking availability; Space for approx. 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	Approx. 6 feet		
Notes						

Wet Well			Age	25 years	
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	4		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)		Criticality (1-5)		
Description				
Material		Dimensions		
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	51								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/14/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Buildin;	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	25 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	2	
Material	Concrete		Dimensions	86" outside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3.5		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	4		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)	4		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Myers; P18G2728GPW			Quantity	2	Age	25 years
Design Point	100	gpm	49	tdh	Capacity Checked	Yes	No
Condition (1-5)	1			Criticality (1-5)	3		
Notes							

Miscellaneous						
Washdown Water	Yes	No	Backflow Assembly	Yes	No	
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)			
SCADA	Yes	No				

- Genset owned by rehab center, located within fence and powers LS-51
- Some corrosion on discharge piping and valve piping
- No major issues
- Built in 1993
- Wet well Coating is worn

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	61							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from Ocasta St
Parking	Space for approx. 3 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	11 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	2		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	5' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof	Age	11 years	
Condition (1-5)	2		Criticality (1-5)	2	
Description					
Material	CMU construction w/ shingled roof		Dimensions	16'x20'	
Intrusion Alarm	No				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	61								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	11 years	
Condition (1-5)			Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	11 years	
Vault Condition (1-5)	1		Vault Criticality (1-5)	2	
Material	Concrete		Dimensions	55.5"x7'	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	1		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	1		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)	1		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Ebara; ZDLX DDL			Quantity	2	Age	11 years
Design Point		gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)	3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Mostly reliable
- Occasional bouts of ragging
- Floats
- Valves are fine
- Teenage station

New pumps should be included in 20-year CIP

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	61
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	1.7	2.0	5.4
Civil	2.0	2.0	4.0
Structural	1.7	5.0	8.3
Pumping Systems	1.3	3.0	4.0
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	1.0	5.0	5.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	2.0	1.0	2.0
Instrumentation	2.0	5	10.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	62							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5 critical

General Site Conditions/Access	
Access	Directly adjacent NW Glade Court
Parking	Limited; Parking on street for approx 2-3 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age		
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	2		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	
Condition (1-5)	1		Criticality (1-5)	1
Description				
Material	CMU construction w/ metal roof		Dimensions	
Intrusion Alarm	N			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	62						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1 good	5 bad		Criticality	1 not critical	5 critical	

HVAC (Control Building)				Age		
Condition (1-5)	2			Criticality (1-5)	1	
Continuous Supply	Yes	No		Supply Fan	Yes	No
Exhaust Fan	Yes	No		Heat	Yes	No
Notes						

Piping, Valves, and Gauges				Age		
Vault Condition (1-5)		2		Vault Criticality (1-5)		1
Material		Concrete		Dimensions	56"x7'	
Coating Material				Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No		Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)		2		Isolation Valve Criticality (1-5)		1
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)		3		Piping Criticality (1-5)		2
Check Valve Condition (1-5)		2		Check Valve Criticality (1-5)		2
Air/Vac Valve Condition (1-5)		N/A		Air/Vac Valve Criticality (1-5)		N/A
Pressure Gauge Condition (1-5)		2		Presssure Gauge Criticality (1-5)		1
Flow Meter Condition (1-5)		N/A		Flow Meter Criticality (1-5)		N/A
Notes						

Pumps							
Make/Model	EBARA; DLFU			Quantity	2	Age	
Design Point		gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)		2	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Privacy fence
- Trouble free
- Wet well is fine
- Some corrosion on discharge piping
- Overflow vault

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	62
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	1.9	2.0	6.5
Civil	1.0	2.0	2.0
Structural	1.7	5.0	8.3
Pumping Systems	2.0	3.0	6.0
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	2.0	1.0	2.0
Instrumentation	2.0	5	10.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	63								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/16/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Single lane paved road at the intersection of NE Yale Way and Trica Ave NE
Parking	Space for approx. 1 commercial vehicle and 2 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	14 years	
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	3.8		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	5' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof	Age	14 years	
Condition (1-5)	2		Criticality (1-5)	2	
Description					
Material	CMU construction w/ shingled roof		Dimensions	13'x238"	
Intrusion Alarm	No				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	63						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	14 years	
Condition (1-5)			Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	14 years	
Vault Condition (1-5)	1		Vault Criticality (1-5)	2	
Material	Concrete		Dimensions	8' diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	2		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate		Plug		
Piping Condition (1-5)	2		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)	2		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	2		Presssure Gauge Criticality (1-5)	1	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Ebara; DLFU			Quantity	2	Age	12 years
Design Point		gpm		tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)	3		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Originally a grinder, replaced with new pumps
- Used to have grease issues, its declined, better now
- Everything is fine
- Valves are good, pumps are good
- Non-standard genset (Katolight) but it works
- Wet well coating is peeling
- Built in 2005

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	63
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	1.9	2.0	6.5
Civil	2.0	2.0	4.0
Structural	2.3	5.0	11.3
Pumping Systems	2.0	3.0	6.0
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	2.0	1.0	2.0
Instrumentation	2.0	5	10.0
Electrical and Power Distribution	1.0	5	5.0

Notes: A lower score indicates better condition or lower criticality

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:		64							
Basin:		Central Kitsap							
Assessment By:		Peter Cunningham, Andrew Henson, Tom Hubert							
Access provided by:		Jim Foley							
Date of Visit:		9/14/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Access via Bonneville Power Administration power corridor; Good accessibility; Gate w/ lock at BPA power corridor entrance
Parking	Large parking availability; Space for 2 commercial vehicles and approx. 5 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	Approx. 6 feet	
Notes					

Wet Well			Age	17 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	1	
Wet Well Material	Concrete		Dimensions	6' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building	N/A			
Building	Shed	Roof	Age	
Condition (1-5)			Criticality (1-5)	
Description				
Material			Dimensions	
Intrusion Alarm				
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	64								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/14/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	17 years	
Vault Condition (1-5)	3		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	4		Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	1	
Check Valve Condition (1-5)	4		Check Valve Criticality (1-5)	1	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Hydromatic; S4MVX 13425-034-1			Quantity	2	Age	17 years
Design Point	70	gpm	46	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)	1		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Old but ok
- Has overflow tank
- Pigtail
- Tee for bypass/pig launch
- Wet well coating is worn
- Broken handle on cabinet

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	64
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Andrew Henson, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/14/2020

Category	Condition	CoF	Condition*CoF
Overall	2.9	2.0	9.8
Civil	2.0	2.0	4.0
Structural	3.0	5.0	15.0
Pumping Systems	3.3	3.0	10.0
Motors (greater than 25 hp only)	3.3	3.0	10.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.0	5	15.0
Electrical and Power Distribution	2.0	5	10.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	65						
Basin:	Central Kitsap						
Assessment By:	Petrer Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Accessible from NE Wise St near its intersection with Illahee R NE
Parking	Limited parking; Space for approx. 1 commercial vehicle and 1 pickup truck
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type			Fence Height		
Notes					

Wet Well			Age	26 years	
Pump Station Configuration		Submersible	Dry Pit		Suction Lift
Condition (1-5)	4		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	8' inside diameter	
Coating Material	Epoxy		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well			Age	26 years	
Condition (1-5)	2		Criticality (1-5)	3	
Dry Well Material	Steel		Dimensions	8' inside diameter	
Coating Material	Polyurethane enamel		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)			Age	26 years	
Condition (1-5)	2		Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	26 years
Condition (1-5)	2		Criticality (1-5)	2
Description				
Material	Brick construction w/ metal roof		Dimensions	20'x12'
Intrusion Alarm	No			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	65						
Basin:	Central Kitsap						
Assessment By:	Petrer Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	26 years	
Condition (1-5)			Criticality (1-5)	1	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges	(Dry can)		Age	26 years	
Vault Condition (1-5)			Vault Criticality (1-5)		
Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	2		Isolation Valve Criticality (1-5)	2	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	2		Piping Criticality (1-5)	3	
Check Valve Condition (1-5)	2		Check Valve Criticality (1-5)	3	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Fairbanks Morse; 5435			Quantity	4	Age	26 years
Design Point	313	gpm	320	tdh	Capacity Checked	Yes	No
Condition (1-5)	3			Criticality (1-5)	3		
Notes	*Pumps 1&2 and 3&4 are arranged in series						

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Push pull station (pumps are in series)
- Bioxide injected into wet well
- Pretty trouble free
- Check valves are approx. 10 years old
- Generator is old 2 stroke Detroit but it works
- Bioxide installed a few months ago (replaced hypo system)
- Pumps are ok
- Bubbler

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	65
Basin:	Central Kitsap
Assessment By:	Petrer Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	3.0	2.0	11.4
Civil	3.0	2.0	6.0
Structural	3.0	5.0	15.0
Pumping Systems	2.3	5.0	11.7
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	2.0	5.0	10.0
Valve Systems or Assemblies	2.5	2.0	5.0
Support Systems	3.0	1.0	3.0
Instrumentation	3.5	5	17.5
Electrical and Power Distribution	5.0	5	25.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	67						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/15/2020						
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Direct access from Washington Ave NE
Parking	Space for approx. 3 pickup trucks and 1 commercial vehicle
Notes	

Site Security and Safety					
Facility Fenced	Yes	No	Privacy Fence	Yes	No
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	3 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	1		Criticality (1-5)	5	
Wet Well Material	Concrete		Dimensions	18'x14'	
Coating Material	Raven lining		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof	Age	23 years	
Condition (1-5)	1		Criticality (1-5)	3	
Description					
Material	CMU construction w/ metal roof		Dimensions 18'x24'		
Intrusion Alarm	No				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	67							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	23 years		
Condition (1-5)			Criticality (1-5)	2		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes	*Supply air infiltrates via acoustical louvers					

Piping, Valves, and Gauges			Age	3 years		
Vault Condition (1-5)	1		Vault Criticality (1-5)	3		
Material	Concrete		Dimensions	17'x14'3"		
Coating Material	N/A		Access Hatch Fall Protection	Yes	No	
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No	
Isolation Valve Condition (1-5)	2		Isolation Valve Criticality (1-5)	3		
Isolation Valve Type	Gate	Plug				
Piping Condition (1-5)	1		Piping Criticality (1-5)	5		
Check Valve Condition (1-5)	1		Check Valve Criticality (1-5)	5		
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A		
Pressure Gauge Condition (1-5)	1		Presssure Gauge Criticality (1-5)	2		
Flow Meter Condition (1-5)	1		Flow Meter Criticality (1-5)	3		
Notes						

Pumps							
Make/Model	Flygt; NP3301			Quantity	3	Age	3 years
Design Point	3900	gpm	43 tdh	Capacity Checked	Yes	No	
Condition (1-5)	1			Criticality (1-5)	5		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- New station
- Possible site for Bioxide installation
- Takes all flow from Poulsbo

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	67
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	1.5	5.0	4.3
Civil	2.0	2.0	4.0
Structural	1.0	5.0	5.0
Pumping Systems	1.3	3.0	4.0
Motors (greater than 25 hp only)	1.0	3.0	3.0
Piping Systems	1.0	5.0	5.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	3.5	1.0	3.5
Instrumentation	1.0	5	5.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	68						
Basin:	Central Kitsap						
Assessment By:	Peter Cunningham, Tom Hubert						
Access provided by:	Jim Foley						
Date of Visit:	9/16/2020						
Condition	1 good	5 bad	Criticality	1 not critical	5 critical		

General Site Conditions/Access	
Access	Access via road leading to Klahowya High School
Parking	Space for approx. 1 commercial vehicle and 3 pickup trucks
Notes	

Site Security and Safety					
Facility Fenced	**Yes**	No	Privacy Fence	Yes	**No**
Fence Material/type	Chain link		Fence Height	6'	
Notes					

Wet Well			Age	22 years	
Pump Station Configuration		**Submersible**	Dry Pit	Suction Lift	
Condition (1-5)	2		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions	8' inside diameter	
Coating Material	N/A		Access Hatch Fall Protection	Yes	**No**
Hatch Lock	**Yes**	No	Intrusion Alarm	Yes	**No**

Dry Well	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Dry Well Material			Dimensions		
Coating Material			Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building				
Building	Shed	Roof	Age	22 years
Condition (1-5)	2		Criticality (1-5)	2
Description				
Material	CMU construction w/ shingle roof		Dimensions	12'x21'4"
Intrusion Alarm	No			
Notes				

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	68							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/16/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	22 years		
Condition (1-5)	2		Criticality (1-5)	1		
Continuous Supply	Yes	No	Supply Fan	Yes	No	
Exhaust Fan	Yes	No	Heat	Yes	No	
Notes						

Piping, Valves, and Gauges			Age	22 years		
Vault Condition (1-5)	2		Vault Criticality (1-5)	2		
Material	Concrete		Dimensions	93"x75"		
Coating Material	N/A		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	2		
Isolation Valve Type	Gate		Plug			
Piping Condition (1-5)	4		Piping Criticality (1-5)	3		
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	3		
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A		
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A		
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A		
Notes						

Pumps								
Make/Model				Quantity	2	Age	22 years	
Design Point	310	gpm	106	tdh	Capacity Checked	Yes	No	
Condition (1-5)	3			Criticality (1-5)	3			
Notes								

Miscellaneous					
Washdown Water	Yes*	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

*Eyewash station located in control building

- Overflow storage tanks – valve is inside one of the tanks, currently submerged in groundwater
- Works ok
- Only serves school
- Chlorine no longer in use
- Pumps work fine, clogged occasionally
- Corrosion on discharge piping
- Wet well is ok
- Valves may not be exercised
- Power blip causes pump to fail if running
- Panel is close to wet well – falling hazard
- School gates close at 3 pm, ops will cut lock if needed, park and walk if not

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	68
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/16/2020

Category	Condition	CoF	Condition*CoF
Overall	2.2	2.0	7.9
Civil	1.0	2.0	2.0
Structural	2.0	5.0	10.0
Pumping Systems	3.0	3.0	9.0
Motors (greater than 25 hp only)	3.0	3.0	9.0
Piping Systems	4.0	5.0	20.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	2.0	1.0	2.0
Instrumentation	2.0	5	10.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	69								
Basin:	Central Kitsap								
Assessment By:	Peter Cunningham, Tom Hubert								
Access provided by:	Jim Foley								
Date of Visit:	9/15/2020								
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	Good access from single lane paved driveway off of NE Beaumant LN
Parking	Space for approx. 3 pickup trucks and 1 commercial vehicle
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chain link		Fence Height	6'		
Notes						

Wet Well			Age	22 years		
Pump Station Configuration		Submersible	Dry Pit	Suction Lift		
Condition (1-5)	2		Criticality (1-5)	2		
Wet Well Material	Concrete		Dimensions	5' inside diameter		
Coating Material	Epoxy		Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

Dry Well	N/A		Age			
Condition (1-5)			Criticality (1-5)			
Dry Well Material			Dimensions			
Coating Material			Access Hatch Fall Protection		Yes	No
Hatch Lock	Yes	No	Intrusion Alarm		Yes	No

HVAC (Dry Well)	N/A		Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Control Building					
Building	Shed	Roof		Age	22 years
Condition (1-5)	1		Criticality (1-5)	1	
Description					
Material	CMU construction w/ metal roof		Dimensions		
Intrusion Alarm					
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	69							
Basin:	Central Kitsap							
Assessment By:	Peter Cunningham, Tom Hubert							
Access provided by:	Jim Foley							
Date of Visit:	9/15/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age		
Condition (1-5)			Criticality (1-5)		
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes					

Piping, Valves, and Gauges			Age	22 years	
Vault Condition (1-5)	2		Vault Criticality (1-5)	2	
Material	Concrete		Dimensions	114" diameter	
Coating Material	Epoxy		Access Hatch Fall Protection	Yes	No
Hatch Lock	Yes	No	Intrusion Alarm	Yes	No
Isolation Valve Condition (1-5)	3		Isolation Valve Criticality (1-5)	1	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	3		Piping Criticality (1-5)	2	
Check Valve Condition (1-5)	3		Check Valve Criticality (1-5)	2	
Air/Vac Valve Condition (1-5)	N/A		Air/Vac Valve Criticality (1-5)	N/A	
Pressure Gauge Condition (1-5)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	N/A		Flow Meter Criticality (1-5)	N/A	
Notes					

Pumps							
Make/Model	Flygt; 3127			Quantity	2	Age	<10 years
Design Point	160	gpm	99	tdh	Capacity Checked	Yes	No
Condition (1-5)	2			Criticality (1-5)	2		
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Pumps are 4-5 years old
- Lots of grease
- Flygt pumps fixed problems with grease and rags

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	69
Basin:	Central Kitsap
Assessment By:	Peter Cunningham, Tom Hubert
Access provided by:	Jim Foley
Date of Visit:	9/15/2020

Category	Condition	CoF	Condition*CoF
Overall	2.0	2.0	6.9
Civil	1.0	2.0	2.0
Structural	1.7	5.0	8.3
Pumping Systems	2.7	3.0	8.0
Motors (greater than 25 hp only)	2.7	3.0	8.0
Piping Systems	3.0	5.0	15.0
Valve Systems or Assemblies	2.0	2.0	4.0
Support Systems	2.0	1.0	2.0
Instrumentation	2.0	5	10.0
Electrical and Power Distribution	1.0	5	5.0
Notes: A lower score indicates better condition or lower criticality			

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APPENDIX F
PIPE OCI DATA

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3017-H17-3016	606436	6/11/2019	Roots	80.00	Light	ROOTS AI 164 FT
J17-4036-H17-3085	606417	6/5/2019	Roots	80.00	Light	ROOTS IN MANHOLE H17=3085 DOWNSTREAM SIDE IN THE SAND COLLAR
H16-2014-H16-2013	606483	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
M15-1006-M15-1005	607751	10/21/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF M/H M15-1005
L17-1023-L17-1022	607903	1/12/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L17-1023
L17-1023-L17-1022	607903	1/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1023-L17-1022	607903	1/12/2021	Cracks or Fractures	40.00	Severe Cracking	
L17-1023-L17-1022	607903	1/12/2021	Break or Failure	0.00	Collapse	
L17-1023-L17-1022	607903	1/12/2021	Lining or Repair Failure	80.00	Minor	
H16-2059-H16-2111	606521	6/27/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE H16-2111
G16-3015-G16-3014	606236	1/16/2019	Roots	80.00	Light	ROOTS IN THE SAND COLLAR IN MH 3014
G16-3015-G16-3014	606236	1/16/2019	Worn Surface	60.00	Moderate	
B28-4043-B28-4041	607312	7/2/2020	Roots	50.00	Medium	ENTIRE MANHOLE IS COVERED IN ROOTS
H15-2046-H15-2042	606888	12/10/2019	Belly or Sag	80.00	Minor (<10%)	
B28-4039-B28-4038	607335	7/8/2020	Roots	30.00	Heavy	ROOTS IN THE SIDE SERVICE AT 43 AND 84 FEET
H17-3065-H17-3064	606406	6/5/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1053-L17-1052	606603	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1053-L17-1052	606603	7/22/2019	Roots	80.00	Light	Wall of L17-1052
L17-1053-L17-1052	606603	7/22/2019	Worn Surface	80.00	Minor	
L17-1053-L17-1052	606603	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1053-L17-1052	606603	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D23-2123-D23-2122	604815	8/23/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2123-D23-2122	604815	8/23/2017	Obstruction or Intrusion	80.00	Minor	
D23-2123-D23-2122	604815	8/23/2017	Cracks or Fractures	80.00	Minor Cracking	
J20-3057-J20-3056	607728	10/19/2020	Roots	80.00	Light	ROOTS IN THE JOINT AT 116.8

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3019-H17-3018	606390	5/30/2019	Roots	50.00	Medium	ROOTS AT 216 AND 375 FT FROM UPPER M/H
H17-3019-H17-3018	606390	5/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G15-3019-G15-3040	606015	1/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-4101-G16-4100	606796	10/1/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-2002-G16-2001	606553	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1034-L17-1033	607898	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
M18-4026-M18-4025	607869	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
L17-1047-L17-1043	606607	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1047-L17-1043	606607	7/22/2019	Worn Surface	80.00	Minor	
L17-1047-L17-1043	606607	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1047-L17-1043	606607	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J20-3060-J20-3059	607725	10/19/2020	Roots	80.00	Light	ROOTS IN MANHOLE J20-3060
A28-3015-A28-3014	607381	7/16/2020	Roots	30.00	Heavy	ROOTS IN THE UPPER MANHOLE COVERING THE BOTTOM
G16-2030-G16-2029	606306	1/16/2019	Roots	80.00	Light	246" VERY SMALL
G16-4059-G16-4057	606737	9/11/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2061-H16-2058	606515	6/26/2019	Belly or Sag	40.00	Severe (>30%)	
H15-4034-H15-4003	606120	2/7/2019	Roots	80.00	Light	Roots in the sand collar
J17-2009-J17-2008	607516	8/19/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1049-L17-1047	606606	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1049-L17-1047	606606	7/22/2019	Worn Surface	80.00	Minor	
L17-1049-L17-1047	606606	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1049-L17-1047	606606	7/22/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1049-L17-1047	606606	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-4003-G16-4005	606802	10/2/2019	Belly or Sag	80.00	Minor (<10%)	
H17-3038-H17-3037	606463	6/13/2019	Break or Failure	15.00	Hole Void Visible	
J16-1007-J16-1006	607041	2/10/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-1014-G16-1013	605822	8/29/2018	Belly or Sag	80.00	Minor (<10%)	
G16-1014-G16-1013	605822	8/29/2018	Break or Failure	0.00	Collapse	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3084-G16-3078	606276	1/16/2019	Roots	30.00	Heavy	ROOTS IN THE MANHOLE EVERYWHERE ALL 3 SAND COLLARS AND STRETCHING DOWN THE PIE
G16-4088-G16-4084	606771	9/17/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4018-B28-4017	607334	7/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
B28-4046-B28-4039	607300	6/24/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J19-2012-J19-2011	607941	2/2/2021	Belly or Sag	80.00	Minor (<10%)	
M16-1034-M16-1033	605599	7/2/2018	Inflow and Infiltration	60.00	Running or Trickling	
H16-4046-H16-4016	606381	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-1094-J16-1095	607036	2/10/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1064-L17-1063	607962	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1050-L17-1049	606605	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1050-L17-1049	606605	7/23/2019	Worn Surface	80.00	Minor	
L17-1050-L17-1049	606605	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1050-L17-1049	606605	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M18-4009-M18-4008	607845	12/21/2020	Belly or Sag	80.00	Minor (<10%)	
B28-1006-B28-1005	607262	6/1/2020	Inflow and Infiltration	40.00	Gushing or Spurting	
J16-2005-J16-2003	605897	9/25/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4054-B28-4053	607247	5/28/2020	Roots	50.00	Medium	ROOTS IN MANHOLE B28-4054 ALL OVER AND IN THE SAND COLLAR
L17-1024-L17-1023	607901	1/12/2021	Roots	80.00	Light	ROOTBALL IN THE BOTTOM OF MANHOLE L17-1023
J11-3040-J11-3039	605985	12/20/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3040-J11-3039	605985	12/20/2018	Break or Failure	30.00	Hole Soil Visible	
J11-3040-J11-3039	605985	12/20/2018	Cracks or Fractures	80.00	Minor Cracking	
H16-2053-H16-2052	606505	6/25/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
L18-3051-L18-3050	607783	10/27/2020	Belly or Sag	80.00	Minor (<10%)	
J16-1014-J16-1013	607024	2/6/2020	Belly or Sag	40.00	Severe (>30%)	
J16-1071-J16-1070	607048	2/11/2020	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2007-G21-2006	605428	6/18/2018	Belly or Sag	80.00	Minor (<10%)	
G16-2024-G16-2020	606293	1/16/2019	Roots	80.00	Light	ROOTS IN THE LOWER MANHOLE IN THE SANDCOLLAR G16-2020

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L17-1041-L17-1092	607919	1/21/2021	Roots	50.00	Medium	ROOTS IN THE JOINTS AND SAND COLLARS LINE IS ONLY 10 FEET LONG
G16-3036-G16-3035	606180	2/26/2019	Worn Surface	40.00	Severe	
L16-2003-L16-2002	605511	7/2/2018	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-3034-H16-3033	606923	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-3006-J16-3002	605878	10/19/2018	Belly or Sag	80.00	Minor (<10%)	
A28-2032-A28-2031	607161	3/5/2020	Roots	80.00	Light	ROOTS IN THE MANHOLE A28-2031
L17-1065-L17-1064	607961	2/4/2021	Roots	0.00	Blockage	SIDE SERVICE BLOCKED AT 334.4 FROM THE GROCERY STORE
L17-1065-L17-1064	607961	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1065-L17-1064	607961	2/4/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
B28-4024-B28-4021	607239	5/21/2020	Belly or Sag	80.00	Minor (<10%)	
L18-4011-L18-4010	606232	4/3/2019	Roots	80.00	Light	First 4 ft the at 230 ft
L18-4011-L18-4010	606232	4/3/2019	Worn Surface	80.00	Minor	
L18-4011-L18-4010	606232	4/3/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4011-L18-4010	606232	4/3/2019	Cracks or Fractures	80.00	Minor Cracking	
L18-4011-L18-4010	606232	4/3/2019	Break or Failure	15.00	Hole Void Visible	
L18-4011-L18-4010	606232	4/3/2019	Lining or Repair Failure	80.00	Minor	
L18-4011-L18-4010	606232	4/3/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1002-J16-1001	607053	2/11/2020	Roots	50.00	Medium	ROOTS IN MANHOLE J16-1001
G16-2047C-G16-2004	606323	1/16/2019	Roots	50.00	Medium	ROOTS AT THE CLEANOUT CONNECTION
D23-2108-D23-2107	606129	2/14/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-3040-H16-3038	606916	1/3/2020	Belly or Sag	80.00	Minor (<10%)	
G16-4084-G16-4083	606774	9/17/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1096-L17-1054	606601	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1096-L17-1054	606601	7/22/2019	Worn Surface	80.00	Minor	
L17-1096-L17-1054	606601	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1096-L17-1054	606601	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2018-J17-2009	607509	8/19/2020	Obstruction or Intrusion	80.00	Minor	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J17-2018-J17-2009	607509	8/19/2020	Belly or Sag	80.00	Minor (<10%)	
J16-1012-J16-1094	607027	2/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3024-G16-3023	606200	2/28/2019	Roots	50.00	Medium	Roots in the side service connection about 97 ft
J19-3110-J19-3109	607995	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3009-H15-2004	604860	8/21/2017	Maintenance Condition	70.00	Heavy	
G16-4038-G16-4037	606744	9/11/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3021C-G16-3020	606382	1/16/2019	Roots	0.00	Blockage	ROOTS IN LATERAL AND MAIN AT 100 FT BLOCKAGE END CLEAOUT IS FULL OF ROOTS ALSO
L17-1027-L17-1026	607912	1/21/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1027-L17-1026	607912	1/21/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1027-L17-1026	607912	1/21/2021	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Lining or Repair Failure	80.00	Minor	
H16-1054-H16-1017	606363	1/16/2019	Roots	80.00	Light	ROOTS IN THE MANHOLE AND HANGING INTO THE SEWER MAIN
G16-3020-G16-3019	606226	1/16/2019	Roots	30.00	Heavy	ROOTS FROM 65 TO 109 FEET ALMOST BLOCKING NEEDS CUT AND TREATMENT VERY SOON
G16-3020-G16-3019	606226	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
L17-1038-L17-1003	606609	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1038-L17-1003	606609	7/23/2019	Worn Surface	80.00	Minor	
L17-1038-L17-1003	606609	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1038-L17-1003	606609	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-4077-G16-4076	606672	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
G15-3013-G15-3012	606062	1/24/2019	Roots	30.00	Heavy	Roots in drop m/h G15-3012
G21-2029-G21-2028	605371	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
L18-3011-L18-3010	607764	10/22/2020	Roots	50.00	Medium	ROOTS IN THE MANHOLE L18-3010
H16-2016-H16-2015	606494	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-4050-H16-4049	606217	3/28/2019	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3010-G16-3073	606279	1/16/2019	Roots	50.00	Medium	ROOTS IN THE SHELF OF MANHOLE G16-3073
H16-4002-H16-4001	606287	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1003-L17-1002	606610	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1003-L17-1002	606610	7/23/2019	Worn Surface	80.00	Minor	
L17-1003-L17-1002	606610	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1003-L17-1002	606610	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-2006-J16-2005	605898	9/25/2018	Belly or Sag	80.00	Minor (<10%)	
H16-2088-H16-2087	607113	2/24/2020	Roots	80.00	Light	ROOTS IN MANHOLE H16-2087
J16-1047-J16-1046	606617	7/29/2019	Roots	80.00	Light	ONE LARGE ROOT AT 22.5 FT
H16-3011-H16-3010	606944	1/7/2020	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-3011-H16-3010	606944	1/7/2020	Belly or Sag	80.00	Minor (<10%)	
H16-3011-H16-3010	606944	1/7/2020	Lining or Repair Failure	60.00	Moderate	
H16-3011-H16-3010	606944	1/7/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L18-4038-L18-4036	607956	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H15-2002-H15-2001	607107	2/20/2020	Roots	50.00	Medium	Roots in the manhole needs treatment manhole 2001
A28-3029-A28-3018	607331	7/8/2020	Roots	80.00	Light	71FT FROM TOP MANHOLE
H16-2003-H16-2004	606424	6/10/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2003-H16-2004	606424	6/10/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-3030-G16-3029	606195	2/28/2019	Roots	80.00	Light	Roots all along the pipe treat whole line
G16-3030-G16-3029	606195	2/28/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-4046-H17-4045	606820	10/9/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-4046-H17-4045	606820	10/9/2019	Obstruction or Intrusion	60.00	Moderate	
H16-1033-H16-1026	606137	2/20/2019	Roots	80.00	Light	
H16-1033-H16-1026	606137	2/20/2019	Cracks or Fractures	80.00	Minor Cracking	
B28-4019-B28-4018	607333	7/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
B28-4019-B28-4018	607333	7/8/2020	Obstruction or Intrusion	60.00	Moderate	
B28-4019-B28-4018	607333	7/8/2020	Cracks or Fractures	60.00	Moderate Cracking	
B28-4019-B28-4018	607333	7/8/2020	Lining or Repair Failure	80.00	Minor	
B28-4019-B28-4018	607333	7/8/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B28-4013-B28-4012	607360	7/15/2020	Lining or Repair Failure	60.00	Moderate	
L17-1069-L17-1068	607773	10/26/2020	Roots	50.00	Medium	ROOTS 5 FT FROM THE TOP OF THE RUN JUST INSIDE THE M/H ROOTS IN THE SIDE SERVICE AT THE LATERAL 88FT
G16-3073-G16-3078	606280	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE G16-3078
L15-2010-L15-2009	607698	10/12/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G15-3012-G15-3050	606070	1/30/2019	Roots	30.00	Heavy	Roots in both M/Hs upper and lower
H17-3078-H17-3077	606403	6/5/2019	Cracks or Fractures	80.00	Minor Cracking	
G15-2026-G15-2025	606259	4/17/2019	Belly or Sag	80.00	Minor (<10%)	
G15-3010-G15-3009	606073	1/30/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	606786	9/30/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	606786	9/30/2019	Break or Failure	15.00	Hole Void Visible	
H16-1015-H16-1044	606374	1/16/2019	Roots	80.00	Light	ROOTS IN M/H H16-1044
H15-2023-H15-2032	606964	1/8/2020	Inflow and Infiltration	60.00	Running or Trickling	
H15-2023-H15-2032	606964	1/8/2020	Cracks or Fractures	80.00	Minor Cracking	
L18-4036-L18-4037	607958	2/3/2021	Inflow and Infiltration	60.00	Running or Trickling	
M18-4012-M18-4011	607844	12/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3085-H17-3012	606419	6/6/2019	Roots	80.00	Light	ROOT IN MANHOLE H17-3-85 ON THE SHELF
G16-4074-G16-4075	606725	8/19/2019	Belly or Sag	80.00	Minor (<10%)	
H17-3039-H17-3037	606469	6/13/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3039-H17-3037	606469	6/13/2019	Break or Failure	15.00	Hole Void Visible	
J16-4021-J16-4022	607130	2/26/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4021-J16-4022	607130	2/26/2020	Obstruction or Intrusion	60.00	Moderate	
J16-4021-J16-4022	607130	2/26/2020	Worn Surface	60.00	Moderate	
J16-4021-J16-4022	607130	2/26/2020	Lining or Repair Failure	60.00	Moderate	
H16-1038-H16-1037	606379	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-3075-G16-3074	606272	1/16/2019	Worn Surface	60.00	Moderate	
G16-3075-G16-3074	606272	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
G16-3075-G16-3074	606272	1/16/2019	Break or Failure	15.00	Hole Void Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3013-G16-3012	606237	1/16/2019	Roots	80.00	Light	ROOTS AT 200 FT AND IN LOWER MH 3012
G16-3013-G16-3012	606237	1/16/2019	Worn Surface	60.00	Moderate	
G16-4069-G16-4066	606674	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
L18-3031-L18-3029	607810	12/10/2020	Belly or Sag	80.00	Minor (<10%)	
J11-3061-J11-3060	607467	8/11/2020	Worn Surface	60.00	Moderate	
J11-3061-J11-3060	607467	8/11/2020	Cracks or Fractures	60.00	Moderate Cracking	
J11-3061-J11-3060	607467	8/11/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
A28-3004-A28-3002	607168	3/9/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-4012-J16-4011	606625	7/29/2019	Roots	50.00	Medium	ROOTS RIGHT OUTSIDE THE MANHOLE
G15-3003-G15-3002	606056	1/24/2019	Roots	0.00	Blockage	Roots in sand collar
G16-2027-G16-2011	606304	1/16/2019	Roots	50.00	Medium	ROOTS AT 197
H15-2001-LS-34	607108	2/20/2020	Roots	50.00	Medium	Roots in manhole 2001
H17-3040-H17-3039	606468	6/13/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2073-H16-2115	606500	6/25/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-4033-J16-4032	606970	1/9/2020	Inflow and Infiltration	60.00	Running or Trickling	
G16-3042-G16-3041	606224	1/16/2019	Roots	50.00	Medium	ROOTS IN THE SIDE SERVICE CONNECTION AT 17 FEET FROM UPPER MANHOLE
K18-3108-L18-4036	607957	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
L14-3014-L14-3001	607705	10/13/2020	Roots	50.00	Medium	ROOTS IN MANHOLE L14-3001
J20-3063C-J20-3061	607723	10/19/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
M17-4007-M17-4006	605453	6/26/2018	Belly or Sag	80.00	Minor (<10%)	
J16-4018-J16-4017	606622	7/29/2019	Roots	80.00	Light	ROOTS IN LATERAL AT REPAIR 260.7 FT
J11-4017-J11-4010	606979	1/10/2020	Roots	50.00	Medium	ROOTS AT 159 IN A SIDE SERVICE CONNECTION NOT BLOCKING
J11-4017-J11-4010	606979	1/10/2020	Worn Surface	40.00	Severe	
J11-4017-J11-4010	606979	1/10/2020	Break or Failure	15.00	Hole Void Visible	
J11-4017-J11-4010	606979	1/10/2020	Lining or Repair Failure	40.00	Severe	
G21-2014-G21-2002	605379	5/10/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2085-D23-2083	606418	6/6/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-2007-J16-2006	605899	9/25/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2028-G21-2026	605373	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
G21-2028-G21-2026	605373	5/10/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-1030-H16-1029	606136	2/19/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-4049-H16-4047	606218	3/28/2019	Roots	50.00	Medium	H16-4047 Roots at section joint/ wall.
H16-2110-H16-2071	606531	6/27/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3049-J11-3108	604831	8/24/2017	Maintenance Condition	90.00	Light	
J11-3049-J11-3108	604831	8/24/2017	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3049-J11-3108	604831	8/24/2017	Worn Surface	80.00	Minor	
J11-3049-J11-3108	604831	8/24/2017	Cracks or Fractures	80.00	Minor Cracking	
J11-3049-J11-3108	604831	8/24/2017	Lining or Repair Failure	80.00	Minor	
H16-3033-H16-3032	606924	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3031-H17-3030	606475	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-3031-H17-3030	606475	6/20/2019	Break or Failure	30.00	Hole Soil Visible	
H16-3078-H16-3063	607005	1/21/2020	Worn Surface	40.00	Severe	
H16-3078-H16-3063	607005	1/21/2020	Cracks or Fractures	40.00	Severe Cracking	
H16-3078-H16-3063	607005	1/21/2020	Break or Failure	0.00	Collapse	
L18-4051-L18-4050	607967	2/5/2021	Inflow and Infiltration	60.00	Running or Trickling	
L18-4051-L18-4050	607967	2/5/2021	Cracks or Fractures	80.00	Minor Cracking	
L14-3005-LS-14	607924	1/27/2021	Lining or Repair Failure	40.00	Severe	
L14-3005-LS-14	607924	1/27/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-1077-J16-1033	606907	12/26/2019	Belly or Sag	80.00	Minor (<10%)	
G16-2021-G16-2020	606297	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE 2021 SAND COLLAR
M16-1033-M16-1032	605598	7/2/2018	Inflow and Infiltration	60.00	Running or Trickling	
G16-1057-G16-1013	606249	4/17/2019	Roots	50.00	Medium	At sand collar of G16-1013. Root cut this date.
H17-1026-H17-1021	607555	8/28/2020	Roots	50.00	Medium	ROOTBALL IN M/H H17-1027
G15-3014-G15-3051	606048	1/23/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
J18-2010-J18-2009	606593	5/13/2019	Roots	50.00	Medium	J18-2009 SAND COLLAR, SHELF & WALL

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L17-1092-L17-1076	607918	1/21/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L1`7-1092
J16-1072-J16-1071	607044	2/11/2020	Roots	50.00	Medium	ROOTS AT 136 FT IN A JOINT
M18-4051-M18-4040	607854	12/22/2020	Belly or Sag	80.00	Minor (<10%)	
L18-4023-L18-4022	607768	10/22/2020	Belly or Sag	80.00	Minor (<10%)	
G16-3014-G16-3013	606238	1/16/2019	Roots	80.00	Light	ROOTS IN THE LOWER SAND COLLAR
G16-3014-G16-3013	606238	1/16/2019	Worn Surface	60.00	Moderate	
L14-CAP-L14-3015	607703	10/13/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J16-1025-J16-1022	607016	1/24/2020	Roots	50.00	Medium	ROOTS IN SAND COLLAR OF M'H J16-1022
H17-1007-H17-1006	607437	7/30/2020	Roots	80.00	Light	ROOTS AT SAND COLLAR @ IN FLOW H17-1007
H16-1062-H16-1033	606134	2/19/2019	Roots	50.00	Medium	Roots at 49 and 73 ft from the upper manhole
H16-1062-H16-1033	606134	2/19/2019	Cracks or Fractures	80.00	Minor Cracking	
G21-2016-G21-2014	605426	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2016-G21-2014	605426	5/10/2018	Worn Surface	80.00	Minor	
G21-2016-G21-2014	605426	5/10/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2016-G21-2014	605426	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
G16-4106-G16-4105	606675	8/8/2019	Worn Surface	60.00	Moderate	
G16-4106-G16-4105	606675	8/8/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4027-G16-4026	606781	9/30/2019	Break or Failure	15.00	Hole Void Visible	
G16-2007-G16-2006	606318	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1036-L17-1035	607890	1/11/2021	Break or Failure	30.00	Hole Soil Visible	
H15-4040-H15-4037	606115	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2048-H16-2047	606543	6/28/2019	Roots	30.00	Heavy	ROOTS IN BOTH SAND COLLARS OF H16-2048
L18-3016-L18-3015	607814	12/10/2020	Roots	50.00	Medium	ROOTS IN THE LATERAL AND ALSO THE JOINT AT 110.2 FT
J11-3108-J11-3048	604832	8/24/2017	Maintenance Condition	90.00	Light	
J11-3108-J11-3048	604832	8/24/2017	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3108-J11-3048	604832	8/24/2017	Worn Surface	80.00	Minor	
J11-3108-J11-3048	604832	8/24/2017	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3061-J20-3060	607724	10/19/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J20-3060
G16-1050-G16-1046	605800	9/13/2018	Belly or Sag	80.00	Minor (<10%)	
H16-2049-H16-2048	606542	6/28/2019	Roots	30.00	Heavy	ROOTS IN MANHOLE H16-2048 BOTH SAND COLLARS
H16-4012-H16-4011	606855	11/13/2019	Roots	50.00	Medium	ROOTS IN MANHOLE OR POSSIBLY SANDCOLLAR IN MH H16-4011
J19-3112-J19-3111	607993	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-3017-L18-3016	607813	12/10/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L18-3016
F16-2021-F16-2020	605729	8/21/2018	Obstruction or Intrusion	60.00	Moderate	
F16-2021-F16-2020	605729	8/21/2018	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L18-4048-L18-4047	607972	2/5/2021	Roots	50.00	Medium	ROOTS IN MANHOLE L18-4047
H15-4041-H15-4040	606114	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
H17-2011-H17-2010	606588	7/10/2019	Obstruction or Intrusion	60.00	Moderate	
G15-3009-G15-3008	606074	1/30/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-1026-B28-1025	607149	3/4/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2091-D23-2090	604828	8/24/2017	Worn Surface	80.00	Minor	
D23-2091-D23-2090	604828	8/24/2017	Belly or Sag	80.00	Minor (<10%)	
D23-2091-D23-2090	604828	8/24/2017	Lining or Repair Failure	80.00	Minor	
H17-4042-LS-35	606836	10/21/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2081-H16-2080	606547	6/28/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2007-H16-2008	606537	6/28/2019	Roots	50.00	Medium	ROOTS AT 106 AND 227 ALSO AT M/H 22008 IN THE CLEAN OUT
H16-2007-H16-2008	606537	6/28/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-1016-H17-1014	607384	7/22/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4027-B28-4024	607238	5/21/2020	Belly or Sag	80.00	Minor (<10%)	
L18-3010-L18-3009	607763	10/22/2020	Roots	50.00	Medium	ROOTS IN THE MANHOLE L18-3009

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
M15-1001-L15-2007	607693	10/12/2020	Roots	50.00	Medium	ROOTS IN THE JOINTS CONNECTIONS AT 128 AND 153 ALSO ROOTS IN THE LATERS AT 83 AND 36
M15-1001-L15-2007	607693	10/12/2020	Cracks or Fractures	60.00	Moderate Cracking	
M15-1001-L15-2007	607693	10/12/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2093C-H16-2017	606533	6/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2093C-H16-2017	606533	6/27/2019	Break or Failure	15.00	Hole Void Visible	
M15-1010-M15-1006	607750	10/21/2020	Roots	50.00	Medium	ROOTS IN JOINT AT 143
G16-1034-G16-1033	605806	9/17/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2031-J17-2030	607530	8/24/2020	Break or Failure	30.00	Hole Soil Visible	
B28-4060-B28-4090	607228	5/20/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF B28-4060
B28-4035-B28-4034	607298	6/24/2020	Roots	50.00	Medium	AT 195 FT CARRIES ON FOR 13 FEET
B28-4035-B28-4034	607298	6/24/2020	Cracks or Fractures	60.00	Moderate Cracking	
B28-4035-B28-4034	607298	6/24/2020	Lining or Repair Failure	60.00	Moderate	
G16-4026-G16-4018	606752	9/12/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4026-G16-4018	606752	9/12/2019	Break or Failure	30.00	Hole Soil Visible	
M17-1015-M17-1014	607824	12/14/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2019-G21-2018	605376	5/10/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2019-G21-2018	605376	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
J16-2008-J16-2011	606050	1/24/2019	Roots	50.00	Medium	
L18-4045-L18-4038	607955	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H16-4004-H16-4003	606216	3/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
A28-3041-A28-3040	607315	7/2/2020	Roots	30.00	Heavy	ROOTS IN SIDE SERVICE ABOUT 30 FT FROM THE MAIN. CONTACTED HOME OWNER AT 1183 PENNSYLVANIA AND RECOMMENDED HE GET A PLUMBER CLEAN OUTS ARE NOT EASILY ACCESSED
J19-2083-J19-2082	607945	2/2/2021	Roots	50.00	Medium	
H16-3010-H16-3009	606949	1/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3010-H16-3009	606949	1/8/2020	Worn Surface	80.00	Minor	
H16-3010-H16-3009	606949	1/8/2020	Lining or Repair Failure	80.00	Minor	
G21-2033-G21-2007	605427	6/18/2018	Belly or Sag	80.00	Minor (<10%)	
G16-4009-G16-4007	606783	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-1062-J16-1059	606583	7/9/2019	Roots	80.00	Light	ROOTS IN LATERAL JOINT 52.5FT
J16-1062-J16-1059	606583	7/9/2019	Break or Failure	15.00	Hole Void Visible	
L18-3014-L18-3021	607819	12/14/2020	Roots	80.00	Light	ROOTS IN THE CONNECTION 105'
G16-3076-G16-3075	606271	1/16/2019	Roots	80.00	Light	ROOTS STARTING TO APPEAR IN THE SAND COLLAR G16-3075
K10-1074-K10-1007	605411	6/4/2018	Obstruction or Intrusion	60.00	Moderate	
K10-1074-K10-1007	605411	6/4/2018	Lining or Repair Failure	60.00	Moderate	
K10-1074-K10-1007	605411	6/4/2018	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1062-L17-1058	607966	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1062-L17-1058	607966	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3084-J11-3083	606281	4/22/2019	Worn Surface	60.00	Moderate	
J11-3084-J11-3083	606281	4/22/2019	Cracks or Fractures	60.00	Moderate Cracking	
J11-3084-J11-3083	606281	4/22/2019	Break or Failure	30.00	Hole Soil Visible	
J11-3084-J11-3083	606281	4/22/2019	Lining or Repair Failure	60.00	Moderate	
G21-2026-G21-2018	605374	5/10/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2026-G21-2018	605374	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
H16-1040-H16-1002	606570	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4054-H17-1043	607343	7/9/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4018-L17-1069	607793	10/30/2020	Roots	30.00	Heavy	HEAVY ROOTS BETWEEN 267 AND 318 WITH ROOTS IN THE DROP
H15-1068C-H15-1042	605851	10/4/2018	Obstruction or Intrusion	80.00	Minor	
H15-1040-H15-1037	605856	10/5/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3029-G16-3028	606196	2/28/2019	Belly or Sag	40.00	Severe (>30%)	
G21-2021-G21-2020	605431	6/18/2018	Obstruction or Intrusion	60.00	Moderate	
H16-2084-H16-2083	607088	2/18/2020	Roots	80.00	Light	ROOTS AT 48FT FROM THE TOP END MANHOLE
H16-3017-H16-3016	606938	1/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3017-H16-3016	606938	1/6/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
B28-4020-B28-4011	607294	6/11/2020	Belly or Sag	80.00	Minor (<10%)	
G16-1010-G16-1072	606107	2/6/2019	Roots	80.00	Light	Roots in sand collar G16=1010
H16-1006-H16-1005	606045	1/22/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
D23-2113-D23-2112	604818	8/23/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2113-D23-2112	604818	8/23/2017	Cracks or Fractures	80.00	Minor Cracking	
H16-1036-H16-1035	606138	2/20/2019	Roots	30.00	Heavy	Roots at 9' 182,227,238,294 from upper m/h
H16-1036-H16-1035	606138	2/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H15-4004-H15-4003	606128	2/8/2019	Roots	50.00	Medium	Roots just inside at 7 feet
M18-4036-M18-4035	607872	1/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1023-K10-1020	606201	3/4/2019	Roots	30.00	Heavy	Roots at 10ft,21ft,45ft,48ft,50ft,105ft, 106ft, 130ft, 147ft
K10-1023-K10-1020	606201	3/4/2019	Cracks or Fractures	60.00	Moderate Cracking	
K10-1023-K10-1020	606201	3/4/2019	Break or Failure	15.00	Hole Void Visible	
H17-3003-H17-3002	606471	6/19/2019	Roots	50.00	Medium	ROOTS AT 105FT TO 110 FT
L17-1035-L17-4004	607892	1/11/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-3114-J19-3107	608000	3/2/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
H17-1009-H17-1008	607433	7/30/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1056-L17-1055	606599	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1056-L17-1055	606599	7/23/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1056-L17-1055	606599	7/23/2019	Worn Surface	80.00	Minor	
L17-1056-L17-1055	606599	7/23/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1056-L17-1055	606599	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-2029-G16-2011	606305	1/16/2019	Roots	30.00	Heavy	HEAVY ROOTS AT 230.5
H15-4017-H15-4016	604858	9/5/2017	Belly or Sag	80.00	Minor (<10%)	
H16-2020-H16-2018	606480	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2020-H16-2018	606480	6/20/2019	Break or Failure	15.00	Hole Void Visible	
H16-2017-H16-2016	606495	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-2057-H16-2056	606502	6/25/2019	Roots	80.00	Light	ROOTS IN MANHOLE H16-2056
J19-2082-J19-2041	607944	2/2/2021	Roots	50.00	Medium	ROOTS IN MANHOLE J19-2082

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
M18-4002-M18-4001	607881	1/6/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
G21-2039-G21-2001	605432	6/18/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1068-L17-1067	607796	11/2/2020	Roots	30.00	Heavy	HEAVY ROOTS FROM 27FT TO 317FT
M15-1011-M15-1010	607748	10/21/2020	Roots	30.00	Heavy	ROOTS IN LATERAL AT 145FT
G16-3037-G16-3034	606192	2/28/2019	Roots	0.00	Blockage	Roots in side service 95 feet from m/h
G21-2024-G21-2023	605404	5/17/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2079-J19-2012	607939	2/1/2021	Break or Failure	30.00	Hole Soil Visible	
J16-4013-J16-4012	606624	7/29/2019	Roots	50.00	Medium	ROOTS RIGHT OUTSIDE THE MANHOLE
G16-4055-G16-4054	606758	9/16/2019	Roots	50.00	Medium	ROOTS IN THE M/H G16-4053
G16-4055-G16-4054	606758	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4021-G16-4019	606755	9/12/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4021-G16-4019	606755	9/12/2019	Cracks or Fractures	80.00	Minor Cracking	
L18-4011-L18-4012	606233	4/3/2019	Roots	80.00	Light	ROOTS AT 106 IN THE JOINT
L18-4011-L18-4012	606233	4/3/2019	Belly or Sag	80.00	Minor (<10%)	
G21-2034C-G21-2029	605372	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2034C-G21-2029	605372	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
H16-2008-H16-2009	606486	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2008-H16-2009	606486	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-2006-G16-2005	606319	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE 2006 ON THE SHELF
J20-3004-J20-3003	607607	9/25/2020	Roots	50.00	Medium	ROOTS IN LATERAL CONNECTIONS AT 14FT, 108FT, 111FT
L16-2027-L16-2026	605524	7/2/2018	Obstruction or Intrusion	80.00	Minor	
G16-4037-G16-4036	606765	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
M18-1006-M18-4057	607738	10/20/2020	Belly or Sag	80.00	Minor (<10%)	
J16-4024-J16-4038	607070	2/18/2020	Worn Surface	80.00	Minor	
J16-4024-J16-4038	607070	2/18/2020	Lining or Repair Failure	80.00	Minor	
G16-4065-G16-4060	606732	9/10/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3016-G16-3015	606231	1/16/2019	Roots	50.00	Medium	ROOTS IN VARIOUS PLACES WHERE PIPE HAS ERODED
G16-3016-G16-3015	606231	1/16/2019	Inflow and Infiltration	40.00	Gushing or Spurting	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3016-G16-3015	606231	1/16/2019	Worn Surface	40.00	Severe	
G16-3016-G16-3015	606231	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
G16-3016-G16-3015	606231	1/16/2019	Break or Failure	15.00	Hole Void Visible	
G16-3016-G16-3015	606231	1/16/2019	Lining or Repair Failure	40.00	Severe	
H16-2070-H16-2069	606510	6/26/2019	Roots	0.00	Blockage	HEAVY ROOTS IN M/H H16-2070
H16-1002-H16-1019	606380	1/16/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G16-4029-G16-4028	606750	9/12/2019	Roots	80.00	Light	VERY SMALL BIT OF ROOTS AND THE END OF THE RUN81 FT FROM THE TOP END
G16-4029-G16-4028	606750	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-3064-H16-3063	606992	1/16/2020	Worn Surface	60.00	Moderate	
H16-3064-H16-3063	606992	1/16/2020	Obstruction or Intrusion	60.00	Moderate	
H16-3064-H16-3063	606992	1/16/2020	Cracks or Fractures	60.00	Moderate Cracking	
H16-3064-H16-3063	606992	1/16/2020	Break or Failure	0.00	Collapse	
G16-2023C-G16-2021	606295	1/16/2019	Roots	50.00	Medium	ROOTS IN THE CLEAN OUT 2023C
J17-2035-J17-2032	607480	8/17/2020	Roots	50.00	Medium	
H16-2071-H16-2070	606532	6/27/2019	Roots	30.00	Heavy	ROOTS IN THE MANHOLE H16-2070 HEAVY ROOTS
M15-1003-M15-1002	607754	10/21/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF M/HOLE M15-1002
G21-2027-G21-2026	605375	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3038-J11-3037	606698	8/13/2019	Roots	30.00	Heavy	HEAVY ROOTS THROUGHOUT THE WHOLE MAIN, MOST LATERALS HAVE ROOTS IN THEM ALSO
J11-3038-J11-3037	606698	8/13/2019	Obstruction or Intrusion	60.00	Moderate	
J11-3038-J11-3037	606698	8/13/2019	Belly or Sag	80.00	Minor (<10%)	
J11-3038-J11-3037	606698	8/13/2019	Cracks or Fractures	80.00	Minor Cracking	
J11-3038-J11-3037	606698	8/13/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
M15-1005-M15-1004	607752	10/21/2020	Roots	80.00	Light	ROOTS 1 FOOT FROM THE TOP OF THE PIPE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B28-1037-B28-1036	607272	6/2/2020	Roots	50.00	Medium	ROOTS IN MANHOLE B28-1036
J16-4001-LS-11	606637	7/31/2019	Worn Surface	80.00	Minor	
J16-4001-LS-11	606637	7/31/2019	Lining or Repair Failure	80.00	Minor	
H17-2013-H17-2012	606560	7/8/2019	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR H17-2012
G16-4058-G16-4057	606764	9/16/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2118C-H16-2117	606876	11/27/2019	Roots	50.00	Medium	ROOTS IN MH G16-2118C
J16-4036-J16-4035	606966	1/9/2020	Inflow and Infiltration	60.00	Running or Trickling	
H17-3033-H17-3032	606474	6/19/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3033-H17-3032	606474	6/19/2019	Break or Failure	15.00	Hole Void Visible	
H17-3033-H17-3032	606474	6/19/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-2012-H17-2011	606561	7/8/2019	Roots	50.00	Medium	ROOTS IN THE SIDE SERVICE 223FT
G16-3039-G16-3038	606222	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
M18-4021-M18-4014	607864	1/4/2021	Belly or Sag	80.00	Minor (<10%)	
J19-2046-J19-2010	607937	2/1/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J19-2010
G16-2032-G16-2031	606303	1/16/2019	Roots	50.00	Medium	ROOTS AT 123 AND 136
G21-2009-G21-2008	605415	6/5/2018	Belly or Sag	80.00	Minor (<10%)	
G16-2018-G16-2017	606110	2/6/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4009-L18-4008	604848	8/28/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4009-L18-4008	604848	8/28/2017	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4009-L18-4008	604848	8/28/2017	Cracks or Fractures	40.00	Severe Cracking	
L18-4009-L18-4008	604848	8/28/2017	Lining or Repair Failure	80.00	Minor	
L18-4009-L18-4008	604848	8/28/2017	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-3041-H16-3040	606915	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J17-4030-J17-4029	607462	8/11/2020	Roots	80.00	Light	NECK, SECTION JOINT AND SAND COLLAR J17-4030.
G21-2023-G21-2020	605430	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
J16-1081-H16-2110	606529	6/27/2019	Belly or Sag	40.00	Severe (>30%)	
G21-2020-G21-2019	605377	5/10/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2020-G21-2019	605377	5/10/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G21-2017-G21-2016	605425	5/10/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2017-G21-2016	605425	5/10/2018	Obstruction or Intrusion	80.00	Minor	
G21-2017-G21-2016	605425	5/10/2018	Worn Surface	80.00	Minor	
G21-2017-G21-2016	605425	5/10/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2017-G21-2016	605425	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
G21-2017-G21-2016	605425	5/10/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G15-3050-G15-3011	606071	1/30/2019	Roots	0.00	Blockage	Roots at 80 ft from the upper m/h
H16-2022-H16-2021	606489	6/24/2019	Obstruction or Intrusion	60.00	Moderate	
H16-2022-H16-2021	606489	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-2022-H16-2021	606489	6/24/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-1036-J16-1035	606909	12/26/2019	Lining or Repair Failure	80.00	Minor	
J16-1036-J16-1035	606909	12/26/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1088C-L17-1087	607886	1/8/2021	Roots	50.00	Medium	
L17-1088C-L17-1087	607886	1/8/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1088C-L17-1087	607886	1/8/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1043-L17-1038	606608	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1043-L17-1038	606608	7/23/2019	Worn Surface	80.00	Minor	
L17-1043-L17-1038	606608	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1043-L17-1038	606608	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4037-H15-4036	606116	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
G16-3061-G16-3062	606345	1/16/2019	Obstruction or Intrusion	80.00	Minor	
M15-1007-M15-1006	607749	10/21/2020	Roots	30.00	Heavy	ROOTS AT VARIOUS POINTS TREAT WHOLE LINE
M15-1007-M15-1006	607749	10/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
M15-1007-M15-1006	607749	10/21/2020	Cracks or Fractures	80.00	Minor Cracking	
L18-3041-L18-3040	607801	11/2/2020	Roots	80.00	Light	ROOTS AT LATERAL 144.6
B28-4026-B28-4025	607243	5/26/2020	Roots	0.00	Blockage	HEAVY ROOTS IN LATERAL AT 95.5 FEET T3
H21-4005-H21-4004	605395	5/16/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M15-1033-M15-1012	607746	10/21/2020	Roots	80.00	Light	ROOTS ON THE SHELF OF M/H M15-1012
J17-4006-J17-4005	607475	8/12/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3076-J20-3075	607619	9/29/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF J20-3075
G21-2003-G21-2002	605424	6/6/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2003-G21-2002	605424	6/6/2018	Worn Surface	80.00	Minor	
G16-3070-G16-3062	606325	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L15-2012-L15-2011	607691	10/9/2020	Roots	50.00	Medium	ROOTS IN THE SANDCOLLAR AND SHELF OF 15-2011
H16-2111-H16-2058	606520	6/27/2019	Roots	50.00	Medium	ROOTS IN MANHOLE H16-2111
G16-4112-G16-4111	606789	9/30/2019	Roots	50.00	Medium	ROOTS AT 220 AND 240 FROM LOWER M/H
G16-4112-G16-4111	606789	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4112-G16-4111	606789	9/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4112-G16-4111	606789	9/30/2019	Lining or Repair Failure	60.00	Moderate	
G15-2023-G15-2015	606261	4/17/2019	Worn Surface	60.00	Moderate	
G16-4090-G16-4089	606670	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
H15-4007-LS-33	606034	1/16/2019	Roots	0.00	Blockage	Rootball just inside the sand collar down stream
H15-4003-H15-4002	606119	2/7/2019	Roots	80.00	Light	Roots in the sand collar
H16-3063-H16-3062	607006	1/21/2020	Belly or Sag	80.00	Minor (<10%)	
L14-3001-L14-3002	607707	10/13/2020	Roots	50.00	Medium	ROOTS IN MANHOLE L14-3001
J17-4031-J17-4021	607471	8/12/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1026-L17-1022	607902	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
M17-4008-M17-4007	605452	6/26/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2092C-H16-2022	606488	6/24/2019	Roots	50.00	Medium	ROOTS AT 92.5 AND 142
H16-2092C-H16-2022	606488	6/24/2019	Cracks or Fractures	60.00	Moderate Cracking	
H16-2092C-H16-2022	606488	6/24/2019	Break or Failure	15.00	Hole Void Visible	
M18-4023-M18-4022	607861	12/23/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1016-L17-1015	607908	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1016-L17-1015	607908	1/14/2021	Cracks or Fractures	80.00	Minor Cracking	
A28-3036-A28-3035	607309	6/30/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J16-1004-J16-1001	607051	2/11/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR J16-1001

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-2033-G16-2032	606301	1/16/2019	Roots	30.00	Heavy	ROOTS IN A LATERAL AT 135 TREAT LINE FROM UPPER MANHOLE AT 115 TO 140
G16-3026-G16-3025	606197	2/28/2019	Roots	0.00	Blockage	Blockage in side service did a dye test and talked to the owner blockage at 200 ft
M15-1002-M15-1001	607755	10/21/2020	Roots	50.00	Medium	ROOTS IN THE DROP
J16-1058-J16-1056	606574	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
M18-4013-M18-4012	607843	12/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H21-1004-H21-1003	605405	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2028-G16-2027	606312	1/16/2019	Roots	30.00	Heavy	ROOTS IN MANHOLE 2028
L17-1042C-L17-1041	607920	1/21/2021	Roots	50.00	Medium	ROOTS IN THE FIRST 50 FEET
L17-1042C-L17-1041	607920	1/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1042C-L17-1041	607920	1/21/2021	Cracks or Fractures	80.00	Minor Cracking	
L15-2016-L15-2015	607689	10/9/2020	Roots	50.00	Medium	ROOTS IN THE SHELF OF L15-2015
G16-2031-G16-2029	606300	1/16/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4035-H15-4034	606118	2/7/2019	Roots	80.00	Light	Roots in sand collars
H16-3028-H16-3027	606903	12/11/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1092-L17-1038	606302	4/30/2019	Roots	50.00	Medium	ROOTS IN SEVERAL JOINTS 124 AND 329
L17-1092-L17-1038	606302	4/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1086-L17-1017	607889	1/11/2021	Roots	50.00	Medium	ROOTS IN JOINTS AND CRACKS MULTIPLE AREAS 82FT 98 FT AND 103 FT
L17-1086-L17-1017	607889	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1086-L17-1017	607889	1/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1086-L17-1017	607889	1/11/2021	Lining or Repair Failure	80.00	Minor	
L17-1086-L17-1017	607889	1/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H15-2035-H15-2034	606901	12/11/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2018-H16-2014	606482	6/20/2019	Lining or Repair Failure	60.00	Moderate	
K18-3014-LS-1-N	605948	12/3/2018	Belly or Sag	40.00	Severe (>30%)	
M18-4043-M18-4042	607850	12/22/2020	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3043-G16-3042	606223	1/16/2019	Roots	80.00	Light	ROOTS IN THE FIRST 3 FEET OF THE RUN FROM THE TOP MANHOLE
G16-3043-G16-3042	606223	1/16/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-4057-H17-4056	607338	7/9/2020	Belly or Sag	80.00	Minor (<10%)	
G16-2035-G16-2019	606294	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4044-H17-4043	606822	10/9/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4008-J16-4007	606631	7/30/2019	Roots	50.00	Medium	ROOTS AT 237
J16-4008-J16-4007	606631	7/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4057-G16-4055	606759	9/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-4057-G16-4055	606759	9/16/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-3036-H17-3034	606478	6/20/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3036-H17-3034	606478	6/20/2019	Break or Failure	30.00	Hole Soil Visible	
M15-1004-M15-1003	607753	10/21/2020	Roots	50.00	Medium	ROOTS IN THE JOINT AT 114
G16-4098-G16-4002	606800	10/2/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4012-G16-4011	606784	9/30/2019	Roots	80.00	Light	ROOTS IN MANHOLE G16-4012 COMING IN FROM THE RING AND ALSO IN THE SAND COLLAR
H17-1024-H17-1023	607438	7/30/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1087-L17-1086	607887	1/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1087-L17-1086	607887	1/8/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1057-L17-1063	607963	2/4/2021	Roots	80.00	Light	LIGHT ROOTS IN THE TOP OF THE PIPE AT 125 FT
L17-1057-L17-1063	607963	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4089-G16-4088	606671	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4107-G16-4106	606792	10/1/2019	Obstruction or Intrusion	60.00	Moderate	
J16-1017-J16-1016	607018	1/24/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLARS
G16-4102-G16-4100	606770	9/16/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G16-4102-G16-4100	606770	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4102-G16-4100	606770	9/16/2019	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-1085-J16-1012	607026	2/6/2020	Belly or Sag	40.00	Severe (>30%)	
G15-3015-G15-3016	605996	12/26/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J17-1015-J17-2048	607528	8/24/2020	Break or Failure	30.00	Hole Soil Visible	
G16-3017-G16-3016	606230	1/16/2019	Inflow and Infiltration	40.00	Gushing or Spurting	
K18-Cap-K18-3055	604836	8/28/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
G15-3016-G15-3017	605997	11/13/2018	Belly or Sag	80.00	Minor (<10%)	
L17-1089C-L17-1086	607888	1/11/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3033-L18-4045	607954	2/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4038-H15-4037	606125	2/8/2019	Roots	80.00	Light	Roots in side service connections at 7 feet from upper m/h
G16-4017-G16-4009	606782	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1023-H17-1022	607440	7/30/2020	Roots	80.00	Light	ROOTS SAND COLLAR H17-1022
G21-2025-G21-2024	605402	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2025-G21-2024	605402	5/17/2018	Cracks or Fractures	80.00	Minor Cracking	
L17-1017-L17-1016	607907	1/13/2021	Inflow and Infiltration	60.00	Running or Trickling	
J16-4002-J16-4001	606636	7/31/2019	Roots	80.00	Light	ROOTS AT 283 DOWN STREAM
L14-3015-L14-3014	607704	10/13/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF MANHOLE L14-3014
L18-4037-L18-4071	607959	2/3/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4037-L18-4071	607959	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
K18-3016-K18-3106	606202	3/4/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3016-K18-3106	606202	3/4/2019	Lining or Repair Failure	80.00	Minor	
K18-3016-K18-3106	606202	3/4/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2032-H16-2033	606871	11/19/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1007-L17-1006	607922	1/22/2021	Belly or Sag	80.00	Minor (<10%)	
A28-2014-A28-2013	607193	3/17/2020	Roots	0.00	Blockage	ROOTS IN THE LATERAL WITH A BLOCKAGE AT 149FT. ALSO IN THE MANHOLE A28-2013
G16-3048-G16-3047	606678	8/12/2019	Obstruction or Intrusion	80.00	Minor	
G16-3048-G16-3047	606678	8/12/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-2004-J16-2003	605900	9/25/2018	Belly or Sag	80.00	Minor (<10%)	
H17-1017-H17-1013	607389	7/22/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4086-G16-4084	606748	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2094C-H16-2012	606493	6/24/2019	Roots	80.00	Light	ROOTS IN LATERAL CONNECTION
H16-2094C-H16-2012	606493	6/24/2019	Cracks or Fractures	80.00	Minor Cracking	
A28-2026-A28-2010	607148	3/3/2020	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT, AT THE T3 AT 96 FT THERE IS A LARGE ROOT BALL BLOCKING THE CONNECTION
A28-2026-A28-2010	607148	3/3/2020	Cracks or Fractures	80.00	Minor Cracking	
H15-4036-H15-4035	606117	2/7/2019	Roots	80.00	Light	Roots in both sand collars
H16-2009-H16-2010	606485	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2009-H16-2010	606485	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2086-H16-2083	607114	2/24/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
H17-1008-H17-1007	607434	7/30/2020	Roots	80.00	Light	ROOTS AT SAND COLLAR IN FLOW H17--1007
H17-1008-H17-1007	607434	7/30/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1008-H17-1007	607434	7/30/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1003-H17-1002	607577	8/31/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4004-H17-4003	606808	10/3/2019	Roots	50.00	Medium	ROOTS IN M/H H17-4004 AT THE SAND COLLAR
H17-3037-H17-3030	606457	6/13/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2012-H21-1003	605406	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2012-H21-1003	605406	5/17/2018	Obstruction or Intrusion	80.00	Minor	
G21-2012-H21-1003	605406	5/17/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L15-2008-L15-2009	607695	10/12/2020	Roots	80.00	Light	ROOTS AT THE LATERAL NOT BLOCKING
M18-4027-M18-4026	607870	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
B28-4022-B28-4021	607241	5/26/2020	Lining or Repair Failure	80.00	Minor	
J16-4022-J16-4023	607131	2/26/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4022-J16-4023	607131	2/26/2020	Worn Surface	60.00	Moderate	
J16-4022-J16-4023	607131	2/26/2020	Lining or Repair Failure	60.00	Moderate	
L17-1098-L17-1065	607960	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-3025-H16-3023	606930	1/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4031-G16-4029	606749	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-3023-H16-3016	606935	1/6/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3023-H16-3016	606935	1/6/2020	Belly or Sag	80.00	Minor (<10%)	
J19-3109-J19-3108	607997	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2072-H16-2070	606509	6/26/2019	Roots	0.00	Blockage	ROOTS IN H16-2070 BLOCKING ENTANCE AND EXIT
J17-4021-J17-4020	607473	8/12/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J17-2025-J17-2024	607493	8/17/2020	Roots	80.00	Light	J17-2024 WALL
J16-1009-J16-1007	607040	2/10/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1013-H17-1012	607390	7/22/2020	Belly or Sag	80.00	Minor (<10%)	
H16-1021-H16-1020	606568	7/8/2019	Belly or Sag	40.00	Severe (>30%)	
H17-2008-H17-2009	606559	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-2009-LS-37	606563	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1018-H17-1017	607386	7/22/2020	Cracks or Fractures	80.00	Minor Cracking	
L17-1055-L17-1096	606600	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1055-L17-1096	606600	7/22/2019	Worn Surface	80.00	Minor	
L17-1055-L17-1096	606600	7/22/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1055-L17-1096	606600	7/22/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1055-L17-1096	606600	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2024-J17-2023	607483	8/17/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1052-L17-1050	606604	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1052-L17-1050	606604	7/23/2019	Worn Surface	80.00	Minor	
L17-1052-L17-1050	606604	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1052-L17-1050	606604	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2015-G21-2014	605495	7/2/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4007-J16-4027	606653	8/5/2019	Roots	30.00	Heavy	RE TV AFTER ROOT CUT STILL NEEDS MORE CUTTING
G15-2011-G15-2010	606084	2/1/2019	Obstruction or Intrusion	80.00	Minor	
G15-3036-G15-3012	606069	1/30/2019	Roots	0.00	Blockage	Roots in M/H and sand collar
J16-1019-J16-1016	607014	1/24/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF M/H J16-1016
H16-2004-H16-2005	606421	6/6/2019	Roots	30.00	Heavy	ROOTS THROUGH OUT THE LINE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2004-H16-2005	606421	6/6/2019	Belly or Sag	80.00	Minor (<10%)	
M18-4004-M18-4003	607871	1/5/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3069-G16-3068	606235	1/16/2019	Roots	30.00	Heavy	ROOTS AT EVERY SIDE SERVICE TREAT WHOLE PIPE
G16-3069-G16-3068	606235	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3069-G16-3068	606235	1/16/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-3068-G16-3012	606234	1/16/2019	Roots	50.00	Medium	ROOTS IN UPPER AND LOWER MANHOLE
G16-3068-G16-3012	606234	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4100-G16-4099	606797	10/1/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE SECTION JOINTS OF G16-4099
H16-2098-H16-2078	607121	2/25/2020	Roots	50.00	Medium	ROOTS IN BOTH MANHOLE H16-2098 AND 2078
H16-2098-H16-2078	607121	2/25/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-4018C-L17-4004	607893	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-4018C-L17-4004	607893	1/11/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-4027-J16-4006	606654	8/5/2019	Roots	30.00	Heavy	ROOTS 34 FEET FROM THE TOP WILL CUT SIDE SERVICE 8/6/19
H17-2010-LS-37	606562	7/8/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
G15-3008-G15-3007	606256	4/17/2019	Worn Surface	80.00	Minor	
L18-3049-L18-3003	607786	10/27/2020	Belly or Sag	80.00	Minor (<10%)	
J16-4005-J16-4004	606629	7/30/2019	Roots	50.00	Medium	ROOTS AT 35, 273, 275 AND 283 AND 289
J16-4005-J16-4004	606629	7/30/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-4005-J16-4004	606629	7/30/2019	Break or Failure	15.00	Hole Void Visible	
L17-1033-L17-1032	607899	1/12/2021	Roots	80.00	Light	ROOTS JUST INSIDE THE SAND COLLAR OF MANHOLE L17-1032
G15-2020-G15-2019	606257	4/17/2019	Roots	80.00	Light	From top end, 100’
H16-2087-H16-2086	607115	2/24/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
H17-3076-H16-2017	606534	6/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3076-H16-2017	606534	6/27/2019	Break or Failure	15.00	Hole Void Visible	
G16-2034-G16-2009	606309	1/16/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE SAND COLLAR AT G16-2034
H15-2003-H15-2032	607110	2/21/2020	Inflow and Infiltration	60.00	Running or Trickling	
H16-2012-H16-2011	606491	6/24/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1078-L17-1077	607916	1/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1054-L17-1053	606602	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1054-L17-1053	606602	7/22/2019	Worn Surface	80.00	Minor	
L17-1054-L17-1053	606602	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1054-L17-1053	606602	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1041-J16-1044	606612	7/29/2019	Roots	30.00	Heavy	ROOTS AT 1 FT 16 FT AND 73 FT
J16-1041-J16-1044	606612	7/29/2019	Cracks or Fractures	80.00	Minor Cracking	
J11-3039-J11-3037	605984	12/20/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3039-J11-3037	605984	12/20/2018	Cracks or Fractures	80.00	Minor Cracking	
J20-3075-J20-3074	607620	9/29/2020	Roots	50.00	Medium	M/H J20-3074 IN THE SAND COLLAR
J16-1073C-J16-1072	607043	2/11/2020	Cracks or Fractures	80.00	Minor Cracking	
H17-1033-H17-1032	607399	7/27/2020	Belly or Sag	80.00	Minor (<10%)	
G15-3011-G15-3010	606072	1/30/2019	Roots	50.00	Medium	Roots the wall at G15-3011
J16-1055-J16-1054	606576	7/8/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1015-L17-1081	607909	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1048-H17-1011	607393	7/23/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1048-H17-1011	607393	7/23/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-1012-H17-1011	607392	7/23/2020	Break or Failure	30.00	Hole Soil Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-4053-K18-4007	609006	2/3/2022	Roots	50.00	Medium	ROOTS IN STRUCTURE K18-4007
G21-2027-G21-2026	609874	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
G21-2027-G21-2026	609874	11/8/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J20-2002-J20-2001	608801	11/15/2021	Roots	80.00	Light	IN STRUCTURE 2002 AROUND OUTFLOW PIPE
D10-2001-D10-1027	609741	10/4/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1017-L17-1016	607907	1/13/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2046-D23-2042	608186	5/3/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2057-D23-2056	608134	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4071-L17-1058	609532	7/17/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2057-D10-2056	609510	7/6/2022	Cracks or Fractures	80.00	Minor Cracking	
G16-4102-G16-4100	610145	1/18/2023	Obstruction or Intrusion	60.00	Moderate	
H15-4010-H15-4009	610595	8/3/2023	Break or Failure	15.00	Hole Void Visible	
L17-1026-L17-1022	607902	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3049-D23-3032	608201	5/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
M18-4021-M18-4014	607864	1/4/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1015-L17-1081	607909	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2026-J11-3032	608321	5/20/2021	Roots	50.00	Medium	ROOTS AT 15, 27, 29, 36, 45, 55
H16-4003-H16-4002	610359	4/4/2023	Belly or Sag	80.00	Minor (<10%)	
H17-3060-H17-3059	611089	12/28/2023	Roots	80.00	Light	H17-3059
J11-3099-J11-3051	608388	6/10/2021	Obstruction or Intrusion	80.00	Minor	
J11-3099-J11-3051	608388	6/10/2021	Cracks or Fractures	80.00	Minor Cracking	
D10-2054-D10-2053	609507	7/6/2022	Roots	80.00	Light	D10-2053
D10-2054-D10-2053	609507	7/6/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-3106-J11-3072	608426	7/1/2021	Obstruction or Intrusion	80.00	Minor	
J11-3106-J11-3072	608426	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
G15-3036-G15-3012	610466	5/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4015-G16-4013	610128	1/17/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2047C-G16-2004	610448	5/3/2023	Roots	50.00	Medium	
K18-3017-K18-3016	609323	4/27/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L19-4009-L19-4008	610228	2/6/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1035-L17-4004	607892	1/11/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
G15-3014-G15-3051	610256	3/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J19-3109-J19-3108	607997	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4058-G16-4057	610146	1/19/2023	Obstruction or Intrusion	80.00	Minor	
G16-4058-G16-4057	610146	1/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
G15-2019-G15-2018	610393	4/12/2023	Inflow and Infiltration	60.00	Running or Trickling	
D10-2053-D10-2052	609501	6/30/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2053-D10-2052	609501	6/30/2022	Belly or Sag	80.00	Minor (<10%)	
J18-3040-J18-3038	608205	5/5/2021	Roots	50.00	Medium	ROOTS IN STRUCTURE 3038
L17-1010C-L17-1009	608758	10/22/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2078-D23-2077	608082	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3078-J11-3107	608403	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3078-J11-3107	608403	6/22/2021	Roots	50.00	Medium	VARIOUS JOINTS THROUGHOUT MAINLINE.
J11-3078-J11-3107	608403	6/22/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J11-3078-J11-3107	608403	6/22/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3056-J11-3055	608457	7/13/2021	Roots	80.00	Light	
J11-3068-J11-3067	608405	6/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3068-J11-3067	608405	6/22/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3068-J11-3067	608405	6/22/2021	Worn Surface	80.00	Minor	
K18-3069-K18-3002	609352	5/4/2022	Obstruction or Intrusion	80.00	Minor	
F16-3018-F16-3041	610038	12/6/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3057-H17-3056	611072	12/27/2023	Cracks or Fractures	80.00	Minor Cracking	
H17-3057-H17-3056	611072	12/27/2023	Roots	80.00	Light	
H17-3057-H17-3056	611072	12/27/2023	Worn Surface	80.00	Minor	
H16-1062-H16-1033	610457	5/5/2023	Roots	50.00	Medium	ROOTS AT LATERALS
H16-1062-H16-1033	610457	5/5/2023	Cracks or Fractures	80.00	Minor Cracking	
D23-3032-D23-3031	608223	5/6/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K19-1064-K19-1063	609243	4/13/2022	Roots	50.00	Medium	IN DOWNSTREAM STRUCTURE K19-1063
G16-3057-LS-31	610559	7/20/2023	Belly or Sag	80.00	Minor (<10%)	
G21-2024-G21-2023	609877	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4024-D11-4023	609696	9/12/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4024-D11-4023	609696	9/12/2022	Roots	80.00	Light	D11-4024 ROOTS IN MH

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
E23-1006-E23-1005	608087	3/29/2021	Roots	50.00	Medium	SAND COLLAR AND WALL 0F E23-1005
K18-2011-K18-2008	609569	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1078-L17-1077	607916	1/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3063-J11-3058	608525	8/3/2021	Roots	80.00	Light	ON ROOTS LIST
D23-1019-D23-1003	608166	4/27/2021	Roots	80.00	Light	
D23-1019-D23-1003	608166	4/27/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3071-J11-3070	608425	7/1/2021	Roots	80.00	Light	ROOTS AT JOINTS 120'-150', 172'-190', 201', 218'-222' JOINTS
J11-3071-J11-3070	608425	7/1/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3071-J11-3070	608425	7/1/2021	Worn Surface	80.00	Minor	
H15-4036-H15-4035	610513	6/29/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3050-J11-3048	608485	7/20/2021	Roots	80.00	Light	
D11-4061-D11-4060	609618	8/9/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-1020-D23-1019	608156	4/20/2021	Roots	80.00	Light	
J16-4027-J16-4006	610933	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4027-J16-4006	610933	12/1/2023	Roots	80.00	Light	ROOTS IN LATERAL AND JOINTS
J16-4027-J16-4006	610933	12/1/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2012-J19-2011	607941	2/2/2021	Belly or Sag	80.00	Minor (<10%)	
H17-3052-H17-3051	611060	12/20/2023	Break or Failure	30.00	Hole Soil Visible	
H16-3110-H16-3109	610777	9/13/2023	Belly or Sag	80.00	Minor (<10%)	
K18-2027-K18-2025	608890	12/23/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2018-D23-2017	608127	4/8/2021	Roots	50.00	Medium	ROOTS AT 23FT ,34 FT, 201FT, 220FT, 257FT 264FT
L17-1006-L17-1005	608725	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1006-L17-1005	608725	10/18/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2004-H16-2005	611006	12/13/2023	Roots	50.00	Medium	ROOTS IN A COUPLE JOINTS AND LATERAL CONNECTIONS
D23-2093-D23-2090	608061	3/18/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-4023-J11-4026	608465	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2005-K18-2004	609354	5/4/2022	Roots	80.00	Light	K18-2004 ROOTS STARTING TO GROW IN MH

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
F16-3029-F16-3027	610018	12/1/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3058-K18-3057	608731	10/19/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G15-3013-G15-3012	610258	3/8/2023	Roots	30.00	Heavy	DONWSTEAM MAN STRUCTURE
G21-2012-H21-1003	609880	11/8/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1059-L17-1058	609433	6/13/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
G16-1017-G16-1016	610435	4/27/2023	Roots	30.00	Heavy	
L18-4037-L18-4071	607959	2/3/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4037-L18-4071	607959	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2021-H16-2010	611005	12/13/2023	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2021-H16-2010	611005	12/13/2023	Obstruction or Intrusion	80.00	Minor	
H16-2021-H16-2010	611005	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2021-H16-2010	611005	12/13/2023	Cracks or Fractures	40.00	Severe Cracking	
K20-4021-K19-1045	609376	5/24/2022	Roots	80.00	Light	K20-4016 ROOTS AT INFLOW SAND COLLAR
K19-1029-K19-1028	609062	2/15/2022	Roots	80.00	Light	
G16-4016-G16-4015	610117	1/11/2023	Inflow and Infiltration	60.00	Running or Trickling	
G16-4016-G16-4015	610117	1/11/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3021-H17-3018	611067	12/26/2023	Roots	80.00	Light	
J11-3042-J11-3096	608446	7/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3042-J11-3096	608446	7/8/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3042-J11-3096	608446	7/8/2021	Roots	80.00	Light	
J11-3042-J11-3096	608446	7/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-2009-J19-2008	609516	7/12/2022	Roots	80.00	Light	J19-2009-J19-2008 IN STRUCTURE....REQUIRE ROOTX
J20-2007-J20-2006	608792	11/15/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3073-J11-3106	608427	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3073-J11-3106	608427	7/1/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D10-2047-D10-2043	609505	7/6/2022	Roots	80.00	Light	D10-2047
G16-4112-G16-4111	610152	1/19/2023	Inflow and Infiltration	60.00	Running or Trickling	
G16-4112-G16-4111	610152	1/19/2023	Roots	50.00	Medium	roots sticking through patch
G16-4112-G16-4111	610152	1/19/2023	Lining or Repair Failure	60.00	Moderate	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4112-G16-4111	610152	1/19/2023	Cracks or Fractures	40.00	Severe Cracking	
M18-4027-M18-4026	607870	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
K18-2029-K18-2028	608867	12/20/2021	Belly or Sag	80.00	Minor (<10%)	
J19-2080C-J19-2056	608816	11/30/2021	Lining or Repair Failure	80.00	Minor	
K10-1075-K10-1030	608258	5/11/2021	Roots	80.00	Light	
H15-4001-H15-1016	610519	7/6/2023	Roots	30.00	Heavy	HEAVY ROOTS IN UPSTREAM STRUCTURE H15-4001
H15-4001-H15-1016	610519	7/6/2023	Belly or Sag	80.00	Minor (<10%)	
G21-2039-G21-2001	609904	11/14/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
D23-2013-D23-2012	608179	5/3/2021	Roots	80.00	Light	LIGHT ROOTS AT 80' LAT...RECOMMENDING ROOT TREATMENT
D23-1017-D23-1016	608152	4/15/2021	Roots	50.00	Medium	ROOTS AT 27 FT FROM UPPER M/H
D11-1008-D11-1007	609675	9/1/2022	Roots	80.00	Light	@126" AT LATERAL CONNECTION, RECOMMEND FOAM....ADDED TO ROOT TREATMENT LIST 9-1-22
K10-1033-K10-1032	608253	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
D10-1034-D10-1033	609628	8/15/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D11-4022-D11-4021	609698	9/12/2022	Obstruction or Intrusion	80.00	Minor	
G16-1050-G16-1046	610201	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3054-J18-3053	609367	5/23/2022	Roots	30.00	Heavy	J18-3053: ROOTS IN STRUCTURE JOINT
G16-3010-G16-3073	610275	3/13/2023	Roots	50.00	Medium	
D10-2002-D10-2001	609629	8/15/2022	Worn Surface	40.00	Severe	
L17-1087-L17-1086	607887	1/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1087-L17-1086	607887	1/8/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4022-G16-4125	610110	1/9/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4022-G16-4125	610110	1/9/2023	Inflow and Infiltration	60.00	Running or Trickling	
J11-4021-J11-4022	608467	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K19-4013-K19-4012	609038	2/9/2022	Roots	50.00	Medium	K19-4013- ROOTS IN SAND COLLAR JOINT
H16-3022-H16-3016	610839	9/28/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-1034C-H16-1062	610455	5/5/2023	Roots	0.00	Blockage	
H16-1034C-H16-1062	610455	5/5/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-1034C-H16-1062	610455	5/5/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-4027-K18-4026	609319	4/27/2022	Break or Failure	15.00	Hole Void Visible	
J16-4007-J16-4027	610932	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
J11-3024-J11-3023	608332	5/26/2021	Roots	50.00	Medium	ROOTS IN LATERAL AT 22.6FT IN THE RIGHT OF WAY
J16-1040-J16-1041	610919	11/29/2023	Roots	80.00	Light	J16-1041 ROOTS IN MANHOLE
G21-2022-G21-2021	609893	11/10/2022	Roots	50.00	Medium	
J18-2080-J18-2087	609251	4/14/2022	Roots	30.00	Heavy	SEVERE ROOTS IN LATERAL AT 26 FEET UPSTREAM
L17-3009-L17-3008	609106	3/2/2022	Belly or Sag	80.00	Minor (<10%)	
L17-3009-L17-3008	609106	3/2/2022	Roots	80.00	Light	IN LATERAL JOINT
K18-3024-K18-3014	609360	5/6/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3024-K18-3014	609360	5/6/2022	Roots	80.00	Light	K18-3024 ROOTS THROUGH OUT. ROOTS GROWING THROUGH INFLOW SAND COLLAR
K18-4040-K18-4002	608906	1/4/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-1006-H16-1005	610282	3/16/2023	Obstruction or Intrusion	60.00	Moderate	
D23-2019-D23-2018	608126	4/8/2021	Roots	50.00	Medium	ROOTS AT 15 AND 51 FT FROM LOWER M/H
C11-2006-C11-2004	609604	8/2/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1061-K19-1060	609247	4/13/2022	Belly or Sag	80.00	Minor (<10%)	
K18-4074-K18-4073	609351	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
J16-1017-J16-1016	610629	8/9/2023	Roots	80.00	Light	ROOTS IN DOWN STREAM MANHOLE J16-1016 AROUND THE END OF THE PIPE
J19-2083-J19-2082	607945	2/2/2021	Roots	50.00	Medium	
H17-3022-H17-3021	611068	12/26/2023	Belly or Sag	80.00	Minor (<10%)	
H17-3022-H17-3021	611068	12/26/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K19-1006-K19-1005	609121	3/9/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE K19-1006

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G15-3038-G15-3037	610260	3/9/2023	Roots	80.00	Light	G15-3038- ROOTS IN STRUCTURE JOINT
J18-2047-J18-2046	608972	1/28/2022	Roots	80.00	Light	IN UPSTREAM STRUCTURE J18-2047
D23-2058-D23-2057	608133	4/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2058-D23-2057	608133	4/12/2021	Roots	80.00	Light	
D23-2058-D23-2057	608133	4/12/2021	Cracks or Fractures	80.00	Minor Cracking	
M18-2014-M18-2013	610236	3/2/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M18-2014-M18-2013	610236	3/2/2023	Belly or Sag	80.00	Minor (<10%)	
H16-3023-H16-3016	610830	9/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3047C-J11-3045	608439	7/6/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3047C-J11-3045	608439	7/6/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3047C-J11-3045	608439	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3003-J19-3002	608551	8/16/2021	Roots	80.00	Light	WALL AND SAND COLLAR J19-3002
K18-4003-K18-3094	609542	7/18/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
M18-4004-M18-4003	607871	1/5/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3093-G16-3027	610426	4/26/2023	Cracks or Fractures	60.00	Moderate Cracking	
C11-3012-LS-47	609821	10/19/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
C11-3012-LS-47	609821	10/19/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4008-H15-4007	610594	8/3/2023	Roots	50.00	Medium	H15-4007 ROOTS
C11-2014-C11-2013	609738	10/4/2022	Worn Surface	80.00	Minor	
C11-2014-C11-2013	609738	10/4/2022	Obstruction or Intrusion	80.00	Minor	
C11-2014-C11-2013	609738	10/4/2022	Belly or Sag	80.00	Minor (<10%)	
K10-1006-K10-1005	608340	5/27/2021	Belly or Sag	80.00	Minor (<10%)	
K10-1006-K10-1005	608340	5/27/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2008-H16-2009	611010	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1022-G16-1021	610489	5/30/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-2016-K18-2015	609342	5/3/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3011-K18-3010	609537	7/18/2022	Obstruction or Intrusion	80.00	Minor	
K19-1026-K19-1025	609060	2/15/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J19-3040-J19-3039	608538	8/10/2021	Break or Failure	15.00	Hole Void Visible	
J19-3040-J19-3039	608538	8/10/2021	Obstruction or Intrusion	60.00	Moderate	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-4059-K18-4058	609300	4/25/2022	Cracks or Fractures	80.00	Minor Cracking	
G18-4001-LS-9	608163	4/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G18-4001-LS-9	608163	4/22/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2037-K18-2036	609341	5/3/2022	Roots	80.00	Light	K18-2036 MINOR ROOT INTRUSION IN STRUCTURE NEAR TOP
H16-2017-H16-2016	611030	12/18/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2017-H16-2016	611030	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
J11-2022-J11-2040	608533	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
H15-4011-H15-4010	610596	8/3/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-3062-J11-3103	608420	6/28/2021	Roots	50.00	Medium	ROOT CUT WHOLE LINE
J11-3053-J11-3051	608484	7/20/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3082-J11-3105	608381	6/10/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1100-L17-1079	608759	10/22/2021	Inflow and Infiltration	60.00	Running or Trickling	
K18-4068-K18-4009	609349	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
D10-1026-D10-1025	609631	8/25/2022	Roots	80.00	Light	IN STRUCTURE D10-1025
H17-3076-H16-2017	611029	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3076-H16-2017	611029	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3076-H16-2017	611029	12/18/2023	Lining or Repair Failure	80.00	Minor	
K18-4090-K18-4010	608450	7/12/2021	Obstruction or Intrusion	80.00	Minor	
G16-3035-G16-3034	610414	4/21/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1007-L17-1006	607922	1/22/2021	Belly or Sag	80.00	Minor (<10%)	
G16-3026-G16-3025	610418	4/24/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J19-3051-J19-3050	609003	2/3/2022	Roots	80.00	Light	J19-3051 ROOTS IN STRUCTURE
J19-2046-J19-2010	607937	2/1/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J19-2010
K18-4041-K18-4082	608904	1/4/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1092-L17-1076	607918	1/21/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L1`7-1092
D23-1018-D23-1017	608151	4/15/2021	Roots	50.00	Medium	ROOTS IN JOINT 107 FROM LOWER M/H
K18-3033-L18-4045	607954	2/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3027-J20-3024	608840	12/9/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
G21-2023-G21-2020	608051	3/16/2021	Worn Surface	80.00	Minor	
J20-2004-J20-2003	608800	11/15/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2016-H16-2015	611027	12/14/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2016-H16-2015	611027	12/14/2023	Break or Failure	30.00	Hole Soil Visible	
D23-2107-D23-2156	608031	3/10/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2089-H16-2088	611023	12/14/2023	Roots	80.00	Light	H16-2088
C11-2013-C11-2008	609739	10/4/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
C11-2013-C11-2008	609739	10/4/2022	Cracks or Fractures	80.00	Minor Cracking	
K19-4008-K19-4007	609043	2/10/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4008-L18-4007	609293	4/22/2022	Cracks or Fractures	80.00	Minor Cracking	
D23-2054-D23-2053	608139	4/12/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2054-D23-2053	608139	4/12/2021	Roots	30.00	Heavy	CANNOT PROCEDE THROUGH ROOTS
J11-2028-J11-2027	608460	7/14/2021	Belly or Sag	40.00	Severe (>30%)	
K10-1016-K10-1006	608339	5/27/2021	Belly or Sag	80.00	Minor (<10%)	
K19-1056-K19-1055	608959	1/24/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-3084-J11-3083	608377	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3084-J11-3083	608377	6/9/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3094-J11-3014	608399	6/22/2021	Roots	80.00	Light	@ LATERAL PIPE 5'.
K18-3004-K18-3003	609357	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1064-L17-1063	607962	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2052-D10-2051	609482	6/22/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1034-L17-1033	607898	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
B26-2028-B26-2027	610889	11/20/2023	Roots	80.00	Light	ROOTS IN BOTH MANHOLES
B26-2028-B26-2027	610889	11/20/2023	Obstruction or Intrusion	60.00	Moderate	
D10-1001-D11-4055	609614	8/8/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-2033-G16-2032	610394	4/12/2023	Roots	50.00	Medium	
G15-2008-G15-2002	610685	8/17/2023	Belly or Sag	80.00	Minor (<10%)	
J11-2024-J11-2023	608379	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2020-D23-2019	608116	4/6/2021	Roots	80.00	Light	ROOTS IN SIDE SERVEVICE AT 45.9 FEET
K19-1072-K19-1071	609417	6/7/2022	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K19-1072-K19-1071	609417	6/7/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
B26-2034-B26-2033	610883	11/20/2023	Obstruction or Intrusion	80.00	Minor	
J18-3058-J18-3054	609368	5/23/2022	Roots	30.00	Heavy	J18-3054: ROOTS IN STRUCTURE
H15-4002-H15-4001	610518	7/6/2023	Roots	30.00	Heavy	ROOTS IN DOWNSTREAM STRUCTURE H15-4001
K10-1024-K10-1023	608272	5/13/2021	Roots	80.00	Light	AT LATERAL CONNECTIONS...109', 252.6'
K10-1024-K10-1023	608272	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1024-K10-1023	608272	5/13/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3064-J11-3063	608384	6/10/2021	Worn Surface	80.00	Minor	
J11-3064-J11-3063	608384	6/10/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-2011-J11-2026	608320	5/20/2021	Roots	50.00	Medium	roots throughout the whole pipe
J11-3107-J11-3077	608477	7/20/2021	Roots	80.00	Light	SEE ROOTS LIST
J16-4028-H16-3042	610850	10/3/2023	Belly or Sag	80.00	Minor (<10%)	
K10-1053-K10-1005	608304	5/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
K10-1053-K10-1005	608304	5/18/2021	Cracks or Fractures	80.00	Minor Cracking	
J16-4016C-J16-4015	610922	11/29/2023	Roots	80.00	Light	
J16-4016C-J16-4015	610922	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
D23-2038-D23-2036	608189	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-3038-D23-3037	608360	6/7/2021	Roots	50.00	Medium	D23-3038-D23-3037 ROOTS IN JOINT AT
K10-1041-J10-2005	608316	5/20/2021	Roots	50.00	Medium	ROOTS IN MANHOLE AND AT 12 FT
J11-3043-J11-3041	608437	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3043-J11-3041	608437	7/6/2021	Obstruction or Intrusion	80.00	Minor	
G16-4036-G16-4033	610143	1/18/2023	Roots	50.00	Medium	
K18-3003-K18-3002	609356	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-3003-K18-3002	609356	5/5/2022	Obstruction or Intrusion	80.00	Minor	
H16-2007-H16-2008	611009	12/13/2023	Roots	50.00	Medium	PRETTY HEAVY ROOTS IN THE DROP AT THE END OF THIS PIPE
H16-2007-H16-2008	611009	12/13/2023	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-4057-D11-4056	609621	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D11-4009-D11-4008	609728	9/29/2022	Break or Failure	30.00	Hole Soil Visible	
D11-4009-D11-4008	609728	9/29/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D11-4009-D11-4008	609728	9/29/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-2012-K18-2011	609572	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1058-L17-1056	609533	7/18/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1058-L17-1056	609533	7/18/2022	Belly or Sag	80.00	Minor (<10%)	
J16-4013-J16-4012	610921	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4013-J16-4012	610921	11/29/2023	Roots	50.00	Medium	
H17-3072C-H17-3038	609059	2/14/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-1008-K18-1007	609593	7/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4054-G16-4053	610150	1/19/2023	Roots	30.00	Heavy	G16-4053 HEAVY ROOTS IN MH
H16-3113-H16-3112	610760	9/11/2023	Belly or Sag	80.00	Minor (<10%)	
K18-3071-K18-3066	609099	3/1/2022	Obstruction or Intrusion	80.00	Minor	
H15-4016-H15-4013	610599	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4016, NEEDS ROOTX
G21-2014-G21-2002	609898	11/10/2022	Obstruction or Intrusion	60.00	Moderate	
G21-2014-G21-2002	609898	11/10/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K19-4034C-K19-4030	609032	2/7/2022	Roots	80.00	Light	MINOR ROOT INTRUSION AT K19-4034C
G15-3042-G15-3014	610255	3/8/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1033-J16-1032	610618	8/8/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE
K18-3016-K18-3106	609325	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3016-K18-3106	609325	4/28/2022	Break or Failure	15.00	Hole Void Visible	
K18-3016-K18-3106	609325	4/28/2022	Belly or Sag	40.00	Severe (>30%)	
K18-3016-K18-3106	609325	4/28/2022	Worn Surface	60.00	Moderate	
K19-1008-K19-1007	609473	6/17/2022	Roots	30.00	Heavy	K19-1008 HEAVY ROOTS K19-1007 MEDIUM ROOTS
D10-1013-D10-1012	609699	9/13/2022	Belly or Sag	80.00	Minor (<10%)	
D10-1013-D10-1012	609699	9/13/2022	Inflow and Infiltration	60.00	Running or Trickling	
D23-2036-D23-2001	608190	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
H17-3037-H17-3030	611040	12/19/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H17-3037-H17-3030	611040	12/19/2023	Break or Failure	15.00	Hole Void Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3037-H17-3030	611040	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2023-H16-2021	611004	12/13/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2023-H16-2021	611004	12/13/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
CAP-K18-3094	609544	7/18/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L18-4060-L18-4001	608888	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3045-J11-3043	608438	7/6/2021	Belly or Sag	80.00	Minor (<10%)	
J18-2015-K18-1020	609445	6/14/2022	Roots	50.00	Medium	K18-1020: ROOTS IN MH
J11-2017-J11-2014	608322	5/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4088-K18-4087	609301	4/25/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-4088-K18-4087	609301	4/25/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2028-G21-2026	609872	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
K20-4019-K20-4003	609374	5/24/2022	Roots	80.00	Light	K20-4019 ROOTS IN STRUCTURE
K19-1059-K19-1058	609244	4/13/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE K19-1059
K10-1021-K10-1019	608277	5/13/2021	Break or Failure	30.00	Hole Soil Visible	
K10-1021-K10-1019	608277	5/13/2021	Cracks or Fractures	60.00	Moderate Cracking	
G16-4111-G16-4107	610153	1/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3079-G16-3084	610308	3/23/2023	Roots	50.00	Medium	SIGNIFICANT ROOTS IN DOWNSTREAM STRUCTURE G16-3084
D10-2043-D10-2042	609506	7/6/2022	Belly or Sag	80.00	Minor (<10%)	
K18-1016-K18-1015	609450	6/15/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L19-4012-L19-4011	609209	4/7/2022	Obstruction or Intrusion	60.00	Moderate	
E23-1007-E23-1006	608086	3/29/2021	Belly or Sag	80.00	Minor (<10%)	
E23-1007-E23-1006	608086	3/29/2021	Obstruction or Intrusion	60.00	Moderate	
J11-3016-J11-3015	608456	7/13/2021	Obstruction or Intrusion	80.00	Minor	
H16-2015-H16-2014	611026	12/14/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2015-H16-2014	611026	12/14/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2015-H16-2014	611026	12/14/2023	Roots	80.00	Light	H16-2014
K18-3012-K18-3011	609536	7/18/2022	Belly or Sag	40.00	Severe (>30%)	
J16-4009C-J16-4008	610929	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J16-4009C-J16-4008	610929	12/1/2023	Roots	80.00	Light	IN JOINT AT MATERIAL CHANGE
K18-3057-K18-3056	608732	10/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2003-K18-2002	609355	5/4/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-2003-K18-2002	609355	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4004-D11-4003	609737	10/4/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K18-3001-LS-1	609359	5/5/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-3001-LS-1	609359	5/5/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3001-LS-1	609359	5/5/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J18-2088-J18-2008	608617	9/9/2021	Roots	50.00	Medium	J1802008 SECTION JOINT
J19-2068-K20-4012	608829	12/8/2021	Roots	50.00	Medium	ROOTS IN BOTH MANHOLE STRUCTURES
J18-2010-J18-2009	608615	9/9/2021	Roots	50.00	Medium	WALL AND SAND COLLAR OF J18-2009
J11-3072-J11-3069	608415	6/23/2021	Break or Failure	15.00	Hole Void Visible	
J11-3072-J11-3069	608415	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3072-J11-3069	608415	6/23/2021	Belly or Sag	40.00	Severe (>30%)	
K18-3106-K18-3021	609396	6/6/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-3106-K18-3021	609396	6/6/2022	Cracks or Fractures	40.00	Severe Cracking	
K18-3106-K18-3021	609396	6/6/2022	Worn Surface	60.00	Moderate	
K18-3106-K18-3021	609396	6/6/2022	Break or Failure	30.00	Hole Soil Visible	
K18-3106-K18-3021	609396	6/6/2022	Belly or Sag	40.00	Severe (>30%)	
K18-1012-K18-1011	609454	6/15/2022	Roots	80.00	Light	ROOTS IN STRUCTURE 1011
K10-1027-K10-1026	608270	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1027-K10-1026	608270	5/12/2021	Break or Failure	15.00	Hole Void Visible	
J20-2005-J20-2004	608799	11/15/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-1036-H16-1035	610458	5/5/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1036-H16-1035	610458	5/5/2023	Cracks or Fractures	40.00	Severe Cracking	
H16-1036-H16-1035	610458	5/5/2023	Roots	50.00	Medium	SOME ROOTS IN PIPE, SOME GROWING IN FROM LATERALS.
H16-1036-H16-1035	610458	5/5/2023	Break or Failure	15.00	Hole Void Visible	
G21-2029-G21-2028	609870	11/7/2022	Cracks or Fractures	80.00	Minor Cracking	
M18-4036-M18-4035	607872	1/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2040-D23-2039	608180	5/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2040-D23-2039	608180	5/3/2021	Roots	80.00	Light	LIGHT ROOTS AT VARIOUS SPOTS @ LATS...RECOMMENDING ROOT TREATMENT
K10-1032-K10-1026	608254	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L18-1050-L18-1049	610862	5/18/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L18-1050-L18-1049	610862	5/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2025-H16-2024	610996	12/12/2023	Inflow and Infiltration	40.00	Gushing or Spurting	
D24-3011-D24-3010	608013	3/5/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J11-4016-J11-4015	608401	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4016-J11-4015	610745	9/7/2023	Roots	80.00	Light	
H16-4047-H16-4046	610313	3/23/2023	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE H16-4047
F16-2021-F16-2020	610011	11/29/2022	Belly or Sag	80.00	Minor (<10%)	
L17-1029-L17-1028	608767	10/22/2021	Roots	30.00	Heavy	185.0
L17-1029-L17-1028	608767	10/22/2021	Cracks or Fractures	40.00	Severe Cracking	
D23-2072-D23-2071	608073	3/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2072-D23-2071	608073	3/22/2021	Lining or Repair Failure	80.00	Minor	
D10-2022-D10-2021	609588	7/26/2022	Roots	80.00	Light	light in structure D10-2021 ROOTX
J18-2004-J18-2003	608573	8/24/2021	Roots	50.00	Medium	J18-2004 ON WALLS
J18-2004-J18-2003	608573	8/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4099-G16-4098	610154	1/25/2023	Roots	50.00	Medium	G16-4099
D23-2092-D23-2091	608058	3/18/2021	Obstruction or Intrusion	80.00	Minor	
K18-3070-K18-3023	609327	4/28/2022	Roots	80.00	Light	25' UP STREAM
K18-3070-K18-3023	609327	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3018-K18-3017	609322	4/27/2022	Break or Failure	15.00	Hole Void Visible	
J11-2004-J11-2003	608495	7/21/2021	Worn Surface	60.00	Moderate	
J11-2004-J11-2003	608495	7/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-2004-J11-2003	608495	7/21/2021	Lining or Repair Failure	80.00	Minor	
J18-2140-J18-2139	608582	8/25/2021	Roots	80.00	Light	WALL OF J18-2139
J11-4028-J11-4027T	608390	6/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-4028-J11-4027T	608390	6/14/2021	Obstruction or Intrusion	60.00	Moderate	
K18-4005-K18-4003	609266	4/18/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-2013C-J11-2012	608443	7/7/2021	Roots	80.00	Light	
J11-2013C-J11-2012	608443	7/7/2021	Cracks or Fractures	80.00	Minor Cracking	
K19-1004-K19-1087	608927	1/10/2022	Roots	80.00	Light	IN BOTH STRUCTURES
K18-2039-K18-2038	609335	5/2/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2016-J18-2087	609253	4/14/2022	Roots	80.00	Light	
H16-3033-H16-3032	610824	9/26/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-1047-J16-1046	610914	11/29/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3038-G16-3037	610316	3/27/2023	Cracks or Fractures	80.00	Minor Cracking	
G15-2020-G15-2019	610392	4/12/2023	Roots	80.00	Light	
H15-2010-H15-2009	610853	10/3/2023	Roots	80.00	Light	H15-2009
G15-2013-G15-2012	610540	7/12/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-3034-H16-3033	610823	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-2040-J18-2039	608595	8/26/2021	Roots	80.00	Light	J18-2040 FROM LIFTING HOLE OF CONE
J19-2087-J19-2034	609075	2/16/2022	Roots	50.00	Medium	J19-2034 IN STRUCTURE
G16-3039-G16-3038	610315	3/27/2023	Cracks or Fractures	80.00	Minor Cracking	
J20-3024-J20-3023	609047	2/10/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J20-3024-J20-3023	609047	2/10/2022	Roots	50.00	Medium	J20-3024- ROOTS THROUGHOUT BOTTOM OF STRUCTURE
J16-1045-J16-4013	610918	11/29/2023	Roots	50.00	Medium	ROOTS IN PIPE CRACK ROOTS IN MYSTERY MANHOLE
J16-1045-J16-4013	610918	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
J11-3096-J11-3041	608445	7/8/2021	Roots	80.00	Light	
J11-3096-J11-3041	608445	7/8/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3018-J11-3014	608398	6/22/2021	Worn Surface	80.00	Minor	
J11-3018-J11-3014	608398	6/22/2021	Roots	80.00	Light	LIGHT ROOTS IN VARIOUS JOINTS...LOGGED IN ROOTS LIST FOR TREATMENT
J11-3018-J11-3014	608398	6/22/2021	Break or Failure	15.00	Hole Void Visible	
H17-3077-H17-3061	611083	12/27/2023	Roots	80.00	Light	H17-3061
J11-3037-J11-3036	608434	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-3037-J11-3036	608434	7/6/2021	Roots	50.00	Medium	AT VARIOUS JOINTS THROUGHOUT MAIN RUN....TRANSFERRED TO ROOTS LIST
J11-3037-J11-3036	608434	7/6/2021	Break or Failure	30.00	Hole Soil Visible	
D11-4001-D11-1002	609707	9/26/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-3036-G16-3035	610413	4/21/2023	Break or Failure	30.00	Hole Soil Visible	
G16-3036-G16-3035	610413	4/21/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-4109-G16-4108	610186	1/26/2023	Belly or Sag	80.00	Minor (<10%)	
J20-3035C-J20-3034	608831	12/8/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-STUB-H16-1046	610481	5/15/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3067-J11-3104	608430	7/1/2021	Belly or Sag	40.00	Severe (>30%)	
J20-3036-K20-4007	608813	11/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J19-2018-J19-2017	608918	1/6/2022	Roots	80.00	Light	IN J19-2017 STRUCTURE
G21-2036-G21-2028	609869	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4058-D11-4057	609622	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D11-4058-D11-4057	609622	8/15/2022	Roots	80.00	Light	D11-4058
J19-3050-J19-3049	609004	2/3/2022	Roots	80.00	Light	J19-3050 ROOTS IN STRUCTURE
K10-1030-K10-1029	608266	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1030-K10-1029	608266	5/12/2021	Break or Failure	15.00	Hole Void Visible	
K18-4054-K18-4053	609007	2/3/2022	Roots	80.00	Light	ROOTS IN STRUCTURE K18-4054
H17-3032-H17-3031	611050	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3032-H17-3031	611050	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
K19-1055-K19-1002	608960	1/24/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3070-H17-3049	611054	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3071-G16-3070	610310	3/23/2023	Belly or Sag	80.00	Minor (<10%)	
G16-4088-G16-4084	610106	1/3/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3111-J11-3110	608471	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2009-K18-2008	609347	5/3/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-3028-H17-3027	611061	12/26/2023	Cracks or Fractures	80.00	Minor Cracking	
H15-1054-H15-1053	610574	8/1/2023	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-2012-J11-2011	608319	5/20/2021	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT TREAT WHOLE LINE
J11-2012-J11-2011	608319	5/20/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4015-J11-3078	608402	6/22/2021	Roots	80.00	Light	
J11-4015-J11-3078	608402	6/22/2021	Break or Failure	15.00	Hole Void Visible	
J11-4015-J11-3078	608402	6/22/2021	Worn Surface	80.00	Minor	
J11-4015-J11-3078	608402	6/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-4015-J11-3078	608402	6/22/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4015-J11-3078	610744	9/7/2023	Roots	80.00	Light	
K19-1010-K19-1009	609471	6/17/2022	Break or Failure	15.00	Hole Void Visible	
K19-1010-K19-1009	609471	6/17/2022	Roots	80.00	Light	K19-1010 ROOTS IN MH
D11-1043-D11-4066	609667	9/1/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J18-2048-J18-2047	608971	1/28/2022	Roots	50.00	Medium	IN DOWNSTREAM STRUCTURE J18-2047
B26-2029-B26-2028	610888	11/20/2023	Roots	80.00	Light	ROOTS IN INFLOW AND OUTFLOW OF BOTH MANHOLES
B26-2029-B26-2028	610888	11/20/2023	Inflow and Infiltration	60.00	Running or Trickling	
B26-2029-B26-2028	610888	11/20/2023	Obstruction or Intrusion	80.00	Minor	
C11-3003C-C11-3002	609825	10/19/2022	Cracks or Fractures	60.00	Moderate Cracking	
G16-1021-G16-1020	610452	5/3/2023	Roots	50.00	Medium	MAHOLE FULL OF ROOTS STARTING TO COME DOWN INTO CHANNLE
H17-3019-H17-3018	611070	12/26/2023	Roots	30.00	Heavy	IMPASSABLE BEFORE FLUSHING
H17-3031-H17-3030	611043	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3031-H17-3030	611043	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3069-H17-3050	611052	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3069-H17-3050	611052	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
J11-4008-J11-4007	608375	6/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4008-J11-4007	608375	6/8/2021	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT
J18-2023-J18-2022	609465	6/16/2022	Roots	80.00	Light	ROOTS IN LATERAL
G21-2016-G21-2014	609895	11/10/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2016-G21-2014	609895	11/10/2022	Roots	80.00	Light	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H21-4015-H21-4014	609921	11/16/2022	Lining or Repair Failure	80.00	Minor	
L17-1036-L17-1035	607890	1/11/2021	Break or Failure	30.00	Hole Soil Visible	
K19-1019-K19-1018	608922	1/10/2022	Roots	50.00	Medium	IN K19-1019 STRUCTURE
K19-1046-K19-1082	609400	6/6/2022	Lining or Repair Failure	80.00	Minor	
J16-4005-J16-4004	610936	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4005-J16-4004	610936	12/1/2023	Roots	50.00	Medium	ROOTS THROUGHOUT
J16-4005-J16-4004	610936	12/1/2023	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1027-L17-1026	607912	1/21/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1027-L17-1026	607912	1/21/2021	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Lining or Repair Failure	80.00	Minor	
D23-2070-D23-2069	608091	3/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
M18-3010-M18-2015	610238	3/2/2023	Belly or Sag	80.00	Minor (<10%)	
J20-2008-J20-2005	608798	11/15/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3107C-J18-3103	608659	9/27/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2077-D23-2076	608083	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J20-3025-J20-3024	608837	12/9/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
G21-2019-G21-2018	609884	11/8/2022	Belly or Sag	80.00	Minor (<10%)	
K18-4031-K18-4030	609308	4/25/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-1024-H15-1023	610353	4/3/2023	Roots	80.00	Light	H15-1023
J11-3075-J11-3074	608480	7/20/2021	Cracks or Fractures	80.00	Minor Cracking	
H16-1023-H16-1021	610473	5/11/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1023-H16-1021	610473	5/11/2023	Belly or Sag	80.00	Minor (<10%)	
H16-1023-H16-1021	610473	5/11/2023	Obstruction or Intrusion	80.00	Minor	
D23-2082-D23-2081	608070	3/22/2021	Roots	80.00	Light	FOAMING SUGESTED @ 8'-15' FROM D23-2082
H16-1033-H16-1028	610369	4/5/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-1033-H16-1028	610369	4/5/2023	Roots	30.00	Heavy	BLOCKAGE CLEARED, STILL HEAVY ROOTS IN PIPE. HEAVY ROOTS IN SOME LATERALS
G16-1028-G16-1027	610488	5/30/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3039-G15-3037	610261	3/9/2023	Roots	80.00	Light	G15-3039: ROOTS STARTING IN OUTFLOW SAND COLLAR

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2012-H16-2011	611002	12/13/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-2012-H16-2011	611002	12/13/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
G16-1046-G16-1043	610202	1/27/2023	Belly or Sag	80.00	Minor (<10%)	
K18-3088-K18-3022	609330	4/28/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3027-K18-3026	609566	7/20/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3034-J11-3028	608380	6/9/2021	Worn Surface	60.00	Moderate	
J11-3034-J11-3028	608380	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
K19-4007-K19-4006	609044	2/10/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3002-K18-3001	609358	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-4029-G16-4028	610116	1/11/2023	Roots	50.00	Medium	LATERAL JOINT NEAR DOWNSTREAM MH
G16-4029-G16-4028	610116	1/11/2023	Belly or Sag	80.00	Minor (<10%)	
J16-4002-J16-4001	610939	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4002-J16-4001	610939	12/1/2023	Break or Failure	30.00	Hole Soil Visible	
J16-4002-J16-4001	610939	12/1/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2069-D23-2068	608092	3/30/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3110-J19-3109	607995	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1098-L17-1065	607960	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2042-H16-2041	610944	12/4/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2010-J11-2009	608489	7/21/2021	Break or Failure	15.00	Hole Void Visible	
J11-2010-J11-2009	608489	7/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3036-H17-3034	611042	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3036-H17-3034	611042	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
L18-4038-L18-4036	607956	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
J16-4001-LS-11	610941	12/4/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4001-LS-11	610941	12/4/2023	Roots	80.00	Light	ROOTS INSIDE THE WETWELL
J16-4001-LS-11	610941	12/4/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-4007-J11-4019	608376	6/8/2021	Break or Failure	15.00	Hole Void Visible	
J11-4007-J11-4019	608376	6/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3043-J19-3006	609023	2/7/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4059-D11-4058	609620	8/15/2022	Roots	80.00	Light	D11-4058
D11-4059-D11-4058	609620	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3098-J11-3019	608393	6/17/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D11-4003-D11-4002	610288	3/21/2023	Obstruction or Intrusion	80.00	Minor	
J11-3038-J11-3037	608433	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3038-J11-3037	608433	7/6/2021	Worn Surface	80.00	Minor	
J11-4025-J11-4024	608468	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3017-J18-3016	608676	9/28/2021	Roots	50.00	Medium	ROOTS AT LATERAL CONNECTION POINT IN MAIN @81' NO BLOCKAGES
J11-4013-J11-4012	608408	6/23/2021	Roots	80.00	Light	
J11-4013-J11-4012	608408	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4020-J11-4021	608475	7/20/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3152C-J18-3150	608624	9/14/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2071-D23-2049	608128	4/8/2021	Roots	50.00	Medium	D23-2071 ROOTS IN THE PIPE AT 233 FROM UPPER M/H
K20-4013-K20-4002	609373	5/24/2022	Roots	50.00	Medium	ROOTS IN BOTH MANHOLES
J19-2034-J19-2029	609077	2/17/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE J19-2034
K19-1005-K19-1004	609120	3/9/2022	Roots	80.00	Light	ROOTS IN DOWNSTREAM STRUCTURE K19-1004
K19-4002-K19-4001	609114	3/3/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1021-K19-1020	609071	2/16/2022	Roots	80.00	Light	K19-1020- ROOTS IN STRUCTURE
J11-2029-J11-2028	608459	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2085-D23-2083	608067	3/22/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2085-D23-2083	608067	3/22/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3042-K18-3035	608880	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
K10-1008-K10-1074	608315	5/19/2021	Roots	30.00	Heavy	K10-1008-K10-1074 ROOTS THE THE TOP OF THE PIPE 3 FT IN, ROOTS AT 29FT, ROOTS AT 48 FT, 75 FT, 79 FT, 84 FT
D23-3041-D23-3040	608194	5/4/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D10-1030-D10-1029	609625	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D10-2048-D10-2047	609504	7/6/2022	Roots	80.00	Light	D10-2048 D10-2047
K10-1020-K10-1019	608274	5/13/2021	Break or Failure	15.00	Hole Void Visible	
K10-1020-K10-1019	608274	5/13/2021	Roots	50.00	Medium	AT 45'

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4053-G16-4036	610139	1/18/2023	Roots	30.00	Heavy	HEAVY ROOTS IN UPSTREAM MH G16-4053 NEAR BLOCKAGE IN CHANEL
D11-1028-C11-2002	609790	10/12/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
D11-1028-C11-2002	609790	10/12/2022	Worn Surface	60.00	Moderate	
D11-1028-C11-2002	609790	10/12/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4037-H15-4036	610512	6/29/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-1031-H16-1030	610389	4/10/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J11-3095-J11-3036	608455	7/13/2021	Roots	50.00	Medium	MANY MANY JOINTS
J19-2004-J19-2003	608610	8/30/2021	Worn Surface	80.00	Minor	
J11-3104-J11-3066	608440	7/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1086-L17-1017	607889	1/11/2021	Lining or Repair Failure	80.00	Minor	
L17-1086-L17-1017	607889	1/11/2021	Roots	50.00	Medium	ROOTS IN JOINTS AND CRACKS MULTIPLE AREAS 82FT 98 FT AND 103 FT
L17-1086-L17-1017	607889	1/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L17-1086-L17-1017	607889	1/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1086-L17-1017	607889	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
J19-3004-J19-3003	608545	8/12/2021	Roots	80.00	Light	D9 @ 210 SIDESEWER
K18-4086-K18-4039	609303	4/25/2022	Roots	80.00	Light	K18-4039 ROOTS IN STRUCTURE
K18-4086-K18-4039	609303	4/25/2022	Cracks or Fractures	60.00	Moderate Cracking	
K19-4021-K19-1010	609474	6/17/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
E23-1012-E23-1011	608098	3/31/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-3012-G16-3011	610279	3/13/2023	Roots	30.00	Heavy	STRUCTURE
J11-3CAP-J11-3071	608424	7/1/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4034-H15-4003	610515	6/29/2023	Belly or Sag	80.00	Minor (<10%)	
B26-2030-B26-2029	610887	11/20/2023	Roots	80.00	Light	B26-2029- ROOTS ABOVE INFLOW
B26-2030-B26-2029	610887	11/20/2023	Obstruction or Intrusion	80.00	Minor	
J16-4014-J16-4013	610920	11/29/2023	Break or Failure	30.00	Hole Soil Visible	
J16-4014-J16-4013	610920	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
K19-1062-K19-1061	609246	4/13/2022	Roots	80.00	Light	IN UPSTREAM STRUCTURE K19-1062

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L18-4004-K18-3032	609292	4/22/2022	Belly or Sag	80.00	Minor (<10%)	
L18-4004-K18-3032	609292	4/22/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4004-K18-3032	609292	4/22/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
G21-2015-G21-2014	609897	11/10/2022	Obstruction or Intrusion	60.00	Moderate	
G21-2015-G21-2014	609897	11/10/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4056-K18-4054	609094	3/1/2022	Roots	80.00	Light	IN K18-4054 STRUCTURE
J16-1011-J16-1010	610705	8/22/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3012-G15-3050	610465	3/8/2023	Roots	30.00	Heavy	ROOTS IN BOTH MANHOLES, SEVERE IN G15-3012.
K18-3094-K18-3005	609545	7/18/2022	Break or Failure	15.00	Hole Void Visible	
K18-3094-K18-3005	609545	7/18/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K20-4006-K20-4005	608807	11/17/2021	Roots	80.00	Light	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
L17-1011-L17-1009	608729	10/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1011-L17-1009	608729	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D10-2049-D10-2048	609481	6/22/2022	Roots	80.00	Light	D10-2048
D10-2049-D10-2048	609481	6/22/2022	Belly or Sag	80.00	Minor (<10%)	
K18-3108-L18-4036	607957	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
F16-4002-F16-4006	609987	11/28/2022	Roots	80.00	Light	IN UPSTREAM SAND COLLAR
G16-4026-G16-4018	610120	1/11/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4026-G16-4018	610120	1/11/2023	Roots	80.00	Light	ROOTS IN LATERAL
D23-2034-D23-2033	608117	4/7/2021	Roots	50.00	Medium	ROOTS AT 133FT FROM BOTTOM M/H
J11-3049-J11-3108	608391	6/17/2021	Roots	80.00	Light	ROOTS IN JOINTS 130'-140'
J11-3049-J11-3108	608391	6/17/2021	Cracks or Fractures	80.00	Minor Cracking	
G21-2009-G21-2008	609889	11/9/2022	Belly or Sag	80.00	Minor (<10%)	
G16-4063-G16-4061	610094	12/28/2022	Obstruction or Intrusion	80.00	Minor	
L17-1042C-L17-1041	607920	1/21/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1042C-L17-1041	607920	1/21/2021	Roots	50.00	Medium	ROOTS IN THE FIRST 50 FEET
L17-1042C-L17-1041	607920	1/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4006-L18-4005	608892	12/23/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1060-L17-1059	609432	6/13/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2093C-H16-2017	611028	12/18/2023	Lining or Repair Failure	80.00	Minor	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2093C-H16-2017	611028	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2093C-H16-2017	611028	12/18/2023	Break or Failure	15.00	Hole Void Visible	
D23-2068-D23-2067	608093	3/30/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-3104-H16-3094	610792	9/18/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3057-J18-3056	609362	5/6/2022	Roots	50.00	Medium	J18-3057 ROOTS IN MANHOLE
G16-4005-LS-8	609053	2/11/2022	Roots	50.00	Medium	ROOTS IN JOINT AT 62 FEET
G16-4005-LS-8	610157	1/25/2023	Roots	80.00	Light	
G16-4005-LS-8	610157	1/25/2023	Obstruction or Intrusion	60.00	Moderate	
K18-1032-K18-1025	609273	4/19/2022	Obstruction or Intrusion	60.00	Moderate	
K18-1032-K18-1025	609273	4/19/2022	Cracks or Fractures	40.00	Severe Cracking	
K18-1032-K18-1025	609273	4/19/2022	Break or Failure	30.00	Hole Soil Visible	
K18-2013-K18-2012	609573	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3048-K18-3049	609529	7/17/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3034-D23-3033	608222	5/6/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2009-H16-2010	611011	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2090-D23-2085	608066	3/22/2021	Obstruction or Intrusion	80.00	Minor	
D23-2090-D23-2085	608066	3/22/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1004-L17-1003	608726	10/18/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-4003-G16-4005	609052	2/11/2022	Roots	80.00	Light	ROOTS BEGINNING TO FORM IN 2 LATERALS
K10-1023-K10-1020	608273	5/13/2021	Roots	80.00	Light	LIGHT ROOTS @112.3'
K10-1023-K10-1020	608273	5/13/2021	Cracks or Fractures	60.00	Moderate Cracking	
K18-2007-K18-2006	609571	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3089-K18-3026	609105	3/1/2022	Roots	80.00	Light	IN K18-3089 SAND COLLAR JOINT
K18-3089-K18-3026	609105	3/1/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3103-J11-3061	608419	6/28/2021	Roots	50.00	Medium	
J16-1032-J16-1031	610615	8/8/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE J16-1032
L17-1009-L17-1005	608727	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1009-L17-1005	608727	10/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-4004-H16-4003	610347	3/29/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L18-4036-L18-4037	607958	2/3/2021	Inflow and Infiltration	60.00	Running or Trickling	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B26-2035-B26-2034	610882	11/20/2023	Obstruction or Intrusion	80.00	Minor	
H16-2022-H16-2021	610994	12/12/2023	Inflow and Infiltration	60.00	Running or Trickling	
H16-2022-H16-2021	610994	12/12/2023	Cracks or Fractures	40.00	Severe Cracking	
H16-2022-H16-2021	610994	12/12/2023	Break or Failure	15.00	Hole Void Visible	
K19-1013-K19-1004	608926	1/10/2022	Roots	80.00	Light	IN K19-1004 STRUCTURE
J11-3040-J11-3039	608431	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
D11-1009-D11-1008	609734	10/4/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-1009-D11-1008	609734	10/4/2022	Belly or Sag	80.00	Minor (<10%)	
J16-1058-J16-1056	610902	11/28/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3052-J11-3099	608387	6/10/2021	Roots	80.00	Light	
G15-2010-G15-2009	610546	7/12/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-4017-J11-4010	608412	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
G15-3056-G15-3003	610522	7/10/2023	Obstruction or Intrusion	60.00	Moderate	
D23-2118-D23-2117	608077	3/24/2021	Roots	80.00	Light	FINE ROOTS AT JOINT
D23-2001-D23-1002	608191	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-3037-J18-3030	608265	5/12/2021	Roots	80.00	Light	ROOTS IN STRUCTURE J18-3037,
D11-4040-D11-4039	609518	7/14/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3042-H17-3041	611058	12/20/2023	Cracks or Fractures	80.00	Minor Cracking	
G15-3050-G15-3011	610263	3/8/2023	Roots	80.00	Light	ROOTS IN PIPE JOINT, NEEDS FOAMED
B26-2033-B26-2032	610884	11/20/2023	Obstruction or Intrusion	80.00	Minor	
L17-1024-L17-1023	607901	1/12/2021	Roots	80.00	Light	ROOTBALL IN THE BOTTOM OF MANHOLE L17-1023
D11-4023-D11-4022	609697	9/12/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L16-2024-L16-2022	609793	10/13/2022	Belly or Sag	80.00	Minor (<10%)	
J11-3088C-J11-3084	608444	7/7/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3088C-J11-3084	608444	7/7/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3088C-J11-3084	608444	7/7/2021	Obstruction or Intrusion	80.00	Minor	
J16-1025-J16-1022	610624	8/9/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE 1022
L14-3005-LS-14	607924	1/27/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L14-3005-LS-14	607924	1/27/2021	Lining or Repair Failure	40.00	Severe	
D10-1014-D10-1013	609700	9/13/2022	Obstruction or Intrusion	80.00	Minor	
D10-1014-D10-1013	609700	9/13/2022	Inflow and Infiltration	60.00	Running or Trickling	
J18-3014-J18-3013	608692	9/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-4017-H15-4016	610601	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4016
D23-2044-D23-2043	608174	4/28/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2044-D23-2043	608174	4/28/2021	Roots	80.00	Light	REFER TO ROOTS LIST FOR FOOTAGES...LIGHT ROOTS AT VARIOUS SPOTS THROUGHOUT PIPE
D23-3040-D23-3038	608195	5/4/2021	Belly or Sag	80.00	Minor (<10%)	
H16-3016-H16-3013	610840	9/28/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
K10-1019-K10-1044	608275	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-4006-K18-4005	609265	4/18/2022	Inflow and Infiltration	60.00	Running or Trickling	
E23-1005-E23-1004	608088	3/29/2021	Roots	50.00	Medium	E23-1004 @ SAND COLLAR
G16-4027-G16-4026	610119	1/11/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4027-G16-4026	610119	1/11/2023	Roots	50.00	Medium	MINOR ROOTS THROUGHOUT
G16-4027-G16-4026	610119	1/11/2023	Obstruction or Intrusion	80.00	Minor	
D11-4035-D11-4034	609808	10/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3069-J11-3067	608429	7/1/2021	Belly or Sag	40.00	Severe (>30%)	
J11-3069-J11-3067	610185	1/26/2023	Break or Failure	30.00	Hole Soil Visible	
J11-3069-J11-3067	610185	1/26/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3069-J11-3067	610185	1/26/2023	Inflow and Infiltration	60.00	Running or Trickling	
G21-2031-G21-2007	609887	11/9/2022	Belly or Sag	80.00	Minor (<10%)	
M17-1011-M18-4061	608974	1/28/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1041-L17-1092	607919	1/21/2021	Roots	50.00	Medium	ROOTS IN THE JOINTS AND SAND COLLARS LINE IS ONLY 10 FEET LONG
H16-2118-H16-2117	610957	12/5/2023	Roots	80.00	Light	ROOTS IN UPSTREAM MH H16-2118C
K18-3023-K18-3086	609328	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3023-K18-3086	609328	4/28/2022	Roots	50.00	Medium	
J20-2003-J20-2002	609050	2/10/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
J20-2003-J20-2002	609050	2/10/2022	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2024-H16-2023	610997	12/12/2023	Worn Surface	80.00	Minor	
D23-2064-D23-2063	608096	3/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2005-J11-2004	608494	7/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L16-2016-L16-2015	609801	10/13/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM MH L16-2016
K19-1040-K19-1039	609409	6/7/2022	Roots	80.00	Light	K19-1039 ROOTS IN MANHOLE
D23-1022-D23-1021	608148	4/14/2021	Roots	0.00	Blockage	109 FROM UPPER MANHOLE CANNOT CONTINUE TOOTS TO HEAVY TO GET PAST
J11-2040-J11-2004	608534	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-4075C-K18-4074	609350	5/4/2022	Roots	80.00	Light	ROOT INTRUSION STARTING IN CLEANOUT
K18-2040-K18-2036	609337	5/2/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2065-J18-2064	608648	9/23/2021	Roots	50.00	Medium	IN STRUCTURE J18-2064
J18-2065-J18-2064	608648	9/23/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K19-1043-K19-1039	609406	6/6/2022	Roots	80.00	Light	IN STRUCTURE K19-1039
J11-3055-J11-3054	608422	6/28/2021	Roots	50.00	Medium	ROOTS THROUGH OUT LINE
L17-1005-L17-1004	608724	10/18/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1005-L17-1004	608724	10/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
K18-4039-K18-4038	609305	4/25/2022	Roots	80.00	Light	K18-4039: ROOTS IN STRUCTURE
K19-1009-K19-1008	609472	6/17/2022	Obstruction or Intrusion	80.00	Minor	
K19-1009-K19-1008	609472	6/17/2022	Roots	30.00	Heavy	K19-1008
H17-3061-H17-3060	611084	12/27/2023	Roots	80.00	Light	H17-3060
G16-1072-G16-1007	610632	8/10/2023	Belly or Sag	80.00	Minor (<10%)	
D23-2056-D23-2055	608142	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2056-D23-2055	608142	4/12/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1089C-L17-1086	607888	1/11/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3055-J18-3054	609364	5/6/2022	Roots	50.00	Medium	J18-3054 ROOTS IN STRUCTURE
D23-1012-D23-1011	608149	4/15/2021	Roots	50.00	Medium	D23-1012-D23-1011 283 FROM LOWER M/H ROOTS IN THE JOINT
D11-4068-D11-4067	609716	9/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K10-1028-K10-1027	608269	5/12/2021	Roots	80.00	Light	IN MAIN/LATERAL 60'-75'

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K10-1028-K10-1027	608269	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2113-K18-2108	609232	4/11/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-2113-K18-2108	609232	4/11/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-1034-LS-69	610592	8/3/2023	Roots	80.00	Light	IN INSERT A TEE JOINT
G16-3009-G16-3008	610278	3/13/2023	Lining or Repair Failure	80.00	Minor	
M18-4026-M18-4025	607869	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
G16-3095-G16-3001	609868	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
J19-2082-J19-2041	607944	2/2/2021	Roots	50.00	Medium	ROOTS IN MANHOLE J19-2082
J20-3021-K20-4007	609366	5/16/2022	Roots	30.00	Heavy	J20-3021: ROOTS IN STRUCTURE
K10-1052C-K10-1051	608282	5/17/2021	Roots	80.00	Light	SMALL ROOT IN THE LATERA CONNECTION AT 45 FT
H17-3074C-H17-3033	611048	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-1039-G16-1038	610397	4/19/2023	Belly or Sag	80.00	Minor (<10%)	
E23-1008-E23-1003	608069	3/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D23-1009-D23-1008	608158	4/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2033-G21-2007	609886	11/9/2022	Roots	30.00	Heavy	HEAVY ROOTS IN THE LATERAL AT THE TOP END OF PIPE
G16-3084-G16-3078	610409	4/20/2023	Roots	50.00	Medium	ROOTS IN UPSTREAM MH G16-3084
J16-1014-J16-1013	610692	8/21/2023	Belly or Sag	40.00	Severe (>30%)	
J19-3052-J19-3051	609001	2/2/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-1066-H16-1065	610463	5/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3033-H17-3032	611049	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
J18-3038-J18-3037	608207	5/5/2021	Roots	80.00	Light	IN STRUCTURE J18-3038 AND 3037 ROOT X
D23-2123-D23-2122	608025	3/9/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3032-J11-3031	608442	7/6/2021	Roots	80.00	Light	ON ROOTS LIST
K18-2020-K18-3041	608851	12/15/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	610871	5/17/2022	Cracks or Fractures	60.00	Moderate Cracking	
G16-4006-G16-4005	610135	1/17/2023	Cracks or Fractures	60.00	Moderate Cracking	
M18-4002-M18-4001	607881	1/6/2021	Inflow and Infiltration	40.00	Gushing or Spurting	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H15-4009-H15-4008	610593	8/3/2023	Cracks or Fractures	80.00	Minor Cracking	
D10-2027-D10-2016	609521	7/14/2022	Cracks or Fractures	80.00	Minor Cracking	
D10-2027-D10-2016	609521	7/14/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1027-K19-1026	608901	12/23/2021	Roots	80.00	Light	IN UPSTREAM MH
L17-1061-L17-1060	609431	6/13/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2007-J19-2006	609477	6/17/2022	Roots	80.00	Light	J19-2007
J19-2007-J19-2006	609477	6/17/2022	Belly or Sag	80.00	Minor (<10%)	
H15-4012-H15-4007	610604	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4007
K19-1007-K19-1006	609122	3/9/2022	Roots	50.00	Medium	ROOTS IN DOWNSTREAM STRUCTURE K19-1006
D23-1002-D23-1001	608192	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-2118-J18-2117	608567	8/18/2021	Roots	80.00	Light	WALL OF J18-2117
G16-4011-G16-4010	610131	1/17/2023	Roots	30.00	Heavy	G16-4011: ROOTS IN STRUCTURE CAUSING I&I
G16-4011-G16-4010	610131	1/17/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1005-H16-1004	610283	3/16/2023	Inflow and Infiltration	60.00	Running or Trickling	
G15-3051-G15-3013	610257	3/8/2023	Roots	80.00	Light	COMING FROM BEHIND LADDER
D11-1011-D11-1008	609733	10/3/2022	Roots	80.00	Light	ROOTS IN LAST 15-20 FEET OF PIPE DOWNSTREAM
G16-1038-G16-1037	610398	4/19/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1038-G16-1037	610398	4/19/2023	Belly or Sag	80.00	Minor (<10%)	
J19-2017-J19-2015	608847	12/9/2021	Roots	80.00	Light	IN STRUCTURE
J16-1076-J16-1075	610865	10/24/2023	Worn Surface	80.00	Minor	
J19-2079-J19-2012	607939	2/1/2021	Break or Failure	30.00	Hole Soil Visible	
K10-1022-K10-1020	608276	5/13/2021	Roots	50.00	Medium	@49.8' @170.9'
K10-1022-K10-1020	608276	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-2035C-J18-2034	608593	8/26/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-3011-H16-3010	610838	9/28/2023	Belly or Sag	40.00	Severe (>30%)	
H16-3011-H16-3010	610838	9/28/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
K18-2046-K18-2045	609345	5/3/2022	Roots	80.00	Light	K18-2045: ROOTS IN STRUCTURE
D23-2119-D23-2118	608023	3/9/2021	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2119-D23-2118	608023	3/9/2021	Break or Failure	0.00	Collapse	
H17-3034-H17-3030	611041	12/19/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3034-H17-3030	611041	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
H17-3034-H17-3030	611041	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
J11-2018-J11-2017	608463	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3039-J18-3038	608206	5/5/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3099-J18-3098	608705	9/30/2021	Break or Failure	15.00	Hole Void Visible	
J18-3099-J18-3098	608705	9/30/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-4029-D11-4028	609641	8/29/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4029-D11-4028	609641	8/29/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3017-J11-3015	608532	8/5/2021	Obstruction or Intrusion	80.00	Minor	
J11-3017-J11-3015	608532	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1070-K10-1022	608318	5/20/2021	Roots	80.00	Light	ROOTS AT 80.4 IN LATERAL
E23-1004-D23-2071	608089	3/30/2021	Worn Surface	60.00	Moderate	
E23-1004-D23-2071	608089	3/30/2021	Cracks or Fractures	60.00	Moderate Cracking	
J16-1075-J16-1074	610868	10/25/2023	Roots	80.00	Light	J16-1075 ROOTS STARTING IN STRUCTURE WALL
L16-2022-L16-2021	609795	10/13/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1014-K19-1013	608925	1/10/2022	Roots	80.00	Light	IN K19-1013 STRUCTURE
G16-4055-G16-4054	610149	1/19/2023	Roots	80.00	Light	G16-4054: ROOTS IN MH
D11-1014-D11-1013	609776	10/11/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE D11-1014 AND LATERAL THAT TIES IN
D10-2042-LS-49	609597	7/14/2022	Belly or Sag	80.00	Minor (<10%)	
G16-3018-G16-3017	610528	7/11/2023	Worn Surface	80.00	Minor	
G16-3073-G16-3078	610276	3/13/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
D23-2091-D23-2090	608059	3/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-4022-K18-4021	609313	4/26/2022	Cracks or Fractures	80.00	Minor Cracking	
K19-1022-K19-1018	608921	1/10/2022	Roots	50.00	Medium	IN K19-1022 STRUCTURE AND ENTERING PIPE
D11-4034-D11-4024	609809	10/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2004-G21-2002	609894	11/10/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2004-G21-2002	609894	11/10/2022	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J18-2012-J18-2011	608556	8/16/2021	Roots	80.00	Light	J18-2011 WALL AND SAND COLLAR
D23-2076-D23-2075	608084	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-4022-J11-4023	608466	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4072-G16-4071	610060	12/8/2022	Inflow and Infiltration	60.00	Running or Trickling	
G16-4062-G16-4061	610092	12/28/2022	Cracks or Fractures	80.00	Minor Cracking	
G21-2026-G21-2018	609873	11/7/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3036-K18-3035	608881	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2015-D23-2013	608159	4/21/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2118-D23-2152	608037	3/11/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2118-D23-2152	608037	3/11/2021	Roots	80.00	Light	LIGHT ROOTS AT LATERAL
K10-1035-K10-1034	608249	5/11/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3030-J18-3029	608241	5/10/2021	Roots	80.00	Light	AT OUT FLOW OF J18-3030
J16-1004-J16-1001	610852	10/3/2023	Roots	50.00	Medium	ROOTS IN J16-1001
H16-2092C-H16-2022	610993	12/12/2023	Roots	80.00	Light	
H16-2092C-H16-2022	610993	12/12/2023	Break or Failure	30.00	Hole Soil Visible	
H16-2092C-H16-2022	610993	12/12/2023	Cracks or Fractures	60.00	Moderate Cracking	
J19-2008-J19-2004	608611	8/30/2021	Worn Surface	80.00	Minor	
J16-4003-J16-4002	610938	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
J16-4003-J16-4002	610938	12/1/2023	Roots	80.00	Light	
K19-1057-K19-1056	608958	1/24/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-4014-J11-4018	608407	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2035-K18-2011	609338	5/2/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
H17-3038-H17-3037	611039	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3038-H17-3037	611039	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
J11-3015-J11-3094	608400	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3015-J11-3094	608400	6/22/2021	Break or Failure	30.00	Hole Soil Visible	
B26-2048-B26-2047	610880	11/16/2023	Break or Failure	0.00	Collapse	
K18-3030-K18-3028	609564	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
D23-2010-D23-2009	608218	5/6/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-4009-J11-4008	608389	6/14/2021	Roots	50.00	Medium	ROOTS MAINLY TO 60 FT IN
J11-3059-J11-3101	608385	6/10/2021	Roots	80.00	Light	@ JOINTS @ 41', 55', 65'
G16-1047-G16-1046	610200	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2047-D23-2046	608177	4/28/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2047-D23-2046	608177	4/28/2021	Cracks or Fractures	80.00	Minor Cracking	
G21-2020-G21-2019	608052	3/16/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2020-G21-2019	609883	11/8/2022	Belly or Sag	80.00	Minor (<10%)	
G16-2035-G16-2019	610500	5/31/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1039-K10-1033	608251	5/11/2021	Roots	50.00	Medium	
K10-1039-K10-1033	608251	5/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K10-1039-K10-1033	608251	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1039-K10-1033	608251	5/11/2021	Break or Failure	15.00	Hole Void Visible	
J18-2063-J18-2004	608650	9/23/2021	Obstruction or Intrusion	80.00	Minor	
J18-2063-J18-2004	608650	9/23/2021	Roots	50.00	Medium	J18-2004 IN STRUCTURE
J11-3100-J11-3053	608423	6/28/2021	Cracks or Fractures	80.00	Minor Cracking	
J16-4012-J16-4011	610934	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
K18-3067-K18-3008	608948	1/18/2022	Belly or Sag	80.00	Minor (<10%)	
G16-2031-G16-2029	610380	4/6/2023	Roots	80.00	Light	
K18-4017-K18-4016	608236	5/10/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4045-L18-4038	607955	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
G21-2034C-G21-2029	609871	11/7/2022	Roots	30.00	Heavy	HEAVY ROOTS AT END OF PIPE
G21-2034C-G21-2029	609871	11/7/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3040-H17-3039	611036	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3040-H17-3039	611036	12/18/2023	Cracks or Fractures	80.00	Minor Cracking	
K18-3006-K18-3005	609096	3/1/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K18-2022-K18-2021	608849	12/15/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2114-D23-2113	608026	3/10/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1013-L17-1012	608730	10/18/2021	Obstruction or Intrusion	60.00	Moderate	
K18-4048-K18-4047	608791	11/9/2021	Obstruction or Intrusion	60.00	Moderate	
H16-4001-H16-1018	610322	3/28/2023	Inflow and Infiltration	60.00	Running or Trickling	
J11-2016-J11-2015	608324	5/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4057-L18-4028	609197	3/30/2022	Worn Surface	80.00	Minor	
L18-4057-L18-4028	609197	3/30/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-2044-K18-2043	609239	4/11/2022	Inflow and Infiltration	80.00	Weeping or Dripping	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-1015-K18-1014	609451	6/15/2022	Roots	80.00	Light	K18-1014 ROOTS IN STRUCTURE
J11-3019-J11-3018	608394	6/17/2021	Roots	80.00	Light	ROOTS IN JOINTS FROM 35' TO 55'
J11-3019-J11-3018	608394	6/17/2021	Obstruction or Intrusion	60.00	Moderate	
J11-3019-J11-3018	608394	6/17/2021	Worn Surface	80.00	Minor	
J20-2001-J20-3055	608802	11/15/2021	Roots	80.00	Light	IN STRUCTURE 3055
G16-3015-G16-3014	610273	3/13/2023	Cracks or Fractures	40.00	Severe Cracking	
G16-3015-G16-3014	610273	3/13/2023	Roots	50.00	Medium	
L17-1033-L17-1032	607899	1/12/2021	Roots	80.00	Light	ROOTS JUST INSIDE THE SAND COLLAR OF MANHOLE L17-1032
L17-4018C-L17-4004	607893	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-4018C-L17-4004	607893	1/11/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1065-L17-1064	607961	2/4/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1065-L17-1064	607961	2/4/2021	Roots	0.00	Blockage	SIDE SERVICE BLOCKED AT 334.4 FROM THE GROCERY STORE
L17-1065-L17-1064	607961	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L16-2017-L16-2016	609800	10/13/2022	Roots	30.00	Heavy	ROOTS IN DOWNSTREAM MH -L16-2016
J19-3114-J19-3107	608000	3/2/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
J18-2019-J18-2018	609515	7/12/2022	Roots	80.00	Light	J18-2018 IN STRUCTURE....REQUEST ROOT X TREATMENT
D23-2051-D23-2050	608141	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1016-L17-1015	607908	1/14/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1016-L17-1015	607908	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Roots	80.00	Light	LIGHT ROOTS IN THE TOP OF THE PIPE AT 125 FT
L17-1057-L17-1063	607963	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
K20-4007-K20-4006	609365	5/16/2022	Roots	50.00	Medium	K20-4007: roots in structure
K10-1010-K10-1007	608346	5/27/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1010-K10-1007	608346	5/27/2021	Roots	80.00	Light	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3106-H16-3105	610790	9/18/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-4011-J16-4006	610935	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
D23-2012-D23-2009	608216	5/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3081-J11-3066	608523	8/3/2021	Roots	80.00	Light	REFER ROOTS LIST
D23-2108-D23-2107	608030	3/10/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D10-1032-D10-1031	609623	8/15/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4002-D11-4001	610302	3/22/2023	Obstruction or Intrusion	80.00	Minor	
J19-2006-J19-2005	609478	6/17/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-4011-J11-4010	608409	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4011-J11-4010	608409	6/23/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4011-J11-4010	608409	6/23/2021	Break or Failure	30.00	Hole Soil Visible	
J11-4011-J11-4010	608409	6/23/2021	Worn Surface	80.00	Minor	
H16-3038-H16-3034	610822	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3049-LS-2	608753	10/20/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3050-D23-3049	608200	5/4/2021	Belly or Sag	80.00	Minor (<10%)	
D23-3050-D23-3049	608200	5/4/2021	Obstruction or Intrusion	60.00	Moderate	
F16-4009-F16-4002	609986	11/28/2022	Roots	80.00	Light	IN DOWNSTREAM SAND COLLAR MH F16-4002
L17-1023-L17-1022	607903	1/12/2021	Break or Failure	0.00	Collapse	
L17-1023-L17-1022	607903	1/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1023-L17-1022	607903	1/12/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L17-1023
L17-1023-L17-1022	607903	1/12/2021	Cracks or Fractures	40.00	Severe Cracking	
L17-1023-L17-1022	607903	1/12/2021	Lining or Repair Failure	80.00	Minor	
L18-4067-L18-4066	608896	12/23/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L18-4067-L18-4066	608896	12/23/2021	Obstruction or Intrusion	80.00	Minor	
K18-3028-K18-3027	609565	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-2025-K18-2024	608891	12/23/2021	Inflow and Infiltration	60.00	Running or Trickling	
G16-1013-G16-1019	610493	5/30/2023	Roots	80.00	Light	
J19-3112-J19-3111	607993	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2030-J11-2029	608458	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4047-K18-4046	608790	11/9/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4101-G16-4100	610156	1/25/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2087-D23-2086	608064	3/18/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-3099C-K18-3052	609320	4/27/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-3099C-K18-3052	609320	4/27/2022	Belly or Sag	40.00	Severe (>30%)	
K18-3099C-K18-3052	609320	4/27/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-3044-J11-3043	608436	7/6/2021	Obstruction or Intrusion	80.00	Minor	
J11-3044-J11-3043	608436	7/6/2021	Break or Failure	15.00	Hole Void Visible	
J11-3044-J11-3043	608436	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-1003-D23-1002	608172	4/27/2021	Roots	80.00	Light	
K10-1009-K10-1008	608313	5/19/2021	Roots	80.00	Light	K10-1009-K10-1008 ROOTS IN THE LATERAL 29 FT FROM THE UPPER M/H, 58 FT FROM UPPER M/H, 137 FROM UPPER M/H
K10-1009-K10-1008	609008	2/4/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K10-1009-K10-1008	609008	2/4/2022	Roots	50.00	Medium	SIDE SERVICE BLOCKED BY ROOTS AND POSSIBLY COLLAPSED
K19-4014-K19-4013	609029	2/7/2022	Roots	50.00	Medium	ROOT BUILD UP IN K19-4013
B26-2031-B26-2030	610886	11/20/2023	Obstruction or Intrusion	80.00	Minor	
H17-3050-H17-3049	611053	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3050-H17-3049	611053	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
D11-4026-D11-4025	609689	9/6/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
D11-4047-D11-4045	609684	9/6/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2017-G21-2016	609891	11/9/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K17-2011-LS-39	608742	10/19/2021	Worn Surface	80.00	Minor	
G21-2025-G21-2024	609876	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3035-K18-3031	608882	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4080-L18-4079	609278	4/20/2022	Obstruction or Intrusion	80.00	Minor	
D10-1002-D10-1001	609613	8/8/2022	Belly or Sag	40.00	Severe (>30%)	
G21-2003-G21-2002	609903	11/14/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2003-G21-2002	609903	11/14/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-2006-K18-2005	609353	5/4/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4051-L18-4050	607967	2/5/2021	Inflow and Infiltration	60.00	Running or Trickling	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L18-4051-L18-4050	607967	2/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1054-K10-1053	608303	5/18/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1054-K10-1053	608303	5/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
G16-3070-G16-3062	610311	3/23/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3037-G15-3036	610262	3/9/2023	Belly or Sag	80.00	Minor (<10%)	
D23-2011-D23-2010	608219	5/6/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
K19-1020-K19-1019	609072	2/16/2022	Roots	80.00	Light	K19-1019- ROOTS IN STRUCTURE
K18-4001-K18-3003	609270	4/19/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K19-1038-K19-1037	609410	6/7/2022	Roots	80.00	Light	ROOTS IN LATERAL 49' DOWNSTREAM
J16-4015-J16-4014	610923	11/29/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-4031-G16-4029	610115	1/11/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3065-J11-3064	608383	6/10/2021	Worn Surface	80.00	Minor	
G16-1051-G16-1050	610197	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1051-G16-1050	610197	1/27/2023	Obstruction or Intrusion	80.00	Minor	
J19-2086-J19-2008	608612	8/30/2021	Roots	80.00	Light	
K19-1037-K19-1036	609411	6/7/2022	Roots	80.00	Light	K19-1036 ROOTS ON LADDER RUNGS
G16-2037-G16-2018	610634	8/10/2023	Belly or Sag	80.00	Minor (<10%)	
J11-4012-J11-4011	608410	6/23/2021	Worn Surface	80.00	Minor	
J11-4012-J11-4011	608410	6/23/2021	Break or Failure	30.00	Hole Soil Visible	
J11-4012-J11-4011	608410	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2057-K18-2031	609257	4/18/2022	Belly or Sag	80.00	Minor (<10%)	
H16-2094C-H16-2012	611003	12/13/2023	Break or Failure	30.00	Hole Soil Visible	
H16-2094C-H16-2012	611003	12/13/2023	Roots	50.00	Medium	
H16-2094C-H16-2012	611003	12/13/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3054-H17-3053	611075	12/27/2023	Break or Failure	30.00	Hole Soil Visible	
K18-4026-K18-4025	609312	4/26/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2006-J18-2005	608639	9/16/2021	Roots	80.00	Light	ROOTS IN J18-2005 APPLYING ROOT TREATMENT
K18-1018-K18-1017	609448	6/15/2022	Roots	80.00	Light	K18-1017 ROOTS IN STRUCTURE
J19-2019-J19-2018	608919	1/10/2022	Roots	80.00	Light	IN J19-2019 STRUCTURE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4012-G16-4011	610132	1/17/2023	Roots	50.00	Medium	G16-4012 ROOTS IN MH CAUSING I&I
G16-4012-G16-4011	610132	1/17/2023	Inflow and Infiltration	60.00	Running or Trickling	
K10-1037-K10-1036	608245	5/11/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K10-1037-K10-1036	608245	5/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1088C-L17-1087	607886	1/8/2021	Roots	50.00	Medium	
L17-1088C-L17-1087	607886	1/8/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1088C-L17-1087	607886	1/8/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1088C-L17-1087	610746	9/7/2023	Break or Failure	30.00	Hole Soil Visible	
L17-1088C-L17-1087	610746	9/7/2023	Roots	0.00	Blockage	
K18-1009-K18-1008	609592	7/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-4044-K18-4024	609309	4/25/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-4044-K18-4024	609309	4/25/2022	Cracks or Fractures	80.00	Minor Cracking	
J16-1027-J16-1025	610622	8/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2066-D23-2065	608094	3/30/2021	Roots	80.00	Light	ROOTS IN LATERAL @60.4
C11-3010-C11-3008	609711	9/27/2022	Belly or Sag	80.00	Minor (<10%)	
J11-3102-J11-3058	608416	6/28/2021	Belly or Sag	80.00	Minor (<10%)	
H15-1023-H15-1001	610356	4/3/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-1030-H16-1029	610390	4/10/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
K18-4058-K18-4036	609295	4/22/2022	Cracks or Fractures	60.00	Moderate Cracking	
D23-2045-D23-2044	608173	4/27/2021	Roots	80.00	Light	IN D23-2045
L18-4048-L18-4047	607972	2/5/2021	Roots	50.00	Medium	ROOTS IN MANHOLE L18-4047
H16-4048-H16-4047	610312	3/23/2023	Roots	50.00	Medium	ROOTS IN DOWNSTREAM STRUCTURE H16-4047
H15-1001-G15-2011	610544	7/12/2023	Break or Failure	15.00	Hole Void Visible	
K18-2041-K18-2040	609339	5/2/2022	Roots	80.00	Light	K-18-2040: ROOT NEAR TOP OF STRUCTURE
J11-3089-J11-3095	608454	7/13/2021	Roots	80.00	Light	ON ROOTS LIST
L17-1062-L17-1058	607966	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1062-L17-1058	607966	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
K19-1060-K19-1059	609248	4/13/2022	Roots	50.00	Medium	BOTH STRUCTURES K19-1060-K19-1059
H16-3041-H16-3040	610820	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3041-H16-3040	610820	9/26/2023	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J16-4008-J16-4007	610931	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3078-G16-3009	610277	3/13/2023	Inflow and Infiltration	60.00	Running or Trickling	
J19-2067-J19-2068	608828	12/8/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
K18-3031-K18-3030	609563	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-4018-J11-4013	608406	6/23/2021	Roots	80.00	Light	
J11-3046-J11-3045	608435	7/6/2021	Roots	80.00	Light	ON ROOTS LIST
J11-3046-J11-3045	608435	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3046-J11-3045	608435	7/6/2021	Worn Surface	80.00	Minor	
J11-3046-J11-3045	608435	7/6/2021	Obstruction or Intrusion	80.00	Minor	
G16-4089-G16-4088	610086	12/15/2022	Belly or Sag	80.00	Minor (<10%)	
D23-2143-D23-2142	608367	6/7/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2062-D23-2061	608193	5/4/2021	Worn Surface	80.00	Minor	
J11-3051-J11-3048	608528	8/3/2021	Worn Surface	80.00	Minor	
H16-4002-H16-4001	610360	4/4/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3044-J18-3043	608204	5/5/2021	Roots	80.00	Light	J18-3043 STRUCTURE HAS LIGH ROOTS...RECOMMEND ROOT X TREATMENT
K18-3008-K18-3007	609426	6/8/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-4067-K18-4066	608784	11/9/2021	Belly or Sag	80.00	Minor (<10%)	
K19-4022-K19-4025	609475	6/17/2022	Roots	80.00	Light	K19-4022
L17-1039-L17-1038	610348	3/30/2023	Belly or Sag	80.00	Minor (<10%)	
L17-1039-L17-1038	610348	3/30/2023	Obstruction or Intrusion	60.00	Moderate	
L17-1039-L17-1038	610348	3/30/2023	Lining or Repair Failure	40.00	Severe	
J16-4004-J16-4003	610937	12/1/2023	Roots	80.00	Light	
J16-4004-J16-4003	610937	12/1/2023	Break or Failure	15.00	Hole Void Visible	
G16-4087-G16-4086	610108	1/3/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4013-G16-4010	610129	1/17/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2024-G16-2020	610383	4/7/2023	Belly or Sag	60.00	Moderate (10 to 30%)	

consor

APPENDIX G
WWTP CONDITION ASSESSMENT

Central Kitsap Wastewater Treatment Plant

Facility Name: 100 Headworks Building

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Headworks Building	1000				2009		
Decant Station	N/A				1997		
Decant Pump 1	N/A				1997		
Decant Pump 2	N/A				1997		

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 102 Screens

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Raw Sewage Sampler	MME 1020				2009	SOUTHWELL CONTROLS	BVS-CM2RC9-CDF
Mechanical Fine Screen	SCN 1021 SCN 1023				2009	MAHR BAR SCREEN	MSI ENCLOSED
Bar Screen	SCN 1022				2009		
Screenings	CON 1025				2009	Headworks Inc.	TU300
Screenings Compactor	MME 1026				2009	Headworks Inc.	SW W220/ MME1026

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 110 Grit Removal

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Grit Pump 1	P 1111				2009	MORRIS	CT3X3-16HC2
Grit Pump 2	P 1112				2009	MORRIS	CT3X3-16HC2
Grit Pump 3	P 1121				2009	MORRIS	CT3X3-16HC2
Grit Pump 4	P 1122				2009	MORRIS	CT3X3-16HC2
Primary Influent Sampler	MME 128				2009	SIRCO	BVS-CM2RB1-CD
Grit Washer 1 Mixer	MXR 1027				2009	HEUBER	COANDA RosF4
Grit Washer 1 Auger	AUG 1027				2009	HEUBER	COANDA RosF4
Grit Washer 2 Mixer	MXR 1028				2009	HEUBER	COANDA RosF4
Grit Washer 2 Auger	AUG 1028				2009	HEUBER	COANDA RosF4
Equipment Gallery Sump Pump 1	P 1251				2009		
Equipment Gallery Sump Pump 2	P 1252				2009		
Clarifiers Drain Pump	P 1253				2009		
Grit Tank Air Blower	B 1276				2009	Robuschi	RBS 66 F
Grit Tank Air Blower - Standby	B 1277				2009		RBS 66 F

Grit Tank Agitation Blower							

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 120 Primary Clarifiers

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Primary Clarifier 1 Structure	N/A				1977		
Primary Clarifier 1 Rake and Skimmer Mechanism	N/A				1977		
Primary Clarifier 2 Structure	N/A				1977		
Primary Clarifier 2 Rake and Skimmer Mechanism	N/A				1977		

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 140 Headwoks Odor Control

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Headworks Biofilter Blower	B 1061				2009	M.K. Plastics Inc	DHK-NW 2450
Headworks Biofilter Humidifier	HUM 1062				2009		
Headworks Biofilter	BIOF 1060				2009		
Headworks Biofilter Sump Pump	P 1071				2009	Wilo	HC20.1-6/32KEx

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 190 Plant Wastewater Sump

Unit Process: 100 – Preliminary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Plant Wastewater Sump	T 1090				2009		
Plant Wastewater Sump Pump 1	P 1091				2009	Wilo	FA10.78
Plant Wastewater Sump Pump 2	P 1092				2009	Wilo	FA10.78

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 200 Power and Blower Building

Unit Process: 200 – Secondary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Power and Blower Building Structure	N/A				1996		
Aeration Blower 1	B 2001				1996		
Aeration Blower 2	B 2002				1996		
Aeration Blower 3	B 2003				2016		
Aeration Blower 4	B 2004				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 210 Aeration Basins 1, 2 & Utilidor

Unit Process: 200 – Secondary Treatment

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Aeration Basin 1/2 Structure	N/A				1977		
Aeration Basin 1 Mixer 1	MXR 2115				1999	Aqua-Aerobic	
Aeration Basin 1 Mixer 2	MXR 2116				1999	Aqua-Aerobic	
Aeration Basin 1 Mixer 3	MXR 2117				2016	Aqua-Aerobic	
Aeration Basin 1 Mixer 4	MXR 2118				2016	Aqua-Aerobic	
Mixed Liquor Recycle Pump	P 2140				2016	Wilo USA LLC	T17-8/16REx
Mixed Liquor Recycle Pump	P 2190				2016	Wilo USA LLC	T17-8/16REx
Aeration Basin 2 Mixer 1	MXR 2165				1999	Aqua-Aerobic	
Aeration Basin 2 Mixer 2	MXR 2166				1999	Aqua-Aerobic	
Aeration Basin 2 Mixer 3	MXR 2167				2016	Aqua-Aerobic	
Aeration Basin 2 Mixer 4	MXR 2168				2016	Aqua-Aerobic	
Primary Sludge Pump 1	P 1001				2009	Penn Valley	
Primary Sludge Pump 2	P 1002				2009	Penn Valley	
Scum Pump	P 1003				1977	MARLOW	PE 82 W
Primary Sludge Pump 3	P 1004				1977		
Scum Grinder	GDR 1005				1977	Muffin Monster	

RAS Pump 1	P 2511				1977	WORTHINGTON	6MF-11
RAS Pump 2	P 2512				1977	WORTHINGTON	6MF-11
RAS Pump 3	P 2513				1977	WORTHINGTON	6MF-11
RAS Pump 4	P 2514				1977	WORTHINGTON	6MF-11
RAS Pump 5	P 2515				1977	WORTHINGTON	6MF-11
Basins 1/2 WAS Pump 1	P 2531				1977	CUTLER HAMMER	AF93AGOCOO5D
Basins 1/2 WAS Pump 2	P 2532				1977		AF93AGOCOO5D
Channel Blower 1	B 2541					GARDNER/DENVER	H7PDRA
Channel Blower 2	B 2542					GARDNER DENVER	H7PDRA

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Secondary clarifier drain?

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 300 Process Water System

Unit Process: 300 – Disinfection and Water Distribut

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Process Water Pump 1	P 3001	newer			1977	ALLIS-CHALMERS	2000-150
Process Water Pump 2	P 3002				1977	ALLIS-CHALMERS	2000-150
Process Water Pump 3	P 3003	newer plus purple motor			80's?	ALLIS-CHALMERS	2000-151

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 220 RAS/WAS/Classifier

Unit Process: 200 – Preliminary Treatment

Equipment Name:	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Basins 3/4 WAS Pump 1	P 2201				2016	Vogelsang	VX186-130Q
Basins 3/4 WAS Pump 2	P 2202				2016	Vogelsang	VX186-130Q
Classifier Blower	B 2205				2016		
Classifier Selector Diffuser Grid	ME 2206				2016		
RAS Box Mixer 1	MXR 2210				2016		
RAS Box Mixer 2	MXR 2211				2016		
Channel Blower 3	B 2543				2016	Aerzen	GM 015L-00
Channel Blower 4	B 2544				2016	Aerzen	GM 025S-00

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 230 Aeration Basins 3 & 4

Unit Process: 200 – Secondary Treatment

Equipment Name:	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Aeration Basins Electrical Bldg							
Aeration Basin 3 Mixer 1	MXR 2315				2016	EPIC International	2-1200 SS DPM
Aeration Basin 3 Mixer 2	MXR 2316				2016	EPIC International	2-1200 SS DPM
Aeration Basin 3 Mixer 3	MXR 2317				2016	EPIC International	2-1200 SS DPM
Aeration Basin 3 Mixer 4	MXR 2318				2016	EPIC International	2-1200 SS DPM
Aeration Basin 4 Mixer 1	MXR 2365				2016	EPIC International	2-1200 SS DPM
Aeration Basin 4 Mixer 2	MXR 2366				2016	EPIC International	2-1200 SS DPM
Aeration Basin 4 Mixer 3	MXR 2367				2016	EPIC International	2-1200 SS DPM
Aeration Basin 4 Mixer 4	MXR 2368				2016	EPIC International	2-1200 SS DPM
Mixed Liquor Recycle Pump	P 2340				2016	Wilo	RZP 40.89-8/16 S7
Mixed Liquor Recycle Pump	P 2390				2016	Wilo	RZP 40.89-8/16 S7
Aeration Basin 3 Drain Pump	P 2345				2016	Wilo	FA10.826
Aeration Basin 4 Drain Pump	P 2395				2016	Wilo	FA10.826

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 240 Carbon Feed System

Unit Process: 200 – Secondary Treatment

Equipment Name:	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Carbon Addition Support Bldg							
Methanol Storage Tank	T 2400				2016	T Bailey	Custom
Methanol Metering Pump 1	P 2401				2016	Watson Marlow	520R 2C
Methanol Metering Pump 2	P 2402				2016	Watson Marlow	520R 2C
Methanol Metering Pump 3	P 2403				2016	Watson Marlow	520R 2C
Methanol Metering Pump 4	P 2404				2016	Watson Marlow	520R 2C

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 250 Secondary Clarifiers

Unit Process: 200 – Secondary Treatment

Equipment Name:	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Foam Wasting Pump	P 2500				2016	Wilo	FK17.1-6/12KEx
Secondary Clarifier 1 Structure	N/A				1977		
Secondary Clarifier 1 Rake and Skimmer Mechanism	COL 2510				1997	EIMCO	C40LT DRIVE
Secondary Clarifier 2 Structure	N/A				1977		
Secondary Clarifier 2 Rake and Skimmer Mechanism	COL 2520				1997	EIMCO	C40LT DRIVE

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 301 Reclaimed Water Feed Pumps

Unit Process: 300 – Disinfection and Water Distribut

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Reclaimed Water Feed Pump 1	P 3011				2016	Peerless Pump	12HXB
Reclaimed Water Feed Pump 2	P 3012				2016	Peerless Pump	14HH
Reclaimed Water Feed Pump 3	P 3013				2016	Peerless Pump	14HH
Reclaimed Water Chlorine Residual Sample Pump	P 3021				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 310 UV Disinfection

Unit Process: 300 – Disinfection and Water Distribut

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
UV Bank A (Channel 1)	UVB 3111				2019	Trojan	Signa
UV Bank B (Channel 1)	UVB 3112				2019	Trojan	Signa
UV Bank C (Channel 1)	UVB 3113				2019	Trojan	Signa
UV Bank A (Channel 2)	UVB 3211				2019	Trojan	Signa
UV Bank B (Channel 2)	UVB 3212				2019	Trojan	Signa
UV Bank C (Channel 2)	UVB 3213				2019	Trojan	Signa

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 340 Outfall

Unit Process: 300 – Disinfection and Water Distribut

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Outfall					1977		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 400 Rotary Drum

Unit Process: 400 – WAS Thickening

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
WAS Thickening Building	B 4000				2016		
WAS Flocculation Tank Mixer	MXR 4010				2016		
WAS Flocculation Tank	T4014				2016	FKC	FT-540GL
Rotary Drum Thickener	RDT 4012				2016	FKC	RST-S755x3600L
RDT Spray Cleaning Bar	MME 4013				2016		
TWAS Pump	P 4020				2016	NOV MONO	CW052AJ2R1/E8BV
Emulsion Polymer Pump	P 4051				2016	NETZCH	80102-F111680-A
Polymer Dilution Water Booster Pump	P 4053				2016		
Emulsion Polymer Mixer	MXR 4052				2016	FLUID DYNAMICS	L8S-6000-35P-I6-4
Emulsion Polymer Tote Mixer	MXR 4055				2016		
Polymer Tank 1	T 4065				2016		
Polymer Tank 2	T4075				2016		
Polymer Feed Pump 1	P 4080				2016	NETZCH	MP-650
Polymer Feed Pump 2	P 4090				2016	NETZCH	MP-650
Polymer Static Mixer	MXR 4095				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 450 Thickened Sludge

Unit Process: 400 – WAS Thickening

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Thickened Sludge Blending Tank	T 4502				2016		
TSBT Carbon Canister	MME 4503				2016		
TSBT Circulation Pump	P 4506				2016	NOV MONO	C1BBC11RMA/E8BQ
Digester Feed Pump 1	P 4510				2016		
Digester Feed Pump 2	P 4520				2016		
Digester Feed Pump 3	P 4530				2016		
Hauled Sludge Transfer Pump	P 4508				2016	NOV MONO	C1BBC11RMA/E8BQ

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 450 Thickened Sludge

Unit Process: 400 – WAS Thickening

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Thickiner Control Bldg							
Gravity Thickener 1 Structure	N/A				1977		
1 Rake and Skimmer	N/A				1977	DORR OLIVER	S-9 SPEC 30-S-1
Gravity Thickener 2 Structure	N/A				1977		
2 Rake and Skimmer	N/A				1977	DORR OLIVER	S-9 SPEC 30-S-1
Gravity Thickener Blower	N/A				1977		
Gravity Thickener Biofilter	N/A				1977		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 470 Non-potable Water

Unit Process: 400 – WAS Thickening

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Utility Water Shock Suppresser	MME 4701				2016		
Utility Water Backflow Preventor	MME 4720				2016		
Air Gap Tank	T 4703				2016	PolyProcessing	Custom
Nonpotable Water Pump 1	P 4704				2016	Grundfos	CR20-3
Nonpotable Water Pump 2	P 4705				2016	Grundfos	CR20-3
Nonpotable Water Pump 3	P 4706				2016	Grundfos	CR20-3
Nonpotable Hyrdopneumatic Tank	T 4707				2016	AMTROL	WX-453-C

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 500 Septage System

Unit Process: 500 Septage System

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Septage Rock Trap	SEPT 5010				2009		
Septage Screen	SCN 5010				2009		
Tank	T 5011				2009		
Septage Odor Control Tower	ORT 5020				2009		
Septage Odor Control Blower	BLO 5020				2009		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 600 Digester Feed

Unit Process: 600 Anaerobic Digesters

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Digester Control Bldg							
Anaerobic Digester 1	T 6100				1977		
Anaerobic Digester 2	T 6200				1977		
Digester Feed Pump 1	P 6011				1977	WORTHINGTON PUMP	14 MNC -16
Digester Feed Grinder 1	G 6012				1977	MUFFIN MONSTER	30001-1206-CI
Digester Feed Pump 2	P 6021				1977	WORTHINGTON PUMP	14 MNC -16
Digester Feed Grinder 2	G 6022				1977	MUFFIN MONSTER	30001-1206-CI
Digester Sludge Recirculation Pump 1	P 6101				1977	WEMCO	CE
Digester Sludge Recirculation Pump 2	P 6201				1977	WEMCO	CE
Digester Sludge Mixing Pump 1	P 6110				1977	WORTHINGTON PUMP	14 MNC -16
Digester Sludge Mixing Pump 2	P 6211				1977	WORTHINGTON PUMP	14 MNC -16
Digester Withdrawl Pump 1 (Not Used?)	P 6191				1999	WEMCO	C
Digester Withdrawl Pump 2 (Not Used?)	P 6192				1999	WEMCO	C

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 670 Digested Gas

Unit Process: 600 Anaerobic Digesters

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Digester Gas Sediment Trap	SEP 6701				2016	Varec Biogas	233 Series
Air Separator	SEP 6801				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 680 Boilers

Unit Process: 600 Anaerobic Digesters

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Digester Boiler 1	B 6801				1977	CLEAVER BROOKS	CBH- 200X-70
Digester Boiler 2	B 6802				1977	CLEAVER BROOKS	CBH- 200X-70
Expansion Tank 1	T 6801				1977	ITT, BELL & GOSSET	ATFL
Expansion Tank 2	T 6802				1977	ITT, BELL & GOSSET	ATFL
Expansion Tank 3	T 6803				2016		
Hot Water Recirc Pump 1	P 6101				1977		
Hot Water Recirc Pump 2	P 6102				1977		
Hot Water Recirc Pump 3	P 6302				1977		
Hot Water Recirc Pump 4	P 6402				1977		
Digester Heat Exchanger 1	HEX 6101				1977	AMER. HEAT RECLAIM CO	134
Digester Heat Exchanger 2	HEX 6201				1977	AMER. HEAT RECLAIM CO	134

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 710 Dewatering

Unit Process: 700 Sludge Processing

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Sludge Processing Building	BLDG 7000				1977		
Filter Press Feed Pump (Not Used)	P 7101				1977		
Filter Press Grinder (Not Used)	GDR 7104				1977		
Centrifuge 1 Sludge Grinder	GDR 7111	ONE GRINDER IS OLD AND ONE IS NEW			1999	Muffin Monster	30004T-1206-DI-206
Centrifuge 2 Sludge Grinder	GDR 7121				1999		
Centrifuge 1 Sludge Feed Pump 1	P 7112				1999	Seepex	BN 70-12
Centrifuge 2 Sludge Feed Pump 2	P 7122				1999	Seepex	BN 70-12
Centrifuge 1 Hydraulic Pump Unit	HPU 7110				2019		
Centrifuge 2 Hydraulic Pump Unit	HPU 7120				2019		
Centrifuge 1	CFG 7110				2019	Centrisys	CS21-4HC
Centrifuge 2	CFG 7120				2019	Centrisys	CS21-4HC
Service Air Compressor 1	CP 7030				1999	Quincy Northwest	F-15
Service Air Compressor 2	CP 7031				?		

Service Air Dryer 1	MME 7035				1999		
Service Air Dryer 2	MME 7036				?		
Crane	MME 7131				1999		
Bulk Polymer Tank	T 7051				1999		
Centrate Pump 1	P 7151				1999	Gorman Rupp	T3A3-B
Centrate Pump 2	P 7152				1999	Gorman Rupp	T3A3-B
Septage Pump 1	P 7161				1999		
Septage Pump 2	P 7162				1999		
Septage Grinder	GDR 7163				1999		
Odor Reduction	ORT 7190				1999	Spunstrand	Custom
Sludge Processing	B 7191				1999	Hartzell Fan	413-22-FAR3

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 720 Coagulation and Polymer

Unit Process: 700 Sludge Processing

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Alum Storage Tank	T 7201				1996		
Heated Water Pump	P 7209					SCOT	Motorpump
Coagulation System Transfer Pump 1	P 7210				2019		
Coagulation System Transfer Pump 2	P 7220				2016		
Sludge Polymer Blender	SPB 7210				2019	Sharpe	SIMFLOC-5.0
Dewatering Polymer Dilution Unit 1	MME 7221				1999	US Filter-Stranco	M3000-P15BX-V
Dewatering Polymer Dilution Unit 2	MME 7222				1999	US Filter-Stranco	M3000-P15BX-V
Dewatering Tank 1	T 7231				1999		
Dewatering Tank 2	T 7232				1999		
Polymer Mixer 1	MXR 7231				1999		
Polymer Mixer 2	MXR 7232				1999		
Polymer Feed	P 7241				1999	Seepex	BN 10-12
Polymer Feed	P 7242				1999	Seepex	BN 10-12

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 730 Hypochlorite

Unit Process: 700 Sludge Processing

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Sodium Hypochlorite Tank	T 7300				1999		
Hypochlorite Recirculation Pump 1	P 7310				1999	Magnatex	ME Series
Hypochlorite Recirculation Pump 2	P 7320				1999	Magnatex	ME Series
Hypochlorite Metering Pump 1	P 7330				1999		
Hypochlorite Metering Pump 2	P 7340				1999		
Reclaimed Water Hypochlorite Metering Pump 1	P 7401				2016		
Reclaimed Water Hypochlorite Metering Pump 2	P 7402				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 820 Reclaimed Water Filters

Unit Process: 800 Reclaimed Water

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Reclaimed Water Bldg							
Coagulation System Inline Mixer	MXR 8212				2016	MixTec	2500 2-182T-D
Reclaimed Water Filter 1	FLT 8201				2016	Parkson	DSF-50 DBTF
Reclaimed Water Filter 2	FLT 8202				2016	Parkson	DSF-50 DBTF
Reclaimed Water Filter 3	FLT 8203				2016	Parkson	DSF-50 DBTF
Reclaimed Water Filter Air Compressor 1	CP 8210				2016		
Reclaimed Water Filter Air Compressor 2	CP 8211				2016		
Air Compressor 1 Refr Dryer	DRY 8210				2016		
Air Compressor 2 Refr Dryer	DRY 8211				2016		
Common Air Compressor Desic Dryer	DRY 8210A				2016		
Coagulation System Day Tank	T 8400				2016		
Reclaimed Water Coagulation System Metering Pump 1	P 8401				2016	Watson Marlow	520UmAN/R2

Reclaimed Water Coagulation System Metering Pump 2	P 8402				2016	Watson Marlow	520UmAN/R2
Dechlorination System Solution Mixer	MXR 8600				2016	MixTec	1057
Reclaimed Water Ascorbic Acid Metering Pump	P 8601				2016	Watson Marlow	520UmAN/R2
Tempered Water Supply	TWS 8760				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 900 Hear Reservoir Pumps

Unit Process: 900 Cogeneration

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Heat Reservoir Pump 1	P 9001				2016	Bell & Gossett	E-1510 2.5BB7.5
Heat Reservoir Pump 2	P 9002				2016	Bell & Gossett	E-1510 2.5BB7.5

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 910 Waste Gas Burner

Unit Process: 900 Cogeneration

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Waste Gas Burner	WGB 9111				2016	Varec	SPC244E G/S D171101RA

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 920 Gas Treatment

Unit Process: 900 Cogeneration

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
H2S Removal Vessel 1	VE 9201				2016	Unison Solutions	BGS-75
H2S Removal Vessel 2	VE 9202				2016	Unison Solutions	BGS-76
Digester Gas Inlet Separator	SEP 9211				2016		
Air Cooled Glycol Chiller	CLR 9212				2016	Johnson Thermal Systems	JTS-4SIA-4YS
Chilled Glycol Circulation Pump	P 9212				2016	JOHNSON THERMAL SYSTEMS	SPC75-3T
Condensate Pump	P 9213				2016	Liquiflo	45s6PEEN210
Digester Gas Heat Exchanger	HEX 9216				2016		
Glycol Solution Expansion Tank	T 9219				2016		
Blower	B 9221				2016		
Vessel 1	VE 9231				2016	Unison Solutions	BGS-75
Vessel 2	VE 9232				2016	Unison Solutions	BGS-76
Digester Gas Particulate Filter	FLT 9241				2016		

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Equipment Name: 930 Engine

Unit Process: 900 Cogeneration

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Cogeneration							
Engine/Generator	GEN 9301					2G Cenergy	2G-KWK-250BG
Exaust Heat Recovery Silencer	HEX 9311					2G Cenergy	
Supplemental Silencer	SIL 9311						
HT Expansion Tank	T 9311						
HT Circuit Pump	P 9311					Grundfos	TP 65-190/4
Intercooler Radiator	CLR 9321						
LT Expansion Tank	T 9321						
LT Circuit Pump	P 9321					Grundfos	UPS 32-160 F 220
Heat Recovery Heat Exchanger	HEX 9331					SONDEX	SL 140
Heat Recovery Pump	P 9331					Grundfos	UPS 65-160 F 340
Waste Heat Radiator	CLR 9311						

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

Central Kitsap Wastewater Treatment Plant

Facility Name: 050 Miscellaneous

Unit Process: 050 Miscellaneous

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-4)	Serviceability (1-4)	Install Year	Manufacturer	Model
Generator Building							
Fuel Storage Tank							
Standby Generator							
Administration Building							
Modular Offices							
Operations Facilities Building							
Shop and Maintenance Building							
Stormwater Decant Facility							
Backflow Preventer Building							

*Condition (1= very good, 5 = very poor). Criticality (1=Not critical, 4 = critical). Serviceability (1= very good, 4= very poor)

Notes:

Recommended Improvements:

APPENDIX H
CENTRAL KITSAP WWTP AERATION
DIFFUSER EMERGENCY
REPLACEMENT BASIS OF DESIGN,
MURRAYSMITH, NOVEMBER 2020

consor

Technical Memorandum

Date: November 16, 2020

Project: Wastewater Facility Plan and Sewer Plan Update

To: Barbara Zaroff, PE, PMP
Christopher Sheridan
Kitsap County, WA

From: Miaomiao Zhang, PE, PMP
Jefferson Moss, PE
Murraysmith

Reviewed By: Erika Schuyler, PE, PMP
Craig Anderson, PE

Re: Central Kitsap WWTP Aeration Diffuser Emergency Replacement Basis of Design

Introduction

The Central Kitsap Wastewater Treatment Plant (WWTP) is experiencing a high failure rate of the strip-type aeration diffusers (AEROSTRIP®) installed in the aeration basins. The failed diffusers alter the desired air distribution within various aeration zones and reduce the oxygen transfer efficiency. The diffusers require urgent repair or replacement to keep the Central Kitsap WWTP in NPDES permit compliance. An additional benefit of completing the repair or replacement work is that it will prepare the WWTP for the upcoming biological nutrient removal optimization and future nutrient removal regulation.

This technical memorandum discusses the conditions of the existing strip diffusers and presents the alternatives evaluation used to determine the preferred alternative to address the failing strip diffusers. The memorandum also evaluates and verifies the viability of fitting Sanitaire disc diffuser grids inside the existing aeration basins, and investigates the capacity of the existing aeration blowers to provide sufficient airflow and pressure with the new disc diffuser system.

In summary:

Three alternatives to address the failing diffusers were developed with life cycle costs and it was confirmed that the existing aeration blowers can provide sufficient airflow and pressure via the existing air distribution piping with a new diffuser system under various operating conditions that meet the oxygen demand established in the 2015 Resource Recovery Project. The three alternatives are:

- Alternative A – Continuing ongoing repair or replacement of the strip diffusers
- Alternative B – Complete replacement of the strip diffusers
- Alternative C – Complete replacement with Sanitaire disc diffuser grids inside the four existing aeration basins.

Alternative C is the recommended alternative based on the lowest life cycle cost opinion and the observed issues with the existing AEROSTRIP® diffusers by Murraysmith. The County agrees with the recommendation and has given direction to proceed with the design of Alternative C.

There are other membrane disc diffuser manufacturers that could provide a comparable diffuser system to Sanitaire. However, given the nature of this emergency, the fact that the County staff is familiar with the Sanitaire diffuser system, and the proven success of the Sanitaire diffuser system, direct procurement from Sanitaire as the sole-sourced manufacturer is the recommended approach.

Background

The Central Kitsap WWTP was constructed in 1977 to provide wastewater treatment in the Central Kitsap service area. Surface aerators provided air to Aeration Basins 1 and 2. In 1996, the aerators were replaced with a fine bubble diffused aeration system consisting of three Lamson multi-stage centrifugal blowers, aeration air distribution piping, and Sanitaire 7-inch membrane disc diffusers. In 2015, the Resource Recovery Project installed two new aeration basins (Aeration Basin 3 and 4) which were fitted with AEROSTRIP® diffusers. The 7-inch disc diffusers in existing aeration basins were replaced with the same AEROSTRIP® diffusers. In addition, one of the existing Lamson blowers was replaced by two new Aerzen high-speed turbo blowers.

Strip diffusers were selected for their improved oxygen transfer efficiency, however, the strip diffusers have been failing at a high rate. Each of the four basins contains 303 diffusers, thus the plant has 1,212 diffusers total. In the first four years of operation, staff replaced 54 diffusers total among the four aeration basins. In the fifth year of operation, the plant had an estimated 123 diffusers fail. The manufacturer-claimed useful life of these diffusers is 10 years, however the observed life is much shorter than that, even though Kitsap County (County) staff has been performing the recommended preventative maintenance procedures.

The strip diffusers typically fail when the membrane rips as shown in **Figure 1**, which allows air to escape though the hole in the membrane. Small rips can be repaired, but larger rips require the complete replacement of the strip diffuser. Failure of the strip diffusers is especially problematic because when one strip in a grid fails, it causes a pressure drop for the entire grid, which limits or eliminates the capacity for the other strips to emit air. With most of the air escaping though the broken strip as large bubbles (**Figure 2**), the effective oxygen transfer efficiency and treatment capacity are greatly reduced.

Figure 1
Failed Strip Diffusers at Central Kitsap WWTP

Figure 2
Coarse Bubbles from Failed Strip (Left) and Fine Bubbles from Functional Strip (Right)

Alternatives Evaluation

Diffuser Technology Comparison

The existing AEROSTRIP® diffusers are a relatively new technology that emerged approximately 15 years ago. Compared to the more conventional disc diffusers, these low flux diffusers offer higher oxygen transfer efficiency, resulting in some energy saving for the aeration systems. The manufacturer also claims the polyurethane membrane material is more resistant to the biological fouling and lasts longer than ethylene propylene diene monomer (EPDM) membrane.

Sanitaire fine bubble disc diffusers are a proven technology, with several decades of aeration application, including successful use at Central Kitsap WWTP for many years. They utilize the EPDM rubber membrane mounted onto a plate or diffuser holder. Table 1 summarizes the physical and operational comparisons between these two types of diffusers.

Table 1
Disc and Strip Diffuser Physical and Operational Comparisons

Type	Manufacturer	Product	Membrane Material	Operating air flow range (scfm/ft^2)	Standard Oxygen Transfer Efficiency (SOTE)
Disc Diffusers	Sanitaire	Silver Series II Membrane Discs	EPDM	1.2-11 (0.5 to 4.5 scfm per disc which is 0.41 ft^2)	2-2.5% per ft submergence
Strip Diffusers	Aerzen (Ovivo)	AEROSTRIP Type Q	Polyurethane	0.3-7.1	2.6-3.0% per ft submergence

Murraysmith has found that some wastewater utilities have had acceptable experience using AEROSTRIP® diffusers for close to ten years without significant failure. But other utilities have had similar experience to what Central Kitsap WWTP has observed. Based on an evaluation of published literature and experience gathered from other facilities that utilize AEROSTRIP® diffusers, the following are some of the advantages and disadvantages of the AEROSTRIP® comparing to the Sanitaire Silver Series II:

Advantages of AEROSTRIP®:

- Higher oxygen transfer efficiency
- Ability to mount lower to the basin floor (additional efficiency improvement)

Disadvantages of AEROSTRIP®:

- Much higher upfront capital cost
- Higher headloss across the diffuser (approximately 1 psi)
- Use of a polyurethane material which is more UV and chlorine sensitive
- Potential for the membrane material to fold or crease when not in operation which creates a weak/failure point
- Rectangular design that can lead to uneven stresses and failures at the perimeter restraints
- Due to the large panel surface area, the failure of one diffuser can have much bigger impact to the overall air distribution in a grid
- Manufacturer required daily diffuser flexing (increased blower control complexity)

Alternatives with Cost Comparison

The three alternatives considered to address the failing diffusers are described below. The 20-year life cycle costs of these alternatives are estimated based on the listed assumptions. Appendix A includes the details of the cost opinions and comparison.

Alternative A - Continue Ongoing Replacement of Strip Diffusers

Alternative A represents the current maintenance approach of replacing the strip diffusers as they fail. Based on the current failure rate, it is assumed that on average, 200 strips will fail each year after five years of use. This is an annual failure rate of 16 percent, which is equivalent to a mean lifespan of 6 years. It is assumed for this alternative that the County will incorporate this diffuser strip replacement into an ongoing maintenance program at Central Kitsap WWTP, so the costs are presented as a maintenance cost. These annual maintenance cost assumptions are summarized below:

- $500 material cost for each strip
- 10% administrative overhead cost for all material purchases
- 2-hours of installation labor for each diffuser strip
- 16-hours of labor per basin for draining, cleaning and refilling basins for diffuser replacement work
- 12-hours of labor per basin for typical cleaning and maintenance
- $60/hour labor rate for all labor

Providing oxygen to aeration basins is typically the highest energy demand at a treatment facility. Annual power requirements for aeration were estimated using the blower manufacturer's reported horsepower needed to provide the air flow required, which is then converted to an electrical load in kilowatts and multiplied by an assumed electrical cost of $0.07 per hour. The air requirement for Alternative A was assumed to be 20 percent higher than the vendor calculated air demand for the working strip diffusers as a result of the pressure and bubble size inefficiencies from the failed strip diffusers.

Alternative B - Replacement of Strip Diffusers with New Strip Diffusers

Alternative B represents the complete and immediate replacement of the existing strip diffusers with the same product and includes future replacements occurring on the manufacturer suggested 10-year lifespan. Capital costs assumptions for the complete diffuser replacement projects are summarized below:

- $500 material cost for each strip
- 20% markup on material cost for installation

- 12% markup on material and labor cost for general contractor overhead and profit
- 8% markup on material and labor cost for mobilization
- 8% markup on material and labor cost for general conditions
- 10% markup on total construction cost for contingency
- 25% markup on total construction cost for engineering, legal, and administration

Alternative B also assumes an annual average of 15 diffusers breaking prematurely and are replaced by the County as a maintenance item, which is consistent with the County's current experience with the strip diffusers. Maintenance cost assumptions are same as those listed above for Alternative A.

Power costs were calculated with the same method as Alternative A, but with the vendor calculated air demand (no efficiency loss).

Alternative C - Replacement of Strip Diffusers with New Disc Diffusers

Alternative C represents the complete and immediate replacement of the existing strip diffusers with Sanitaire Silver Series II membrane disc diffusers with future replacements occurring on the manufacturer suggested 10-year lifespan. The capital costs were calculated based on an estimate from the vendor as summarized below:

- $77,000 material cost per basin for the entire diffuser system
- 20% markup on material cost for installation
- $5,000 in demolition costs for each basin to remove the existing diffuser system
- 12% markup on material and labor cost for general contractor overhead and profit
- 8% markup on material and labor cost for mobilization
- 8% markup on material and labor cost for general conditions
- 10% markup on total construction cost for contingency
- 25% markup on total construction cost for engineering, legal, and administration

It is assumed that no diffuser disc replacement maintenance will be required in the middle of the 10-year diffuser lifespan, but the disc diffusers still require regular cleaning. These annual maintenance cost assumptions are summarized below:

- 12-hours of labor per basin for typical cleaning and maintenance
- $60/hour labor rate for all labor

Power costs were calculated with the same method as the other alternatives, with the air demand reported by the disc diffuser vendor. The oxygen transfer efficiency using membrane disc diffusers is lower than that using the strip diffusers.

The net present value parameters used for the analysis are applicable to all alternatives and are summarized below:

- Discount rate: 5 percent
- Number of years: 20
- Annual inflation: 3 percent

Table 2 summarizes the results of the net present value analysis. Alternative C requires about half of the capital cost of Alternative B and has the lowest life cycle cost.

Table 2
Net Present Value Summary

Alternative	Capital Cost	Annual Maintenance Cost	Annual Operating Cost	Diffuser Replacement Frequency (year)	Life Cycle Cost (Net Present Value)
A. Repair Failed Strip Diffusers	$ -	$ 140,720	$ 121,461	1	$ 4,311,000
B. Replace with Strip Diffusers	$ 1,257,000	$ 16,770	$ 101,217	10	$ 4,960,000
C. Replace with Disc Diffusers	$ 691,000	$ 6,720	$ 118,911	15	$ 3,106,000

Disc Diffuser Design Verification

This section is to verify the feasibility of Alternative C from the engineering perspective, specifically the disc diffuser design and existing blowers' operation.

Aeration Design Criteria

The aeration design criteria were developed as part of the Resource Recovery Project in 2015. **Table 3,** below, summarizes the standard oxygen transfer requirements (SOTR) at each zone per aeration basin as defined in the diffuser specification in 2015. Murraysmith's understanding is that these SOTRs were determined to provide a wide range of operation flexibility and were based on a total of six aeration basins (two additional aeration basins to be built in the future) to handle the design flow and loads in year 2030. Aeration basin modes of operation designed into the 2015 project include Modified Ludzack-Ettinger (MLE), 4-stage Bardenpho, or step feed operation. These SOTRs include the oxygen demand to achieve the biological nutrient removal (BNR) expected in the 2015 project. The maximum sustained SOTR is the required volumetric flow rate maintained for three months and the maximum short-term SOTR is the needed volumetric flow rate sustained for three hours. The SOTR for each condition will not necessarily occur at the same time.

Although the BNR optimization activity that is currently underway with the current Facility Plan efforts may result in some refinement of these SOTRs, the decision has been made that the diffuser replacement will be evaluated based on the existing SOTRs due to the urgency of the project.

Table 3
Design Standard Oxygen Transfer Requirements, lb O_2/day (per basin)

Zone	Startup Minimum	Design Average	Max Sustained	Max Short-term
1	--	--	1,800	2,340
2	3,730	4,120	5,080	5,900
3	2,620	2,890	3,750	4,830
4	1,830	2,010	2,760	4,210
5	--	--	1,450	3,060
6	1,080	1,180	1,740	3,090
Total	**9,260**	**10,200**	**16,580**	**23,430**

Note: From Resource Recovery Project Specification Section 11236

Sanitaire Disc Diffuser Design

Sanitaire provided their preliminary proposal of the Silver Series II 9-inch (SSII-9) membrane disc diffuser system to meet the oxygen requirement in **Table 3**. **Table 4** summarizes the estimated airflow rate in each zone by Sanitaire using the standard oxygen transfer efficiency (SOTE) for this system. The SOTEs used range from 1.69 percent per foot of submergence to 2.14 percent per foot of submergence depending on the zone and operating scenario. These are on the lower end of the range, as shown in Table 1, which is conservative.

Table 4
Sanitaire SSII-9 Diffuser Airflow, scfm (per basin) and SOTE

Zone	Startup Minimum	Design Average	Max Sustained	Max Short-term
1	--	--	249	336
2	445	492	622	735
3	322	355	475	631
4	229	252	361	580
5	--	--	205	484
6	142	155	242	467
Total	**1,139**	**1,254**	**2,154**	**3,233**
Average SOTE	**32.4%**	**32.4%**	**30.7%**	**28.9%**

Note: From Appendix B - Sanitaire proposal submitted on July 16, 2019

The diffuser manufacturer provided guaranteed oxygen transfer rates based on standard conditions tailored to the installation site conditions. Murraysmith performed an independent calculation of the airflow based on the given SOTR, SOTE of Sanitaire SSII-9, oxygen content in air, and density of air under various temperature and humidity in summer and winter conditions. The conclusion is that the airflow provided by Sanitaire is within 2 percent of the airflows calculated by Murraysmith considering seasonal variation.

The preliminary diffuser layout is included in Sanitaire's proposal (**Appendix B**). **Table 5** below summarizes the number, density, and header spacing of the disc diffusers.

Table 5
Sanitaire Disc Proposal – Number of Discs per basin, Density, and Header Spacing

Zone	No. of Discs	AT/AD Ratio[1]	Header Spacing (ft)
1	124	24.8	4.00
2	405	7.1	2.42
3	270	11.4	3.92
4	192	16.0	3.92
5	102	28.2	4.00
6	120	25.6	3.92
Total Per Basin	**1,213**		

[1]AT/AD is the area of tank floor divided by area of diffusers.

A larger AT/AD number means less tank floor is covered by diffusers. AT/AD of 20 suggests that approximately 5 percent of the tank floor is covered with diffusers. AT/AD of 7 suggests that approximately 14 percent of the tank floor is covered with diffusers. A AT/AD higher than 5 is reasonable.

The diffusers are tapered from Zones 2 to 5, with Zone 2 having the most diffusers and Zone 5 having the least. The header spacing ranges from 2.42 feet (Zone 2) to 4 feet (Zone 1 and 5). The spacing in Zone 2 is tight, but adequate for maintenance.

In a summary, the SSII-9 diffuser system proposed by Sanitaire is reasonable and will be able to meet the air and oxygen requirements specified in Resource Recovery project.

Blowers Operation

The plant has four aeration blowers to supply process air to the four aeration basins. Two multi-stage centrifugal Lamson blowers were installed in 1996. Each of the Lamson blowers has a 250-horsepower (hp) motor without a variable frequency drive (VFD). The airflow output is controlled by the blower inlet butterfly control valve. The other two high-speed Aerzen turbo blowers were installed in 2015 with the Resource Recovery Project. Each is rated at 4,000 cubic feet per minute (cfm) at 8.9 psi at 100-degree inlet temperature, or 4,400 cfm at 8.9 pounds per square inch (psi) at 20-degree inlet temperature. Each Aerzen blower is equipped with a 200-hp motor and integrated VFD. All four blowers discharge to a common 30-inch header which conveys air from the blower building to the aeration basins 1 and 2 area and aeration basins 3 and 4 area.

To determine the system pressure requirements and the blower's operation condition, the entire air distribution system was modeled using AFT Fathom, a commercially available modeling software. The maximum headloss through the Sanitaire diffuser system is defined through the maximum pressure at the top of each air piping dropleg. **Table 6** summarizes the modeled operation conditions and the corresponding blower discharge pressures. The following text summarizes the results of the analysis for each operation condition.

Table 6
Modeled Aeration Conditions and Blower Discharge Pressure

Condition	1 - Startup Minimum	2 - Design Average	3 - Max Sustained	4 - Max Short-term
Airflow per basin (scfm)				
Zone 1	--	--	249	336
Zone 2	445	492	622	735
Zone 3	322	355	475	631
Zone 4	229	252	361	580
Zone 5	--	--	205	484
Zone 6	142	155	242	467
Total per basin	1,139	1,254	2,154	3,233
Total for four basins	4,560	5,000	8,600	12,900
Pressure at dropleg (psi)	7.3	7.35	7.5	8.54
Blower discharge pressure (psi)	**7.6**	**7.7**	**8.2**	**9.9**
Number of blowers in operation	1	1 Lamson or 2 Aerzen	2	3 with reduced flow [1]

[1]Lamson blowers cannot provide the discharge pressure under this condition. The total flow delivered will have to be reduced.

Condition 1 - Startup Minimum

In the startup minimum operational condition, the blowers need to deliver approximately 4,560 standard cubic feet per minute (scfm) of air at the pressure of 7.6 psi. Based on the blower curves, it appears any one of the four blowers will be able to meet this requirement. **Figure 3a** shows the operating point of one Aerzen blower under this condition. The Aerzen blower's VFD allows the speed to vary between approximately 50 percent to 100 percent, providing a flexible operation range. **Figure 3b** shows the operating point of one Lamson blower under this condition. The Lamson multi-stage centrifugal blowers rely on the throttle of the inlet airflow control valve to achieve the required flow. It appears the inlet valve will need to create approximately 1 psi of additional pressure drop so the blower operation can stay along the curve to deliver 4,560 scfm of air.

Figure 3a
Aerzen Blower Operating Point under Condition 1

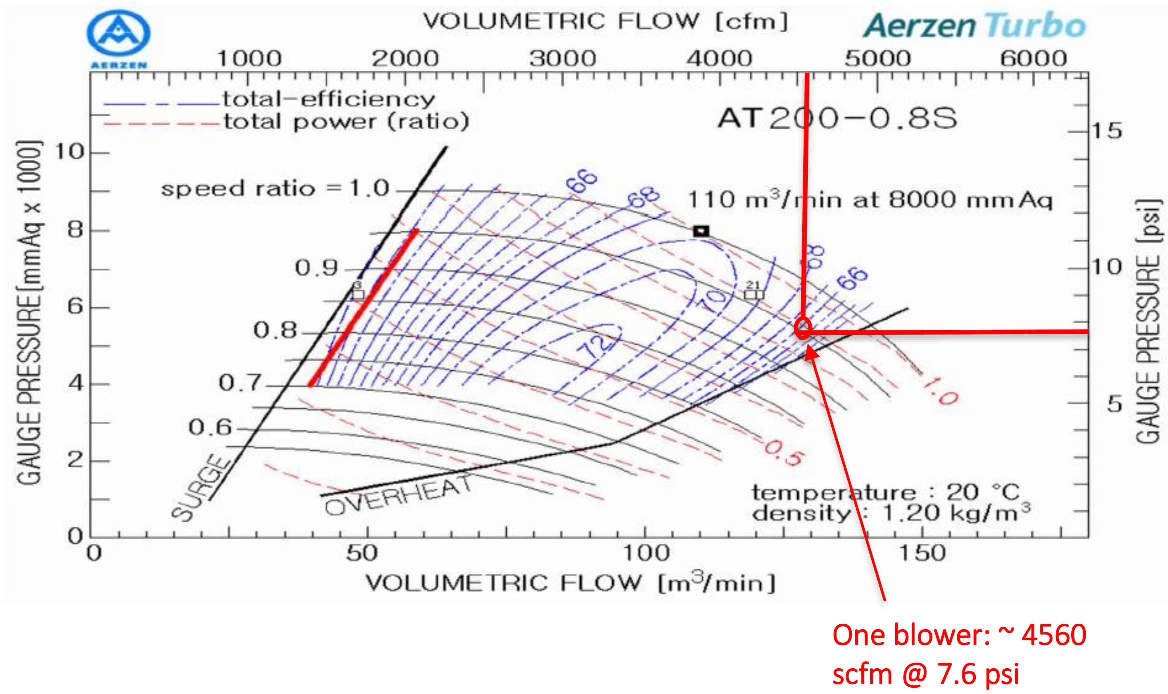
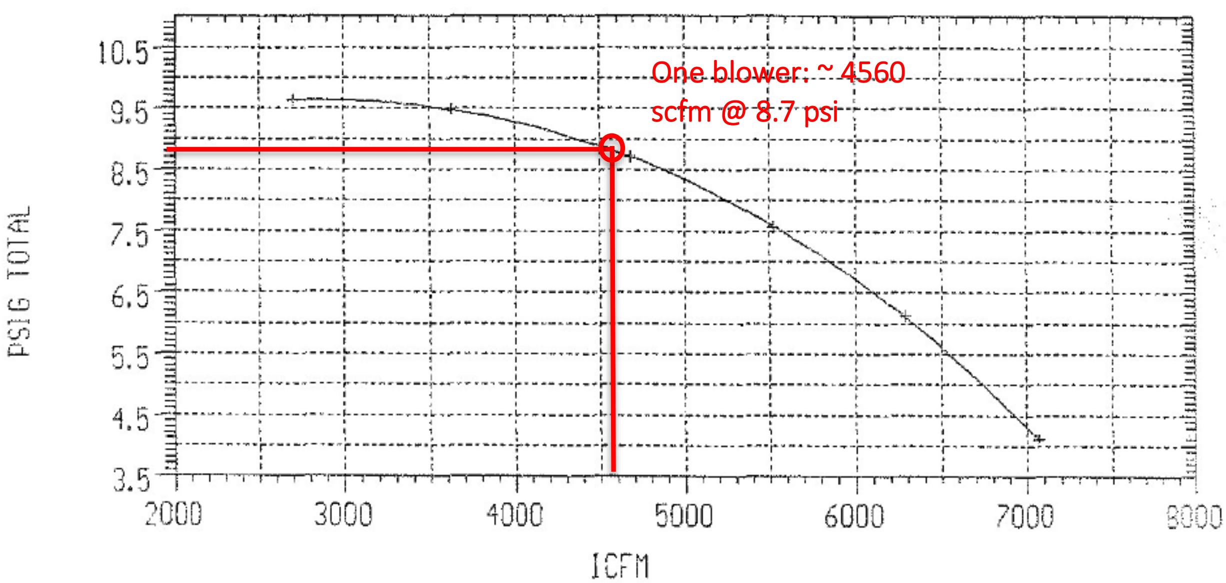


Figure 3b
Lamson Blower Operating Point under Condition 1



Condition 2 – Design Average

The blowers need to deliver approximately 5,000 scfm of air at the pressure of 7.7 psi. Based on the blower curves, it appears one Lamson blower or two Aerzen blowers will be able to meet that requirement. A single Aerzen blower will reach the far-right end of the curve and into the overheat condition. **Figures 4a and 4b** show the operating point of Aerzen blower and Lamson blower under this condition.

Figure 4a
Aerzen Blower Operating Point under Condition 2

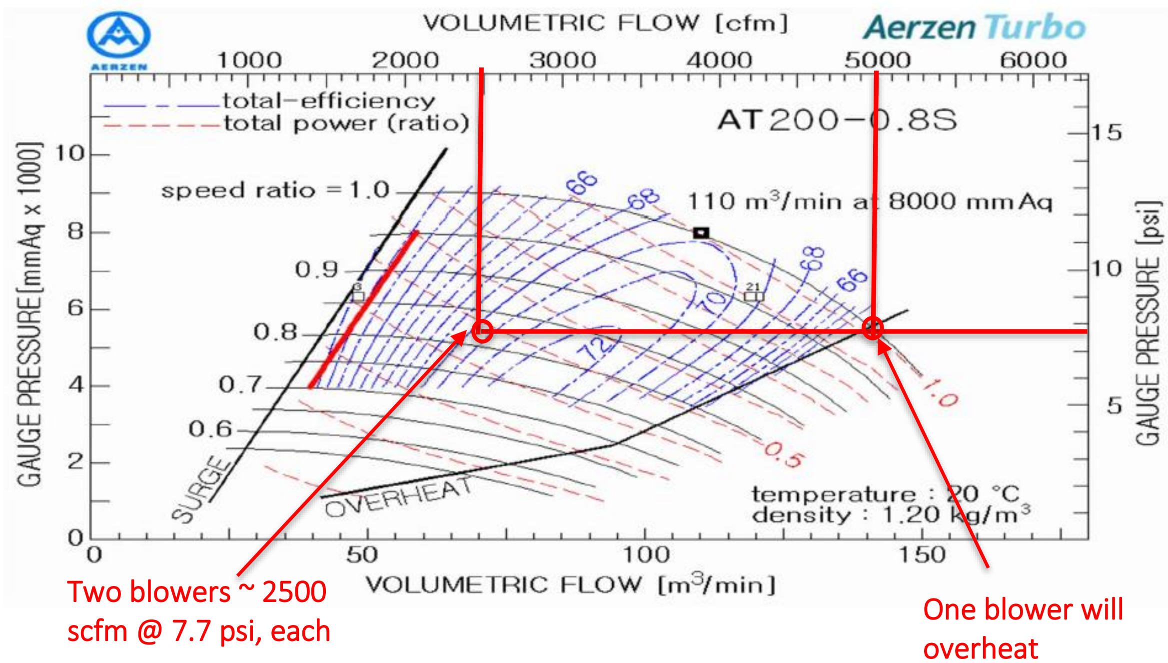
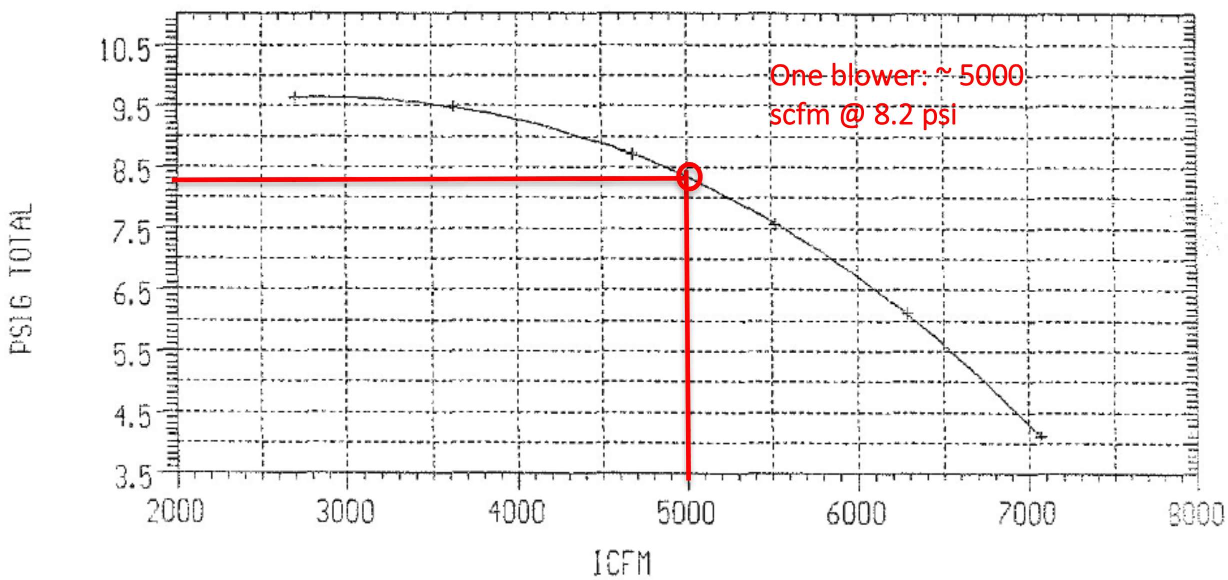


Figure 4b
Lamson Blower Operating Point under Condition 2



Condition 3 – Maximum Sustained

The blowers need to deliver approximately 8,600 scfm of air at the pressure of 8.2 psi. Based on the blower curves, it appears two Lamson blowers or two Aerzen blowers will be able to meet that requirement. **Figures 5a and 5b** show the operating point of two Aerzen blowers and two Lamson blowers under this condition.

Figure 5a
Aerzen Blower Operating Point under Condition 3

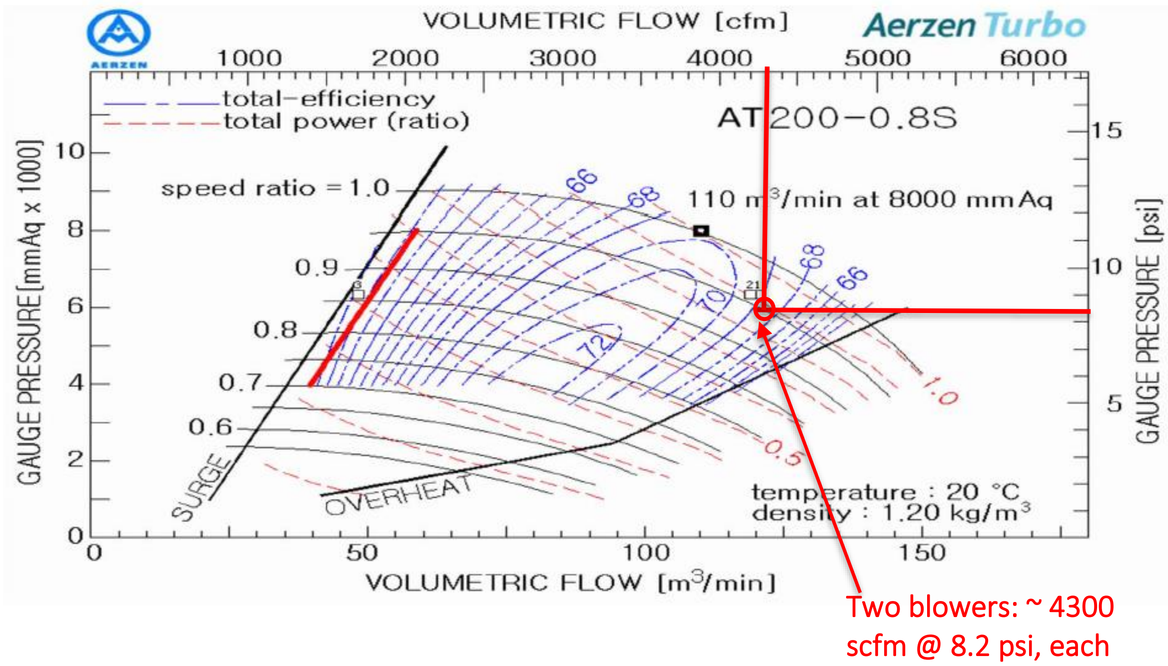
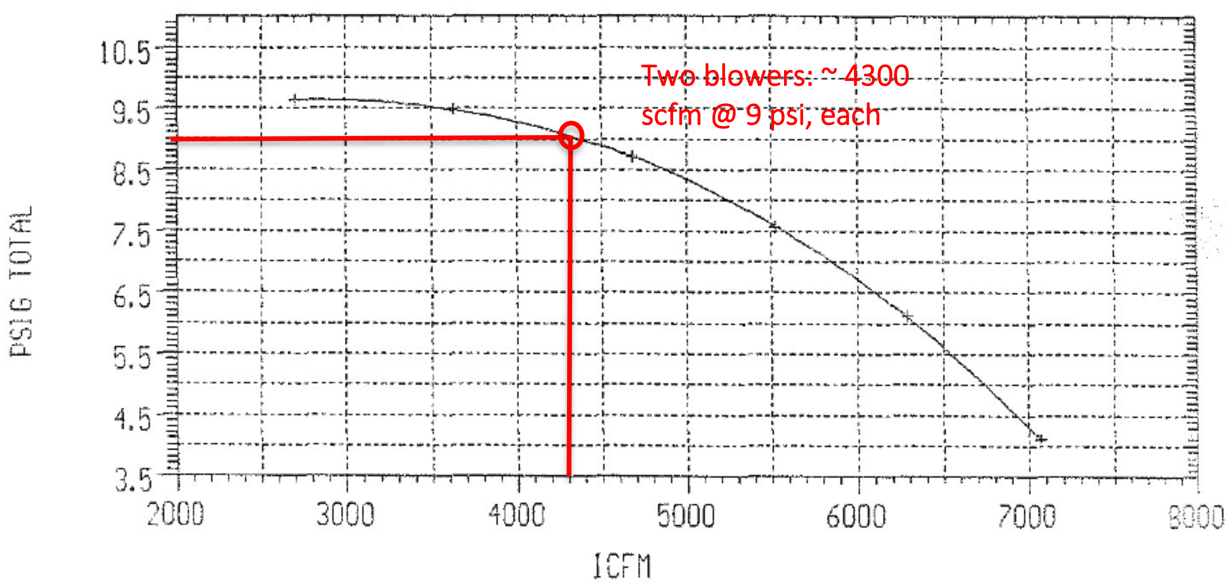


Figure 5b
Lamson Blower Operating Point under Condition 3



Condition 4 – Maximum Short-term

The blowers need to deliver approximately 12,900 scfm of air at the pressure of 9.9 psi at the maximum short-term condition. This is a pressure Lamson blowers cannot achieve based on the blower curve, and therefore, the existing four blowers will not be able to deliver this much air. The model estimates the highest airflow in the system to maintain a less than 9.5 psi pressure is about 10,000 scfm, 22 percent less than the design flowrate. Based on the review of the available 2015 Resource Recovery Project design documents, Murraysmith's understanding of this maximum short-term condition is when the Central Kitsap WWTP is operated at the step feed mode during the design peak flows, and this condition will not last for more than three hours. Although not ideal, when airflow is compromised during these conditions, it should not cause immediate impact to the aeration basin performance. In addition, since this condition is not expected to occur in the near future, no immediate blower upgrade is needed due to the diffuser replacement. However, as flow and loads increase, and the aeration basins 5 and 6 are needed, the County should consider increasing the blower capacity by replacing the Lamson blowers with the higher-capacity turbo blowers. This recommendation will be documented in the Facility Plan.

Conclusions

The 20-year life cycle cost comparison of three alternatives A) continuing ongoing replacement of the strip diffusers, B) complete replacement of the strip diffusers, or C) complete replacement with disc diffusers showed that Alternative C is the most economical alternative considering the on-going diffuser maintenance and repair/replacement effort.

The evaluation of the Sanitaire Silver Series II membrane disc diffusers indicates this system is able to meet the required oxygen demand with the reasonable number of diffusers and layout.

The evaluation of the existing blowers and air piping system shows that the existing Lamson and Aerzen blowers will be able to supply air to the existing four aeration basins under most of the design conditions with at least one redundant blower. Under the maximum short-term condition, Lamson blowers cannot operate at the required pressure, so the total delivered airflow will be lower than the design value. The maximum short-term condition is not a critical condition and is not anticipated to occur soon, therefore no immediate blower upgrade is needed. Murraysmith recommends the County considers replacing those two Lamson blowers when the plant flow and loads get closer to the 2030 design values, and aeration basins 5 and 6 are required.

Based on the above conclusions, Murraysmith recommends replacing the existing AEROSTRIP® diffusers with Sanitaire Silver Series II membrane disc diffusers. While there are other membrane disc diffuser manufacturers that could provide a comparable diffuser system to Sanitaire, given the nature of this emergency, the fact that the County staff is familiar with the Sanitaire diffuser system, and the proven success of the Sanitaire diffuser system, direct procurement from Sanitaire as the sole-sourced manufacturer is the recommended approach.

Appendix

Appendix A - Diffuser Replacement Lifecycle Cost Estimate

Appendix B - Sanitaire Proposal, July 2019

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APPENDIX A

Central Kitsap WWTP
Diffuser Replacement Lifecycle Cost Estimate

Alternative	Capital Cost	Annual Maintenance Cost	Annual Operating Cost	Diffuser Replacement Frequency (year)	Life Cycle Cost (Net Present Value)
A. Repair Failed Strip Diffusers	$ -	$ 140,720	$ 121,461	1	$ 4,311,000
B. Replace with Strip Diffusers	$ 1,257,000	$ 16,770	$ 101,217	10	$ 4,960,000
C. Replace with Disc Diffusers	$ 691,000	$ 6,720	$ 118,911	10	$ 3,106,000

Net Present Value (NPV) Calculation:

Discount Rate i = 5.0%
Annual Inflation = 3.0%
n = 20

	A. Repair Failed Strip Diffusers				B. Replace with Strip Diffusers				C. Replace with Disc Diffusers			
Year	Inflated Maintenance Cost	Inflated Operating Cost	Inflated Diffuser Construction Cost	Inflated Annual Cost	Inflated O&M		Inflated Membrane Replacement Cost	Inflated Annual Cost	Inflated O&M		Inflated Membrane Replacement Cost	Inflated Annual Cost
2021	$ 140,720	$ 121,461	-	262,181	$ 16,770	$ 101,217	1,257,000	1,374,987	$ 6,720	$ 118,911	691,000	816,631
2022	$ 144,942	$ 125,105	-	270,046	$ 17,273	$ 104,254	-	121,527	$ 6,922	$ 122,479	-	129,400
2023	$ 149,290	$ 128,858	-	278,148	$ 17,791	$ 107,381	-	125,173	$ 7,129	$ 126,153	-	133,282
2024	$ 153,769	$ 132,724	-	286,492	$ 18,325	$ 110,603	-	128,928	$ 7,343	$ 129,938	-	137,281
2025	$ 158,382	$ 136,705	-	295,087	$ 18,875	$ 113,921	-	132,796	$ 7,563	$ 133,836	-	141,399
2026	$ 163,133	$ 140,806	-	303,939	$ 19,441	$ 117,339	-	136,780	$ 7,790	$ 137,851	-	145,641
2027	$ 168,027	$ 145,031	-	313,058	$ 20,024	$ 120,859	-	140,883	$ 8,024	$ 141,986	-	150,010
2028	$ 173,068	$ 149,381	-	322,449	$ 20,625	$ 124,485	-	145,110	$ 8,265	$ 146,246	-	154,511
2029	$ 178,260	$ 153,863	-	332,123	$ 21,244	$ 128,219	-	149,463	$ 8,513	$ 150,633	-	159,146
2030	$ 183,608	$ 158,479	-	342,086	$ 21,881	$ 132,066	-	153,947	$ 8,768	$ 155,152	-	163,920
2031	$ 189,116	$ 163,233	-	352,349	$ 22,537	$ 136,028	1,689,303	1,847,868	$ 9,031	$ 159,807	928,646	1,097,484
2032	$ 194,789	$ 168,130	-	362,920	$ 23,214	$ 140,108	-	163,322	$ 9,302	$ 164,601	-	173,903
2033	$ 200,633	$ 173,174	-	373,807	$ 23,910	$ 144,312	-	168,222	$ 9,581	$ 169,539	-	179,120
2034	$ 206,652	$ 178,369	-	385,021	$ 24,627	$ 148,641	-	173,268	$ 9,869	$ 174,625	-	184,494
2035	$ 212,852	$ 183,720	-	396,572	$ 25,366	$ 153,100	-	178,466	$ 10,165	$ 179,864	-	190,029
2036	$ 219,237	$ 189,232	-	408,469	$ 26,127	$ 157,693	-	183,820	$ 10,470	$ 185,260	-	195,729
2037	$ 225,814	$ 194,909	-	420,723	$ 26,911	$ 162,424	-	189,335	$ 10,784	$ 190,818	-	201,601
2038	$ 232,589	$ 200,756	-	433,345	$ 27,718	$ 167,297	-	195,015	$ 11,107	$ 196,542	-	207,649
2039	$ 239,566	$ 206,779	-	446,345	$ 28,550	$ 172,316	-	200,866	$ 11,440	$ 202,439	-	213,879
2040	$ 246,753	$ 212,982	-	459,736	$ 29,406	$ 177,485	-	206,892	$ 11,784	$ 208,512	-	220,295
2041	$ 254,156	$ 219,372	-	473,528	$ 30,288	$ 182,810	2,270,282	2,483,380	$ 12,137	$ 214,767	1,248,023	1,474,927
NPV				**$ 4,311,230**				**$ 4,959,876**				**$ 3,106,322**

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APPENDIX B

Diffused Aeration Equipment

for

Central Kitsap WWTP

Aeration Basin 1

Sanitaire #29580-19s
July 16, 2019

Sanitaire Aeration Design Inputs for: Central Kitsap WWTP, Sanitaire #29580-19s

Tank Geometry

1 Train Consisting of:

Parameter	Units	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6
Parallel Reactors		1	1	1	1	1	1
Pass Process		A/O	Aerobic	Aerobic	Aerobic	A/O	Aerobic
SWD	ft	16.5	16.5	16.5	16.5	16.5	16.5
Submergence	ft	15.6	15.6	15.6	15.6	15.6	15.6
Volume	ft³	20,796.9	19,456.2	20,796.9	20,796.9	19,456.2	20,796.9
Reactor Geometry:		Rect	Rect	Rect	Rect	Rect	Rect
Length	ft	25.2	23.6	25.2	25.2	23.6	25.2
Width	ft	50.0	50.0	50.0	50.0	50.0	50.0

Oxygen/Air Distribution

	Zone	1	2	3	4	5	6
	Pass	1	2	3	4	5	6
Design Avg			40.4%	28.3%	19.7%		11.6%
Max Sustained		10.9%	30.6%	22.6%	16.6%	8.7%	10.5%
Max Short Term		10.0%	25.2%	20.6%	18.0%	13.1%	13.2%

Oxygenation

Parameter	Units	Design Avg	Max Sustained	Max Short Term
No. Trains Operating		1	1	1
Oxygen Requirement	lb/day	10,200.0-S	16,580.0-S	23,430.0-S

Standard Oxygen Correction Factor Parameters

Parameter	Units	Design Avg	Max Sustained	Max Short Term
Site Elevation	FASL	132	132	132
Ambient Pressure	PSIA	14.64	14.64	14.64
Water Temperature	°C	21	21	21

Notes:

Bold, Italicized text indicate assumptions made by Sanitaire

A - Indicates Actual (AOR) Requirement.

S - Indicates Standard Condition (SOR) Oxygen requirement.

If the AOR/SOR parameter is not given, then its value will be evaluated later if suitable alpha, beta, D.O., theta, pressure, and temperature data is supplied.

Round tanks are evaluated as rectangular tanks diameter equal to length and equal surface area.

Annular tanks are evaluated as rectangular tanks of width equal to the annular width and equal surface area.

Sanitaire Project Name: Central Kitsap WWTP
Sanitaire Project #29580-19s
Design Summary

	Units	Operating Point & O2 Distribution		
		Design Avg Design Avg	Max Sustained Max Sustained	Max Short Term Max Short Term
No. Trains in Operation		1	1	1
No. Grids in Operation		4	6	6
No. Operating Diffusers		987	1,213	1,213
SOR	lb/day	10,200	16,580	23,430
SOTE	%	32.4	30.7	28.9
Total Air Rate	scfm	1,255	2,154	3,234
Min.Diffuser Air Rate	scfm/diff.	1.21	1.54	1.81
Max. Diffuser Air Rate	scfm/diff.	1.31	2.02	4.75
Static Pressure	psig	6.76	6.76	6.76
Diffuser DWP @ Min Air	psig	0.49	0.52	0.54
Diffuser DWP @ Max Air	psig	0.5	0.56	0.79
Pressure @ Top of Dropleg	psig	7.35	7.5	8.54
Est. Blower Efficiency		70%	70%	70%
Est. Motor Efficiency		90%	90%	90%
Shaft Power	Bhp	51.16	89.38	149.3
Est. Motor Electrical Load	kW	42.41	74.09	123.8
Est. Standard Aeration Efficiency	#SOR/BHP-hr	8.31	7.73	6.54

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging. Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other

technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 20°C

(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Central Kitsap WWTP
Sanitaire Project #29580-19s
Consulting Engineer:
Operating Condition: Design Avg
Oxygen Distribution: Design Avg

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	2	3	4	5	6	
SWD	ft	16.50	16.50	16.50	16.50	16.50	16.50	
Subm	ft	15.61	15.61	15.61	15.61	15.61	15.61	
Volume	ft³	20,796.9	19,456.2	20,796.9	20,796.9	19,456.2	20,796.9	81,846.9
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		1	1	1	1	1	1	
Grid Count			1	1	1		1	4
Dropleg Diameter	inches		8	6	6		6	
At/Ad			7.1	11.4	16.0		25.6	
Diffuser Density	% Floor		14.08%	8.78%	6.25%		3.90%	
Diffusers/Grid			405	270	192		120	987

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha								
Beta								
Theta								
D.O.	mg/l							
Water Temp	°C		21	21	21		21	
AOR/SOR								
Oxygen Distribution	%/Zone		40.4%	28.3%	19.7%		11.6%	100.0%
AOR	lb/day							
SOR	lb/day		4,120.0	2,890.0	2,010.0		1,180.0	10,200.0
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	scfm/ft²		0.12	0.12	0.12		0.12	
Safety Factor	%							
Mixing Air (8)	scfm		141.5	151.2	151.2		151.2	
Process Air (for SOR)	scfm		492.1	354.9	252.3		155.2	
Design Air (1,7)	scfm		492.1	354.9	252.3		155.2	1,254.5
Diffuser Air Rate	scfm/Diff.		1.21	1.31	1.31		1.29	1.27
Delivered SOR	lb/day		4,120.0	2,890.0	2,010.0		1,180.0	10,200.0
Delivered SOTE	%		33.4%	32.5%	31.8%		30.3%	32.4%
Pressure @ Top of Dropleg	psig		7.32	7.35	7.34		7.34	7.35
Shaft Power	Bhp		20.0	14.5	10.3		6.3	51.2

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Central Kitsap WWTP
Sanitaire Project #29580-19s
Consulting Engineer:
Operating Condition: Max Sustained
Oxygen Distribution: Max Sustained

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	2	3	4	5	6	
SWD	ft	16.50	16.50	16.50	16.50	16.50	16.50	
Subm	ft	15.61	15.61	15.61	15.61	15.61	15.61	
Volume	ft³	20,796.9	19,456.2	20,796.9	20,796.9	19,456.2	20,796.9	122,100.0
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		1	1	1	1	1	1	
Grid Count		1	1	1	1	1	1	6
Dropleg Diameter	inches	8	8	6	6	6	6	
At/Ad		24.8	7.1	11.4	16.0	28.2	25.6	
Diffuser Density	% Floor	4.03%	14.08%	8.78%	6.25%	3.55%	3.90%	
Diffusers/Grid		124	405	270	192	102	120	1,213

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha								
Beta								
Theta								
D.O.	mg/l							
Water Temp	°C	21	21	21	21	21	21	
AOR/SOR								
Oxygen Distribution	%/Zone	10.9%	30.6%	22.6%	16.6%	8.7%	10.5%	100.0%
AOR	lb/day							
SOR	lb/day	1,800.0	5,080.0	3,750.0	2,760.0	1,450.0	1,740.0	16,580.0
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	151.2	141.5	151.2	151.2	141.5	151.2	
Process Air (for SOR)	scfm	249.1	621.8	475.2	360.6	204.9	242.1	
Design Air (1,7)	scfm	249.1	621.8	475.2	360.6	204.9	242.1	2,153.7
Diffuser Air Rate	scfm/Diff.	2.01	1.54	1.76	1.88	2.01	2.02	1.78
Delivered SOR	lb/day	1,800.0	5,080.0	3,750.0	2,760.0	1,450.0	1,740.0	16,580.0
Delivered SOTE	%	28.8%	32.6%	31.5%	30.5%	28.2%	28.7%	30.7%
Pressure @ Top of Dropleg	psig	7.50	7.39	7.45	7.47	7.50	7.50	7.50
Shaft Power	Bhp	10.3	25.5	19.6	14.9	8.5	10.0	89.4

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Central Kitsap WWTP
Sanitaire Project #29580-19s
Consulting Engineer:
Operating Condition: Max Short Term
Oxygen Distribution: Max Short Term

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	2	3	4	5	6	
SWD	ft	16.50	16.50	16.50	16.50	16.50	16.50	
Subm	ft	15.61	15.61	15.61	15.61	15.61	15.61	
Volume	ft³	20,796.9	19,456.2	20,796.9	20,796.9	19,456.2	20,796.9	122,100.0
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		1	1	1	1	1	1	
Grid Count		1	1	1	1	1	1	6
Dropleg Diameter	inches	8	8	6	6	6	6	
At/Ad		24.8	7.1	11.4	16.0	28.2	25.6	
Diffuser Density	% Floor	4.03%	14.08%	8.78%	6.25%	3.55%	3.90%	
Diffusers/Grid		124	405	270	192	102	120	1,213

Oxygen Transfer

Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha								
Beta								
Theta								
D.O.	mg/l							
Water Temp	°C	21	21	21	21	21	21	
AOR/SOR								
Oxygen Distribution	%/Zone	10.0%	25.2%	20.6%	18.0%	13.1%	13.2%	100.0%
AOR	lb/day							
SOR	lb/day	2,340.0	5,900.0	4,830.0	4,210.0	3,060.0	3,090.0	23,430.0
Air Rate (7)	scfm							

Performance

Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	151.2	141.5	151.2	151.2	141.5	151.2	
Process Air (for SOR)	scfm	336.1	735.0	631.1	580.2	484.1	467.1	
Design Air (1,7)	scfm	336.1	735.0	631.1	580.2	484.1	467.1	3,233.6
Diffuser Air Rate	scfm/Diff.	2.71	1.81	2.34	3.02	4.75	3.89	2.67
Delivered SOR	lb/day	2,340.0	5,900.0	4,830.0	4,210.0	3,060.0	3,090.0	23,430.0
Delivered SOTE	%	27.8%	32.0%	30.5%	29.0%	25.2%	26.4%	28.9%
Pressure @ Top of Dropleg	psig	7.70	7.46	7.61	7.83	8.54	8.15	8.54
Shaft Power	Bhp	14.3	30.4	26.5	24.9	22.4	20.8	149.3

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
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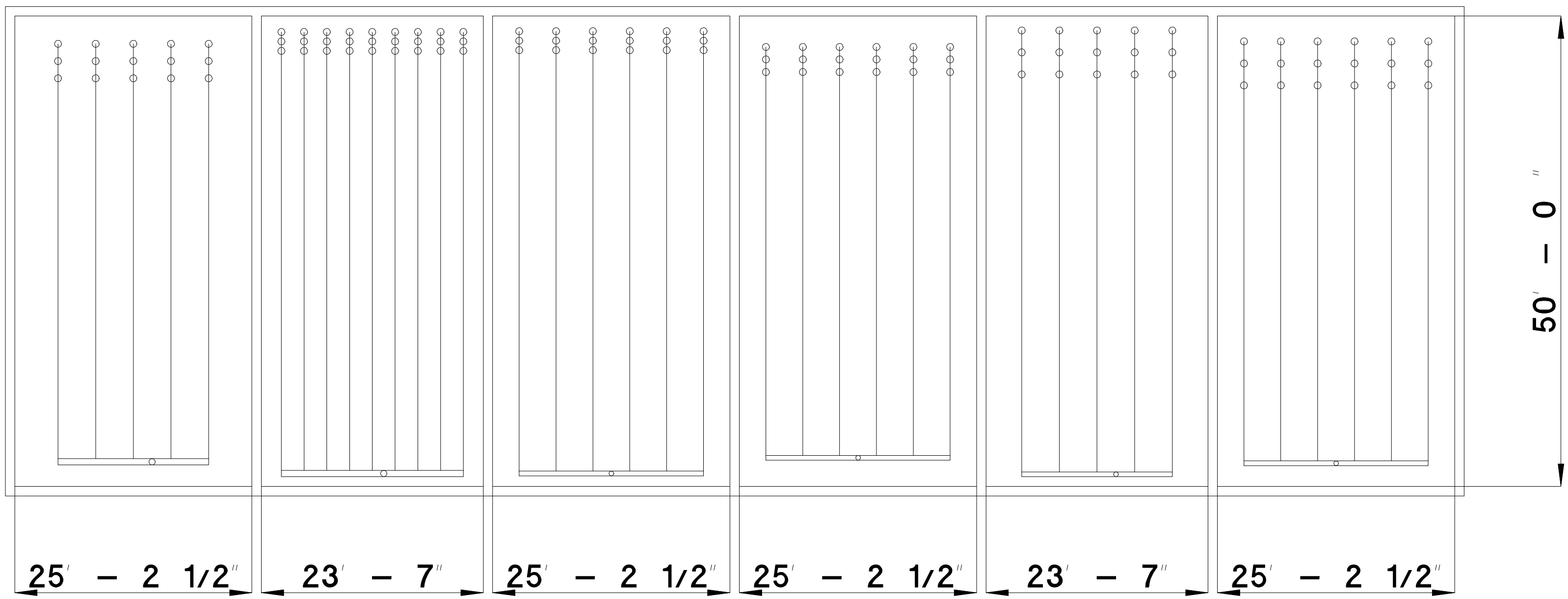
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²



Single Train Information

Grid No	Grid Count	Drop Leg ∅"	Header Count	Header Spc,ft.	Header Len,ft.	Discs/Grid	At/Ad	Discs/Train
1	1	8	5	4.00	44.75	124	24.79	124
2	1	8	9	2.42	47.25	405	7.10	405
3	1	6	6	3.92	47.25	270	11.39	270
4	1	6	6	3.92	43.92	192	16.01	192
5	1	6	5	4.00	47.42	102	28.20	102
6	1	6	6	3.92	45.08	120	25.62	120

Total Discs/Train 1213

Note: Some headers may be omitted for clarity

PRELIMINARY - THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS OR CONSTRUCTION

Sanitaire
a xlyem brand
BROWN DEER, WISCONSIN 53223

CUST NO.

DWG NO.

Central Kitsap WWTP
9" Disc Aeration System

DRAWN BY	DATE	MODEL	JOB
BB	7/16/19		29580–19s
CHKD BY	DATE		SHEET
APPVD BY	DATE		

consor

APPENDIX I
CONDITION ASSESSMENT RED FLAG FINDINGS AND MITIGATION RECOMMENDATIONS, MURRAYSMITH, OCTOBER 2020

Technical Memorandum

Date: October 20, 2020

Project: Facility Plan and Sewer Plan Update

To: Barbara Zaroff, PE, PMP
Christopher Sheridan
Kitsap County, WA

From: Miaomiao Zhang, PE, PMP (Murraysmith)
John Koch, PE (HDR)
Tom Perry, PE (Murraysmith)
Peter Cunningham, PE (Murraysmith)
Erika Schuyler, PE, PMP (Murraysmith)

Re: Condition Assessment Red Flag Findings and Mitigation Recommendations

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Introduction

The Murraysmith and HDR team conducted a 4-day condition assessment field visit at Kitsap County's (County) four wastewater treatment plants and over forty selected pump stations from 9/14/2020 to 9/17/2020. This memorandum documents the "red flag" issues observed during the visits and provides the Engineer's opinion on the consequence of failure and potential solutions. The "red flag" issues are ones that pose health and safety risks or could result in imminent failure. The red flag issues were identified through discussions with plant staff and field verification. Although this list of "red flag" issues is intended to be as complete as possible, there is always a risk that other unknown issues exist due to the nature of wastewater treatment plants and pump stations. A detailed engineering analysis has not been performed and some of the solutions may warrant further study prior to implementation.

Central Kitsap Treatment Plant (CKTP)

Red Flag 1 – Digester 2 Seal Failure

Issue: Approximately two linear feet of annular seal on the east side of Digester 2 has failed (Figure 1). The top sealant is missing. At least one foot deep of the fill material under the sealant is also missing resulting in a void space. The exposed digester cover skirt does not appear to be coated and is severely corroded.

Consequence of failure: Biogas and sludge may leak through the space, resulting in the loss of the digester. If failure occurs, the plant will have to meet solids retention time requirements from EPA Part 503 with only one digester online. Leaking biogas poses health and safety risks due to its toxicity and explosive potential, and are also corrosive to the concrete and metal components of the digester structure.

Potential solution: The temporary solution is to repair the seal per the cover manufacturer's standard and the Detail E/G4 of 1991 digester cover replacement drawings. Routine inspection of the digester seals is recommended. Long term solution for a reliable digestion operation will be evaluated as part of the Facility Plan update.

Figure 1 – CKTP Digester 2 Seal Failure

Red Flag 2 – Leaking Digester PRVs

Issue: The pressure relief valves (PRVs) on both digesters are leaking. Strong biogas odor and the sound of biogas leaking from the PRVs were observed at both digester PRVs. The PRV on Digester 2 appears to have more significant leakage than Digester 1.

Consequence of failure: Leaking digester PRVs reduce biogas storage and pose health and safety risk due to biogas toxicity and explosive potential. The leaking digester PRVs also contribute to the corrosion of digester structure and odors at the plant.

Potential solution: Contact Varec field service staff to service and repair the PRVs. The isolation valves and flame arrestors should also be inspected and serviced, as needed.

Red Flag 3 – Aged In-Plant Pump Station

Issue: The in-plant pump station is in poor condition, with one of the pumps failed, coating on the concrete inside of the wetwell falling off, and the pipes severely corroded (Figure 2). There is no bypass route to allow the pump station to be taken offline for maintenance. Currently a mobile diesel pump is used as a backup.

Consequence of failure: If the in-plant pump station is down, there are limited options to get the plant sanitary sewage and the recycle streams back to the process.

Potential solution: The short-term solution is to maintain the diesel pump and replace the broken pump with a larger unit. The long-term solution may be to replace the in-plant pump station with sufficient capacity to handle the in-plant flows, provide odor control and overflow to other process basins for redundancy.

Figure 2 – CKTP In-Plant Pump Station

Red Flag 4 – Failing Aeration Diffusers

Issue: The Aerostrip diffusers in multiple zones have failed in the last couple of years. The diffusers have long lead times and are difficult to procure in emergency situations.

Consequence of failure: Broken diffusers significantly reduce the oxygen transfer efficiency, making it impossible to control the aeration air. Large quantity of failed diffusers will result in the loss of the aeration basin.

Potential solution: The short-term solution is to repair and replace the diffusers to the best ability of the plant staff and have a significant number of spare diffusers on hand. A long-term solution may be to replace the diffusers with an industry proven type acceptable to plant staff.

Red Flag 5 – Leaking Roof Penetrations over Boilers

Issue: It appears the roof penetrations over the two boiler stacks are leaking. The ducting, piping, valves, and panels under the boilers show significant signs of corrosion (Figure 3).

Consequence of failure: The boilers were installed in 1977 and may be nearing the end of their useful life. Corrosion and water getting into the conduit or panels could result in the failure of the boilers.

Potential solution: Repair the leaking roof. Clean or replace the components.

Figure 3 – Rusty Boiler Components due to the Leaking Roof Penetrations

Red Flag 6 – Insufficient Ventilation in Headworks Electrical Room

Issue: Ventilation in the headworks electrical room can't keep the room temperature down in summer; during the site visit, it was 77 degrees F when the thermostat was set at 72 degrees F. Strong hydrogen sulfide smells and some corrosion near the conduit grounding were noticed.

Consequence of failure: Excessive heat and a corrosive environment will cause eventual failure of the controls and VFDs.

Potential solution: Inspect the ventilation currently provided to the room. Add additional cooling, if needed. Install a Purafil positive pressurization unit to keep the room pressurized with air free of corrosive gas.

Red Flag 7 – Insufficient Ventilation and Heating in the Lab and Admin Building

Issue: The ventilation system in the lab and administration building is from the original construction in 1977. Issues observed include:

- The east lab has a positive pressure. The west lab, which was converted from the training and lunchroom approximately 15 years ago, has a negative pressure when the fume hood exhaust is on. Fugitive gas has been noted in the administration room during lab analyses. Based on a review of 1977 design drawings, no ventilation was provided to the training and lunchroom (now the west lab) or the administration room. The east lab was designed to have approximately 1,000 cfm of exhaust air and higher supply airflow, resulting in positive pressure. Lack of ventilation in the west lab and positive pressure in the east lab do not meet the laboratory standards, while lack of ventilation in the administration room exposes the staff to the risk of hazardous gases from the lab.
- The air handling fan for the entire building (installed in 1977) is missing approximately half of its blades, resulting in reduced capacity.
- The heating provided by the heat water loop from the boiler cannot keep up with the heating demand in the space. The lab must use the wall mounted air conditioner to supplement the heating.

Consequence of failure: Lack of ventilation in all lab spaces and positive pressure in the east lab will violate the NFPA 45 Standard on Fire Protection for Laboratories using Chemicals, posing the potential health and safety risk to the staff working in the lab or near the lab.

Potential solution: Contract a HVAC testing and balancing company to inspect and balance the existing HVAC system, and replace the equipment as needed. Install the ventilation system in the west lab and the administration room.

Other Treatment Plants

Red Flag 1 – Operator Safety in Hypochlorite Room at Manchester Treatment Plant (MTP)

Issue: Strong and pungent chlorine odor was noticed inside the hypochlorite room. Although there is a supply fan and exhaust fan in the room, it is not certain if they work. There is no emergency shower/eyewash in the room (Figure 4).

Consequence of failure: High concentration of chlorine fumes will pose a health risk to the operator with exposure. No shower/eyewash in the room and keeping the door always closed violates building code and OSHA requirements.

Potential solution: Clean up chemical residual that causes chlorine fumes, especially from the secondary containment sump. Check and ensure sufficient ventilation. Install a shower or eyewash and a gas chlorine sensor in the room.

Figure 4 – MTP Sodium Hypochlorite Storage Room

Red Flag 2 – Operator Safety and Classification of Headworks Room at Suquamish Treatment Plant (STP)

Issue: The screening channel, the odor control scrubber, and the WAS rotary drum thickener are all in the same room (Figure 5). The screening channel cover plates were open. Strong hydrogen sulfide odor was observed during the visit. The room is Class 1 Division 1 or Class 1 Division 2 depending on ventilation provided. The room does not currently meet all the NFPA 820 requirements, i.e. combustible gas (LEL) detection is missing, explosion proof panels have bolts missing, and most motors are not explosion proof.

Consequence of failure: Flammable gas migrating from headworks channel could cause fire or explosion if ventilation is insufficient or shut down.

Potential solution: Install LEL alarm. Tighten and replace the missing bolts at the enclosures. Keep the screening channel cover plate on and make sure the airspace under the cover is kept under negative pressure so that no foul air escape into the room. Inspect the odor control fan to make sure the room is always ventilated at 12 air changes per hour.

Figure 5 – STP Headworks Room

Pump Stations

Red Flag 1 – Broken Conduits at PS-30

Issue: Broken conduits to the panel are within the classified area of the wet well hatch.

Consequence of failure: Gas intrusion to the classified area pose health and safety risk due to explosive potential.

Potential solution: Fix the conduits and move the panel further away from the wet well hatch.

Red Flag 2 – Broken Pump Shaft at PS-24

Issue: One pump shaft was broken.

Consequence of failure: Loss of pump could result in pump station not being able to convey influent flows that could possibly result in a spill.

Potential solution: The County O&M staff are aware of the issue and working on fixing it.

APPENDIX J

CKTP DIGESTER IMPROVEMENTS,

BROWN AND CALDWELL, 2016

consor

Technical Memorandum

701 Pike Street, Suite 1200
Seattle, Washington 98101

T: 206-624-0100
F: 206-749-2200

Prepared for: Kitsap County

Project Title: CKTP Digester Improvements

Project No.: 143270

Technical Memorandum

Subject: CKTP Digester Improvements

Date: February 10, 2016

To: Floyd Bayless, Kitsap County Project Manager

From: Bill Persich, Brown and Caldwell Project Manager

Copy to: Barbara Zaroff

Prepared by: ______________________
Bill Persich, P.E., WA 17516, Expiration 4/9/2016

Reviewed by: ______________________
Tadd Giesbrecht, P.E.

Table of Contents

List of Figures

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Section 1: Background and Problem Summary

The purpose of this Technical Memorandum (TM) is to evaluate several improvements for the existing digesters identified by plant staff. The digesters were originally constructed in 1978 and replacement covers were added in 1991. Subsequent planning studies identified the future need to substantially modify and expand the existing digester complex due to an increase in projected solids loadings and due to aging infrastructure. Initially, it was thought that these major renovations and upgrades would be needed by 2017, however, due to the Headworks project in 2009 and the latest Resource and recovery project, the growth derived driving force for these major improvements has been pushed back to approximately 2028 or beyond. The Headworks project improved grit capture and helped increase the hydraulic residence time in the existing digesters by virtue of reducing the quantity of grit trapped in the digester (grit merely takes up valuable space within). Similarly, the Resource and Recovery project provided improved secondary treatment aeration efficiency and separate WAS thickening that allows the digesters to be fed with a higher solids content raw sludge, thus also increasing digestion hydraulic residence time.

Although it is recognized that major upgrades and renovations will be needed for the digester complex, these upgrades are expensive and can fortunately be postponed for a while, assuming the existing infrastructure can remain serviceable. This TM will focus on relatively minor improvements that can improve process efficiency, system maintainability, and service life.

Section 2: Descriptions of Specific Areas of Concern

After review of the existing drawings and input from plant staff, a list of four proposed areas of concern for the existing digesters is as follows:

- Digester mixing optimization
- Digester cover and skirt coating integrity
- Digester cover annular seal integrity
- Digester dewatering wells integrity

This section describes the nature of each specific concern, whereas the subsequent section identifies and evaluates alternatives and options to provide cost effective worthwhile improvements that will complement future overall digester complex upgrades, or at least not result in large, stranded investments.

2.1 Digester Mixing Optimization

During the recent digester cleaning effort, it was noticed that a spool piece had been removed from the suction piping of the existing digester sludge mix pumps. Drawings depicting the current geometry of the digester piping system are shown in Figures 1(a) to 1(f). Figures 1(a) to 1(d) are drawings labeled M30 to M33 from the original construction of the digesters in 1978. Figures 1(e) and 1(f) are drawings labeled G3 and G4 and show the modifications to the digesters performed in 1991. The drawings are all color-coded (see the legend on Figure 1(a). Figures 1(d) and 1(f) show the suction piping to the sludge mixing pumps (identified with red shading), in addition to marking the pipe spool that was taken out of service, reportedly sometime in the early 1990s. As a result, the digester sludge mix pump draws suction only from the open end of the suction pipe located a few feet above the digester bottom. The original design in 1978 included a vertical central draft tube that served to draw sludge from the top of the digester to the inlet of the pump. It is possible the suction piping was modified by plant staff as described above, to eliminate suction from the top of the digester, as this may have caused potential foam or scum to clog of the vertical draft tube inlet, with corresponding reductions in flow from the sludge mixing pumps. Note that the top of the liquid surface in the digester can be prone to foaming and scum formation. Another plausible (and perhaps most likely) reason is that plant staff wanted the capability of lowering the liquid level in the digester from time to time. In this instance, flow would not have been able to enter the central draft tube.

The mixing pump discharge locations are shown in green shading. Currently there are three discharge nozzles returning this sludge back to the tank. Two nozzles are located in a lower ring main at nearly the same elevation of the modified suction entrance, and one other discharge nozzle (labeled as a scum breaker) is located at a higher elevation. A single manual valve control s flow to the twin lower nozzle ring main, and a separate manual valve controls flow to the upper discharge nozzle. It is reported that the valves to each of the upper discharge nozzles are kept closed resulting in no flow to this upper scum breaker.

Note that the drawings shown in Figures 1(a) to 1(d) are out of date with respect to how digested sludge is removed from the digester. Currently, the sludge transfer pumps shown on these drawings are disabled and digested sludge is transferred to the Sludge Processing Building via taps on the sludge mix pump discharge piping system.

The concern raised by plant staff is to identify and evaluate means to improve and optimize digester mixing by examining modifying the current mixing system geometries.

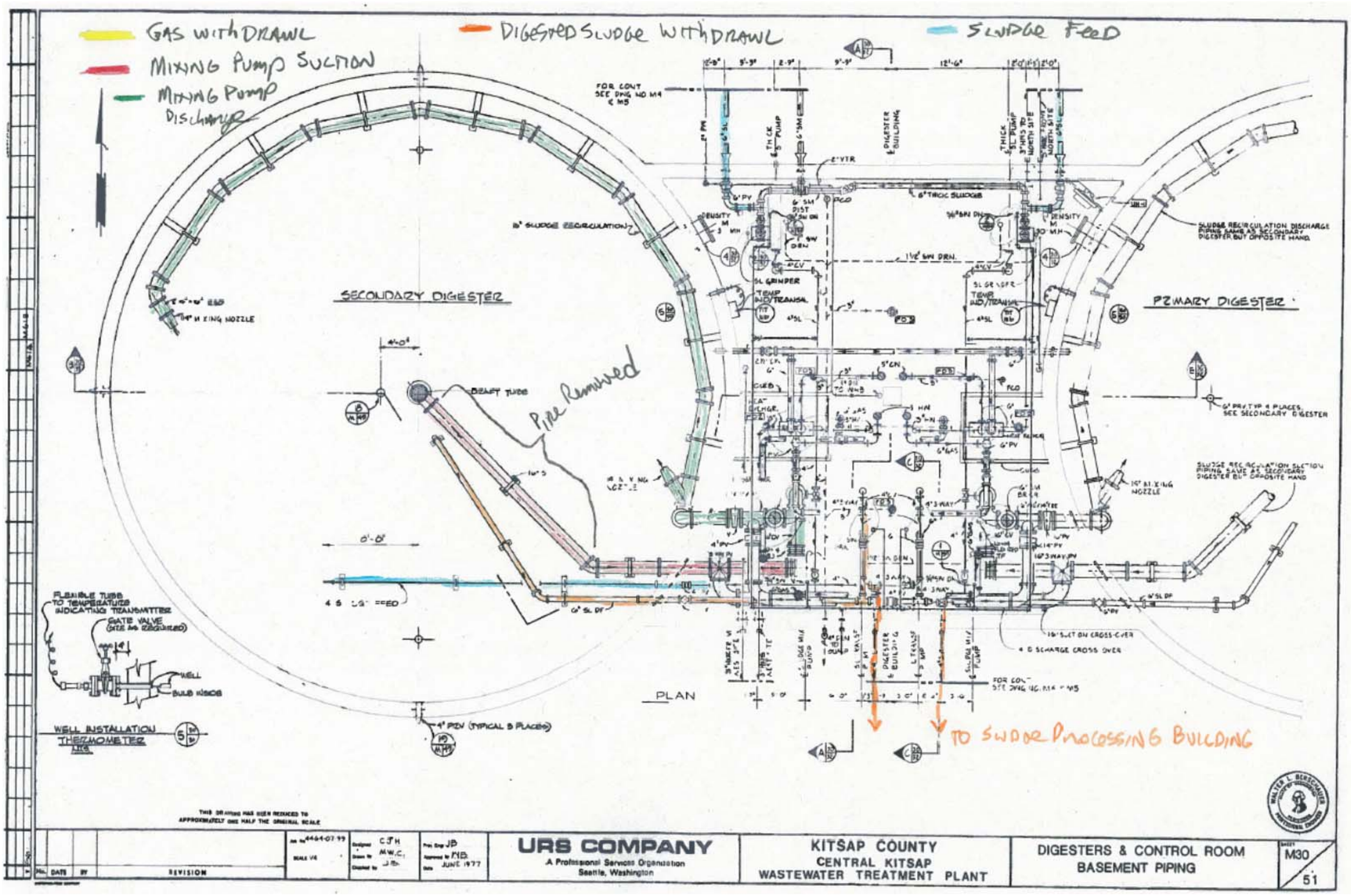


Figure 1(a). Digester drawing M30

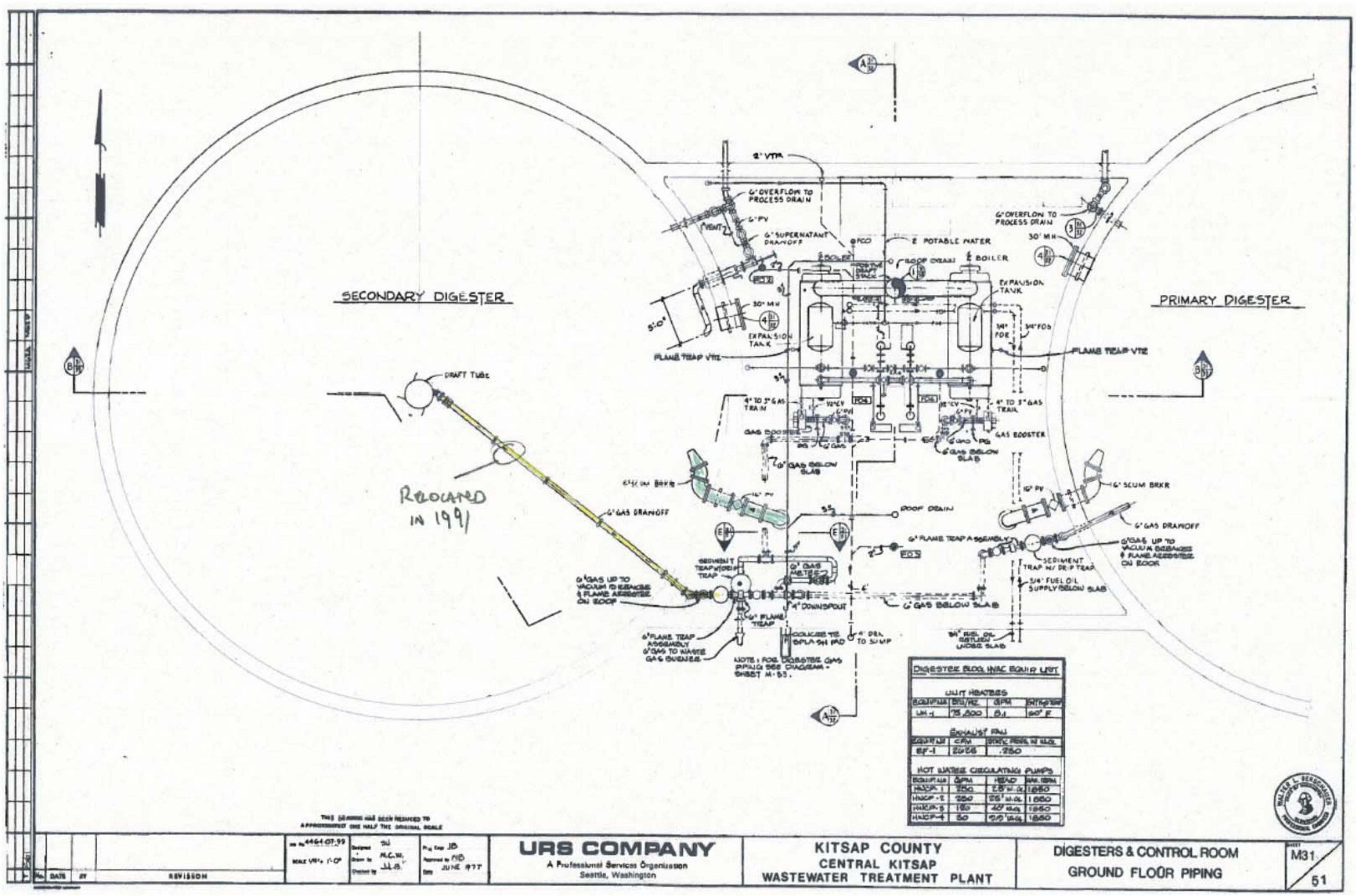


Figure 1(b). Digester drawing M31

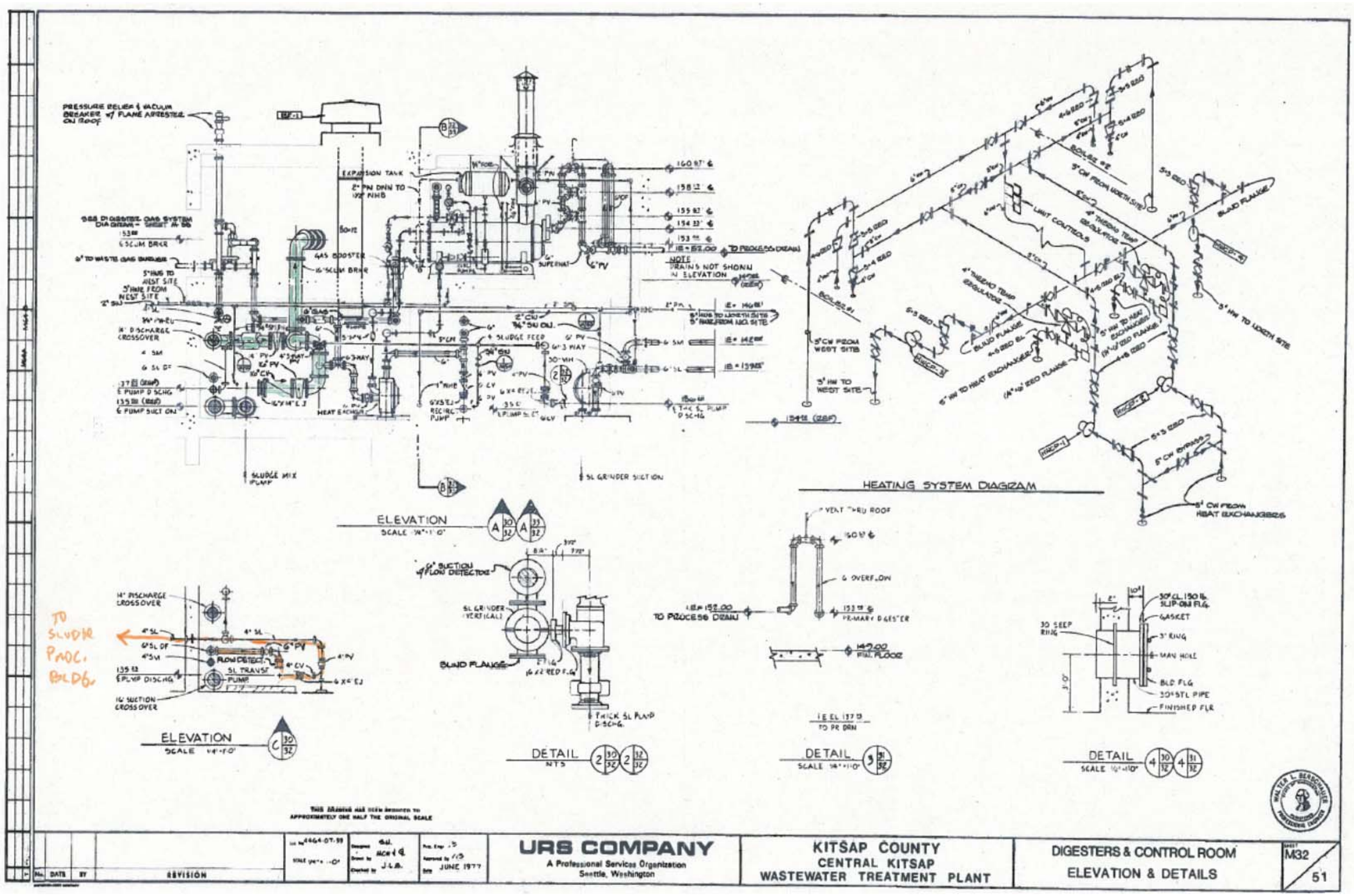


Figure 1(c). Digester drawing M32

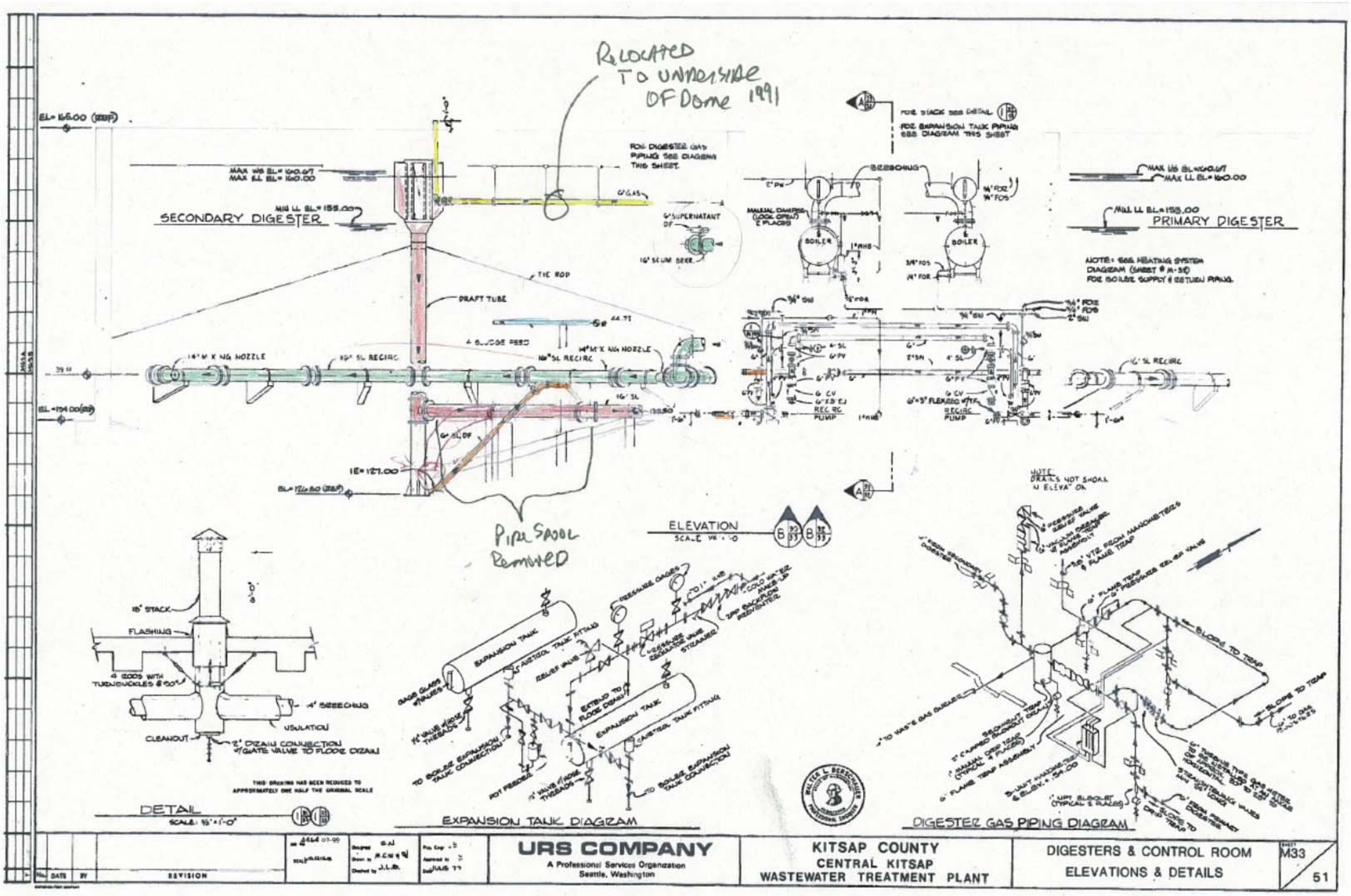


Figure 1(d). Digester drawing M33

Brown AND Caldwell

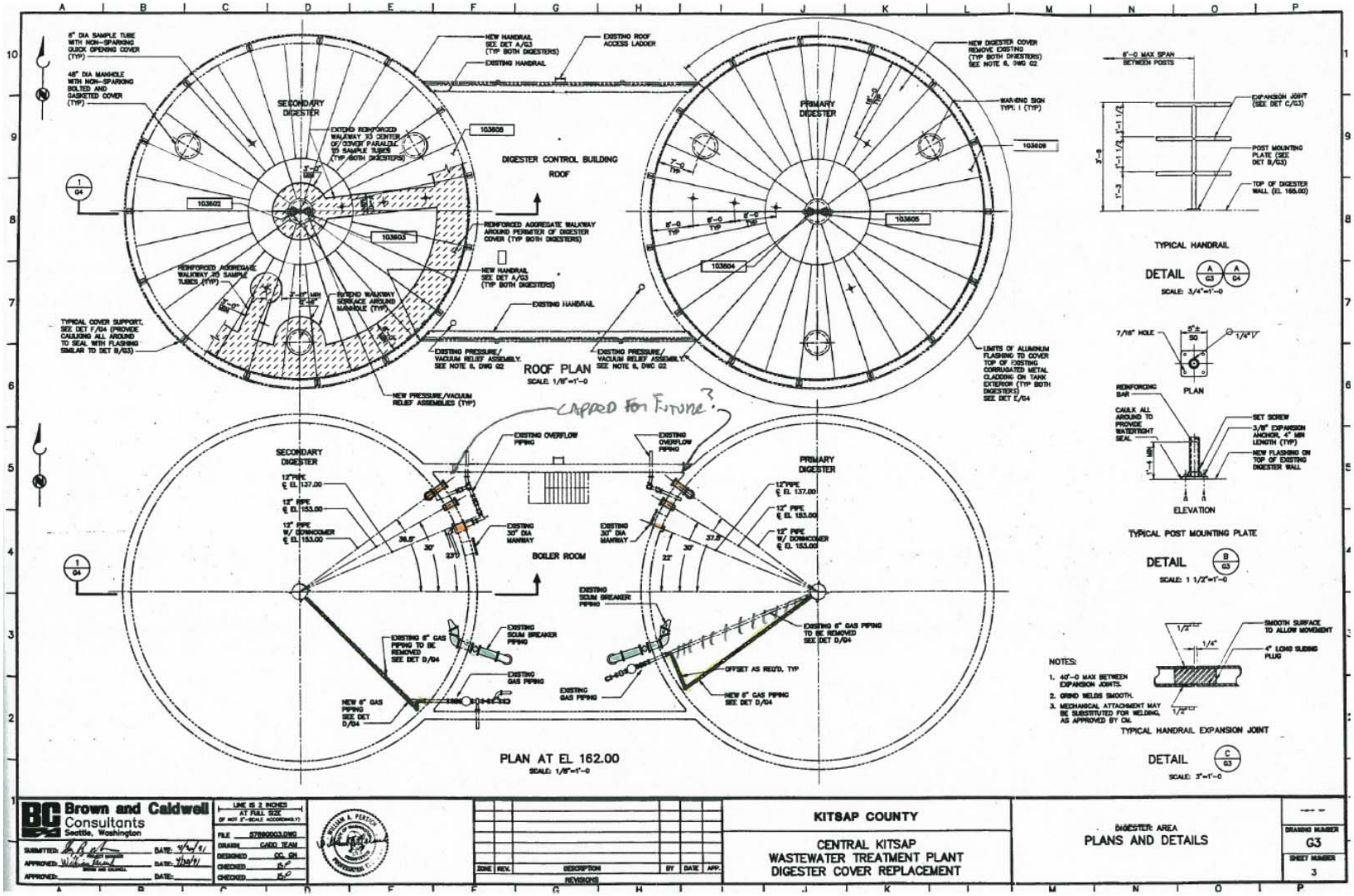


Figure 1(e). Digester drawing G3

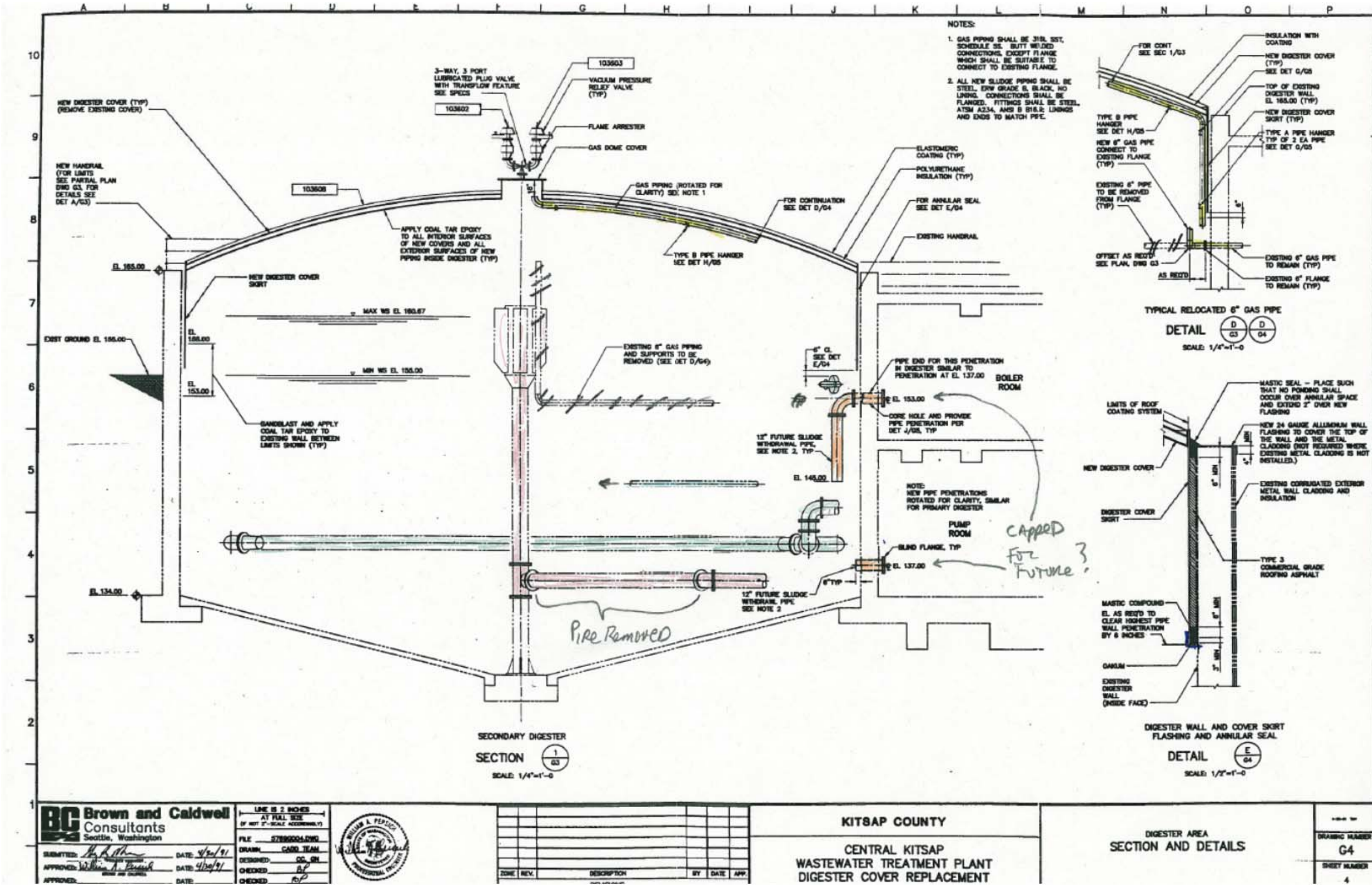


Figure 1(f). Digester drawing G4

2.2 Digester Cover and Skirt Coating Integrity

The integrity of the coating system for the digester covers is a concern due to the need to protect these valuable assets from corrosion. This includes concerns of coating failures associated with the top of the covers, the underside exposed to digester contents, and to the external surfaces of the digester skirt shown in Figure 1(f). The coating at the top of the covers is obviously visible and over time has shown evidence of blistering in spots. Note that the top of the covers are accessed by maintenance staff and additional coating layers have been added to high traffic areas. The coating system for the top of the digester covers was specified in 1991 to be a cured aromatic urethane elastomer with a two-part aliphatic urethane elastomer top coat. These two coating systems were placed atop a sprayed on polyurethane foam insulation

The coating integrity on the underside of the digester cover was intended to be inspected during scheduled digester cleaning cycles. During the last cleaning cycle, there was insufficient time to inspect carefully the integrity of the coating. From a brief entrance inspection with hand held flashlights, the perspective from the bottom of the tank may have suggested that the condition of the interior coating system did not present any glaring or obvious defects. The concern with this brief inspection was that it was not definitive with respect to coating integrity. However, in an anaerobic environment within the digesters, corrosion is not expected to be problematic owing to the absence of dissolved oxygen. The original coating for the interior surfaces of the digester cover, applied in approximately 1991, was specified as coal tar epoxy. This was considered an appropriate coating for this application at the time, but this coating system is no longer permitted due to health and environmental concerns.

The external surfaces of the digester cover skirt (below the top of the annular seal, may or may not have been coated. The specifications in 1991 stated, “Rim plate assemblies and skirts and all associated surfaces shall be painted as specified…” If the external skirt surfaces were not coated, a significant portion of this metal surface was in direct contact with roofing asphalt as shown in Figure 1(f). Asphalt would have protected steel from corrosion. Areas that were not in contact with asphalt (e.g. sand) may be exposed to some corrosion should water enter into this area. However, there is no free flow of water in this area and any water that does enter would have been rendered anaerobic over time, effectively mitigating long-term corrosion reactions.

2.3 Digester Cover Annular Seal Integrity

It has been known for some time that the digester annular seals at the top of the digester between the concrete wall and steel cover are prone to failure. A few years ago, these seals did fail and sludge leaked out of the digesters. The original construction details of the annular seal are shown in Figure 1(f)-Detail E. Note that this detail only pertains to Digester 2 (formerly the primary digester). The seal detail was changed for Digester 1 (formerly the secondary digester) as explained in Attachment A. These seals consist of layers of oakum, asphalt, sand, and mastic as was commonly used for these types of seals in the past. Over time, parts of some of the seal materials may have become degraded and dislodged.

This original seals, installed around 1991, started failing at several locations. Plant staff reports that the digesters can successfully hold pressure as long as the liquid level stays above 22 to 23 feet above the bottom of the digester. At liquid levels below this elevation (and the elevation of the bottom of the steel digester cover shirt), gas can escape via the annular seal. The liquid level in the digesters must be kept higher than the bottom of the digester cover shirt. Note that the liquid level in the digester cannot be allowed to get too high, otherwise gas pressure in the digester can provide sufficient driving head to force sludge through the annular seal and create a sludge leak at the top of the digester. As the maximum pressure design of the digester is approximately 13 inches of water column, as seen in Figure 1 (f), sludge can theoretically rise up through the annular seal if the liquid level in the digester rises to elevation 163.9, however the elevation of the overflow pipe is located at elevation 160.67 as seen in Detail 3 of Figure 1 (c).

Assuming the overflow pipe is functioning correctly, the maximum permissible liquid level in the digester is set lower than this point of physical leak potential to provide sufficient operating cushion and freeboard.

A few years ago, plant staff injected expansive hydrophilic foam in several locations to stem these digester leaks and the results were satisfactory. However, it is recognized that these remedial measures are considered temporary and further risk of seal failures exist.

2.4 Digester Dewatering Wells Integrity

During periods when the digesters are emptied and taken out of service for cleaning, it has been noticed that the structural relief valves placed in the floor of the digester do pass ground water into the digesters. This is intended to help relieve hydrostatic forces under the digesters and prevent damage or uplift of the floor slab. As a result, there is always a pool of water at the bottom of the empty digesters that hinders effective cleaning.

Local ground water wells were installed to provide a local cone of depression around the digesters to alleviate the migration of ground water into the digesters, but these wells have not functioned correctly and are in need of repair. From an inspection of the existing record drawings, it appears these wells are not properly documented. They appear to be shallow unlined holes drilled into the ground that would permit installation of portable pumps. Many of these wells have collapsed or have been filled in and pumps cannot be successfully lowered within.

Section 3: Evaluation and Selection of Recommended Improvements

This section evaluates and selects the recommended improvements for the areas of concern identified in Section 2. These recommendations are intended to be somewhat interim and relatively modest in scope because of potential major upgrades planned for the future.

3.1 Digester Mixing Improvements

As described in Section 2.1, a section of pipe has been removed from the sludge mix pumping system. By examination of Figure 1(d) and 1(f), it appears that the resultant sludge mix piping geometry may foster some hydraulic short-circuiting within the digester. The current piping modification sharply reduces the degree of vertical mixing within the digester. The only means of promoting any degree of hydraulic horizontal mixing would be by the use of the single scum breaker discharge nozzle set at elevation 153.00. Merely restoring the missing pipe spool section may not contribute to improved mixing because of the potential of clogging and reduced sludge mix pumps flows as discussed in Section 2.1. Options are developed to provide improvements to digester mixing.

3.1.1 Options

Upon review of the drawings, there are several options that are proposed to improve sludge mixing. A listing of these options is as follows:

- Option 1: Do Nothing
- Option 2: Increase Flows to the Upper Scum Breaker Nozzle
- Option 3: Add an Upper Discharge Ring Main System
- Option 4: Reroute Some of the Sludge Mix Pump Flows Upwards Through the Central Draft Tube
- Option 5: Increase Sludge Mix Pump Flows

- Option 6: Turn One Lower Ring Main Discharge Nozzle Upwards
- Option 7: Lower Sludge Mix Pump Suction Pipe to Bottom of Digester Cone
- Option 8: Replace the Sludge Mix Pump System with Linear Mixers

Note that some of these options will have some variants and that some of these options can be used together.

3.1.1.1 Option 1: Do Nothing

This obvious option is to do nothing, but continue to monitor digester performance. As described in Section 1, digester performance is expected to have been improved by virtue of better grit removal and higher concentrations of raw sludge being fed to the digesters. Digester performance is monitored by examining trends in unit gas production (mass of methane produced per mass of volatile solids loaded or destroyed), percent volatile solids reduction, the rate of grit accumulation (only when the digester is taken out of service and cleaned), and other indicators such a pH, alkalinity, volatile fatty acids, and temperature variations. If these values mimic typical rates for high rate digesters and if no degradation is observed, then it may be permissible to make no physical changes other than to continue monitoring. It is reported that volatile solids reduction rates are about 60 percent, a value indicative of efficient digestion. However, this option does have some risk. A digester with poor mixing may perform well under ideal conditions, but under plant upset or shock organic loading conditions, it may not. Recent experiences with taking one digester out of service resulted in the on-line digester becoming acidic (sour). Mitigation of this risk can be made by performing additional pre-planning steps prior to the subsequent time a digester is placed out of service, however, the impacts caused by poor mixing could still render the digesters less capable to handle unplanned upsets. A study published in December 16, 2014 (see Attachment B) indicated that the present hydraulic mixing system is adequate for smaller digesters but that the volumetric mixing turn over time is longer than desired for larger digesters.

3.1.1.2 Option 2: Increase Flows to the Upper Scum Breaker Nozzle

The single upper scum breaker nozzle provides the only hydraulic energy vector to contribute to any measure of vertical mixing. To increase flows via this outlet, an operational strategy might entail a periodic manual closing of the lower sludge mix pump ring manifold isolation valve while the upper scum breaker isolation valve is left open. This intuitive approach to increasing flows to the upper part of the digester is simple to implement via a standard operating procedure adjustment, however the magnitude of the benefits to digester mixing cannot be estimated unless a thorough computational fluid dynamic (CFD) investigation is performed. Based on the relatively high cost of this form of hydraulic analysis, it is judged that this option of changing the cycle times for flow through the upper scum breaker valve could be suggested as-is, without the need for a CFD study. Any resultant mixing benefits may only be discerned by observing digester performance gains described in Section 3.1.1.1. A variation of this option is to reduce labor impacts by motorizing these two isolation valves and program their cyclical operations via SCADA.

3.1.1.3 Option 3: Add an Upper Discharge Ring Main System

This option provides an additional sludge mix discharge pipe ring main at an elevation ranging from 153.00 to 158.00, analogous to the existing lower discharge ring main. This new upper ring main, fitted with two discharge nozzles, would replace the single existing scum breaker nozzle. It would be expected that this option might increase mixing efficiency within the digester. However, as stated in Section 3.1.1.2, without a CFD analysis, the impacts can only be surmised. In this instance, this option is consistent with future digester upgrades (with external pump mixing) and would not present a stranded investment. In 1998, partial design drawings (*Central Kitsap Wastewater Treatment Plant Contract IIA Expansion*, Brown and Caldwell) were prepared to outline the features of the future digester improvement project (referred to as the 1998 design modifications). The design concept at that time included placing two sludge mix pump discharge ring mains at elevations 158.00 and 145.50, respectively. Although this option has merit, the magnitude of the expected benefits cannot be estimated and compared to the cost of this option.

3.1.1.4 Option 4: Reroute Some of the Sludge Mix Pump Flows Upwards Through the Central Draft Tube

The description for this option includes modifying the sludge mix pump discharge manifold to convey the pump flow through the existing lower ring main and also to discharge flow from the base of the existing central draft tube to the top of the pipe (reverse flow from the original design intent). In this instance, some of the flow would be conveyed to the upper portions of the digester to help induce vertical mixing. Note that the existing central draft tube would also require modification to distribute flow laterally within the upper strata of the digester. The top of the central draft tube would need to be re-fabricated to attach proper hydraulic distribution piping or other similar mechanism. As with Options 2 and 3, the magnitude of the improvements to mixing efficiency cannot be determined without CFD modeling. Intuitively, this option will be relatively expensive to construct.

3.1.1.5 Option 5: Increase Sludge Mix Pump Flows

Improved mixing performance can be enhanced by increasing flows from the existing sludge mix pumps. In order not to affect motor horsepower and subsequent electrical system impacts, any flow capacity increase should be limited by the existing motor size. However, a study published in December 16, 2014 (see Attachment B), indicated that the existing pumps will operate closer to their best efficiency point as a result of mixing thicker sludge. In addition, these 15 horsepower motors would be operating close to their electrical power limitations. As a result, minor modifications to increase pump output are not practical.

3.1.1.6 Option 6: Turn One Lower Ring Main Discharge Nozzle Upwards

By examination of Figures 1(a), 1(b), and 1(d), some gains in vertical sludge mixing may be obtained by turning upward the most distant nozzle in the lower ring main (only one nozzle). Currently this nozzle is aimed horizontally. This suggested option may appear to be somewhat intuitive, but confirmation of its benefit would require CFD analysis. As this option is relatively low cost, it could be considered as a stand-alone suggestion, but the results will require subsequent digester performance monitoring to understand its affect.

3.1.1.7 Option 7: Lower Sludge Mix Pump Suction Pipe to Bottom of Digester Cone

In this option, the inlet end of the sludge mix pump suction pipe is routed along the digester bottom to the low point in the cone. This is consistent with the 1998 design modifications suggested for the future digester upgrade project with use of external pump mixing. This approach helps to minimize grit accumulations at the bottom of the digester. It is unlikely that this modification will have any significant impact on mixing performance, unless a CFD analysis is performed. This option is also a stand-alone option that may be relatively low cost but would be recommended as a general feature of improved digester piping for any new digester pump mix design. Any resultant mixing benefits may only be discerned by observing digester performance gains described in Section 3.1.1.1.

3.1.1.8 Option 8: Replace the Sludge Mix Pump System with Linear Mixers

This option represents a significantly different means of mixing than had been considered in past studies. Since development of the 1998 design modifications, new mixing technologies have been developed. In the past, Kitsap staff have indicated a preference for continuing the existing external pump mixing system. Recognizing that this not the most efficient means to mix digesters, this shortcoming was weighed against the simplicity, ease of access, and familiarity of continuing with the existing mixing system, In this manner, both internal and external draft tubes mixing systems were rejected, and the 1998 design modifications introduced a new external sludge pumping digester mixing system.

However, since 1998, a new mixing linear motion digester mixing system has been developed and may hold promise as an effective, yet simple mixing system. Unlike earlier concepts of draft tube mixers, large cranes are not needed to extract the mixing system motors, shafts, and impellers. The linear motion mixing system consists of a small motor mounted atop the existing gas dome that is connected to a mechanical oscillator to provide a slow, vertical mixing motion to digester contents via a plunger type of device (similar to certain domestic washing machines). This device is shown in Figure 2.

Figure 2. Linear motion digester mixer

Source: Ovivo Inc.

The principle advantages of this type of mixer are its simplicity, mixing efficiency, rag-shedding properties, and relatively low horsepower. This mixer tends to provide uniform mixing with little turbulence or creation of vortices. This option will be relatively expensive compared to the other options. There currently may not be a lot of clear evidence confirming these relatively new type of mixers are as effective as other mixing systems, but if verified and installed, they would tend to simplify any new digester pumping room layout configuration. It is reported that the Puyallup Wastewater Treatment Plant uses this type of mixing system. Moreover, as this type of mixer may significantly reduce mixing energy requirements, there may be an opportunity to involve an energy savings company (ESCO) to obtain energy grant funding (if available) for this installation. Each of the two existing sludge mix pumps includes a 15 hp motor whereas the motor horsepower for each of these two linear mixers could be approximately 5 hp or less.

The key attraction of this type of mixing system is the simplicity it offers, and if proven effective, this mixing system would be consistent with a future digester upgrade project. Installation of this type of mixer would require the piping appurtenances currently mounted on the gas dome be relocated. A link to one manufacturer's web site for this type of product is as follows:

http://www.ovivowater.com/product/municipal/municipal-wastewater/sludge-treatment-anaerobic-digestion/digestion-mixing/ovivo-lm-mixer-linear-motion/

3.1.2 Summary of Digester Mixing Options and Recommendations

The eight digester mixing options are summarized in Table 1.

Table 1. Digester Mixing Options Summary and Recommendations

Mixing option	Description	Features	Advantages	Disadvantages	Relative cost
1	Do nothing	Increased monitoring	• No cost	• Risk of digester upset at high loadings	None
2	Increase flow to upper nozzle	Shift more flow to scum breaker nozzle	• Relatively simple. • May improve mixing. • Does not require taking digester out of service (OOS).	• Increase labor effort or add cost for motorized valves. • Mixing improvements undetermined. • Sludge mix pump hydraulics need to be checked.	Low
3	Add upper ring main	New ring main consistent with future digester pump mixing.	• Likely to improve mixing. • Consistent with future pump mixing design.	• Magnitude of mixing benefits uncertain. • Requires taking digester out of service (OOS).	Moderate
4	Reverse flow in draft tube	Re-fabricate the draft tube to permit reverse flow and mix upper zone of digester.	• May improve mixing.	• Not consistent with future pump mixing design. • Mixing improvements undetermined. • Requires taking digester OOS.	Moderate to high
5	Increase pump flow	Modify pumps to increase flow, without changing motor horsepower.	• Relatively simple	• The pump motors are operating at near the motor horsepower limits. • Further modifications are not practical.	Not applicable
6	Turn one lower nozzle upwards	Aim one lower nozzle to help mix upper zone.	• Relatively simple. • May improve mixing.	• Mixing improvements undetermined. • Requires taking digester OOS.	Low
7	Pump suction to cone bottom	Directs suction to cone bottom	• Helps keep grit in suspension for removal. • Consistent with future pump mixing design.	• Risk of digester upset at high loadings as a stand-alone option. • Mixing improvements unlikely as a stand-alone option. • Requires taking digester OOS.	Low
8	Linear motion mixer	New mixer located atop gas dome	• Simple, energy efficient, and likely to improve digester mixing. • Energy grants may be available.	• Relatively new technology. • Must relocate digester gas PRVs. • Requires taking digester OOS.	High

From Table 1, the following items are recommended:

- As per Option 1, continue to monitor digester performance
- Option 2 is low cost and may provide some measurable digester mixing benefits. Note that the sludge mix pump hydraulic performance will need to be checked to verify that this option does not negatively impact pump performance. As this option is not likely to significantly improve mixing as a stand-alone option, it is not recommended as a viable and independent option.
- Combining Options 3 and 7 together will improve mixing and are consistent with future digester designs using external pump mixing. Doing these together mitigates disadvantage of taking digester out of service. The preliminary construction cost estimate for Options 3 and 7 combined is approximately $450,000.
- Option 8 will likely improve mixing and reduce energy costs, but requires further investigation. The preliminary construction cost estimate for Option 8 is approximately $960,000.
- Options 4, 5, and 6 are not recommended because they are either infeasible or the possible mixing benefits are relatively minor.

Note that a preliminary cost estimate for select options is shown in Attachment C.

3.2 Digester Cover and Skirt Coating Inspection and Repair Recommendations

The recommendations for inspection of the coating system on the digester covers can be subdivided into the three types of surfaces described in Section 2.2.

The exposed exterior surfaces of the digester can easily be inspected and repaired as required. It has been observed that some coating blistering is apparent, but as long as the blisters are not growing in any significant manner, and as long as they are not punctured, then repairs can be postponed. It is important to minimize access to areas with paint blisters as walking on them can cause them to break open. If there are any areas that need repair, the area in question would need to be adequately prepared can cleaned in accordance with the paint suppliers recommendations and the general guidance found in past construction project paint specifications. The choice of repair coating could range from matching the existing coatings to finding new coatings that are compatible with the existing coating system.

The condition of the interior coating within the digesters should be inspected the next time the digester is emptied for cleaning or for any new construction project. As stated in Section 2.2, corrosion is not likely in an anaerobic environment. It is recommended that scaffolding of other similar means be provided to enable a close up view of the interior coating. This workspace will need adequate ventilation and lighting to permit safe confined space entry for this inspection. Note that the surface of the interior coating may need to be washed to remove any buildup of scum and sludge prior to the coating inspection. Any coating damage that needs repair should be coordinated with the paint supplier providing a replacement coating for the original coal tar epoxy. If the coating inspection reveals that the coating is in reasonable condition, any major coating repair could be deferred until the next major digester upgrade project.

Inspection of the condition of the external surfaces of the cover skirt is not practical unless the entire cover is removed. Most likely, this will never be necessary as corrosion is not expected to be a problem in this area. If a new annular seal is installed as described in Section 3.3, then a partial inspection of any exposed metal surfaces can be made, followed by applicable repair. Based on the likelihood of minimal corrosion in this area, any repair work that might be needed could be deferred until the next major digester upgrade project.

Note that removal of any existing coatings, especially the coal tar epoxy coating, will require provisions for handling hazardous waste. For this reason, it may be prudent to wait until the future digester upgrade project to initiate large-scale repair of the coating system.

The preliminary construction cost estimate for exterior recoating of the digester covers is approximately $190,000, as shown in Attachment C.

3.3 Digester Cover Annular Seal Improvements

The purpose of proposed digester annular seal improvements are to reduce the risk of digester leaks, both sludge and odors. These leaks have occurred in the past. It is recognized that future digester upgrade projects will permit a more permanent fix to this problem but this investigation will be used to discuss remedies for the interim period. Some potential remedies will be consistent with the future design concepts of digester modifications.

3.3.1 Options

There are four basic options for repair of the digester annular seals. These options are listed below, are described in the subsequent sections:

- Option 1: Repair Leaks as they Occur Using Expansive Hydrophilic Foam
- Option 2: Replace the Seals with New Materials Similar to the Original Design
- Option 3: Replace the Seals with Neoprene Expansion Joints
- Option 4: Attach Steel Plates and Provide Continuous Welded Seal

3.3.1.1 Option 1: Repair Leaks as they Occur Using Expansive Hydrophilic Foam

This option continues the practice of injecting expansive hydrophilic foam to deal with leaks as they first materialize. Note this can also be employed to any portion of the annular seal that look suspect or that may be prone to imminent failure. This technique was applied by plant staff in the past and may have involved some outside contractor support. Any portion of the seal that is suspect is targeted for this type of repair, Small holes are drilled into the seal and expansive hydrophilic foam is pressure injected to provide a temporary seal. Plant records should indicate exactly which foam was applied. To date, this method of repair has been satisfactory; however, neither the current integrity of this repair, nor its longevity can be estimated. As a result, this option can be considered viable as an interim measure. The longer a permanent repair is postponed, the greater is the risk of more seal failures.

3.3.1.2 Option 2: Replace the Seals with New Materials Similar to the Original Design

This option is relatively easy to understand, as the design concepts are already documented. There may be an opportunity to replace some minor components such as oakum with more contemporary substitutions. However, this option may be relatively difficult to implement. The length of the cover skirt appears to be approximately 10 feet by inspection of Figure 1(f). To utilize this option, the entire annular seal materials between the skirt and cover would have to be removed in a manner to facilitate installation of new seal materials. This may likely require that the surfaces of the concrete wall and outer skirt would have to be thoroughly cleaned. The contact area requiring this degree of cleaning is very narrow and deep, and methods to clean and inspect these surfaces are problematic. As a result this approach may require removal of the covers, as task that can be considered expensive and perhaps destructive to the integrity of the cover itself. Based on these concerns, this option is not recommended. Alternatively, the County may wish to engage a Contractor to provide ideas and suggestions for removing the covers to provide access for installing a new seal of this type. It may become necessary to cut apart the covers to get proper access for this type of repair. Based on these concerns, this option is not recommended.

3.3.1.3 Option 3: Replace the Seals with Neoprene Expansion Joints

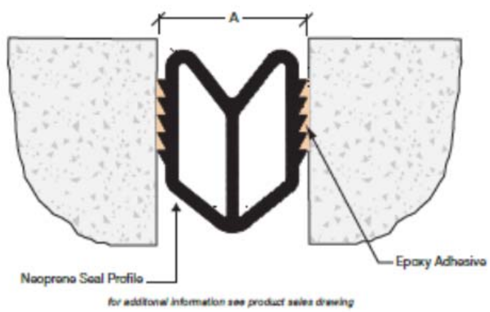
This option uses manufactured neoprene expansion joint seals to take the place of the upper reaches of the existing seals. An illustrative example section view of this type of expansion joint is shown in Figures 3(a) and 3(b). Note that these materials are used for highway, bridge, and tunnel expansion joints that are subject to weather, wheel loads, and significant movement between joints. Based on a recent telephone communication with Paul Biesinger, Regional Sales Manager of Watson Bowman Acme Corp. (800-677-4922, extension 5470), this product should be suitable for this digester application. A link to the web site of this potential vendor is provided below:

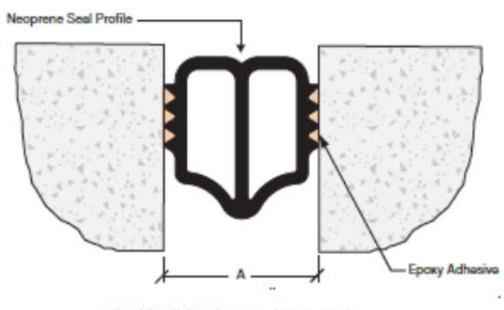
https://wbacorp.com/products/bridge-highway/joint-seals/

Jeene®

Multi-Directional Structural Sealing Joint System

Jeene® is a patented structural sealing joint system comprised of a neoprene profile, which is air-pressurized and bonded in place with a specially formulated epoxy adhesive. When properly installed, the high performance Jeene® joint system will not tear away, protrude out of, or slip from its original position when exposed to repeated mechanical or thermal movements. Complete adhesion of the epoxy to the profile and joint wall is achieved due to the air inflation during installation. Jeene® is the most durable, versatile, cost-effective, and watertight expansion joint in the industry.





FEATURES:

- Accommodates forces associated with multi-directional movements
- Resistant to hydrostatic pressure
- Allows for the combination of shear, rotation and skew movements
- Accommodates thermal movement

RECOMMENDED FOR:

- Sealing joints on bridges roadways and tunnels
- Expansion joints requiring multi-directional movement
- Linear, angular, or circular expansion joint applications

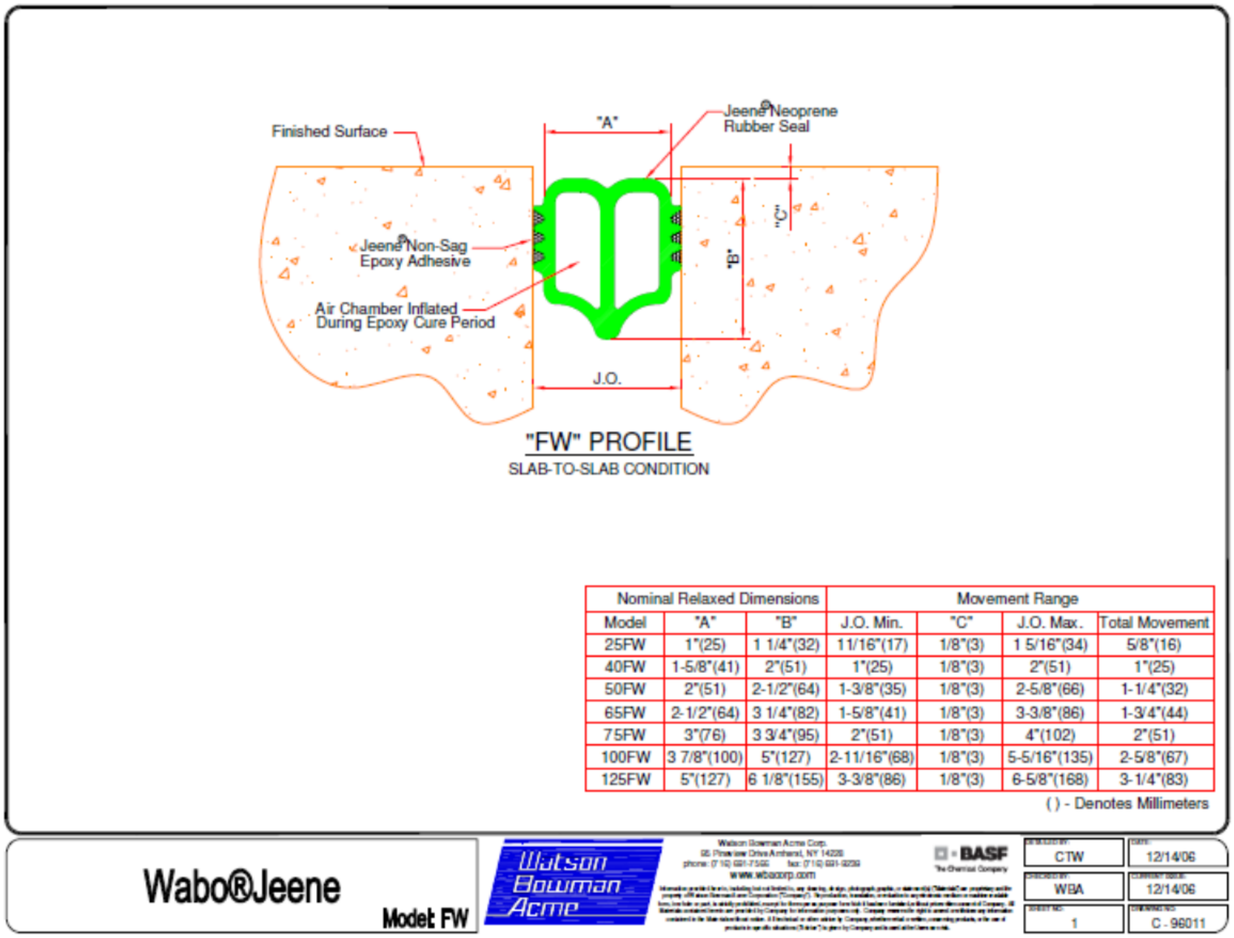
	Model #	Required Joint Gap				Horizontal Movement Range "A"					
		Width		Depth		Min.		Max.		Total	
		in	mm	in	mm	in	mm	in	mm	in	mm
W	25W	1.000	25	2.000	51	0.500	13	1.500	38	1.000	25
	40W	1.625	41	2.750	70	0.750	19	2.375	60	1.625	41
	50W	2.000	51	3.125	79	1.000	25	3.000	76	2.000	51
	65W	2.500	64	4.125	105	1.250	32	3.875	98	2.625	67
	75W	3.000	76	5.375	137	1.500	38	4.500	114	3.000	76
	100W	3.875	98	5.500	140	2.000	51	5.875	149	3.875	98
	25FW	1.000	25	2.000	51	0.625	16	1.375	35	0.750	19
	40FW	1.625	41	3.000	76	1.000	25	2.125	54	1.125	29
	50FW	2.000	51	3.500	89	1.375	35	2.625	67	1.250	32
	65FW	2.500	64	4.375	111	1.750	44	3.375	86	1.625	41
FW	75FW	3.000	76	4.750	121	2.000	51	3.875	98	1.875	48
	100FW	3.875	98	5 .875	149	2.625	67	5.250	133	2.625	67
	125FW	5.000	1 27	7.000	178	3.375	86	6.625	168	3.250	83

Profile size should be chosen to match the gap opening at median temperature range of expected movement. Inch measurements have been converted from metric and rounded to nearest 1/8". Consult your WBA Representative with your special design requirements.

Watson Bowman Acme 800.677.4922 www.wbacorp.com 7

Figure 3(a). Neoprene expansion joint section

Brown AND Caldwell



Nominal Relaxed Dimensions			Movement Range			
Model	"A"	"B"	J.O. Min.	"C"	J.O. Max.	Total Movement
25FW	1"(25)	1 1/4"(32)	11/16"(17)	1/8"(3)	1 5/16"(34)	5/8"(16)
40FW	1-5/8"(41)	2"(51)	1"(25)	1/8"(3)	2"(51)	1"(25)
50FW	2"(51)	2-1/2"(64)	1-3/8"(35)	1/8"(3)	2-5/8"(66)	1-1/4"(32)
65FW	2-1/2"(64)	3 1/4"(82)	1-5/8"(41)	1/8"(3)	3-3/8"(86)	1-3/4"(44)
75FW	3"(76)	3 3/4"(95)	2"(51)	1/8"(3)	4"(102)	2"(51)
100FW	3 7/8"(100)	5"(127)	2-11/16"(68)	1/8"(3)	5-5/16"(135)	2-5/8"(67)
125FW	5"(127)	6 1/8"(155)	3-3/8"(86)	1/8"(3)	6-5/8"(168)	3-1/4"(83)

( ) - Denotes Millimeters

Figure 3(b). Neoprene expansion joint section

A neoprene rubber expansion joint can be extruded as one long, continuous piece (approximate length, 220 feet), and have been extruded as long as 500 feet for past applications by this vendor. The expansion joint comes in a variety of widths and lengths, and the width delivered would be slightly larger than the annular gap to ensure the joint is continually compressed when installed. This compression behavior would be important to verify in this case as the annular gap is not expected to be of uniform width. In this installation, epoxy would be provided between the expansion joint and the mating contact surfaces. According to the recent telephone discussion, this type of expansion joint should be adequate to resist the maximum pressure force (approximately 13 inches of water column) that would tend to force the expansion joint material upwards. If there remains a concern about resisting this upward force, a series of slightly cantilevered metal plates can be bolted to the top of the digester concrete wall to provide thrust blocking. Moreover, a special detail to show how a pressure tight closure is made between the two mating ends of the expansion joint would also be required. There is also a potential to experience a maximum vacuum force of 2 inches of water column that would tend to pull the seal downwards.

An apparent advantage of this type of joint system is that only the top few inches of the existing annular seal would have to be completely removed to permit installation of this type of expansion point.

If this type of system is desired, further consultation with qualified vendors would be necessary to identify the specific materials that are applicable. To date, information of where this type of annular seal has been used for a similar digester application has not been found.

3.3.1.4 Option 4: Attach Steel Plates and Provide Continuous Welded Seal

This option requires at a continuous band or strip of steel be welded to either the bottom of the skirt or to the top, and then bolted (with neoprene gasket) to the digester concrete wall. In effect, this provides a pressure tight and continuous seal between the digester cover and the concrete wall. There may be some difficulties with this approach associated with the need to cope with thermal and other expansion stresses that will occur between cover and concrete wall. Moreover, the use of continuous welding to install a welded seal may itself cause warpage on the digester cover. It will also be necessary to recoat the digester cover near any welding damage. Based on these concerns, this option cannot be recommended.

3.3.2 Recommendations

Based upon the preceding discussion of annular joints, only two recommendations can be made. If a short-term repair is sought, Option 1 to repair leaks with expansive hydrophilic foam as they form or about to form is recommended. This may be adequate until the digester undergo significant modifications in a future digester upgrade project.

If a more permanent annular seal repair is desired before a future digester upgrade project, it is recommended that the neoprene expansion joint concept discussed in Option 3 be investigated further. One approach would be to contact a local sales representative for this type of seal to bring out a seal sample and demonstrate its installation. The goal of this is to get an expert opinion by a qualified sales representative and to investigate the means for plant staff to install this type of system. The preliminary construction cost estimate for this expansion joint concept is approximately $170,000, as shown in Attachment C.

3.4 Digester Dewatering Wells Recommendations

From the discussion in Section 2.4, the recommendation would be to engage a hydrogeologist for design consultation and construct new dewatering wells. These wells could be drilled and kept relatively shallow. It is further recommended that these wells be lined with PVC casings to provide bore hole integrity. A preliminary planning level construction cost estimate for the installation of a dewatering well would be approximately $6,000, per well. Refer to Attachment C for more details.

Attachment A: Modification of Digester 1 Annular Seal Documentation

(GRN)

Brown and Caldwell
Consultants
100 West Harrison Street
Seattle, WA 98119-4186
(206) 281-4000
Fax (206) 286-3510

January 22, 1993

Mr. Don Hatch
Olympic Western Company
1938 First Avenue South
Seattle, Washington 98134

14-5769-13/2

Subject: Central Kitsap Wastewater Treatment Plant
Digester Cover Replacement Project--
Proposed Contract Modification No. 8

Dear Mr. Hatch:

This letter requests a cost proposal for Proposed Contract Modification No. 8. Please disregard the PCM 8, previously distributed during our meeting to investigate the annular seal at the CKWWTP on February 19, 1993. The following is description of the task item:

1. Modify Annular Seal of the Secondary Digester--Modify annular seal in accordance with the attached detail. Place a 6-inch minimum thick layer of oakum at bottom of annular seal. Add a 10- to 12-inch layer of dry commercial blast grade sand on top of oakum layer. On top of lower sand layer place roadway asphalt, U.S. 0:1 AR4000, to approximately 12 inches from top of wall, in accordance with manufacturer's recommendations. Add a 6- to 8-inch layer of dry commercial blast grade sand on top of asphalt layer. Reduce top mastic layer from 6-inch minimum penetration below top of wall to 4 inches. Mastic layer shall be Sikaflex 2cNS/SL or equal, applied as recommended by manufacturer.

Item 1 shall be completed for the secondary digester only. We would appreciate any comments you may have regarding the constructability of the new seal; specifically, are there constructability concerns which could degrade the quality of the annular seal system? We do not perceive that this change will impact the schedule. If you have no constructability concerns,

hatch-9.wpw/cp

Mr. Don Hatch
January 22, 1993
Page 2

please prepare a proposal for change in costs as a result of the task. Please call if you have any questions.

Very truly yours,

BROWN AND CALDWELL

Chris Cleveland
Project Engineer

CJC:cjc:cp
Attachments

cc: Mr. Paul Dour, Kitsap County Public Works
Mr. Ron Moore, Central Kitsap Wastewater Treatment Plant
Mr. Gary Newman, Brown and Caldwell
Mr. Jack Pawlitschek, Brown and Caldwell

BC PROPOSED CONTRACT MODIFICATION # 8

	ROUTING	SENT	REC'D
OWNER: KITSAP COUNTY	CM to CONTRACTOR		
PROJECT: CKWWTP DIGESTER COVER	CONTRACTOR to CM		
CONTRACTOR: OLYMPIC WESTERN	CM to OWNER		
	OWNER to CM		

NOTIFICATION

The following changes to the contract are being considered: Page 1 of

Modification to Annular seal of Secondary Digester (see attached Detail sketch). Any flashing and coating requirements as shown on Detail E/S4 shall not change.

This is believed to be a ☐ no cost ☒ no time change

☐ Attachments

☒ Submit itemized quotation for performing change

By Construction Manager ____________ To Contractor on date 1/23/93

CONTRACTOR'S RESPONSE

This is ☐ is not ☐ a cost change

This is ☐ is not ☐ a time change

We are submitting the following quotation:

	COSTS (DOLLARS)	TIME (DAYS)
☐ ADD	______	______
☐ DEDUCT	______	______
☐ Itemization Attached		

By ____________ To Construction Manager on date ______

CM RECOMMENDATION

☐ Change Order per quotation above

☐ Change Order as modified, to wit:

	COSTS (DOLLARS)	TIME (DAYS)
☐ ADD	______	______
☐ DEDUCT	______	______

Quotation is:

☐ Lump Sum

☐ Per Unit Price

☐ Change Order on a time and material basis

☐ Other ____________

By ____________ To Owner on date ______

OWNER'S RESPONSE

☐ Approved as recommended - Prepare Change Order

☐ Not Approved ☐ Abandoned (Change Initiated by City or Engineer)

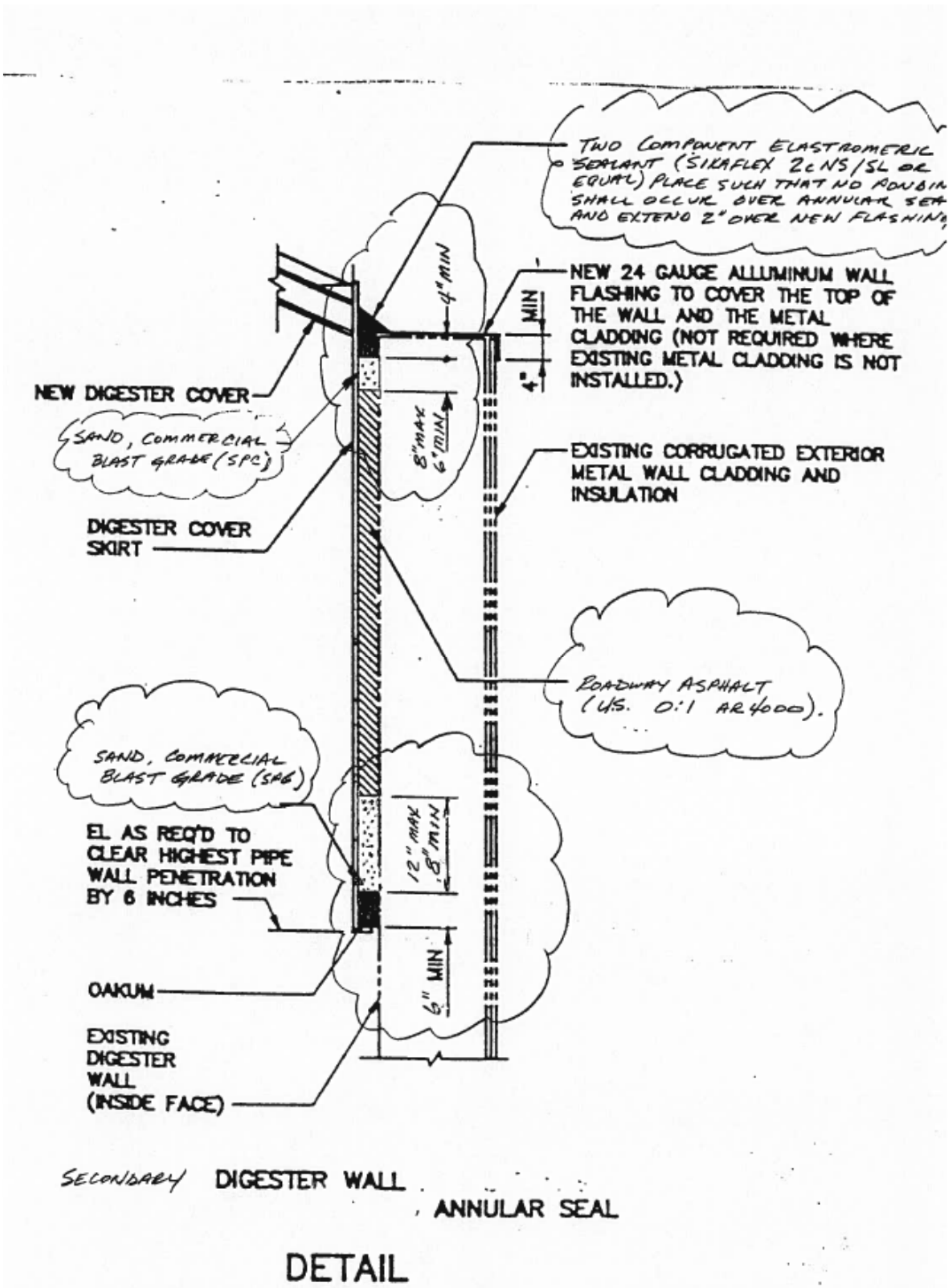
Remarks/Reasons: ____________

☐ Follow Up as Follows: ____________

☐ Other: ____________

By ____________ Date ______ To CM on date ______

Brown AND Caldwell


TWO COMPONENT ELASTROMERIC SEALANT (SIKAFLEX 2c NS/SL OR EQUAL) PLACE SUCH THAT NO BONDING SHALL OCCUR OVER ANNULAR SEAL AND EXTEND 2" OVER NEW FLASHING
4" MIN
NEW 24 GAUGE ALLUMINUM WALL FLASHING TO COVER THE TOP OF THE WALL AND THE METAL CLADDING (NOT REQUIRED WHERE EXISTING METAL CLADDING IS NOT INSTALLED.)
4" MIN
NEW DIGESTER COVER
SAND, COMMERCIAL BLAST GRADE (SPC)
8" MAX 6" MIN
EXISTING CORRUGATED EXTERIOR METAL WALL CLADDING AND INSULATION
DIGESTER COVER SKIRT
ROADWAY ASPHALT (U.S. O:1 AR4000).
SAND, COMMERCIAL BLAST GRADE (SPG)
EL AS REQ'D TO CLEAR HIGHEST PIPE WALL PENETRATION BY 6 INCHES
12" MAX 8" MIN
OAKUM
6" MIN
EXISTING DIGESTER WALL (INSIDE FACE)
SECONDARY DIGESTER WALL ANNULAR SEAL
DETAIL

Attachment B: CKTP Digester Sludge Pump Investigation

Attachment B

CKWTP Digester Sludge Pump Investigation

EJJ 12/16/14

Introduction

The digester sludge pumps for mixing and heating at the Central Kitsap Treatment Plant (CKTP) were investigated for the impacts of pumping thicker sludge. The new sludge thickening system will increase raw sludge solids concentrations fed to the digesters from the current concentration of about 3.1 percent to about 5.1 percent. The volatile solids destruction in the digesters will cause the digested sludge solids concentrations for these feed sludges to be about 1.5 percent and 2.8 percent solids, respectively. Digested sludge at 1.5 percent will behave very similar to water. Digested sludge at 2.8 percent solids will behave differently than water depending on the sludge velocity. The sludge pumps used for mixing the digester and for circulating sludge through the heat exchangers (HEXs) will be effected and pump at lower flow rates. However, the operating ranges are still acceptable and close to the best efficiency points. Sludge mixing in the digester will be reduced, and the overall effect on digester performance is unknown at this time.

Methodology

Two methodologies were employed for analyzing the sludge head loss for the pump system curves: using sludge head loss factors developed based on Mulbarger's research from *Pump Station Design* [1], and using the EPA's methodology for sludge head loss calculations and Mulbarger's research on sludge rheology properties [1,2]. The higher of the two friction factor multipliers based on the two methodologies was used for the new thicker solids. The multiplication factors are applied to the piping head loss for water as recommended in *Pump Station Design.* Additionally, a 50 percent multiplication factor was applied to the minor losses in the pump system for the thicker sludge. This is a conservative application. The sludge heat exchanger head loss was estimated as a worst case from the manufacturer as 2 pounds per square inch (psi) higher than the design value of 4.33 psi. The pump system curve for the existing thinner sludge is assumed to be equivalent to that of water. The pump curves were received from the pump manufacturers and the design points taken from the pump submittal information. The two methodologies described above each have a "routine operation" multiplier, and a "worst case" multiplier for design. Both cases were analyzed.

Results

The results of the analysis show the original pump design was fairly conservative in the predicted head loss. Both pump designs predicted a higher head loss than for the routine operating case at 1.5 percent solids. Table 1 shows that even under the worst case conditions with 2.8 percent solids, the head loss through the two systems are equal to or just above the design values. The flow rate for the sludge mix pump may decrease by as much as 10.1 percent with the thicker sludge based on these calculations (4,260/4,740 = 89.9 percent), but will likely be very similar to the existing system. The sludge HEX pump flow rate may decrease by as much as 15.8 percent (250/297 = 84.2 percent). Largely the flow rate decrease for the sludge HEX pump is caused by the increase in head loss estimated by the heat exchanger manufacturer. This head loss increase is likely a conservative value. The results are shown on the pump curves also in Figure 1 and Figure 2 after the conclusion section.

Table 1. Sludge Pump Estimated Operation

Sludge Pump	Case	Flow, gpm	Head, ft	% of BEP
HEX Pump	Design	250	20	78.3
	1.5% routine	297	18.6	93.0
	1.5% worst case	287	18.9	90.0
	2.8% routine	257	19.8	80.6
	2.8% worst case	250	20.0	78.3
Mix Pump	Design	4,438	9.8	129
	1.5% routine	4,740	8.5	138
	1.5% worst case	4,270	10.4	124
	2.8% routine	4,690	8.7	136
	2.8% worst case	4,260	10.5	124

Discussion

A decrease in flow rate of the sludge mix pumps will result in less mixing of the digesters. The decrease in flow is modest at about 10 percent. The predicted flow rate at worst case conditions and 2.8 percent solids is about equal to the design flow rate, and the pumps will operate closer to their ideal operating range (70 – 120 percent of the Best Efficiency Point (BEP)). The thicker sludge in the digester theoretically would require a higher flow rate to achieve the same mixing.

The existing digester mixing system operates at the lower range of typical design criteria. The mixing system consists of a central withdrawal draft tube, a single sludge pump, and two injection nozzles that do not have symmetric hydraulics. Metcalf and Eddy [3] recommend two criteria for mechanically mixed systems like this: unit power of 0.025 – 0.04 horsepower (hp) per 1,000 gallons of digester volume, and a time to turnover tank contents of 20 to 30 minutes. EPA [4] also recommends two criteria for mechanically mixed systems: unit power of 0.2 – 0.3 hp per 1,000 ft^3 and tank turnover of 20 to 30 minutes. For small digesters, a longer turnover time is typically used for design, generally ranging from 60 to 120 minutes. The two digesters are 65 feet in diameter and each have a volume of about 650,000 gallons. The sludge mix pumps have 15 hp motors and will produce a flow rate of 4,260 gpm at worst case conditions (not including mixing provided by the sludge HEX pumps). This equates to a unit power of 0.023 hp per 1,000 gallons of digester volume or 0.17 hp per 1,000 ft^3, and a turnover time of 152 minutes. The unit power criterion is close to the recommended criteria, and the turnover time is longer than recommended criteria but close to common design values for small digesters.

Many digesters such as this one operate successfully with less than recommended mixing parameters; however, it should be noted that operating at the lower end of the recommended design range may have process implications. Volatile Solids Reduction (VSR) may be slightly lower because of the potentially limited active volume and poor distribution of feed sludge throughout the digester, and the digester will also be at a slightly greater risk of digester upsets related to organic overloading. Also, increased grit deposition will be greater at the lower mixing intensities. Given this, digester loading rates and performance (measured as VSR) should be monitored to ensure adequate performance and stability is achieved. Likewise, grit deposition in the digesters should be investigated when they are taken out of service during construction. A high grit deposition would mean that the mixing system is likely inadequate. Table 2 outlines the recommended monitoring of the digestion process to identify if poor digester mixing intensity is critically impacting performance.

Table 2. Recommended Process Monitoring for Digesters with Low Mixing Intensity

Process Impact	Description	Monitoring	Action
Volatile Solids Reduction (VSR)	VSR may be slightly lower, especially at higher loading rates	Monitor VSR and compare to historical performance.	If VSR is significantly lower than historical values, investigate mixing improvements.
Process Stability	Digester may be at a greater risk for upset, especially at higher loading rates	Monitor digester stability (pH, volatile acids, alkalinity, temperature) and compare to historically values.	More frequent digester upsets (or more frequent instability occurrences) should trigger investigation into mixing improvements.
Grit Accumulation	Grit accumulation is greater at reduced mixing intensities	Assess grit deposition during digester cleaning and compare to previous cleaning events.	If more frequent cleaning or significantly greater debris is identified, investigate mixing improvements.

A decrease in flow rate of the sludge heat exchanger pumps will result in less heat transfer in the heat exchangers. The sludge flow rate will decrease by as much as 16 percent at the worst case condition; however, the flow rate will still be equal to the design flow rate. The heat exchanger vendor estimated this decrease in heat exchanger performance to be about 10 percent for the higher solids concentration (not accounting for any change in flow rate). Based on input from the County, the sludge heat exchanger pumps currently operate about 4 to 5 hours a day on average and longer during the winter months. A lower sludge flow rate through the heat exchanger and the thicker sludge will both cause the sludge heat exchanger pumps to operate for longer periods to heat the digesters. While longer pump run times may use more electricity, it will tend to even out the digester heating through the day making better use of heat from the cogeneration system. Therefore, the increased solids content and reduced flow rate could have a positive effect on the plant's net energy use and the digestion system. The County also presumably has the ability to adjust the three way temperature control valve to increase the hot water temperature sent to the heat exchangers to promote higher heat transfer if desired.

Conclusions

The following conclusions are made from this analysis:

- The sludge mixing flow rate will be up to 10 percent lower with the thicker sludge, but will likely be similar to the existing flow and about equal to the design flow rate. The mixing pump will operate at a better place on its curve and in an acceptable range near its best efficiency point.
- The digester mixing will also be decreased from the current mixing capacity by the thicker sludge in the digester.

- The digester mixing system is less than would be typically designed for a new installation. Review of the VSR, digester stability indicators (pH, volatile acids, alkalinity, and temperature) and grit deposition might provide insight into the mixing adequacy now and with the thicker sludge.
- The sludge HEX pump flow rate will decrease by up to 16 percent, but will still be equal to the design flow rate.
- The sludge HEX pump will operate at a good place on its curve and in an acceptable range near its best efficiency point
- The sludge heat exchanger capacity will be decreased from the current operation by both the thicker sludge and the lower sludge flow rate, but this will spread the heat load out over the day. This will likely make better use of the recovered heat from the cogeneration system. In addition, the County can presumably adjust the three-way temperature control valve to the sludge heat exchangers to increase capacity.

References

[1] Jones, Garr M., Pump Station Design, 3rd edition, Butterworth-Heineman, Burlington, MA, 2008.

[2] Environmental Protection Agency, "Process Design Manual for Sludge Treatment and Disposal," EPA 628/1-79-011, 1979.

[3] Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 4th edition, Mc-Graw Hill, New York, 2003.

[4] EPA. EPA Design Information Report, Journal WPCF, Vol 59, No 3. March 1987.

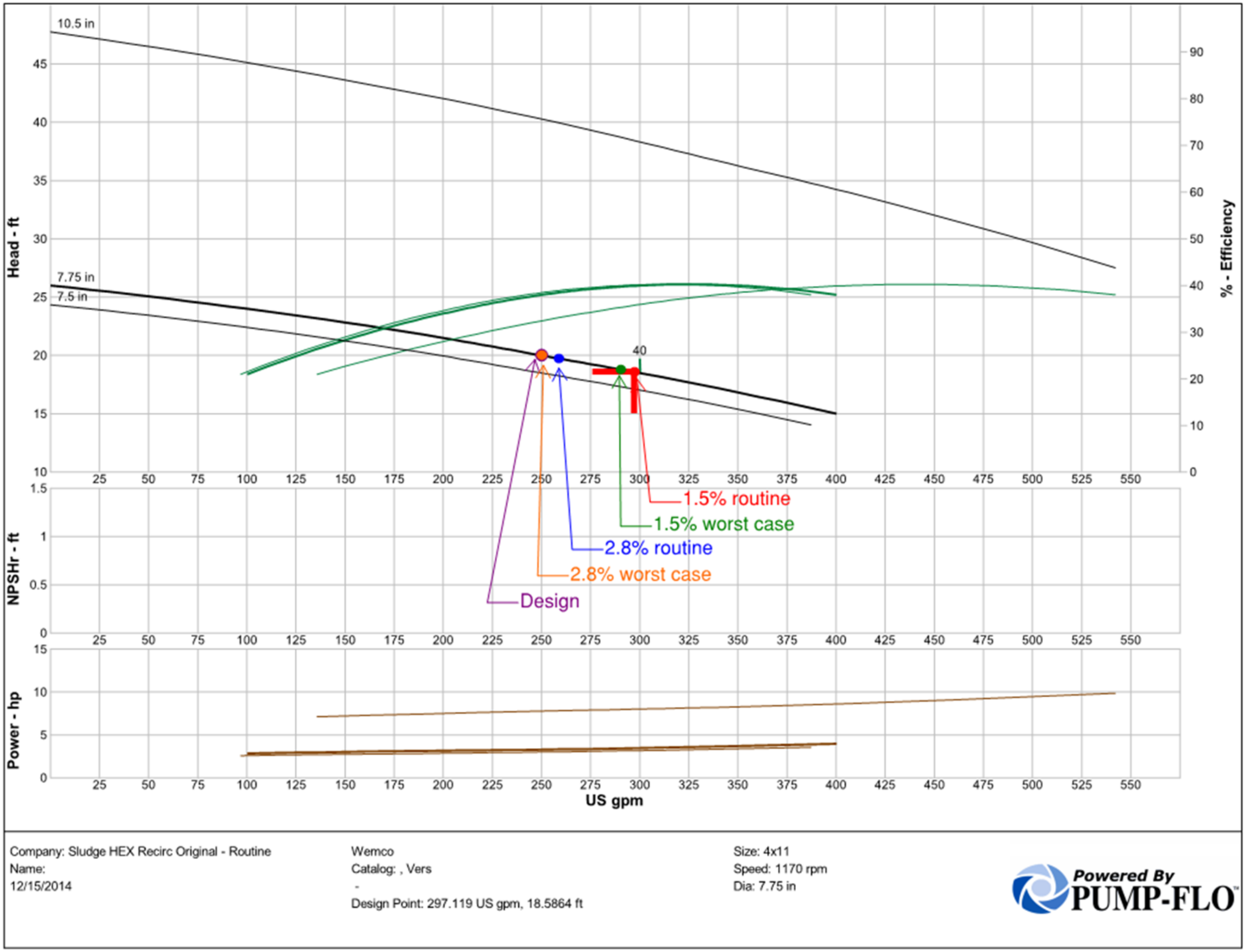


Figure 1. Sludge HEX Pump Estimated Operation

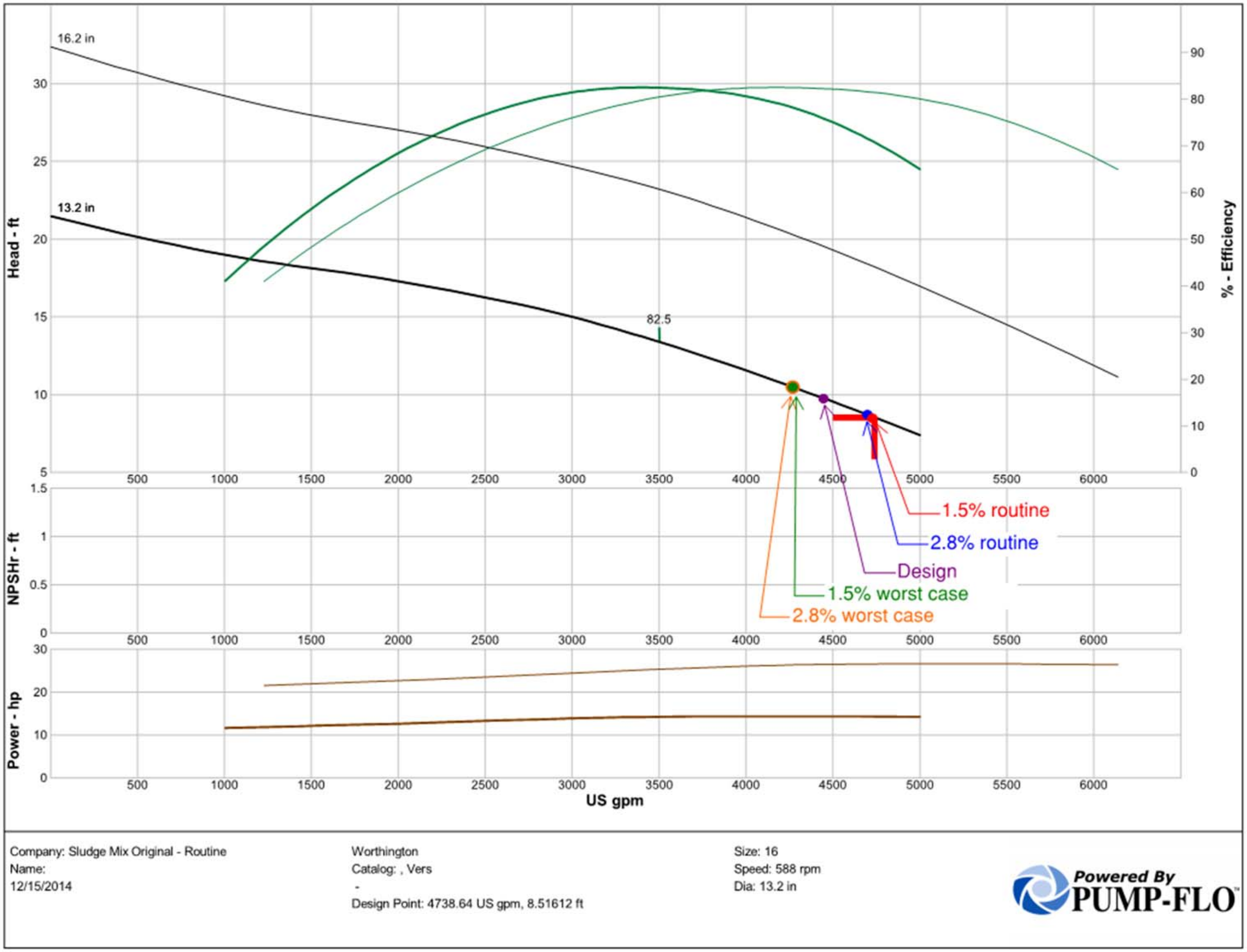


Figure 2. Sludge Mix Pump Estimated Operation

Attachment C: Alternative Evaluation Cost Estimate

KITSAP COUNTY
CENTRAL KITSAP WWTP DIGESTER IMPROVEMENTS ALTERNATIVE EVAULATION
PLANNING LEVEL, CLASS 5 ESTIMATE

Estimator	Dummer, Catherine
BC Project Manager	Bill Persich
BC Office	Seattle
Estimate Issue No.	1
QA/QC Reviewer	Dan Goodburn
QA/QC Review Date	12/23/2015
BC Estimate Number	143270-599-120

Notes

PROCESS LOCATION/AREA INDEX

01 DIGESTER MIXING OPTIMIZATION
- 11 IMPROVE EXISTING PUMP MIX SYSTEM
- 12 REPLACE PUMP MIXING WITH LINEAR MIXER

02 DIGESTER COVER AND SKIRT COATING INTEGRITY
- 21 REPAIR EXISTING COVER TOP INSULATION AND COATING

03 DIGESTER COVER ANNULAR SEAL INTEGRITY
- 31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE

04 DIGESTER DEWATERING WELLS INTEGRITY
- 41 DEWATERING WELL

CENTRAL KITSAP WWTP DIGESTER IMPROVEMENTS ALTERNATIVE EVAULATION

Estimate Breakdown	Takeoff Quantity	Grand Total Unit Price	Gross Total Cost w/Markups
01 DIGESTER MIXING OPTIMIZATION			
11 IMPROVE EXISTING PUMP MIX SYSTEM			
22999 Realign Pump Suction Piping	2.00 LS	22,101.58 /LS	44,203
22999 Automate Lower Ring Main and Scum Breaker Nozzle Operation	2.00 LS	65,979.93 /LS	131,960
22999 Add Upper Ring Main Piping and Nozzles	2.00 LS	133,491.47 /LS	266,983
11 IMPROVE EXISTING PUMP MIX SYSTEM			**443,146**
12 REPLACE PUMP MIXING WITH LINEAR MIXER			
01999 Crane Rental	6.00 DAY	4,912.49 /DAY	29,475
02999 Demolition	2.00 LS	16,602.26 /LS	33,205
11999 New PRV on Extended Gas Dome	2.00 EA	107,660.19 /EA	215,320
11999 Linear Mixer	2.00 EA	339,927.13 /EA	679,854
12 REPLACE PUMP MIXING WITH LINEAR MIXER			**957,854**
02 DIGESTER COVER AND SKIRT COATING INTEGRITY			
21 REPAIR EXISTING COVER TOP INSULATION AND COATING			
02999 Remove Existing Insulation and Protective Coating	6,633.00 SF	12.08 /SF	80,123
07999 PUF Foam Insulation and Coating	6,633.00 SF	15.84 /SF	105,038
21 REPAIR EXISTING COVER TOP INSULATION AND COATING			**185,161**
03 DIGESTER COVER ANNULAR SEAL INTEGRITY			
31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE			
07999 Neoprene Expansion Joint	410.00 LF	312.74 /LF	128,223
07999 Expansion Joint Cover Plate	410.00 LF	91.78 /LF	37,629
31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE			**165,852**
04 DIGESTER DEWATERING WELLS INTEGRITY			
41 DEWATERING WELL			
33999 Dewatering Well	1.00 EA	5,965.14 /EA	5,965
41 DEWATERING WELL			**5,965**

KITSAP COUNTY
CENTRAL KITSAP WWTP DIGESTER IMPROVEMENTS ALTERNATIVE EVAULATION
PLANNING LEVEL, CLASS 5 ESTIMATE

Estimator	Dummer, Catherine
BC Project Manager	Bill Persich
BC Office	Seattle
Estimate Issue No.	1
QA/QC Reviewer	Dan Goodburn
QA/QC Review Date	12/23/2015
Notes	**PROCESS LOCATION/AREA INDEX**

01 DIGESTER MIXING OPTIMIZATION
- **11 IMPROVE EXISTING PUMP MIX SYSTEM**
- **12 REPLACE PUMP MIXING WITH LINEAR MIXER**

02 DIGESTER COVER AND SKIRT COATING INTEGRITY
- **21 REPAIR EXISTING COVER TOP INSULATION AND COATING**

03 DIGESTER COVER ANNULAR SEAL INTEGRITY
- **31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE**

04 DIGESTER DEWATERING WELLS INTEGRITY
- **41 DEWATERING WELL**

Phase	Estimate Breakdown	Item	Quantity		Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit		Total Net Amount
11 IMPROVE EXISTING PUMP MIX SYSTEM												
22999 Realign Pump Suction Piping												
02-41-13.38	Selective demolition, water & sewer piping & fittings, ductile iron pipe, 14"-24", diameter, excludes excavation	1200	50.0	lf	37.40	-	-	5.56	-	42.96	/lf	2,148
22-20-00.30	Piping, water dist, DI, cement lined, 18' L, restrained jt, 16" dia	BC-0006	50.0	lnft	25.44	41.67	-	2.66	-	69.77	/lnft	3,488
22-20-00.31	Piping, water dist, DI, 90< bend or elbow, 16" dia	BC-0036	2.0	ea	636.23	592.80	-	66.42	-	1,295.45	/ea	2,591
22-20-00.31	Piping, fittings, 45<bend, 16" dia.	BC-0121	2.0	ea	636.23	641.34	-	66.42	-	1,343.99	/ea	2,688
22-20-00.32	Stl ftg, gskt & bolt set, 150#, 16" pipe	BC-0061	6.0	ea	374.86	59.50	-	-	-	434.36	/ea	2,606
22-20-00.32	Pipe, st ftng, flg, FS, slip-on, 150 LB flg, wld frt&back, 16" pipe	BC-0376	4.0	ea	1,774.07	264.00	-	32.70	-	2,070.76	/ea	8,283
22-05-29.10	Pipe hanger / supprt, saddle type, 16"pipe size, complete	3400	6.0	ea		300.00	-	-	-	300.00	/ea	1,800
09-91-06.41	Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	150.0	sqft	1.19	0.88	-	-	-	2.07	/sqft	310
	Realign Pump Suction Piping		**2.0**	**LS**	**7,605.34**	**3,948.32**		**403.57**		**11,957.22**	**/LS**	**23,914**
22999 Automate Lower Ring Main and Scum Breaker Nozzle Operation												
22-20-02.80	Valves, semi-steel,eccentric plug, motor operated, 150 psi, Dezurik PEC style, 16" diameter	BC-0046	4.0	ea	2,394.99	8,985.00	-		-	11,379.99	/ea	45,520
22-05-05.10	Valves, strainers and similar, metal, 16" thru 20" diameter, selective demolition	9140	4.0	ea	1,596.66	-	-	-	-	1,596.66	/ea	6,387
26-00-00.02	Electrical and Instrumentation Subcontract - Allowance	BC-0001	1.0	ls			20,000.00	-	-	20,000.00	/ls	20,000
	Automate Lower Ring Main and Scum Breaker Nozzle Operation		**2.0**	**LS**	**7,983.31**	**17,970.00**	**10,000.00**			**35,953.31**	**/LS**	**71,907**
22999 Add Upper Ring Main Piping and Nozzles												
22-20-00.30	Piping, water dist, DI, cement lined, 18' L, restrained jt, 16" dia	BC-0006	170.0	lnft	25.44	41.67	-	2.66	-	69.77	/lnft	11,860
22-20-00.31	Piping, water dist, DI, 90< bend or elbow, 16" dia	BC-0036	4.0	ea	636.23	592.80	-	66.42	-	1,295.45	/ea	5,182
22-20-00.31	Piping, fittings, 45<bend, 16" dia.	BC-0121	16.0	ea	636.23	641.34	-	66.42	-	1,343.99	/ea	21,504
22-20-00.31	Piping, fittings, wye or tee, 16" diameter	BC-0116	2.0	ea	953.70	1,116.41	-	99.56	-	2,169.67	/ea	4,339
22-20-00.31	Piping, fittings, reducer, 16" dia.	BC-0121	4.0	ea	636.23	641.34	-	66.42	-	1,343.99	/ea	5,376
22-20-00.31	Piping, fittings, reducer, 14" dia	BC-0096	4.0	ea	439.26	256.23	-	45.86	-	741.34	/ea	2,965
22-20-00.32	Stl ftg, gskt & bolt set, 150#, 16" pipe	BC-0061	40.0	ea	374.86	59.50	-	-	-	434.36	/ea	17,374
22-20-00.32	Pipe, st ftng, flg, FS, slip-on, 150 LB flg, wld frt&back, 16" pipe	BC-0376	32.0	ea	1,774.06	264.00	-	32.70	-	2,070.76	/ea	66,264
22-05-29.10	Pipe hanger / supprt, bracket type,16"pipe size	3400	16.0	ea	150.00	300.00	-	-	-	450.00	/ea	7,200
01-54-23.70	Scaffolding, steel tubular, regular, labor only erect & dismantle, building interior, floor area, 6'-4" x 5' frames, up to 30' high, excludes planks	0800	10.4	ccf	18.08	-	-	-	-	18.08	/ccf	188
01-54-23.70	Scaffolding, steel tubular, regular, rent/month only for complete system for interior spaces, 6' -4" x 5' frames, excludes planks	0908	10.4	ccf	-	4.38	-	-	-	4.38	/ccf	46
01-54-23.70	Scaffolding, steel tubular, regular, accessory, plank, rent/mo, 2" x 10" x 16' long	2850	80.0	ea	-	10.12	-	-	-	10.12	/ea	810
01-54-23.70	Scaffolding, steel tubular, regular, accessory, stairway section, rent/mo	2900	8.0	ea	-	35.42	-	-	-	35.42	/ea	283
09-91-06.41	Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	500.0	sqft	1.19	0.88	-	-	-	2.07	/sqft	1,034
	Add Upper Ring Main Piping and Nozzles		**2.0**	**LS**	**49,102.86**	**21,372.83**		**1,737.21**		**72,212.90**	**/LS**	**144,426**
	11 IMPROVE EXISTING PUMP MIX SYSTEM											**240,247**

Phase	Estimate Breakdown	Item	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Net Amount
12 REPLACE PUMP MIXING WITH LINEAR MIXER										
01999 Crane Rental										
01-54-33.60	Rent crawler mounted, lattice boom crane, 100 ton, 60' boom	1200	6.0 day	-	-	-	1,667.00	-	1,667.00 /day	10,002
01-54-36.50	Mobilization or demobilization, crane, crawler-mounted, over 75 ton	2300	4.0 ea	768.53	-	-	751.27	-	1,519.79 /ea	6,079
	Crane Rental		**6.0 DAY**	**512.35**			**2,167.84**		**2,680.19 /DAY**	**16,081**
02999 Demolition										
02-22-04.50	General Demolition Crew - Demo piping inside digester and PRV on top of digester	BC-0071	2.0 days	2,489.23	-	-	250.00	-	2,739.23 /days	5,478
02-22-04.50	General Demolition Crew - Demo pumps and piping inside building	BC-0071	4.0 days	2,489.23	-	-	250.00	-	2,739.23 /days	10,957
31-23-23.19	Loading Trucks, F.E. Loader, 3 C.Y.	BC-0006	40.0 cuyd	0.99	-	-	1.24	-	2.24 /cuyd	89
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtm) time per cycle,excvt borrw,loose cubic yards,25 min ld/w/,12 cy truck,cycle 30 miles,35 mph,excld loadng eqpmnt	1469	40.0 lcy	7.82	-	-	9.79	-	17.61 /lcy	705
02-22-03.30	Dump Charge, typical urban city, fees only, bldg constr mat'ls	BC-0006	24.0 ton	-	-	-	-	33.00	33.00 /ton	792
	Demolition		**2.0 LS**	**7,644.04**			**970.62**	**396.00**	**9,010.66 /LS**	**18,021**
11999 New PRV on Extended Gas Dome										
22-20-00.65	Piping, water dist, blk steel, pl end, welded, 1/2" wall, 48" dia	BC-0001	10.0 lnft	310.22	320.00	-	-	-	630.22 /lnft	6,302
22-20-02.00	Pipe, st ftngs, gskt & bolt set, 150#, 48" pipe size	BC-0101	4.0 ea	731.80	3,501.50	-		-	4,233.30 /ea	16,933
22-20-02.00	Pipe, st ftng, flg, FS, slip-on, 150 LB flg, wld frt&back, 48" pipe	BC-0391	4.0 ea	2,128.88	-	-	58.86	-	2,187.74 /ea	8,751
05-05-21.10	Cutting, steel, to 1/2" thick, by hand, incl prep, torch cutting & grinding, excl staging	0100	4.0 lf	2.44	0.36	-	0.04	-	2.83 /lf	11
22-20-02.00	Stl ftg, gskt & bolt set, 150#, 6" pipe	BC-0036	2.0 ea	118.27	13.55	-		-	131.82 /ea	264
22-20-02.00	Stl ftg, weld-on flg, fst, slip-on, 150 lb flg, wld fr&back, 6" pipe	BC-0346	2.0 ea	354.82	33.50	-	9.81	-	398.13 /ea	796
46-06-00.00	6" PRV, digester pressure/vacuum assembly. dual valve with flame trap and 3-way valve	BC-0861	2.0 ea	1,286.11	40,000.00	-	-	-	41,286.11 /ea	82,572
22-05-29.10	Pipe hanger / supprt,saddle type 6"pipe size, complete with roofing repair allowance	3370	2.0 ea	27.12	300.00	-	-	-	327.12 /ea	654
09-91-06.41	Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	100.0 sqft	0.79	0.88	-	-	-	1.67 /sqft	167
	New PRV on Extended Gas Dome		**2.0 EA**	**9,103.27**	**48,994.71**		**127.60**		**58,225.57 /EA**	**116,451**
11999 Linear Mixer										
46-06-00.00	Mixer, linear mixer, roof mounted, 10hp, no control panel. Quote from Ovivo for Model LM12, 12/18/2015	BC-0831	2.0 ea	3,571.91		-	-	152,000.00	155,571.91 /ea	311,144
26-00-00.02	Electrical and Instrumentation Subcontract - Allowance	BC-0001	1.0 ls			75,000.00	-	-	75,000.00 /ls	75,000
	Linear Mixer		**2.0 EA**	**3,571.91**		**37,500.00**		**152,000.00**	**193,071.91 /EA**	**386,144**
	12 REPLACE PUMP MIXING WITH LINEAR MIXER									**536,697**

Phase	Estimate Breakdown	Item	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Net Amount
21 REPAIR EXISTING COVER TOP INSULATION AND COATING										
02999 Remove Existing Insulation and Protective Coating										
07-05-05.10	Selective demolition, thermal and moisture protection, foamed insulation and protective coating	5025	6,633.2 sf	4.20	-	-	-	-	4.20 /sf	27,830
05-15-16.70	Wire rope, temporary cable safety railing, one strand, 1/2" diam, incl. 100' cable, 2 eye bolts, 2 thimbles, 6 clips, 1 turnbuckle	0200	5.0 clf	742.02	462.00	-	-	-	1,204.02 /clf	6,020
02-41-19.23	Rubbish handling, chute, circular, prefabricated steel, 18" diameter, cost to be added to demolition cost.	0400	64.0 lf	43.31	48.57	-	-	-	91.88 /lf	5,880
31-23-23.19	Loading Trucks, F.E. Loader, 3 C.Y.	BC-0006	200.0 cuyd	0.99	-	-	1.24	-	2.24 /cuyd	447
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 30 miles,35 mph,excld loadng eqpmnt	1069	200.0 lcy	6.71	-	-	8.39	-	15.10 /lcy	3,020
02-22-03.30	Dump Charge, typical urban city, fees only, bldg constr mat'ls	BC-0006	5.0 ton	-	-	-	-	33.00	33.00 /ton	165
	Remove Existing Insulation and Protective Coating		**6,633.0 SF**	**5.41**	**0.82**		**0.29**	**0.03**	**6.54 /SF**	**43,361**
07999 PUF Foam Insulation and Coating										
07-21-29.10	Insulation, polyurethane foam, 3#/CF density, 2" thick, R13, sprayed	0320	6,633.2 sf	0.49	1.58	-	0.24	-	2.30 /sf	15,285
07-56-10.10	Elastomeric roofing, hypalon neoprene, fluid applied, non-woven polyester, reinforced, 20 mils thick	0600	6,633.2 sf	4.18	1.49	-	0.61	-	6.27 /sf	41,582
	PUF Foam Insulation and Coating		**6,633.0 SF**	**4.67**	**3.06**		**0.85**		**8.57 /SF**	**56,867**
	21 REPAIR EXISTING COVER TOP INSULATION AND COATING									**100,228**

Phase	Estimate Breakdown	Item	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Net Amount
31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE										
07999 Neoprene Expansion Joint										
09-91-06.41	Surface prep and 2-part expoy application, troweled on to expansion joint before installation	BC-0076	367.3 sqft	20.86	0.00	-	-	-	20.86 /sqft	7,662
07-05-05.10	Waterproofing demolition, mastic seal, remove from joint to 6" deep	0210	410.0 lf	20.96	-	-	-	-	20.96 /lf	8,592
07-05-05.10	Selective demolition, thermal and moisture protection, flashing, sheet metal	0220	820.0 sf	1.74	-	-	-	-	1.74 /sf	1,424
07-71-29.10	Expansion joint, neoprene, for 3" gap. Quote from BASF for Jeene 3" 75FW 12/17/2015	1900	410.0 lf	4.78	94.60	-	-	-	99.38 /lf	40,746
07-65-10.10	Sheet metal flashing, aluminum, flexible, mill finish, .032" thick, including up to 4 bends	0100	820.0 sf	4.63	1.35	-	-	-	5.98 /sf	4,901
05-15-16.70	Wire rope, temporary cable safety railing, one strand, 1/2" diam, incl. 100' cable, 2 eye bolts, 2 thimbles, 6 clips, 1 turnbuckle	0200	5.0 clf	742.02	462.00	-	-	-	1,204.02 /clf	6,020
	Neoprene Expansion Joint		**410.0 LF**	**66.20**	**102.93**				**169.13 /LF**	**69,345**
07999 Expansion Joint Cover Plate										
05-58-09.50	Stainless Steel plate, 316 ss, 6" wide with machined slots and anchor bolts	BC-0026	205.0 sqft	7.42	19.53	-	-	-	26.95 /sqft	5,525
03-82-16.10	Concrete impact drilling, for anchors, 4" d, 3/4" dia, in concrete or brick walls and floors, includes bit cost, layout and set up time, excl anchor	0500	400.0 ea	13.69	0.12	-	-	-	13.81 /ea	5,523
03-63-05.10	Chemical anchoring, for fastener 3/4" diam x 6" embedment, incl epoxy cartridge, excl layout, drilling & fastener	1530	400.0 ea	17.67	5.59	-	-	-	23.26 /ea	9,303
	Expansion Joint Cover Plate		**410.0 LF**	**34.30**	**15.33**				**49.64 /LF**	**20,350**
	31 ADD NEOPRENE EXPANSION JOINT AND COVER PLATE									**89,695**

Phase	Estimate Breakdown	Item	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Net Amount
41 DEWATERING WELL										
33999 Dewatering Well										
31-23-19.30	Wells, for dewatering, with steel casing, 10' to 20' deep, 2' diameter, maximum	0100	32.0 vlf	36.63	42.85	-	7.58	-	87.06 /vlf	2,786
33-44-13.13	Utility area drain, catch basins or manholes frames and covers, cast iron, light traffic, 24" diameter, 300 lb., excluding footing & excavation	1900	1.0 ea	190.56	210.11	-	42.70	-	443.37 /ea	443
	Dewatering Well		1.0 EA	1,362.66	1,581.15		285.31		3,229.12 /EA	3,229
	41 DEWATERING WELL									3,229

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		3,585 hrs	282,457	
Material			260,358	
Subcontract			95,000	
Equipment		644 hrs	27,326	
Other			304,957	
			970,098	**970,098**
Labor Mark-up	10.000 %		28,246	
Material Mark-up	8.000 %		20,829	
Subcontractor Mark-up	5.000 %		4,750	
Construction Equipment Mark-up	8.000 %		2,186	
			56,011	**1,026,109**
Material Shipping & Handling	2.000 %		5,207	
Net Markups			**5,207**	**1,031,316**
Contractor General Conditions	10.000 %		103,131	
			103,131	**1,134,447**
Start-Up, Training, O&M	2.000 %		22,689	
			22,689	**1,157,136**
Undesign/Undevelop Contingency	35.000 %		404,997	
			404,997	**1,562,133**
Bldg Risk, Liability Auto Ins	2.000 %		31,243	
			31,243	**1,593,376**
Contractor Bonds & Insurance	1.500 %		23,901	
			23,901	**1,617,277**
Excise Tax	8.700 %		140,703	
Gross Markups			**140,703**	**1,757,980**
Total				**1,757,980**

APPENDIX K
SUMMARY OF FIELD TESTING OF BIOLOGICAL NUTRIENT REMOVAL OPTIMIZATION, HDR, 2022

FINAL

Kitsap County

Summary of Field Testing for Biological Nutrient Removal Optimization

Central Kitsap Treatment Plant

Kitsap County, Washington
December 16, 2022

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Kitsap County
Central Kitsap Treatment Plant

Summary of Field Testing for Biological Nutrient Removal Optimization

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Prepared by:

Jeffrey Zahller, PE
HDR Engineering, Inc.
(425) 450-6284

I hereby certify that this *Summary of Field Testing for Biological Nutrient Removal Optimization* was prepared by me or under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

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Abbreviations

AA	annual average
AACE	Association for the Advancement of Cost Engineering
ABAC	ammonia-based aeration control
AD	anaerobic digestion
BNR	biological nutrient removal
BOD	biochemical oxygen demand
°C	degree(s) Celsius
CKTP	Central Kitsap Treatment Plant
COD	chemical oxygen demand
County	Kitsap County
d	day(s)
DO	dissolved oxygen
Ecology	(Washington State) Department of Ecology
F&L	flow and load
gpd	gallon(s) per day
gph	gallon(s) per hour
gpm	gallon(s) per minute
HDR	HDR Engineering, Inc.
IMLR	internal mixed liquor recycle
ISE	ion selective electrode
ISS	inert suspended solids
L	liter(s)
lb	pound(s)
MeOH	methanol
mg	milligram(s)
mgd	million gallons per day
MLSS	mixed liquor suspended solids

MLVSS	mixed liquor volatile suspended solids
MM	maximum month
MMWW	maximum month wet weather
MOV	most-open-valve
NGP	Nutrient General Permit
NH_3	ammonia
NH_4	ammonium
NH_3-N	ammonia-nitrogen
NO_3	nitrate
NO_x	nitrite plus nitrate
NPDES	National Pollutant Discharge Elimination System
OPCC	opinion of probably construction cost
PE	primary effluent
psig	pound(s) per square inch gauge
R&R	reclamation and reuse
SCADA	supervisory control and data acquisition
scfm	standard cubic foot/feet per minute
SRT	solids retention time
SVI	sludge volume index
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TSS	total suspended solids
TWAS	thickened waste activated sludge
UV	ultraviolet
VFD	variable-frequency drive
VSS	volatile suspended solids
WAS	waste activated sludge
WW	wet weather
yr	year(s)

1 Background

Kitsap County (County) operates the Central Kitsap Treatment Plant (CKTP), which treats regional wastewater using a multistage process that includes influent screening, grit removal, primary and secondary clarifiers, activated sludge aeration basins, gravity and rotary drum thickening, mesophilic anaerobic digestion (AD), centrifuge dewatering, septage receiving, and ultraviolet (UV) disinfection.

CKTP completed a major upgrade to the biological process in 2016 that allowed for enhanced biological nutrient removal (BNR). The upgrade included the following features:

- Four aeration basins (trains) each fit with six sequential zones for plug flow (operating as essentially a four-stage Bardenpho process).
- Aeration swing zones (Zones 1 and 5 of each basin). Zone 1 typically operates as an anoxic zone.
- Internal mixed liquor recycle (IMLR) pumping system (pumping from Zone 4 to Zone 1 in each basin).
- Methanol (MeOH) addition (supplemental carbon), which can be added to the aeration basin influent or to Zone 5 of each basin.
- High-speed turbo blowers for upgraded aeration capacity.

Figure 1-1 provides a summary schematic of the critical CKTP treatment process as represented by the biological modeling analysis (see Section 2 of this memorandum). The system includes the six-zone (or pass) aeration system, septage (SEPT) hauling, thickened waste activated sludge (TWAS) processing, AD, and methanol addition.

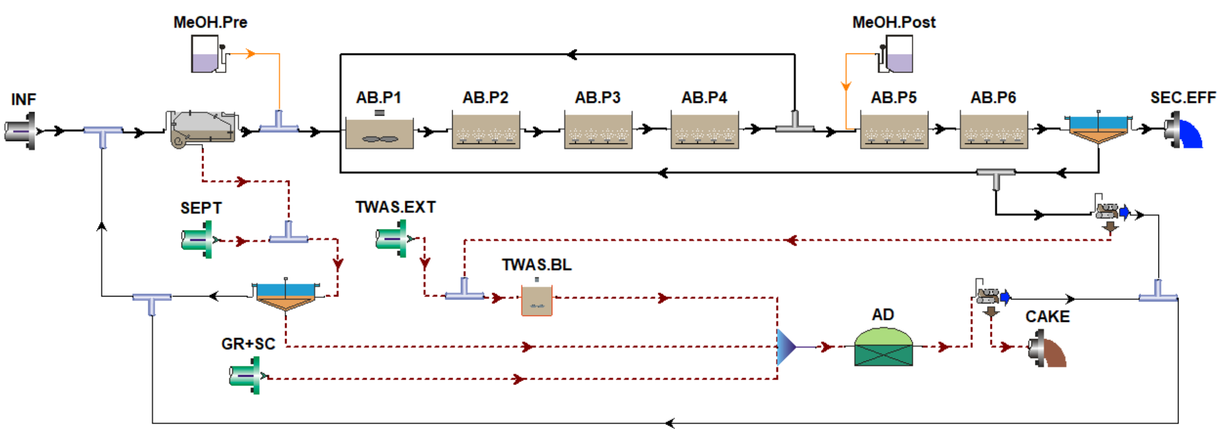


Figure 1-1. Existing CKTP BNR process train (example of single train)

CKTP currently treats the following flows:

- **Annual average (AA):** approximately 5 million gallons per day (mgd)
- **Maximum month (MM):** approximately 7 mgd
- **Peak hour:** greater than 13 mgd
- **Permitted (Design) Annual average (DAA):** 4.6 mgd

1.1 BNR Field Study Goals

Though the extensive biological upgrade in 2016 has provided a variety of new tools for operating CKTP as a BNR plant with significant potential for nitrogen removal, the current CKTP National Pollutant Discharge Elimination System (NPDES) permit does not require this level of aggressive operation. The upgrades were accomplished as a means to prepare CKTP for future nutrient limitations. Consequently, CKTP has never truly been commissioned or operated as a full-scale, continuous BNR facility. In addition, certain features of the BNR process, such as most-open-valve (MOV) aeration control and fully automated control strategies, were never fully implemented or tested.

The initial intent of this field study was to achieve the following goals:

- Provide a full-scale "recommissioning" of CKTP to operate for an extended period in BNR mode to verify what effluent total inorganic nitrogen (TIN) levels are reasonable to achieve
- Provide an opportunity for CKTP operators to gain experience with BNR operation, including learning limitations of the existing system and best practices
- Determine short- and long-term optimization potential for the BNR system for ease of operation and future improvements
- Confirm the ability of CKTP to reach an effluent TIN level of 10 mg/L up to the design flow/loading condition and possible means to reach less than this level within current hydraulic capacity

After initiation of the field study work, the Washington State Department of Ecology (Ecology) issued the Nutrient General Permit (NGP) for Puget Sound in 2021. While the NGP is not yet firmly in place (through comments, revisions, and legal challenges), it provides an additional variable to integrate into the study intent, as the County is included as a moderate discharger with annual TIN limits and will be required to produce BNR optimization planning and documentation as part of the NGP requirements (first submittal of the plan to Ecology is required by March 31st, 2023). Consequently, the field study added the following goals to the initial intent:

- Document all efforts at full-scale optimization completed as part of the field testing process
- Evaluate CKTP BNR capability relative to the proposed NGP annual TIN limits

- Recommend additional optimization efforts, ranked according to value in reducing effluent TIN as well as ease of implementation, for capital improvements planning as well as required optimization planning in the NGP

1.2 BNR Field Study Protocol

To achieve the study goals, the field testing evaluation process was divided into the following steps, each of which is discussed in detail in the referenced sections through this memorandum.

1.2.1 Wastewater Characterization, Modeling, and Test Planning:

The initial steps in the field testing were based on collecting necessary base data, developing a quantitative model of the biological process, determining a feasible list of short-term improvements that can be immediately implemented, and confirming a field testing protocol. The initial stage of work addressed the following items:

- Conduct wastewater characterization sampling to provide updated information for planning analysis (see Section 2)
- Develop an updated process model (BioWin®) to use as a tool for theoretical evaluation of process potential, optimization options, and field testing scenarios (see Section 2)
- Identify potential short-term optimization strategies for immediate implementation as part of the field testing process (see Section 3)
- Develop a preferred field testing protocol (see Section 4)

1.2.2 Short-term Optimization Upgrades, Field Testing, and Summary Documentation

Based on the planning analysis noted above, the following field activities were implemented starting in 2021 and continuing through mid-2022:

- Implement selected short-term improvements for BNR optimization (see Section 3)
- Conduct full-scale field testing to the extent possible given operational limitations (see Section 4)
- Document results of the field testing relative to initial modeling and proposed NGP annual loads (see Section 4)
- Summarize lessons learned and recommended future optimization improvements based on maximum potential value to the County (see Section 5)

2 Sampling and Process Modeling

To provide a baseline for the expected process performance during any field BNR testing, an initial phase of wastewater characterization (field sampling) and process modeling was conducted to both (1) develop an estimate of potential process performance and (2) select a reasonable process configuration to use for the full-scale testing. The following sections provide a summary of the field sampling process and the initial modeling and process configuration recommendations for CKTP.

2.1 Wastewater Characterization Sampling

Appendix A provides a summary of the field sampling protocol that was implemented during October 2020, a period that represented a transition from the dry (warm) to wet (cold) season and was generally representative of an AA condition for CKTP. Testing was focused on CKTP influent and primary effluent (PE) (influent to aeration basins), but also included tracking of solids input from other sources. CKTP receives a significant amount of delivery for septage and grease, as well as all the residual TWAS from smaller regional plants (Manchester, Suquamish, and Kingston).

Appendix A also includes the raw data from the field sampling, which was used to develop influent flow characteristics and calibrate the process models.

Table 2-1 provides a summary of the primary influent process characteristics and flow projections used for the modeling efforts. Table 2-2 provides a summary of the external solids sources (TWAS and septage). Flow and loading include existing numbers (from characterization testing) as well as projected values from the previously developed basis of design documents (Brown & Caldwell 2011) and updated facility planning values provided by Murraysmith (Murraysmith 2021) (MMWW = maximum month wet weather; F&L = flow and load; R&R = reclamation and reuse).

In addition to the base wastewater characteristics as shown, Figure 2-1 and Figure 2-2 provide a summary history of influent temperature and total Kjeldahl nitrogen (TKN) as a reference point for historical trends. TKN tends to range from 50 to 60 milligrams per liter (mg/L), while effluent temperature varies from 12–13 degrees Celsius (°C) to 24°C. For the purpose of modeling efforts, the AA temperature was assumed to be 18°C, with winter and summer as 12°C and 24°C, respectively.

Table 2-1. CKTP influent flow characteristics used for modeling

Parameter		Oct 2020 sampling	R&R project design basis[a]	Murraysmith 2020	Murraysmith 2028	Murraysmith 2042
Annual average						
Q	mgd	3.2	4.8	3.5	4.0	5.4
BOD	lb/d	8,887	10,900	8,817	10,172	13,610
TSS	lb/d	7,259	9,700	7,924	9,142	12,231
TKN	lb/d	1,440	---	1,420	1,640	2,200
BOD	mg/L	333	272	305	305	302
TSS	mg/L	272	242	274	274	272
TKN	mg/L	54	---	49	49	49
BOD/TSS	---	1.22	1.12	1.11	1.11	1.11
MMWW F&L						
Q	mgd	---	6.1	4.940	5.7	7.6
BOD	lb/d	---	12,100	10,116	11,670	15,613
TSS	lb/d	---	11,600	12,535	14,461	19,347
TKN	lb/d	---	---	1,635	1,886	2,524
BOD	mg/L	---	238	246	246	246
TSS	mg/L	---	228	304	304	305
TKN	mg/L	---	---	40	40	40
BOD/TSS	---	---	1.04	0.81	0.81	0.81
Peak flows						
Peak day	mgd	---	13.3	8.5	9.9	13.2
Peak hour	mgd	---	16.9	13.2	16.2	21.6

a. Information based on year 2016 plant rating projections for completed reclamation and reuse project (Brown & Caldwell 2011).

Table 2-2. CKTP external solids influent sources used for modeling

Parameter		CKTP data 2018–2020 excl. outliers	R&R project design basis	Murraysmith 2020	Murraysmith 2028	Murraysmith 2042
Outside TWAS						
Annual average						
Flow	gpd	1,740	4,700	1,650[a]	2,050[a]	2,900[a]
TSS	lb/d	790	1,000	750	930	1,320
MMWW F&L						
Flow	gpd	---	---	2,530[a]	3,130[a]	4,500[a]
TSS	lb/d	---	1,400	1,150	1,420	2,040
Septage						
Annual average						
Flow	gpd	19,600	8,300	22,000	22,000	22,000
BOD	lb/d	1,050	390	---	---	---
TSS	lb/d	3,720	1,410	---	---	---

a. Flow at assumed 5.45% solids concentration.

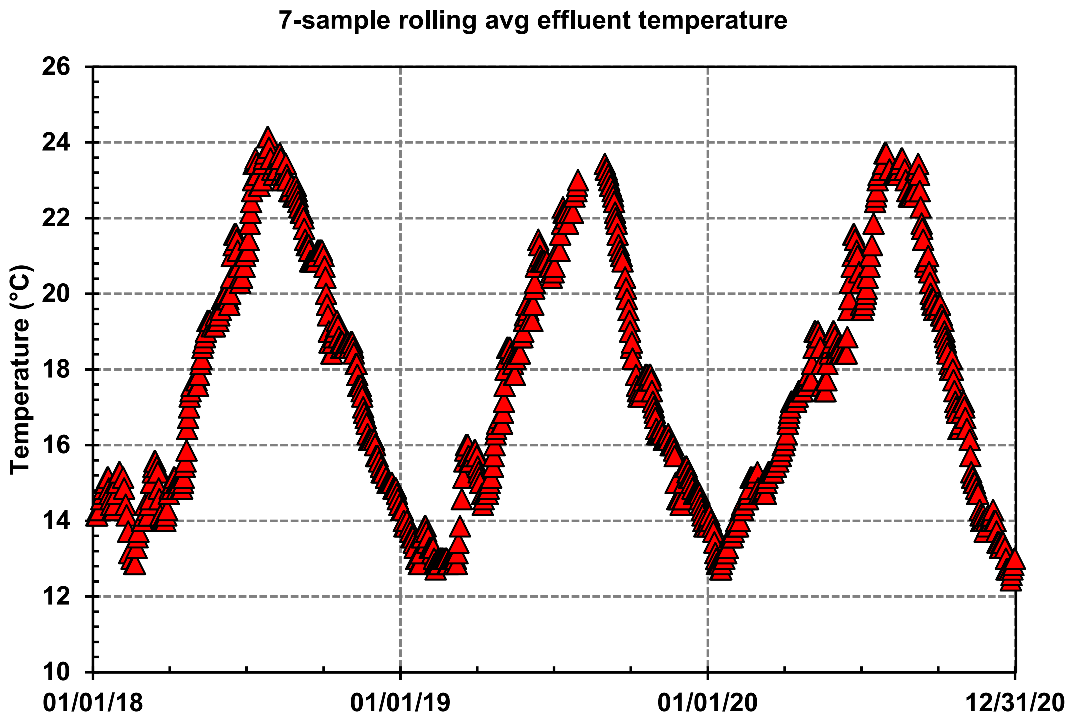


Figure 2-1. CKTP effluent temperature trends (2018–2020)

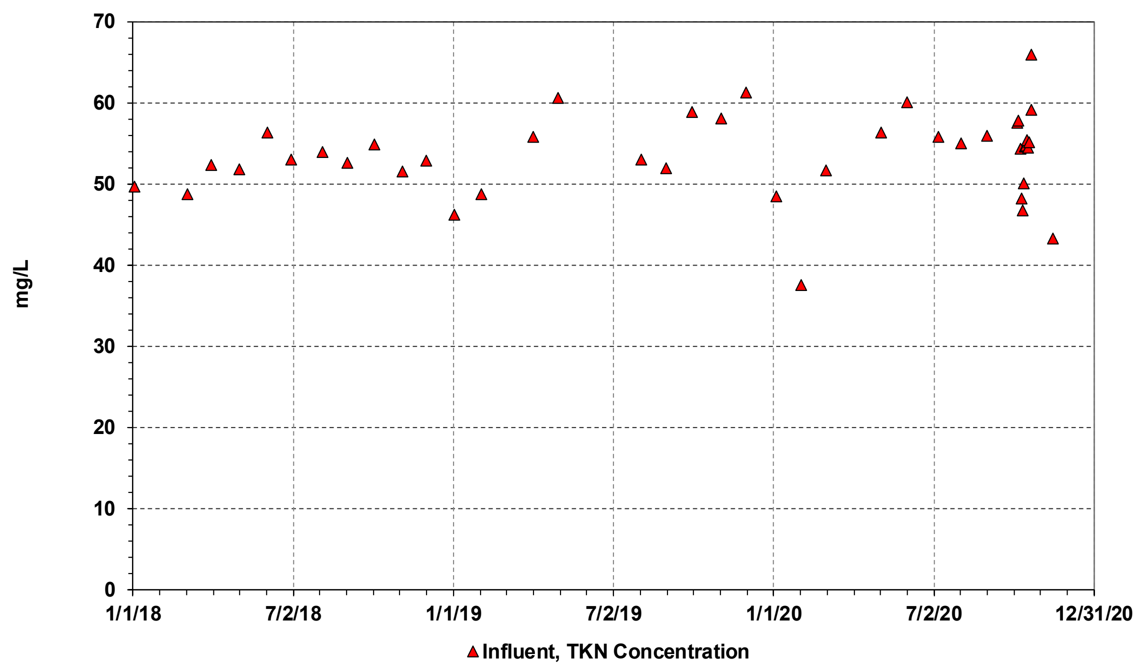


Figure 2-2. CKTP influent TKN trends (2018–2020)

2.2 Summary of Initial Process Modeling

Process modeling was conducted using BioWin software and calibrating according to both historical data trends and wastewater characterization studies (October 2020). Figure 2-3 shows the process schematic layout.

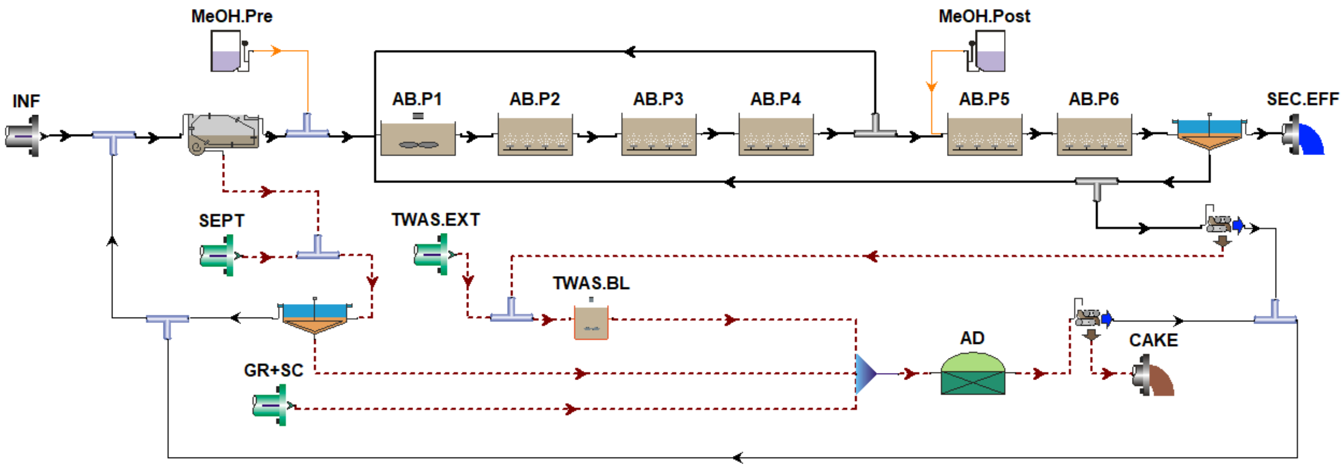


Figure 2-3. Baseline CKTP BioWin process model

For the purposes of this study, all modeling was conducted as steady-state simulations to evaluate long-term performance and to differentiate relative value between alternative operational scenarios (as discussed in the following section).

The grease and scum input (GR+SC) was assumed as follows:

- 1,600 gallons per day (gpd)
- 5,000 mg/L of volatile suspended solids (VSS) = total suspended solids (TSS)
  - TSS = VSS is used for simplicity of modeling assuming minimal inert material in grease and scum and calibrating the grease and scum as a degradable input to the AD.
- 8,000 mg/L of chemical oxygen demand (COD)

Recycled centrate (roughly 1,000 mg/L ammonium-nitrogen [NH_4-N], approximately 20 percent of the secondary TKN load) from the AD dewatering operation, which is returned to CKTP influent, was operated as a continuous flow and consequently assumes a degree of equalization that does not actually exist at CKTP (where centrate flows are often operated only on weekdays during day shifts). For the purpose of the simulations, the equalization is inherent, but the need to address this issue as a critical recommended upgrade is further discussed in Section 4.

Septage (which can be a significant portion, roughly 20 to 30 percent, of the AD solids load) characteristics were simulated as partially digested primary sludge, as shown in Figure 2-4, to produce characteristics matching general CKTP averages as follows:

- 2 percent solids

- Biochemical oxygen demand (BOD) = 6,800 mg/L
- TKN = 1,150 mg/L

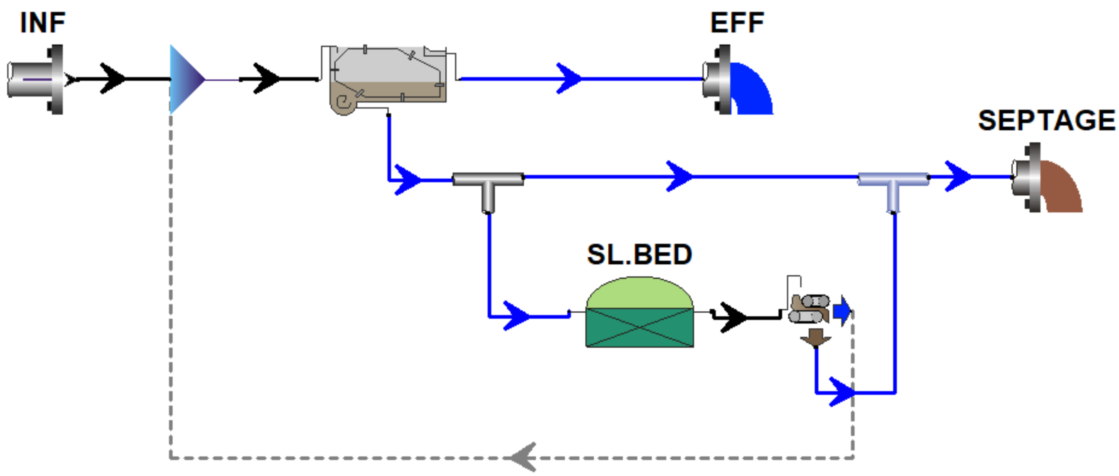


Figure 2-4. Septage simulation for CKTP BioWin process model

TWAS was simulated as a single representative stream from the combined regional plants with basic BNR operation in place (Figure 2-5). The outputs were coordinated with early facility planning assumptions to ensure that loading approximations were in alignment.

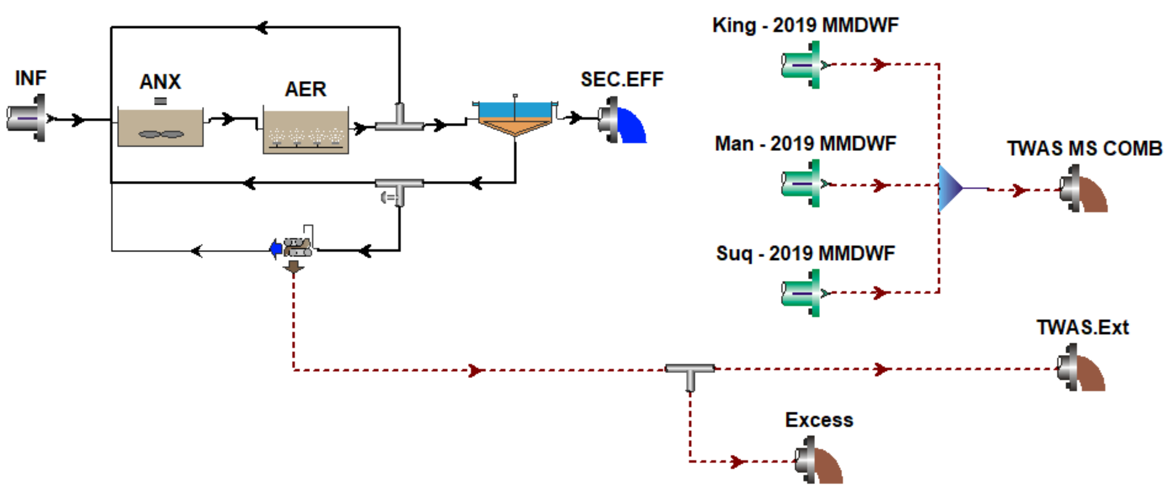


Figure 2-5. TWAS simulation for CKTP BioWin® process model

Once the model was constructed with the essential wastewater characteristics established and in place, a calibration and validation step was conducted to verify that the output was reasonably representative of current CKTP effluent characteristics (per the process shown in Figure 2-6).

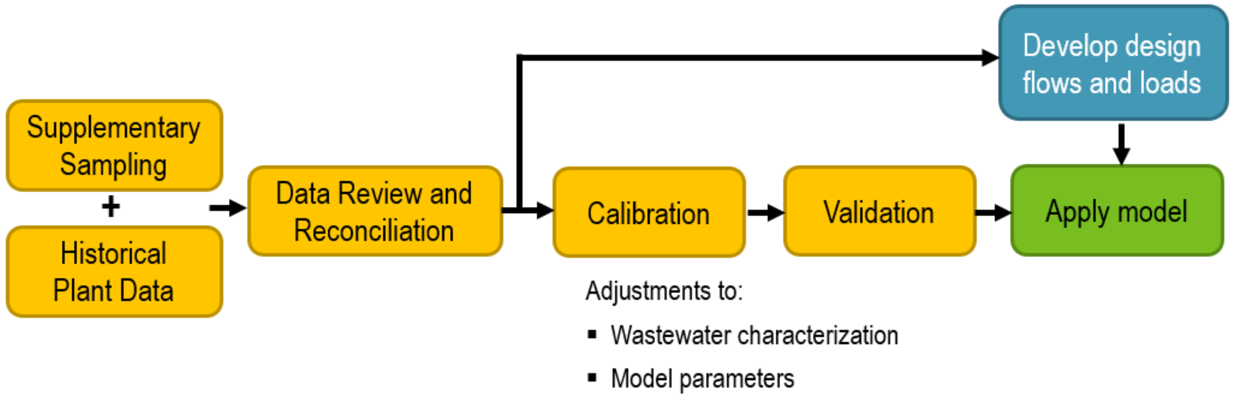


Figure 2-6. General model calibration process

The selected calibration periods were October and December 2018. The October 2018 period was representative of AA conditions and the BOD:TSS ratio was close to the facility planning assumptions for AA flows. The December 2018 period included an observed MM peak TSS load and was reasonably close to the facility planning MM basis. Septage and TWAS loads were close to 2018–2020 averages for both the December and October periods.

Table 2-3 provides a summary of the influent characteristics used (and modified) as part of the calibration process. Key adjustments made to better fit the existing data and facility planning design assumptions were as follows:

- Primary sludge inert suspended solids (ISS) capture derated by 15 percent relative to other solids capture (MMWW)
  - Tuning of mixed liquor volatile suspended solids (MLVSS) fraction (typical all)
- AD local kinetic adjustment: endogenous decay rate increased to 0.03 d^{-1}
  - Tuning of digestion (typical all)
- Two different wet weather (WW) fractionations were developed: AA and MMWW
  - Driven by a fundamentally different design basis per the flow and load projections

Calibration of the models reflects the fact that wastewater characteristics vary, which aligns with historical CKTP data for the representative period. Given the relative level of agreement between the model, the facility planning assumptions, and the available data, the model was considered acceptable for use as a screening tool in comparing different optimization operating scenarios.

Table 2-3. Calibration parameters used in BioWin model for October (2018) and December (2018) periods

		Oct 2018 Calibration	Dec 2018 Calibration Plant Obs	Dec 2018 Adjustment A Diluted to target MS MMWWF BOD conc.	Dec 2018 Adjustment B Adjusted to reach MS MMWWF TSS conc.
	Influent Characteristics - Direct Input (*) and Calculated				
*	Flow [mgd]	3.24	4.05	4.7	4.7
*	COD - Total [mg/L]	650	644.1	555	580
	COD - Filtered [mg/L]	247	196	169	160
	BOD - Total Carbonaceous [mg/L]	313	286	247	246
	BOD - Filtered Carbonaceous [mg/L]	139	108	93	85
	Total suspended solids [mg/L]	282	325	280	305
	Volatile suspended solids [mg/L]	254	287	247	272
*	ISS Total [mg/L]	28	38	33	33
*	N - Total Kjeldahl Nitrogen [mgN/L]	54.0	49.4	42.6	42.6
	N - Ammonia [mgN/L]	37.8	34.6	29.8	29.8
*	P - Total P [mgP/L]	6.2	5.7	4.9	4.9
	P - Soluble PO4-P [mgP/L]	3.1	2.85	2.45	1.47
*	Alkalinity [mmol/L]	5.5	4.0	3.8	3.8
*	pH []	7.1	7.1	7.0	7.0
*	Total Calcium (all forms) [mg/L]	31.6	25	25	25
*	Total Magnesium (all forms) [mg/L]	10.2	8	8	8
*	Gas - Dissolved oxygen [mg/L]	2	2.3	2	2
	BOD	313	286	247	246
	TSS	282	325	280	305
	BOD/TSS	1.11	0.88	0.88	0.80

2.3 Operating (Optimization) Scenario Development

An initial set of seven (A–G) operating scenarios were evaluated using the calibrated BioWin model as a means of selecting the most appropriate process for testing at full scale. Table 2-4 provides a summary of each scenario.

The first three scenarios (A–C) are based on a standard dissolved oxygen (DO) set point operation with a typical value of 2 mg/L in the aerobic zones. Model runs were conducted without carbon addition (A), with carbon addition (B), and with an assumption of sidestream treatment (C) for the centrate (which was modeled as an 80 percent reduction in the centrate nitrogen load).

The second three scenarios (D–F) used ammonia-based aeration control (ABAC) operation (lower DO levels) for a baseline operation (D), ABAC with carbon addition (E), and ABAC with carbon addition and sidestream treatment (F).

The final scenario (G) used an alternative step feed arrangement to the standard model to consider any value this might have relative to the more standard four-stage operation.

Table 2-4. Initial screening of potential operational scenarios for field testing

ID:	Aeration	Methanol Addition	Sidestream Treatment
A	Constant DO = 2 mg/L	---	---
B	Constant DO = 2 mg/L	w/ Methanol	---
C	Constant DO = 2 mg/L	---	w/ Sidestream Treatment
D	Low-DO / ABAC	---	---
E	Low-DO / ABAC	w/ Methanol	---
F	Low-DO / ABAC	w/ Methanol	w/ Sidestream Treatment
G	2-pass Step Feed BNR	---	---

Figure 2-7 provides a summary of the model run (and key assumptions) for the four-stage operational scenarios A–F. Note that aerobic solids retention time (SRT) was a total of 9.3 days, with a 7-day aerobic SRT prior to the Zone (Pass) 5 post-anoxic stage. When operating in ABAC, DO levels were artificially reduced to limit nitrite accumulation. The IMLR was allowed to vary based on achieving a nitrate (NO_3) set point level in Zone (Pass) 1.

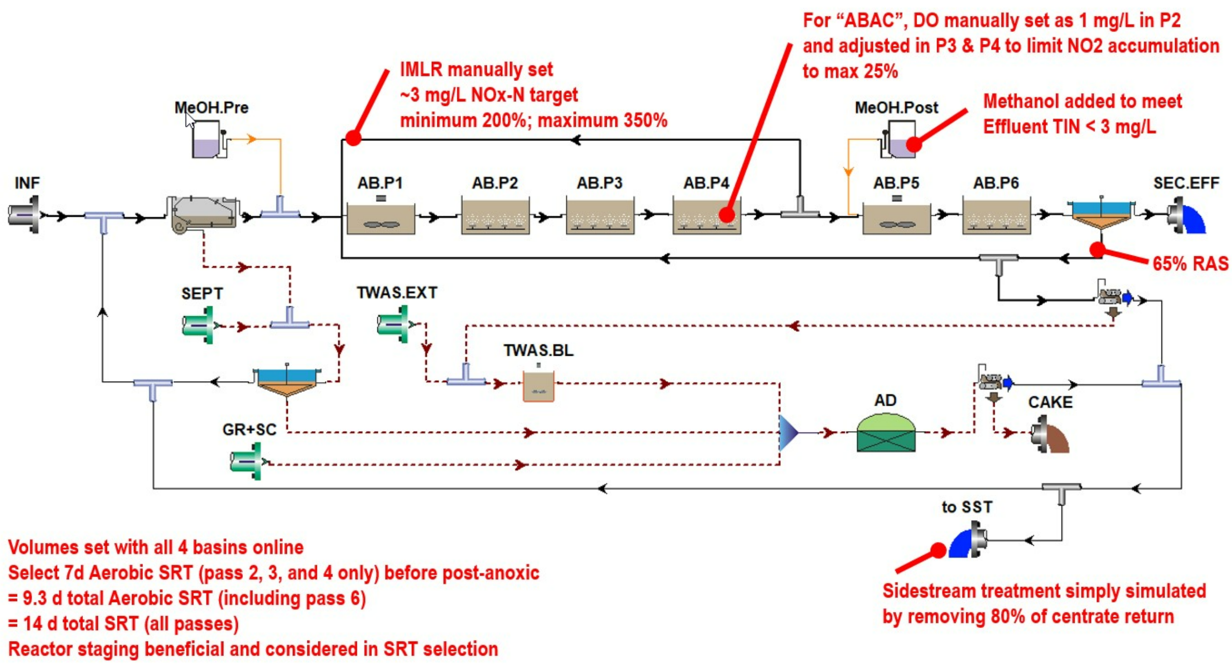


Figure 2-7. Four-stage model used as basis for CKTP Scenarios A–F

Figure 2-8 provides a summary of the model run (and key assumptions) for the step-feed operational Scenario G. Note that aerobic SRT was a total of 9 days when Zone (Pass) 5 was evaluated as an aerobic stage (shown in the figure) and 7 days when it was evaluated as an anoxic stage. The step feed was assumed to be a 50/50 split of PE between Zone (Pass) 1 and Zone (Pass) 3. Zone 3 is operated as an anoxic zone. The IMLR was allowed to vary with different flow rates evaluated.

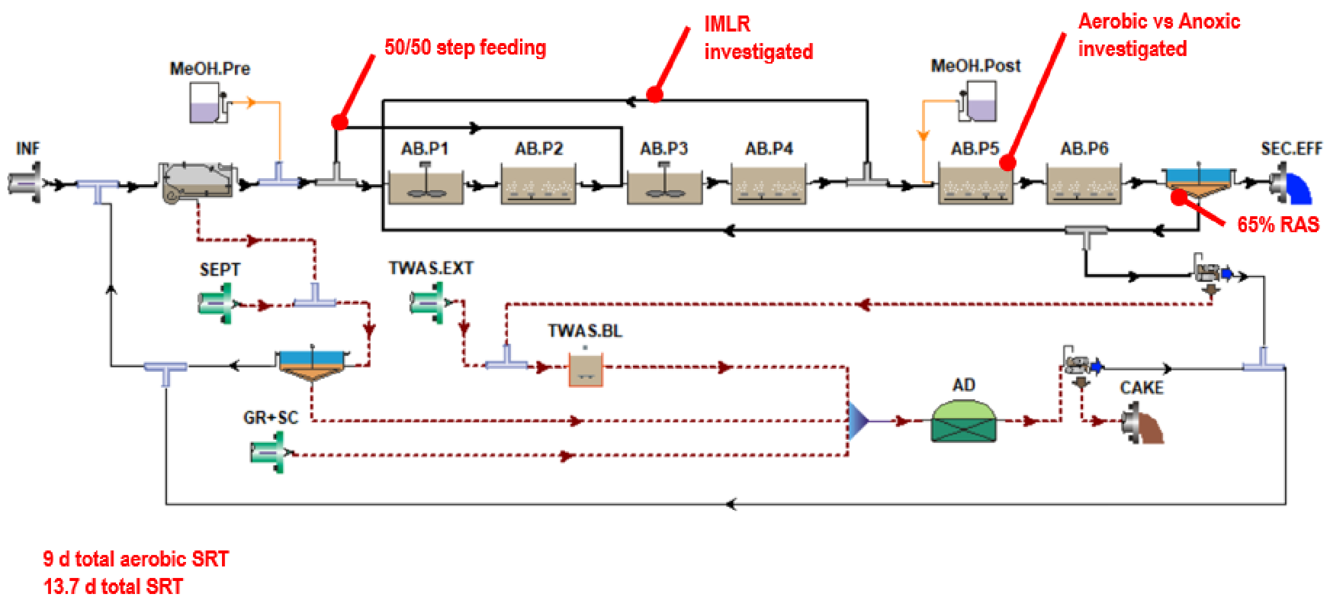


Figure 2-8. Step-feed model used as basis for CKTP Scenario G

Model flows were conducted with the 2028 AA flows, as outlined in Table 2-1. This flow was selected because it represents the nearest term planning level (Murraysmith 2020) as well as a close approximation of the original 2016 basis of design capacity (Brown & Caldwell 2011). The original design is also very close to the currently permitted design conditions for CKTP as outlined in the Ecology Fact Sheet (Permit #WA0030520), which includes an AA flow of 4.6 MGD and AA TSS and BOD of 8,844 mg/L and 8,403, mg/L respectively. As shown in Table 2-5, the 2028 projections are slightly lower in flow, but slightly higher in TSS MM loading, and otherwise are relatively equivalent to the 2016 design capacity. The permitted design is relatively close to the 2028 projects as well, with the particular exception of a higher MM flow of 7.0 MGD for the secondary treatment system. Consequently, performance at the 2028 projected conditions can be considered roughly equivalent to operation at currently permitted design conditions.

Table 2-5. Comparison of 2028 Projected Effluent Limits with Current (Original) 2016 Design Capacity

Parameter	Units	Original Design	2028 Projection	Difference
AA Flow	MGD	4.8	4.0	-17%
MM Flow	MGD	6.1	5.7	-7%
Peak Flow	MGD	16.9	16.2	-4%
BOD Load, AA	lb/d	10,900	10,200	-6%
BOD Load, MM	lb/d	12,100	11,700	-3%
TSS Load, AA	lb/d	9,700	9,140	-6%
TSS Load, MM	lb/d	11,600	14,500	+25%

Table 2-6 provides a summary of the four-stage modeling scenario results. The following are key conclusions to note:

- The BNR operation aligns well with the carbon-limited influent to the aeration basins. The addition of methanol creates a substantial improvement in effluent TIN to less than 3 mg/L. This is reflected in both DO and ABAC operational modes.
- Alkalinity may become problematic without some degree of carbon addition to increase denitrification efficiency.
- IMLR controls will be advantageous for improved denitrification performance.
- Sidestream treatment of centrate could potentially reduce effluent TIN (in DO control) by roughly 5 mg/L (Scenario A versus Scenario C).
- ABAC can effectively lower effluent TIN by nearly 7 mg/L (Scenario A versus Scenario D). This is contingent on the degree of control of nitrite accumulation (at roughly 25 percent per empirical experience with ABAC) to maximize efficiency in denitrification kinetics, which may be more difficult in practice. ABAC mode is sensitive to this parameter. If nitrite levels are closer to this optimum balance, Scenario D effluent TIN could fall as low as 2.8 mg/L because of kinetic efficiency gains.

Table 2-6. Model results for four-stage model Scenarios A–F (2028 AA flows)

ID:	Air and SST	Pre-Anx NOx-N (mg/L)	IMLR Ratio	Pass 4 TIN (mg/L)	Methanol (gpd)	Sec Effl. TIN (mg/L)	Sec. Effl. Alk. (mg/L)
A	DO = 2	5.9	200%	18.0	---	15.8	90
B	DO = 2	2.7	250%	13.8	220	2.5	140
C	DO = 2; SST	3.0	250%	12.4	---	10.2	110
D	ABAC	3.1	300%	11.9	---	9.1	115
E	ABAC	2.4	350%	9.3	110	2.7	140
F	ABAC; SST	0.4	350%	7.5	50	2.4	140

Table 2-7 provides a summary of the step-feed modeling scenario results. Key conclusions to note:

- Step-feed generally distributes carbon (BOD) more efficiently for denitrification, as evidenced by Scenario G.3 in comparison with Scenario A.
- Scenario G.3 has a more optimized nitrite accumulation (20 percent) that provides for relatively efficient kinetics, showing potential for optimized TIN removal without methanol.
- This mode may have some issues relative to going extremely low on TIN because of residual ammonium (NH_4) in Zone (Pass) 5 that gets oxidized but not recycled back to an anoxic zone (so effluent ammonium is very low, but effluent nitrates may still be relatively high).

Table 2-7. Model results for step-feed model Scenario G (2028 AA flows)

ID:	DO (mg/L)	Pre-Anx NOx-N (mg/L)	IMLR Ratio	Zone (Pass) 5	Sec Effl. TIN (mg/L)	Sec Effl. NH3-N (mg/L)	SRT Aer / Tot
G.1	2.0	<0.1	0%	Aerobic	17.9	<0.1	9 / 13.7
G.2	2.0	3.1	200%	Aerobic	12.3	<0.1	9 / 13.7
G.3	2.0	0.5	200%	No air No MeOH	5.9	<0.2	7 / 14

2.3.1 Summary and Recommendation Scenarios for Field Testing

Based on the previously modeled scenarios, workshops were held with the County to determine the most appropriate scenarios to carry forward into field testing (Section 4) as well as inform the short-term optimization upgrades implemented prior to field testing (Section 3).

A general summary of key conclusions from the modeling effort is as follows:

- Steady-state scenarios inherently simulated centrate equalization. More variable and higher effluent composite TIN would be expected for dynamic simulations without equalization (i.e., actual field testing will likely give higher TIN values, all else being equal, given that CKTP does not yet have centrate equalization). However, overall pattern/trends between scenarios would be similar. The addition of equalization will be one of the primary recommendations for future optimization improvements in Section 5.
- Low-DO/ABAC strategies suggest strong optimization potential for the core four-stage BNR process.
- Step-feed BNR, modified with IMLR, may also have optimization potential. But this will require new anoxic mixing in Zone 3 and PE flow splitting control between Zones 1 and 3. Consequently, while there is future value in continuing to evaluate this process, the amount of infrastructure change necessary to implement is more challenging for near-term field testing. While it is recommended to keep this mode available, it is not necessary for BNR in the short term (see Section 5).
- The best performance includes some nitrite accumulation to take advantage of more efficient denitrification kinetics. This is difficult to control and predict, as actual biology will always be more complex with nitrifying bacteria achieving various levels of adaptation to low-DO scenarios.
- It is possible that low-DO and nitrite accumulation may lead to a higher sludge volume index (SVI). Consequently, full-scale implementation of a more aggress low-DO/ABAC approach to BNR will need to observe and characterize SVI impacts over time relative to the value of the BNR operation. CKTP, as part of the 2016 upgrades, does have access to a scum selector box that can help to waste/eliminate filamentous growth from the main liquid stream.

With this summary in mind, it was recommended to proceed with a field testing approach (outlined in Section 4) tailored to the following general requirements:

- Include baseline four-stage BNR, with a fixed IMLR and “normal” DO levels, as a standard for traditional nitrification and denitrification. Operation at this point will provide basic practical experience and data before adding complexity. It is the most “straight-forward” BNR approach and should produce an effluent with significantly lower TIN compared with the assumed concentration baseline from loadings allowed in Ecology’s GP (which would allow Kitsap a TIN well over 20 mg/L on an annual average basis).

- Layer on ABAC and methanol controls as practical to look at a more aggressive BNR approach that has good potential and can be implemented with relatively modest optimization improvements short-term (Section 3).

3 Optimization Upgrades and Field Modifications

As part of the initial optimization process analysis and modeling (outlined in the previous section), HDR Engineering, Inc. (HDR) conducted workshop discussions with the County regarding short-term optimization improvements that either (1) would be new features beneficial for implementation of more aggressive BNR or (2) were originally intended as part of the 2016 biological process upgrade, but were not fully implemented.

Optimization options in this category, while showing clear benefit to the BNR process, would also need to be implemented rapidly (in a matter of months) to be part of the field testing work. Additionally, some of the attempted modifications occurred as a result of field observations noted during the initial phases of testing in an attempt to adjust and refine the system while it was in operation. The optimization options implemented/attempted through the field testing work are as follows, each of which is further outlined in this section:

- Upgraded instrumentation (both DO and ammonium/nitrate)
- Implementation of MOV and improved DO system
- Implementation of ABAC control
- Implementation of improved IMLR control
- Implementation of improved methanol control
- Additional miscellaneous programming modifications:
    - Return activated sludge (RAS) control
    - Basin influent hydraulics
    - Backup aeration

3.1 Instrumentation Upgrades

Initial instrumentation optimization was based on accomplishing two primary goals:

- Upgrade and increase the number of DO probes to allow for additional control and monitoring of the zones within each basin, and to support the control modifications outlined in Section 3.2
- Provide the ability to implement ABAC, IMLR control enhancements, and methanol control enhancements

In conjunction with the County, and based on similar probes used regionally by other municipal agencies, the initial selected probes were Hach units (to work through an SC200 controller) as shown in Figure 3-1.

- **DO probe:** Hach LDO, Model 2
- **Ammonium (NH_4)/NO_3:** Hach AN-ISE combination

These probes were selected for ease of installation, relatively simple operation, familiarity of CKTP staff with Hach products, ability to measure multiple components (in the case of the AN-ISE, both ammonium and nitrate), and use at other regional plants (such as King County and the Cities of Lacey, Olympia, and Tumwater and Thurston County [LOTT] Clean Water Alliance).

While the LDO probe is fairly standard and flexible, the AN-ISE (ion selective electrode) probe, while relatively easy to install, experienced challenges with accurate field calibration and is limited particularly at lower levels of ammonium or nitrate (less than 1 mg/L). Consequently, the use of the probe was correlated with composite and grab samples conducted in the laboratory to ensure that its use for automated controls was reasonable. An alternative analysis selection for future optimization in Zone 5 (where nitrogen levels are relatively low) is discussed in Section 5.

Figure 3-1. Selected DO and NH_4/NO_3 probes for field evaluation

The proposed location for each type of probe is shown in Figure 3-2 and Figure 3-3 and was selected as follows:

- **Zone 1:** NH_4/NO_3
- **Zone 2:** DO
- **Zone 3:** --
- **Zone 4:** DO
- **Zone 5:** NH_4/NO_3
- **Zone 6:** DO/TSS

An additional effluent NH_4/NO_3 probe was installed for the final effluent at the UV disinfection system, which was used for monitoring (and not control).

The intent of the DO probe locations was to provide a point of measurement relative to each aeration control valve (one for Zones 1 and 2, one for Zones 3 and 4, and one for Zones 5 and 6) to allow for a greater degree of automatic operation (Section 3.2).

Ammonium/nitrate probes were located in Zone 1 to provide a basis for measuring ammonium in the first (anoxic) zone as well as the NO_3 level to provide a variable for control of the IMLR pumps when recycling nitrogen to Zone 1 (Section 3.4).

Ammonium/nitrate probes in Zones 1 and 5 also provide a basis for altering the level of aeration based on (near) final NH_4 levels exiting the basin (Section 3.3) or increasing/decreasing methanol dosing to Zone 5 (when operating as an anoxic stage) to improve denitrification and reduce nitrate (Section 3.5).

While additional improvements could certainly be justified, this was considered the baseline level of instrumentation necessary to allow CKTP to make a reasonable attempt at full-scale automated BNR options outlined in Section 4.

The physical location of each probe was based on feasibility related to access points and existing construction as well as optimal process placement.

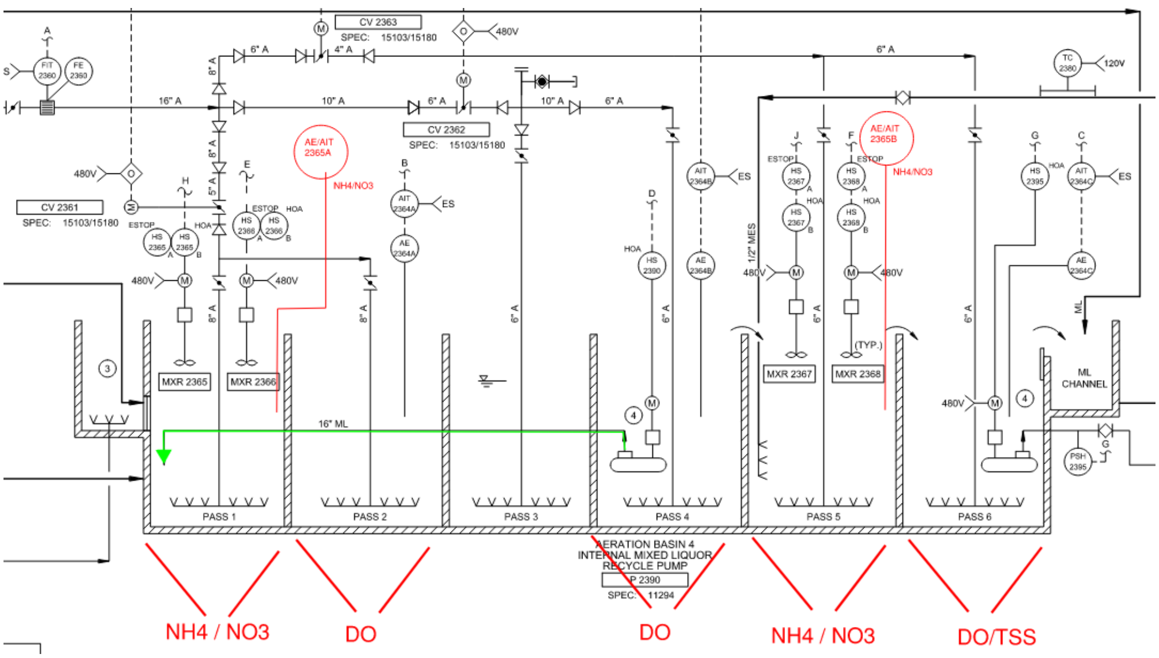


Figure 3-2. Example (Basin 4) upgraded probe distribution for CKTP basins (Zone/Pass 1–6 shown from left to right)

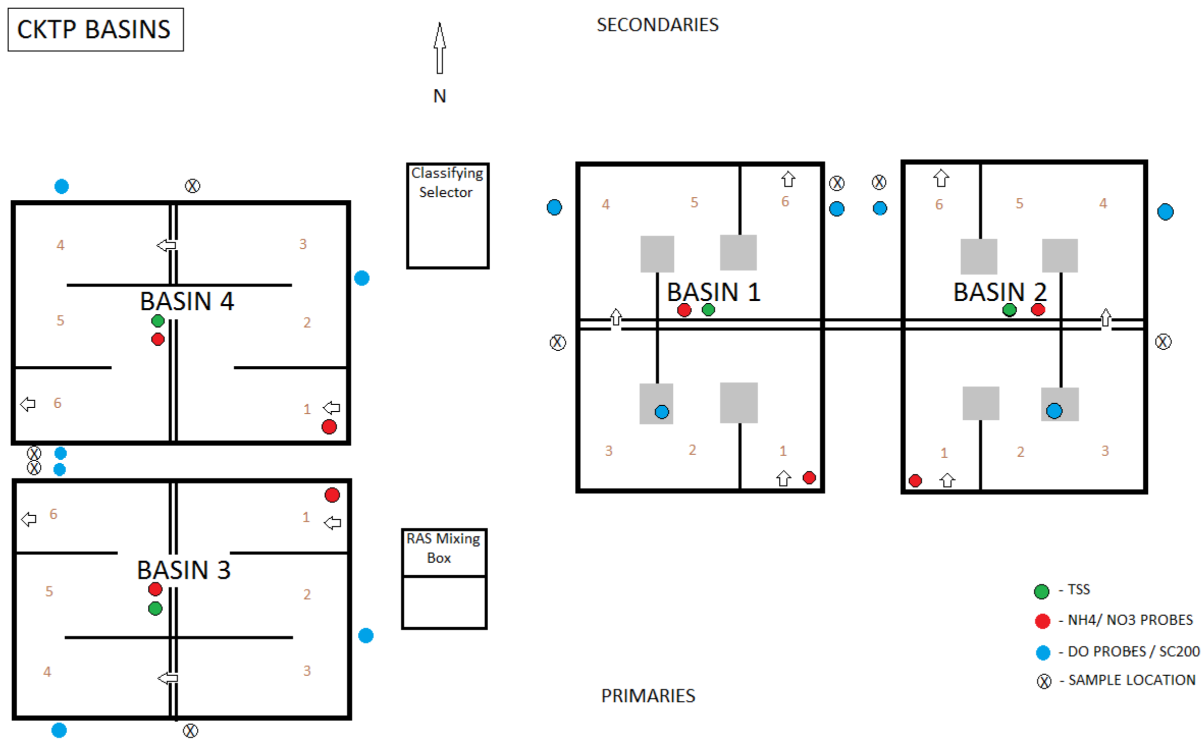


Figure 3-3. Probe and sample locations for each CKTP basin (zone numbers are shown within each basin)

3.2 Aeration Valve and DO Control

As previously noted, each aeration basin is divided into six zones/passes. Three aeration control valves are installed for each aeration basin (Figure 3-4), with one automated valve controlling aeration airflow to each successive pair of zones in the basin (a manual drop leg into each zone is located downstream of the control valve for each zone pair). DO sensors provide monitoring of DO for the three aeration zones as noted in the previous section.

Prior to the field testing, CKTP staff operated the control valves on a manual basis, adjusting airflow to portions of each train as necessary to modulate DO levels and achieve the desired process outcome. To provide a more robust automated approach for BNR, two new aspects of the controls were introduced:

- MOV control of the existing automated valves
- DO control matrix for individualized airflow to each pair of zones in each basin

MOV control, which prior to the testing had not been successful at CKTP, allows for the CKTP control system to modulate both valve position and the aeration header pressure set point so that the system as a whole is energy- and capacity-efficient in the way it delivers air. Essentially, at least one aeration valve must be at the most open end of its control range (an adjustable value, but roughly 70 percent open for a butterfly valve), minimizing pressure drop to achieve the desired flow. The remaining valves can throttle to a greater degree to adjust airflow as needed to meet individual set points. If the air demand in the system decreases, causing the valves to close and throttle flow, the system will recognize this and reduce the pressure set point in the aeration header to allow the valves to open more and avoid wasting air and energy as well as operating valves outside of their linear range of control. If the air demand increases and valves open up but are unable to achieve the desired air delivery, the pressure set point is automatically increased to allow for more air through the valves without opening them past their optimal control range.

The DO control matrix is coupled with the MOV control, allowing operators to set a DO set point for a given DO sensor (monitoring the second in a pair of zones), which in turn will call for more or less air from the control valve based on increasing or decreasing oxygen levels to achieve the desired set point. The set point matrix allows operators to automatically change the DO set point at a given zone throughout the day based on when they anticipate higher or lower loading to the system.

Both modes of operation were implemented and tested as part of the first phase of the field testing outlined in Section 4. Appendix C includes the updated control strategy that was implemented to allow for MOV control and automated DO response.

Figure 3-4. Typical aeration control piping for basins (three branches, each with a control valve, routed to a pair of zones with manual drop legs)

3.3 Ammonia-Based Aeration Control

As an extension of the DO and MOV control modes described previously, given the additional NH_4/NO_3 probes installed as part of the testing process, an ABAC control mode was included as an option to testing after stabilization of the DO control mode.

ABAC, for the case of CKTP, is essentially one additional control step layered on top of the MOV control approach that uses the DO probes. Under the ABAC control mode, the aeration control valve for Zones 5 and 6 continues to modulate to maintain an operator-entered DO set point within Zone 6, while the DO set points for Zones 1 and 2 and Zones 3 and 4 are adjusted incrementally to maintain an NH_4 set point within Zone 5. Consequently, Zone 6 continues to act as a DO polishing stage to ensure that well aerated water is sent to the secondary clarifiers (avoiding potential denitrification and floating of the sludge blanket); however, the bulk of the aerobic tankage (Zones 2–4) is modulated to provide only the air necessary to achieve the given NH_4 set point (within the physical limitations of the current blowers and control valves). The system continues to operate based on DO set points, but the DO set point itself becomes an adjustable variable that is automatically increased or decreased based on the apparent load of ammonium requiring oxidation (see Section 2). The CKTP system is fairly simple, but represents a first attempt to use nitrogen-based control to increase the precision of aeration demands and potentially maximize denitrification by keeping DO as low as possible.

The ABAC mode of operation was tested as part of the second phase of the field testing outlined in Section 4. Appendix C includes the updated control strategy that was implemented to allow for ABAC control.

3.4 Internal Mixed Liquor Recirculation

The existing IMLR pumps (axial flow, variable speed) provide recirculation flow from the end of Zone 4 to the beginning of Zone 1 (Figure 3-5). They essentially provide the recirculation of oxidized ammonium (nitrates) to the Zone 1 pass as a means to use it for anoxic denitrification. The degree of recirculation can be limiting relative to the amount of denitrification that can be achieved. IMLR systems often range from less than 1Q (relative to forward flow, Q) up to 4Q, which tends to maximize the potential denitrification in the initial anoxic zone. The flow rate can be set as a constant flow, or flow paced (modes available to CKTP prior to field testing); however, the optimal approach for BNR and energy efficiency is to tailor the flow rate to the available capacity to denitrify. Simply put, the system recycles the mass of nitrates that the anoxic zone is capable of denitrifying—no more and no less. This has the added benefit of limiting the amount of oxygen that is recirculated to the anoxic zone, allowing it to operate more efficiently.

As part of the field testing process, each basin IMLR system was programmed to allow the operators to operate in two modes:

- **Mode 1 (current):** IMLR flow operates as a function (percentage) of influent flow.

- **Mode 2 (BNR field testing):** A nitrate control mode in which the pump speed is modulated to maintain an operator-entered NO_3 concentration set point in Zone 1 of the basin.

As NO_3 levels in Zone 1 increase above the set point (indicating that the capacity to denitrify has been exceeded), the IMLR pump slows down. As the NO_3 levels in Zone 1 decrease below the set point (indicating additional capacity to denitrify), the IMLR pump speeds up. The pump speed has operator-adjustable minimum and maximum rates to avoid the pumps increasing or decreasing beyond an acceptable range for the equipment.

The IMLR NO_3 control mode of operation was tested as part of the third phase of the field testing outlined in Section 4. Appendix C includes the updated control strategy that was implemented to allow for IMLR control via the Zone 1 NO_3 probe.

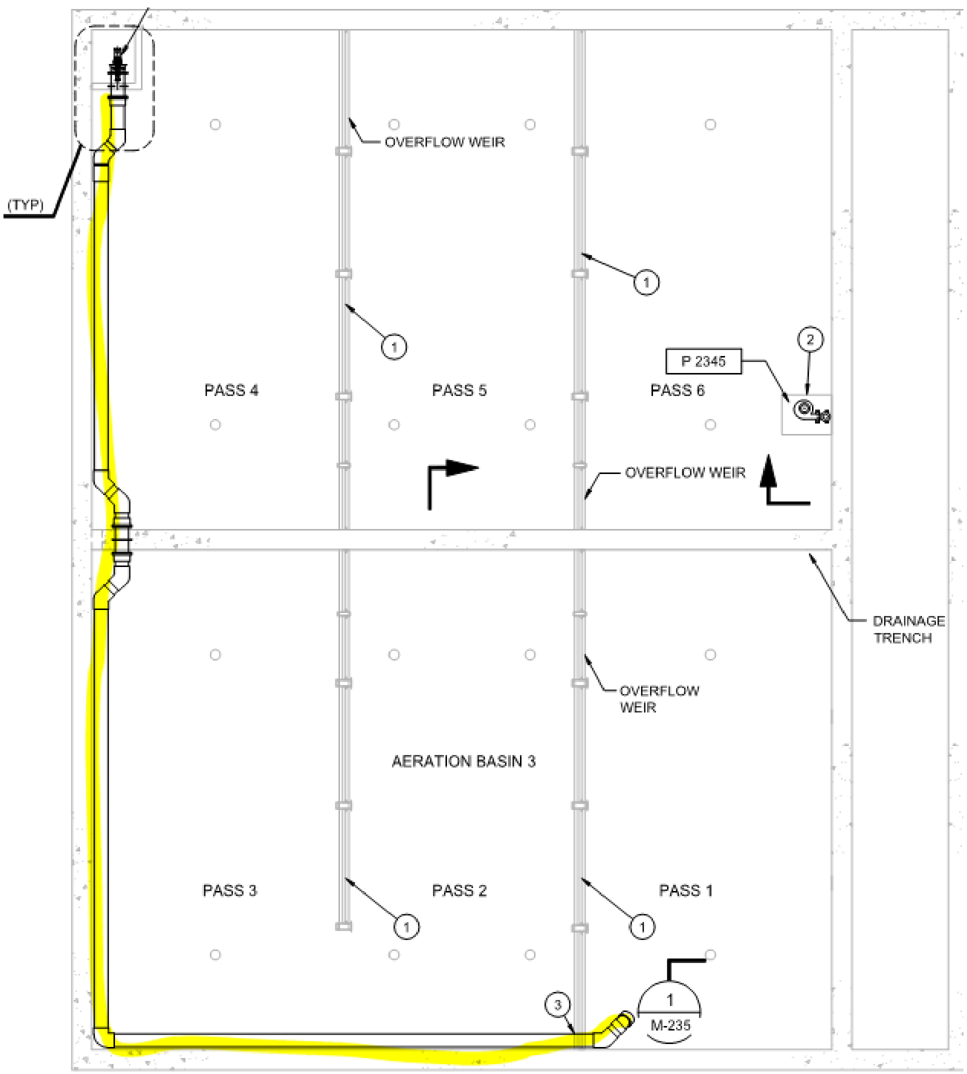


Figure 3-5. IMLR flow path (typical) from Zone (Pass) 4 to Zone (Pass) 1

3.5 Methanol Feed Control

CKTP has access to a single methanol storage tank with metering pumps that can deliver additional carbon (to supplement denitrification) to the biological process either upstream of Zone 1 or within Zone 5 (Figure 3-6). The former (Zone 1) is the normal mode of delivery.

Prior to BNR field testing, the pumps were operated manually with operators selecting a pump speed and manually adjusted as needed based on process response and available methanol storage and delivery schedules (roughly 5 to 10 gallons per hour [gph]). The system programming was also not calibrated correctly to the flow (given the size tubing of the peristaltic pump), so the flow set point would not induce the correct pump speed.

In addition, the storage of methanol is limited to a single tank that limits the ability of plant staff to maintain consistent methanol feed rates when storage levels are lower and delivery times may be restricted (a second tank for storage flexibility has been requested by operations and is listed as a near term improvement in Section 5).

As part of the field testing, two additions were made to the automation of the methanol feed system (along with the existing manual speed-based operation):

- Operators may select a nitrate control mode, where the duty metering pump feed rate is modulated to maintain Zone 5 NO_3 concentrations at an operator-selected set point, as measured by the Zone 5 NO_3 probe in each basin. As NO_3 levels increase, methanol flow rates increase to provide additional carbon to Zone 1 for denitrification (can also be fed to Zone 5 if desired). As NO_3 levels decrease, methanol flow rates are decreased to avoid wasting soluble carbon when additional nitrogen removal is not needed.
  - The pump feed rate has an operator-adjustable maximum rate to prevent feed rates from cycling too high relative to existing methanol storage capacity.
- The speed-to-flow curve was correct so that metering pump speed settings accurately reflect volumetric pumping rates, allowing the system to better estimate instantaneous methanol flow rates.

The upgraded methanol control mode of operation was included in the testing as part of the fourth phase of the field testing outlined in Section 4. However, due to the time constraints of the testing period, the new control mode was only checked for general consistency (flow rates increased as nitrate increased, etc.) shortly after the testing period was completed. Genuine testing while monitoring effluent quality with various setpoints was not completed and is listed as part of the next steps for optimization in Section 5.

Appendix C includes the updated control strategy that was implemented to allow for methanol control via the Zone 5 NO_3 probe.

Figure 3-6. Existing CKTP methanol storage and feed system

3.6 Additional Control Modifications

In addition to the four primary planned BNR optimization upgrades discussed previously (aeration/DO, ABAC, IMLR, methanol), a series of unanticipated field modifications were addressed/investigated during field testing to either improve an existing observed condition or gain data necessary to formulate a long-term optimization plan. The additional areas addressed included:

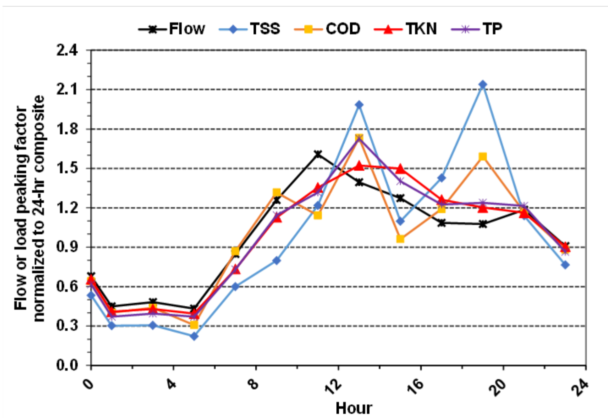
- Constraints related to the constant flow RAS rates
- Aeration basin influent hydraulic flow splitting problems
- Backup aeration capacity

3.6.1 RAS Rate Modifications

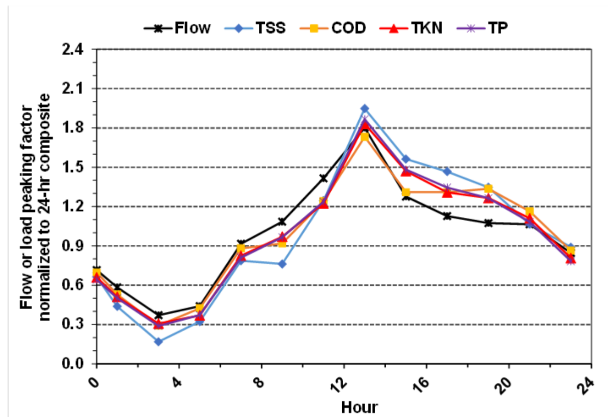
During development of the field sampling protocol (Section 2), CKTP staff noted that the RAS pump system is currently operated on a constant-rate basis, meaning that the flow rate is constant (at the operator-selected level) regardless of the influent flow or loading. The rate is typically around 3 mgd and this constant rate is implemented for two reasons: historical problems that CKTP has had with variable-frequency drives (VFDs) on the RAS pumps, and minimum flows that must be sustained for the suction header style sludge collection devices on the secondary clarifiers to work properly.

In many instances, this constant-flow approach is workable, but it creates a situation where functional inventory (the active mixed liquor suspended solids [MLSS]) available in the biological reactor) may be offset by inactive inventory (MLSS within the secondary clarifier) during peak loading events and can consequently limit BNR capacity.

As an example of this, Figure 3-7 presents a summary of the flow and loading profile (peaking factor relative to 24-hour composite) for 2 days of wastewater characterization sampling conducted in 2020. Overall, the pattern is indicative of the fact that as flows increase, the loading does as well. CKTP is not a situation where increased flows come with reduced concentrations to the extent that loading may remain fairly constant. High loading periods come at the same time as high flow periods.



Based on data for Oct 15-16 event (Th-Fr)



Based on data for Oct 21-22 event (Wed-Th)

Figure 3-7. Example of flow and loading profile for two separate sampling days in 2020

With a constant RAS rate, as flow rates increase, basin inventory (MLSS) tends to shift to the secondary clarifier blankets (flow to the clarifier increases while the return rate stays constant). As flow rates decrease, that inventory is returned to the aeration basins (flow to the clarifier decreases while the return rate stays constant). In a situation where high diurnal loading occurs at periods of high diurnal flows (as with CKTP), the inventory is pushed to the secondary clarifier at precisely the time needed most for active BNR in the aeration basins. This can lead to a problem in achieving theoretical results, as the expected (average) MLSS, while measured accurately on a composite basis, is not in the right place at the right time, and thus functionally appears to derate the system.

To help avoid this scenario, during the field testing a partial flow-paced mode was introduced to the CKTP controls that gave the operators a minimal ability to crudely vary the RAS pump flow rates at a few points during the day. On weekdays, a flow rate could be set at 6 a.m. (4 mgd total, 1,400 gallons per minute [gpm] per clarifier) to increase RAS rates and make sure that inventory was moving to the aeration basins before late-morning peak loadings began to hit. By 5 p.m., the RAS rate was reduced to 2.8 mgd (1,000 gpm per clarifier) and further reduced at the end of the swing shift (approximately

10–11 p.m.) to 2.0 mgd (700 gpm per clarifier, the minimum needed for secondary clarifier operation) until the next morning. On weekends, the RAS flow was set at 4.0 mgd at 6 a.m.–2 p.m., and 2.8 mgd for 2 p.m.–6 a.m.

This operation was not true flow pacing, however; it was a simple way to minimize the effect of inventory loss and attempt to keep the active biology within the aeration tanks at the expected time when peak loads would reach the system.

3.6.2 Influent RAS/PE Hydraulics

During the initial phases of field testing, influent to the aeration basins was routed through the CKTP mixing box, which allows for pre-mixing of the RAS with the PE, or separate routing of the RAS and PE to Zone 1 of the individual aeration basins. Initially, the pre-mixing approach was used in which RAS and PE were mixed together prior to discharge to the individual basins. This is shown in Figure 3-8, in which RAS flow enters from the top of the page (blue) and PE enters from the bottom right (red). In theory, the box has a submersible mixer and would blend the flows prior to discharge to the individual aeration basins (in this case, Basins 1, 3, and 4 were online).

During the early stages of testing, it was noted that Basin 1 tended to have a much higher MLSS concentration relative to Basins 3 and 4. The difference was significant, often varying as high as 1,000 mg/L (i.e., Basin 1 would have 3,200 mg/L and Basins 3 and 4 would have 2,200 mg/L) and well beyond what would be expected from simple sampling variability. As shown in Figure 3-8, it was suspected that the RAS was bypassing directly to the Basin 1 influent gate (which was immediately adjacent to the RAS entry point) and that the PE was favored toward Basins 3 and 4 gates (directly opposite the PE entry and shown in Figure 3-9).

CKTP staff attempted various field modifications (such as adjustments to the submersible mixer, throttling gates, etc.) to alleviate the apparent flow split discrepancy, but the results were not sufficient as it will likely require some form of more permanent baffling to address the issue. For the interim of the testing period, RAS flow and PE were routed separately to Zone 1 of each basin and this significantly reduced the MLSS discrepancies between each basin train.

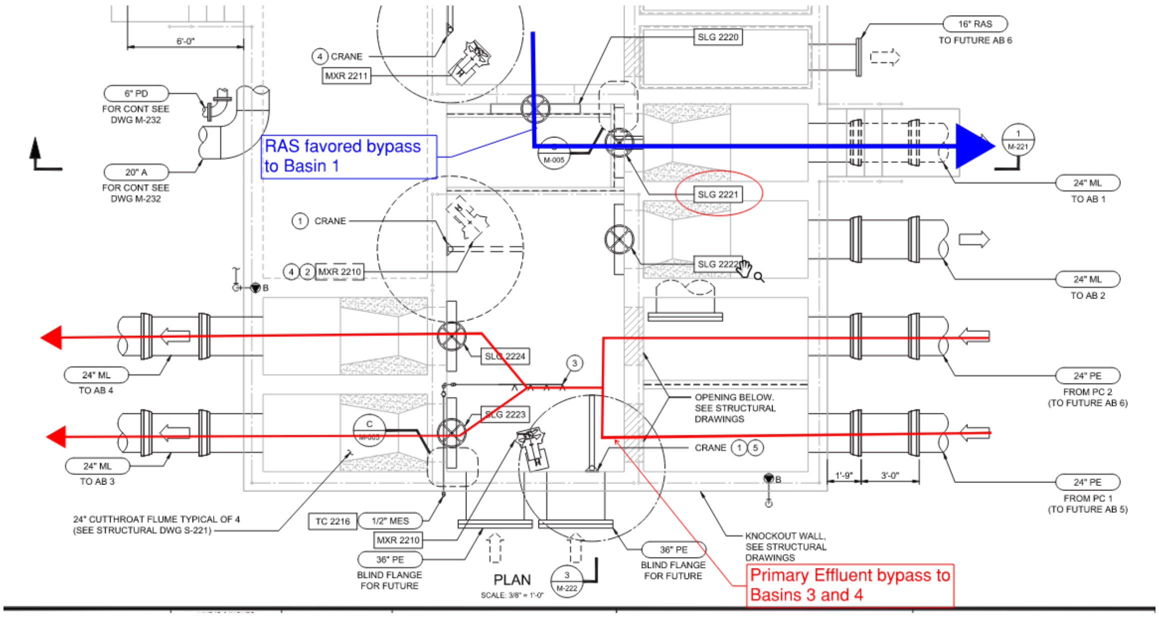


Figure 3-8. Aeration basin influent mixing box (RAS + PE) and likely bypass flow scenario

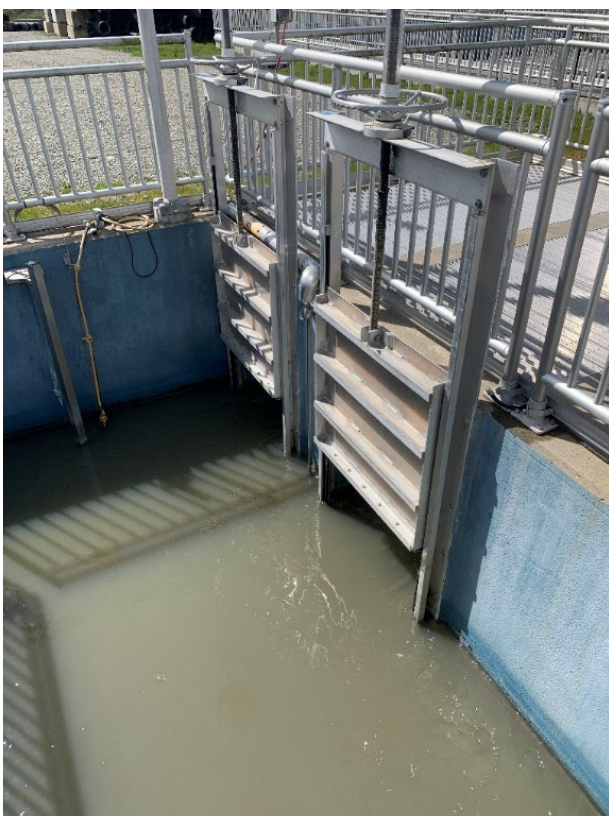


Figure 3-9. Aeration basin influent mixing box (discharge gates to Basins 3 and 4)

3.6.3 Backup Blower Aeration

During normal operation, CKTP typically uses one or both of its Aerzen high-speed turbo blowers (Figure 3-12, added during the 2016 upgrade) to supply aeration air. As outlined in a previous report (Murraysmith 2020), the two Aerzen blowers are sufficient to satisfy the current maximum sustained air demand, up to approximately 8,600 standard cubic feet per minute (scfm). These two blowers were the only ones actively used during the BNR field testing. CKTP also has two existing Lamson multistage centrifugal blowers (Figure 3-11) that can produce a significant amount of air and are used as a backup to the Aerzen blowers (though only one of the two centrifugal blowers is available for use).

Figure 3-10 shows example curves of each blower from the Murraysmith (2020) basis of design report. Field testing of the Lamson blower indicated that the actual output was near 8,000 scfm at 8.6–8.9 pounds per square inch gauge [psig]) with a low range near 3,400 scfm (7.8 psig). The reason for this difference between the apparent performance curve and actual field results was not clear based and a detailed investigation of the differences was not conducted at this time. However, development of a control strategy for use of the Lamson unit was conducted below based on the actual measured field results (not the apparent performance curve).

With the centrifugal blowers not needed for aeration testing, CKTP wanted to implement one of the units as a backup blower in the event that an Aerzen unit dropped out of service (one turbo blower would not be sufficient to meet the air demand). A backup control strategy (included in Appendix C as part of the aeration controls) was implemented to allow a single Aerzen blower to be used up to a set flow rate near its maximum (approximately 4,000–4,500 scfm), which is also well above the minimum of a Lamson blower (approximately 3,400 scfm). If the air demand continued to increase and a second turbo blower was not available, the operating Aerzen blower would stop and the available Lamson unit would come on and operate while air demand remained high. Once the demand dropped below approximately 4,000 scfm (below the Aerzen maximum), the system would transition back to the turbo blower.

This backup strategy would prevent a turbo blower from operating at the same time as a multistage centrifugal (which tends to be unstable and difficult to control with the very different surge characteristics and response times of each blower), but allow them to cover the full range of flows from roughly 2,000 scfm to more than 8,000 scfm. This backup strategy is a near term solution, and ultimately would be phased out once the existing Lamson blowers can be replaced with additional Aerzen blowers (along with a master control panel to operate all turbo blowers as a unit). See Section 5 for blower optimization recommendations.

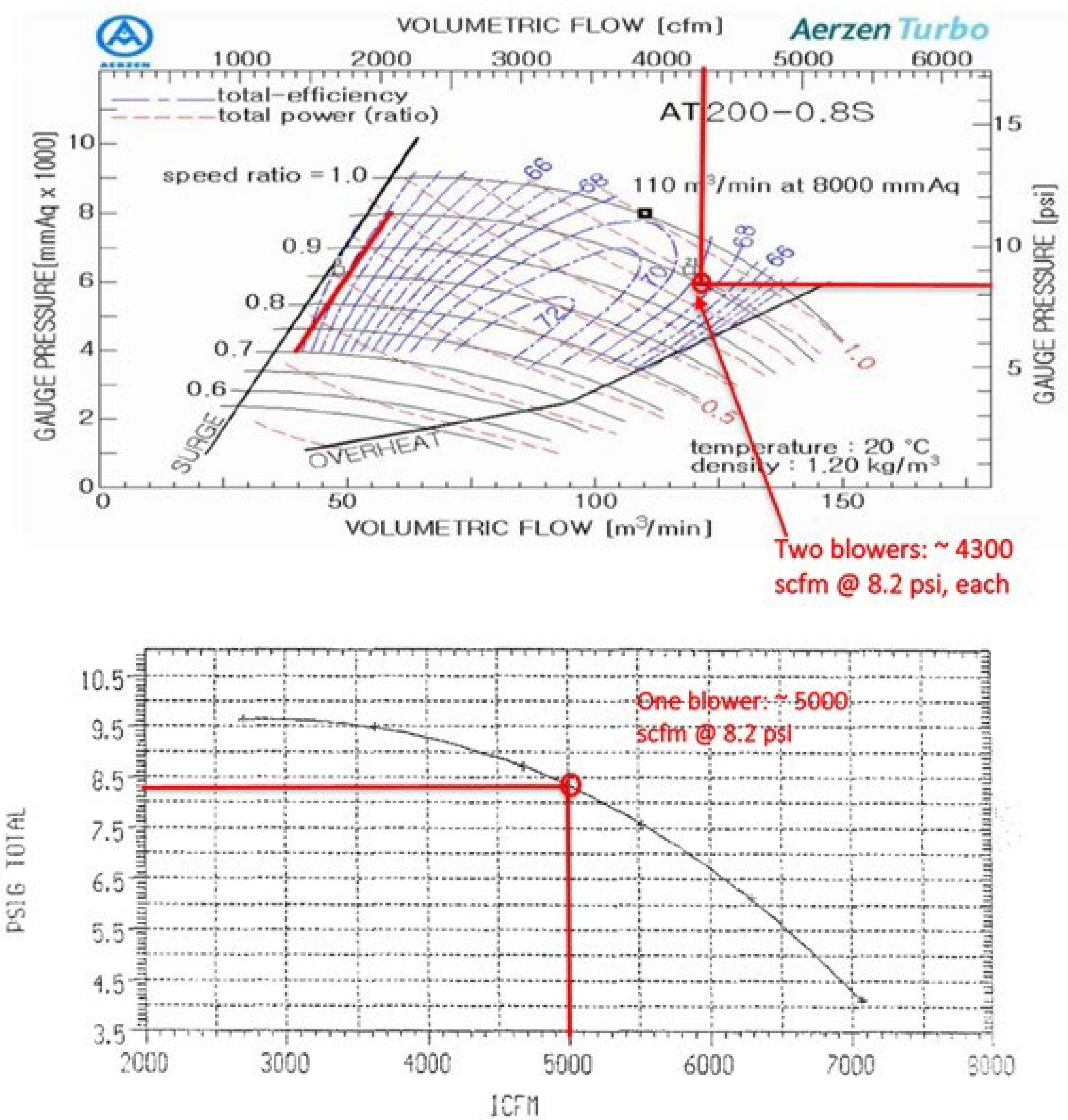


Figure 3-10. Existing CKTP aeration blowers (top curve = high-speed turbine blower; bottom curve = multistage centrifugal)

Figure 3-11. Example Lamson multistage centrifugal blower

Figure 3-12. Example Aerzen high-speed turbo blower

4 Field Testing Results and Summary

Based on the desktop analysis described in Section 2, and the optimization upgrades described in Section 3, the following provides a summary of the field testing protocol; a summary of the major results and observations; and a short discussion of how the field results relate to the original modeling efforts, CKTP capacity, and the NGP.

4.1 Field Testing Protocol

Appendix B provides a summary memorandum outlining the protocol plan (scenarios and sampling requirements) for implementation of full-scale BNR commissioning. Table 4-1 outlines the six periods (A–F) and their intended operational parameters. A short description of each testing period is noted below. Field testing of the process performance overlapped with simultaneous testing (real time) of programming changes related to implementation of the new probes, new MOV control, etc., as outlined in Section 3. Consequently, application of the testing periods varied from the proposed plan and is discussed in Section 4.2. However, the original plan intent (as shown in Table 4-1) is relevant to the purpose of the testing and was still used as the core for guiding field changes. The overall intent of the testing process was to implement BNR in a way that achieved the following (per recommendations from Section 2):

- Introduce stable, baseline nitrification and denitrification with simple/standard DO operation
- Introduce refinement to improve BNR performance and gain operational experience, primarily with:
  - ABAC operation (Zone 5 ammonia control)
  - IMLR automated control (Zone 1 nitrate control)
  - Methanol automated control (Zone 5 nitrate control)

The matrix presented in Table 4-1 is intended to provide a logical sequence in which to test the effect of each unique aspect of the proposed ABAC operation. Controls of the methanol pumps, IMLR, and aeration using the new NH_4/NO_3 probes are introduced in successive periods to allow for a clear understanding of the effects of each one and to minimize the number of variables in play at a given time.

A summary of the intent of each testing period is provided below to give context to the operation. Actual application of the testing (given field conditions) is outlined in Section 4.2. The description and data provided assume that CKTP is operating all four of the basins in parallel; however, only three basins were available for the actual field testing period. Periods E and F were not implemented because of time constraints; however, they are included as they provide a basis for continued testing recommendations in Section 5.

Period A: Baseline Nitrification

The purpose of Period A is to establish full nitrification, under standard DO control, to prepare CKTP biologically for more advanced BNR testing. In this period, CKTP inventories (MLSS and SRT) are adjusted to allow for complete nitrification. Based on previous modeling, the MLSS will need to exceed 2,000 mg/L (3,000 mg/L is preferred if only three basins are online) to achieve this state, and full nitrification is an essential prerequisite for any substantive BNR that would follow. In this mode of operation, DO control, with particular attention to aerobic SRT, is the basis of the standard operating procedure. IMLR and methanol feeds are maintained as indicated, and can be adjusted, if necessary, based on field observation by staff.

Period B: Introduce Nitrate Control of Methanol

The purpose of Period B is to continue operation exactly as established in Period A, but allow for automated control of the methanol via the newly installed NH_4/NO_3 probe in Zone 5. As the nitrate increases, the methanol will increase to provide a carbon source for denitrification.

Period C: Introduce Nitrate Control of IMLR

The purpose of Period C is to continue operation exactly as established in Period B, but add the additional variable of nitrate control for the IMLR pumps. In this case, the controlling variable is the Zone 1 NO_3 levels. As the NO_3 level decreases below the set point, indicating that denitrification capacity is available, the pumps can increase flow. If the level rises above the set point, indicating that additional denitrification is not available, the pumps will slow down.

Period D: Introduce ABAC

The purpose of Period D is to build off of Periods B and C by adding full control of the aeration system via the NH_4/NO_3 probe in Zone 5. MOV valve control and DO operation will still be in place; however, the Zones 2 and 4 DO set points will be automatically adjusted up or down to achieve a particular NH_4 level at the outlet of the basin. In this case, the aeration air is limited to produce only the level of nitrification necessary to meet the set point, with the added benefit of limiting recirculated oxygen from the IMLR pump and improving Zone 1 denitrification. Once Period D has been completed, all the major BNR variables will have had an opportunity for operation at full scale.

Period E: Optimize for Low Total Inorganic Nitrogen with Methanol (if time permits)

The purpose of Period E is to build off of Period D and begin to operate the system to achieve as low an effluent TIN as possible. In this case, the only operational change compared with Period D is to now set the methanol feed control to go to 1 mg/L of nitrate in Zone 5. Consequently, the system will be targeting both very low ammonium (approximately 1 mg/L) and very low nitrate (approximately 1 mg/L). This will be the opportunity to see how low CKTP could go, assuming that all other variables are not limiting. In reality, CKTP is not expected to be able to maintain this level of methanol feed given current storage limitations, so this will be a short-term testing period. However, this information will prove critical for County staff to know the ultimate limits of CKTP (for future optimization) as well as for the purposes of planning any form of capital improvements to the methanol storage and feed system.

Period F: Optimize without Methanol

The purpose of Period F is essentially the same as Period E, but with the additional methanol feed removed. In this case, methanol is either taken off line completely, or kept at a very low dose, to determine the best-case effluent TIN without significant supplemental carbon. This information is helpful both to provide an idea of optimal CKTP operation if methanol supply was interrupted, and to provide a foundation for showing the potential to optimize (perhaps seasonally) while saving money on reduced methanol usage. Ultimately, these data could be used as a basis to determine if an annual operation with Period E in the summer (best TIN possible, lower flows) and Period F in the winter (reduce methanol use, but operate efficient ABAC) could be helpful to the County to balance process efficiency and cost in meeting the NGP.

Table 4-1. Biological nutrient removal testing periods and associated control variables: ABAC noted in red

Component	Process configuration	Primary goals	SRT target and aeration basins online	RAS control	Aeration/DO control	IMLR control	Methanol
A	4-stage	Establish near-complete nitrification	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L (may need to adjust wasting/SRT/ MCRT control and calculations)	Per current practice: constant flow rate (may be adjusted pending initial results)	DO set point control DO = 2 mg/L Zones 2, 4	Flow-paced Initial set point 2.5Q May be adjusted (up to 4Q)	Per current practice: manual set point near 10 gph. Modify as needed to manage pH, alkalinity, sludge blankets. (Methanol at 10–11 gph typically)
B	4-stage	Implement/ test NO_x-based methanol control	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L	Per current practice: Constant flow rate	DO set point control DO = 2 mg/L Zones 2, 4	Flow-paced as per above	NO_x-based NO_3 set point TBD per discussion with Kitsap County based on Period A performance, methanol delivery demand, etc. Zone 5
C	4-stage	Implement/ test NO_x-based IMLR control	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L	Per current practice: Constant flow rate	DO set point control DO = 2 mg/L Zones 2, 4	NO_x-based Set point = 2 mg/L NO_3 in Zone 1	NO_x-based Maintain prior set point Zone 5
D	4-stage	Implement/ test ABAC	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N set point = 1 mg/L May be adjusted over time Zone 5	NO_x-based Set point = 2 mg/L NO_3 in Zone 1	NO_x-based Maintain prior set point Zone 5
E	4-stage	Implement/ test "optimized low TIN"	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N set point ~1 mg/L Zone 5	NO_x-based Set point = 2 mg/L NO_3 in Zone 1	NO_x-based Set point ~1 mg/L NO_3 for low TIN Zone 5
F	4-stage	Implement/ test "optimized no (or low) methanol"	9-day aerobic 14-day total 4 aeration basins MLSS ~2,000–2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N set point ~1 mg/L (may be increased to limit NO_x production) Zone 5	NO_x-based Set point = 2 mg/L NO_3 in Zone 1	Methanol OFF (or low dose as needed to maintain alkalinity, pH, blanket, background methanol-degrader population)

4.2 General Results and Observations

The formal testing period began in January 2022 and continued through the end of July 2022, when construction work on the digesters (and consequent process changes) led to a logical point to halt the initial field testing. Over the course of that period, initial testing was completed for DO/MOV operation, basic ABAC mode, automated IMLR, and an initial function test of automated methanol dosing. This was essentially the intent of Periods A–D as described in Section 4.1, although the implementation was somewhat out of order and the facility maintained some degree of methanol feed during the entire period (there was no opportunity to optimize methanol versus non-methanol operation).

Appendix D provides a notation log of major field observations noted by CKTP staff during the testing period. Key items from that list that are relevant to major periods of process change are outlined below:

- The MOV aeration mode was online immediately at the beginning of the year. Aerations diffusers in all basins were new Sanitaire models replaced in the previous year (Murraysmith 2020).
- Initially all four basins were in operation, but the facility soon reduced that to three basins on January 25, 2022 (Basins 1, 3, and 4), which would remain the basis for the remainder of the testing.
- DO set points generally remained at 2.0 mg/L until ABAC was initiated, although operators did adjust periodically as warranted. IMLR was roughly 200 to 250 percent, adjusted periodically. Methanol was fed manually at low/moderate levels typical of previous CKTP practice (approximately 10 gph).
- RAS and PE mixing was decoupled on February 16, 2022, to improve MLSS distribution between basins.
- HDR began adjustments to RAS rates on March 18, 2022, with additional programming on April 19, 2022, to help alleviate the shifting of solids inventory to the secondary clarifiers during high flow/high loading periods of the day (see Section 3).
- HDR began ABAC programming on April 19, 2022. Basin 1 was placed in ABAC mode on April 27, 2022, pulled back out on May 17, 2022, and then reinstated on May 23, 2022.
- All operating Basins (1, 2, and 4) were placed in ABAC mode on June 1, 2022.
- Automated IMLR (nitrate control) was placed online on June 28, 2022.
- The field study was halted on July 27, 2022, for digester construction work. Automated methanol programming (nitrate control) was implemented on August 2, 2022, for CKTP staff to try as time allows.

Table 4-2 provides an overview of effluent composite nitrogen sampling during the testing period. The results are divided into two categories based on process operation (days when centrate recycle nitrogen loads were included and days with no centrate processing) and time. For the time designation, numbers are shown as averaged per month as well as over the entire testing period, but also separated for the period in which stable and consistent nitrification was occurring (roughly considered approximately March 15, 2022, and following).

Figure 4-1 and Figure 4-2 provide similar information, but graphically display the composite effluent sampling along with markers for critical periods of process changes.

Table 4-2. Effluent nitrogen data for field testing period

Testing Period	Average daily flow (mgd)	Centrate days[b]			Non-centrate days[b]		
		NH_4-N (mg/)	NO_3-N (mg/)	TIN (mg/)	NH_4-N (mg/)	NO_3-N (mg/)	TIN (mg/)
January	4.89	7.51	4.92	12.43	3.44	4.40	7.84
February	3.67	8.85	5.42	14.27	6.32	4.91	11.23
March	3.78	2.70	7.27	9.97	0.93	5.56	6.49
April	3.54	1.58	6.68	8.27	0.64	4.70	5.34
May	3.45	1.87	8.35	10.43	0.94	5.93	6.87
June	3.32	1.61	9.11	10.72	0.64	4.94	5.58
July[a]	3.02	1.43	7.46	8.88	1.01	7.42	8.43
Overall testing period – average	3.69	4.19	6.80	**11.07**	1.71	5.61	**7.32**
3/15/2022 through end of testing period - average	3.37	1.67	8.00	**9.69**	0.77	5.83	**6.60**
Minimum Value	--	0.70	3.98[c]	**6.64**[c]	0.15	2.05	**2.20**

a. July flows through 7/25/2022.

b. Based on available daily composite samples.

c. Discounts 5/31/2022 zero value.

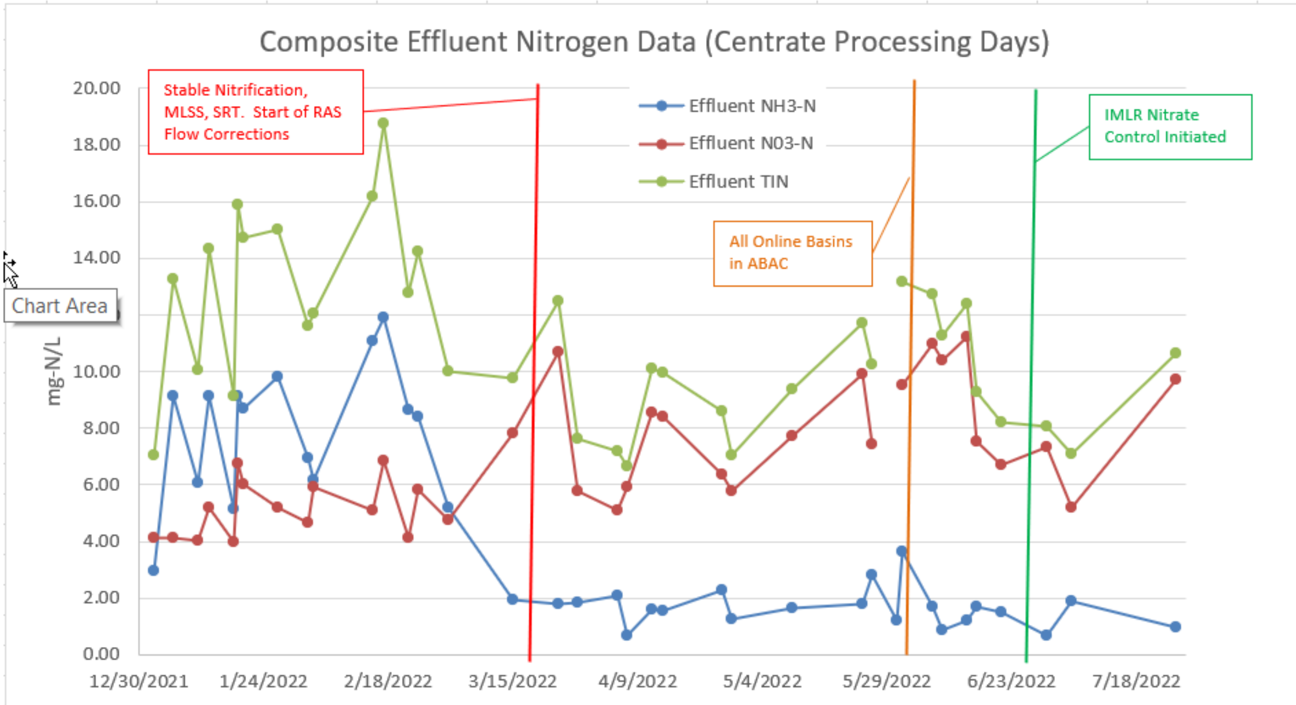


Figure 4-1. Composite effluent nitrogen data during field testing (centrate days)

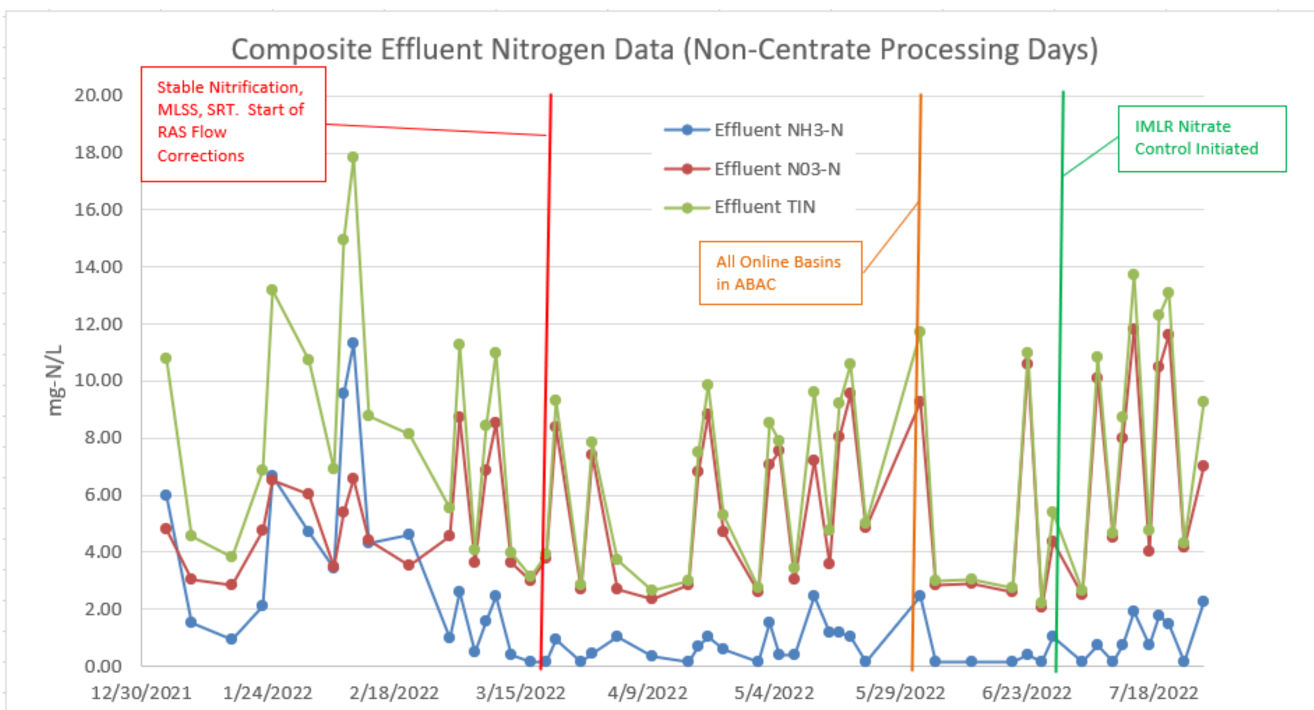


Figure 4-2. Composite effluent nitrogen data during field testing (non-centrate days)

The initial 2 to 3 months of testing were spent assisting CKTP in getting a stable, consistent MLSS and an aerobic SRT high enough (roughly 9 days) to get consistent, reliable nitrification. As can be seen in the figures above, by mid-March CKTP was able to achieve consistently low NH_4 levels and had integrated RAS pacing (to the degree capable), reached relatively stable aeration/DO/MOV controls, and had a reasonably consistent level of MLSS between the online basins (Basins 1, 3, and 4).

ABAC was introduced in May (partially on a single basin) for program testing and was operational (though not fully optimized) on all online basins for June and July. IMLR pacing was introduced near the end of the testing period. While methanol feed was maintained through the testing period on a manual control basis (not flow paced) throughout the testing, the opportunity to introduce automation to the methanol control was not attempted until the end of the test period (the controls were verified and tested; the biological response over time was not yet measured and remains for future refinement).

The following are summary items of note relative to the initial results:

- With stable and relatively complete nitrification in place (roughly mid-March), the average effluent TIN was approximately 9.7 mg/L for centrate processing periods and 6.6 mg/L for non-centrate periods. Even with the limited optimization testing done, CKTP was able to achieve a solid BNR effluent of 5 to 10 mg/L TIN.
- The testing represents results mostly during the winter and cooler spring, which provides a conservative nature to the TIN results given that warmer weather in August and September would likely have even better results.
- The variance in the results (deviation around average) is still relatively high and suggests that while the core process control is working, there is still available room for refinement of the control loops and response. The process could benefit from a further refinement in the selection of process set points (NH_4, NO_3, and DO) as well as improvements to the system response (see Section 4.2.1).
- ABAC operation (June–July) was not refined enough to see a significant difference between operation under that mode versus the MOV-enhanced DO control matrix (March–May). However, some of the lowest effluent TIN numbers were achieved on non-centrate days in June during initial ABAC operation, some with the potential to operate at less than 5 mg/L TIN.
- IMLR operation (with nitrate control), while operating well from a control loop perspective, came into the testing period too late for detailed testing or to develop any conclusions on optimization. However, the process is operational and available as an additional optimization tool.
- Methanol operation (with nitrate control), as with IMLR, is operational and an available tool for CKTP staff, but was not tested or refined during the field testing period (came online at the very end of July/early August). Only a short period of verification (confirming control loop was functional) was able to be implemented so the effect of more detailed control testing on effluent TIN was not established.

Comparison of field results with initial modeling results suggests the degree to which additional optimization would be beneficial to CKTP. Using Table 2-6 (AA projects flows for 2028), which assumed approximately 4 mgd influent flows (slightly higher than the influent flows during the 2022 testing period), the following observations can be made:

- Whether with DO or ABAC operation, and not assuming a significant process change like sidestream treatment, the modeling would suggest that average operation at roughly 3 mg/L TIN is possible. These results are not supported by field tests at this time (see text below).
- Initial field results, while periodically showing effluent values at less than 3 mg/L TIN, performed on average from 5 to 10 mg/L. Given the 6.6–9.7 mg/L effluent TIN average results, this suggests that the next stage of optimization and refinement can focus on the ability to (1) stabilize the BNR performance already achieved and (2) target a further reduction of roughly 5 mg/L on an annual average basis.

4.2.1 Operational Challenges and Limitations

While the testing period was limited and did not present an optimal amount of time to refine and adjust multiple process variables, it did allow CKTP to achieve stable BNR and begin to gain operational experience using more advanced control schemes.

During the process, specific challenges to further optimization were noted as a means to catalog the most useful projects or future process changes that could be used to improve BNR performance and increase operator control. The following sections outline several of the key elements observed during the testing.

Influent Hydraulic Distribution Challenges

As noted in Section 3.6.2, part of the instability during the early portions of the testing was related to the inability to achieve consistent and complete nitrification (and consequently consistent BNR). It is suspected that a portion of this difficulty was directly related to the challenges with achieving sufficient mixing of PE and RAS in the influent distribution box and the consequent inability to keep stable MLSS levels across all active basins.

To keep the testing moving, RAS and PE were rerouted and distributed directly to each basin; however, that approach is not the preferred pathway. Mixing the RAS and PE together prior to the Zone 1 anoxic volume would maximize the use of that volume. Having to route RAS and PE to the anoxic volume separately, and relying on Zone 1 to provide mixing, may lead to a loss of anoxic capacity as portions of the zone will contain RAS and PE that are not well mixed.

Nitrification Challenges

CKTP staff began to use aerobic SRT as a basis for observing process control. This is one of the more critical parameters as it ensures stable residence time for consistent nitrifier growth. For the early months of the testing, nitrification (as evidenced by effluent NH_4 levels) was sporadic. Once RAS flow distribution (and consequently basin MLSS) was better established, coupled with RAS flow control, nitrification was more stable and effluent NH_4 levels were consistently low.

RAS Flow Challenges

As noted in Section 3.6.1, the inability to match RAS flow to influent flow and loads creates an inherent inefficiency within the treatment process in which the "average" MLSS and aerobic SRT, which would broadly appear to be sufficient nitrification, does not reflect the dynamic biology. Solids inventory is pushed to the clarifiers and pulled back to the aeration basins inversely proportional to organic and nitrogen loading. This was addressed, to a small degree, through some programmed step changes in RAS flow, but would benefit from a true flow pacing of the RAS system.

Calibration and Accuracy of New Probes

The testing period allowed for CKTP staff to work with the new NH_4/NO_3 combination probes discussed earlier in Section 3.1. The probes, while workable with the overall control strategy, showed two primary challenges:

- Maintaining calibration and accuracy of the probes was relatively work-intensive for CKTP staff. The probes are a significant effort to maintain and often show deviation from laboratory sampling. The probes would often read higher than field samples.
- The accuracy of Hach ISE probes tends to be limited to greater than 1–2 mg/L ammonium and nitrate. At levels near 1 mg/L and lower, the accuracy is suspect and consequently probes measuring Zone 5 or effluent ammonium would benefit from an alternative probe type (discussed in Section 5).

Air Control Limitations

Airflow distribution, while using new programming for MOV control and accessing new and updated probes, showed a variety of patterns that indicated potential difficulties in air distribution that will warrant further optimization and potentially field modifications. As part of the testing, no changes were made to the control valves or flow meters (air distribution mechanical pipe layout).

Figure 4-3, Figure 4-4, and Figure 4-5 show an example of the DO set point in Zone 2 of each basin during a day when ABAC was operational (so the DO set point varied) and centrate was being recycled to the front of CKTP. Figure 4-6, Figure 4-7, and Figure 4-8 show the same example, but for a day on which centrate was not being recycled (dewatering did not occur). While this is just one example of one zone, it illustrates several issues that occurred regularly throughout the testing period:

- In some instances (Basin 1, Zone 2), the actual measured DO would track fairly well with the set point as it changed.
- In other instances (Basin 3, Zone 2), the DO would have noticeable excursions from the set point, although they would correct after a short period.
- Longer-term deviations (Basin 4, Zone 2) appeared to indicate not simply an issue with short-term response time in the control loop, but a systemic problem related to the valve sizing or airflow minimum that prevented the air from being throttled back enough to reach the targeted set point.
- Optimally, Zone 2 should have a similar demand profile across all basins, as they are in parallel and should be receiving the same flow and ammonium load. As can be

seen, the profile varied, even on the same day, which could be partially due to probe inaccuracy, but may also suggest uneven flow distribution and loading related to the hydraulic distribution challenges noted previously. This is discussed further in the following sections relative to the effects of centrate load equalization.

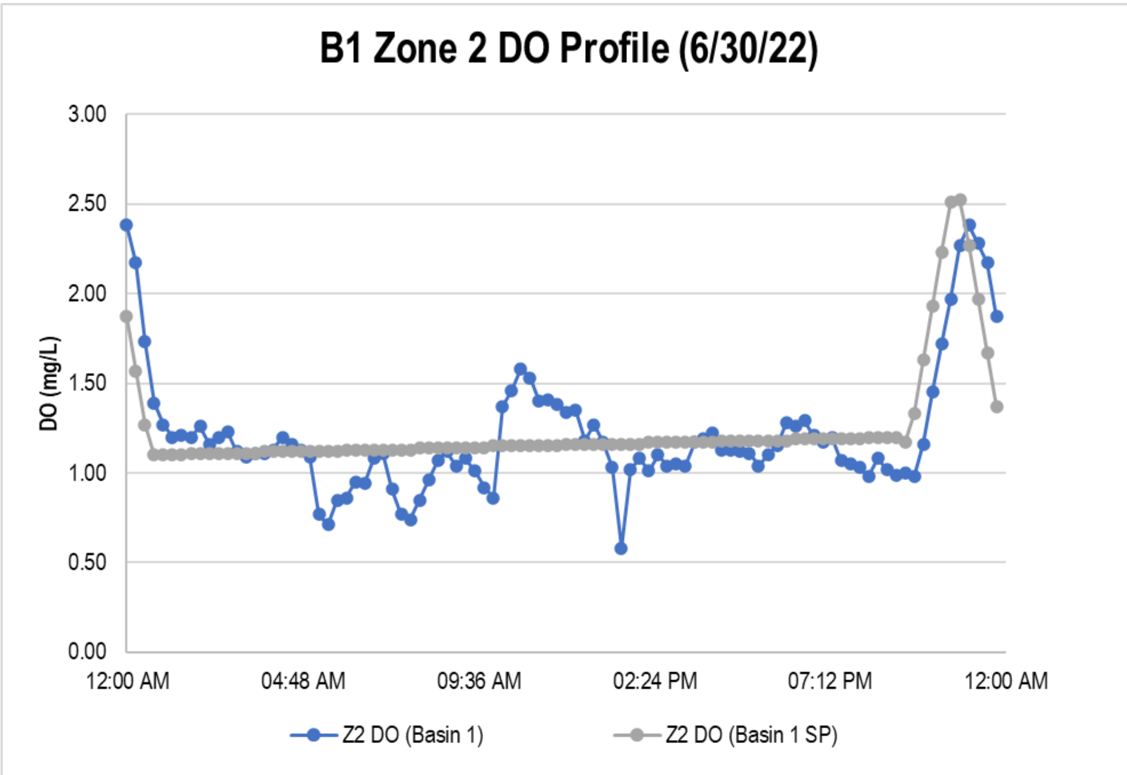


Figure 4-3. Basin 1, Zone 2 DO profile (centrate day)

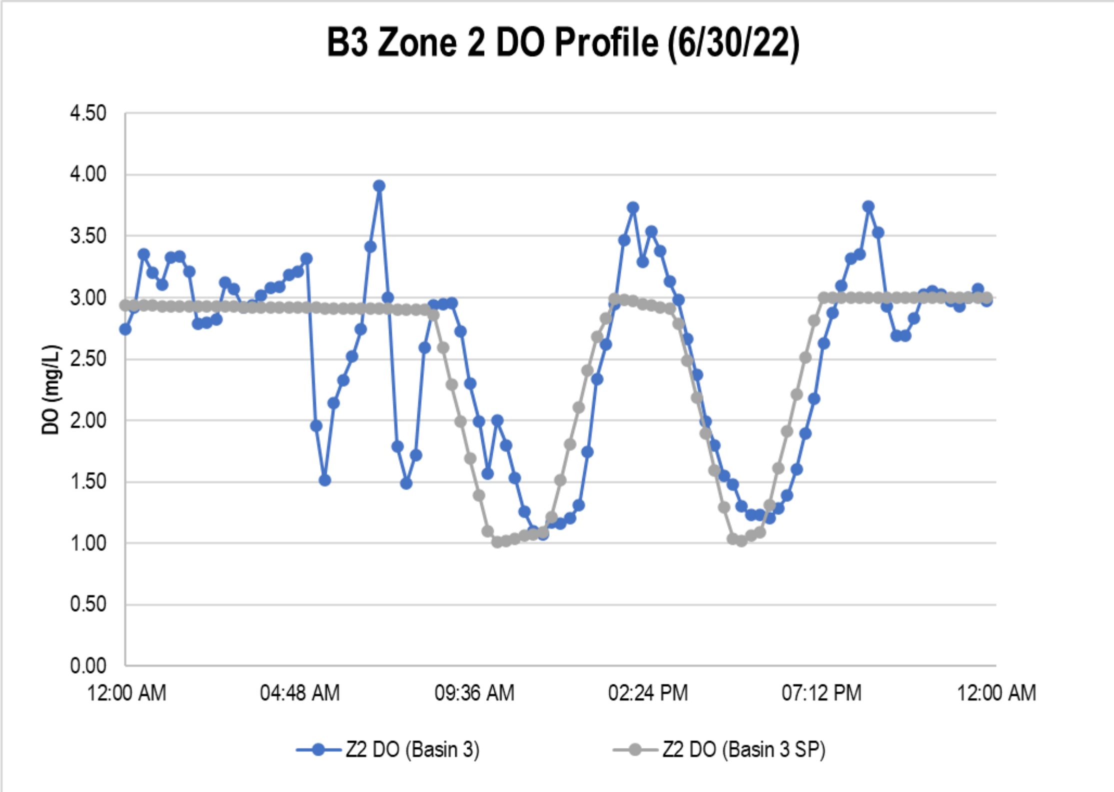


Figure 4-4. Basin 3, Zone 2 DO profile (centrate day)

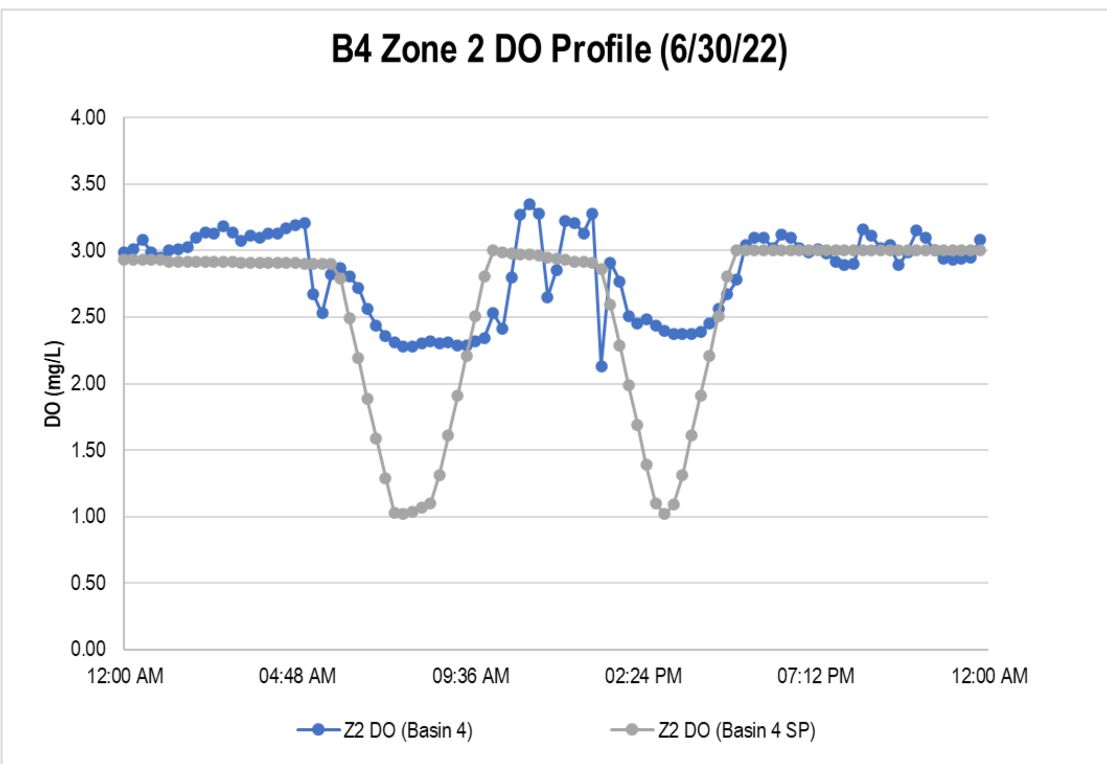


Figure 4-5. Basin 4, Zone 2 DO profile (centrate day)

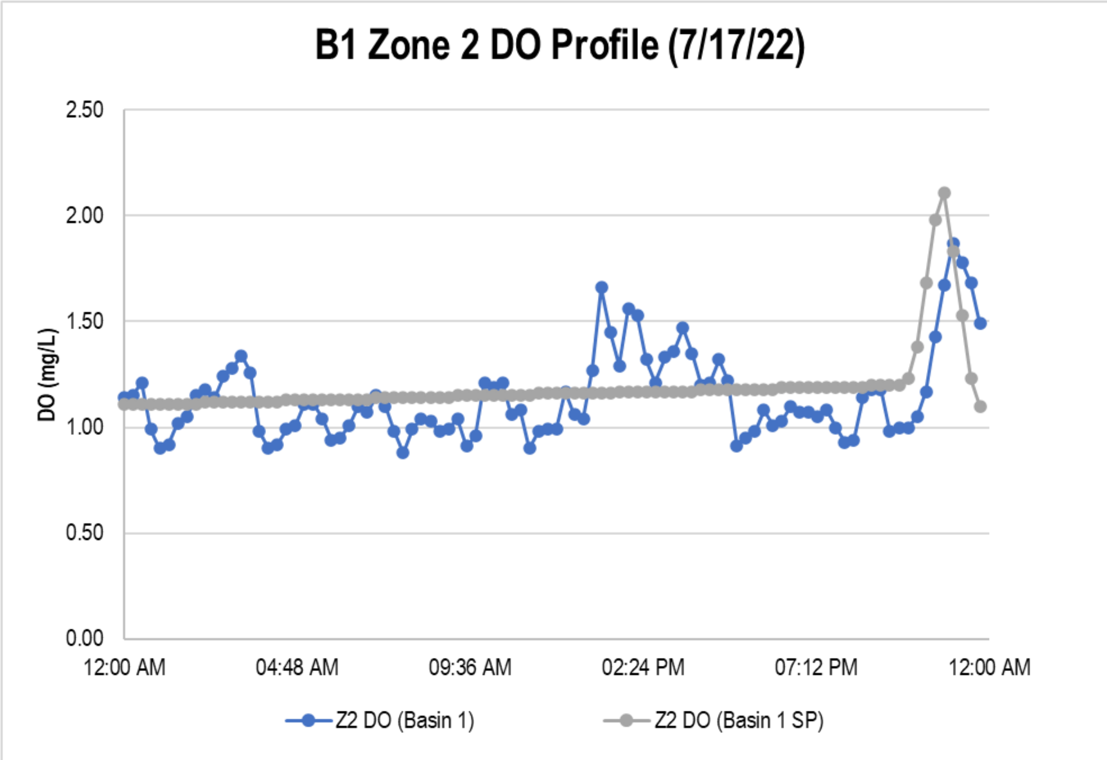


Figure 4-6. Basin 1, Zone 2 DO profile (non-centrate day)

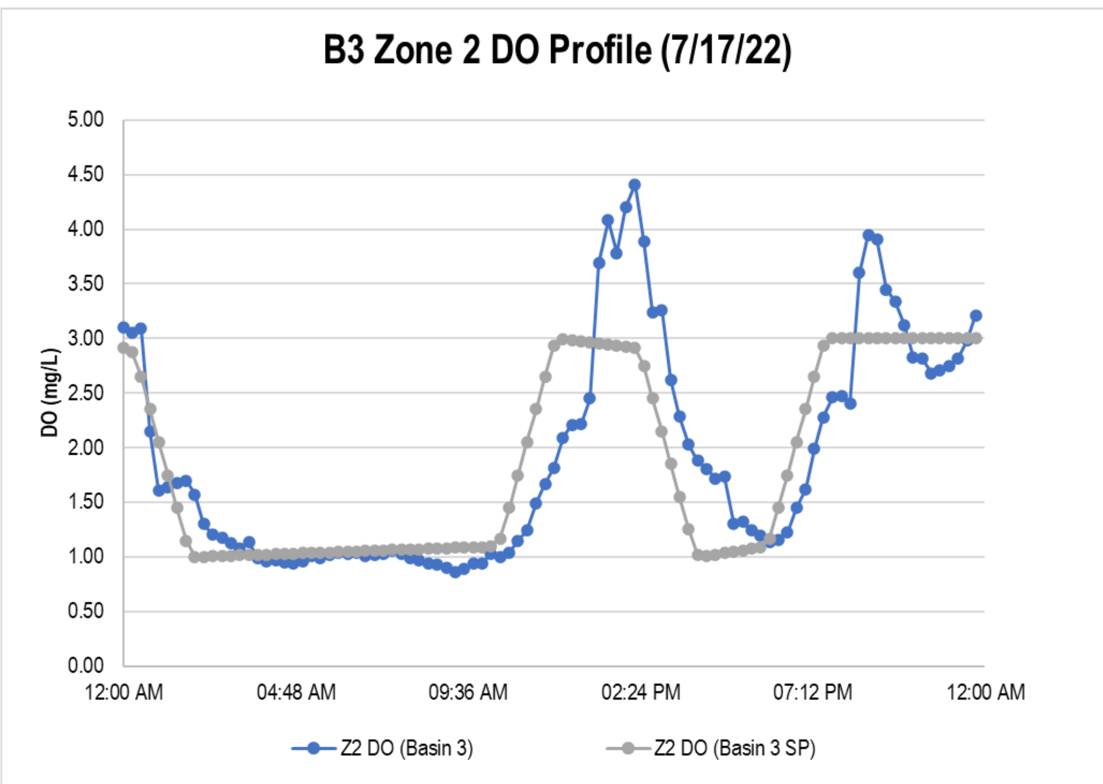


Figure 4-7. Basin 3, Zone 2 DO profile (non-centrate day)

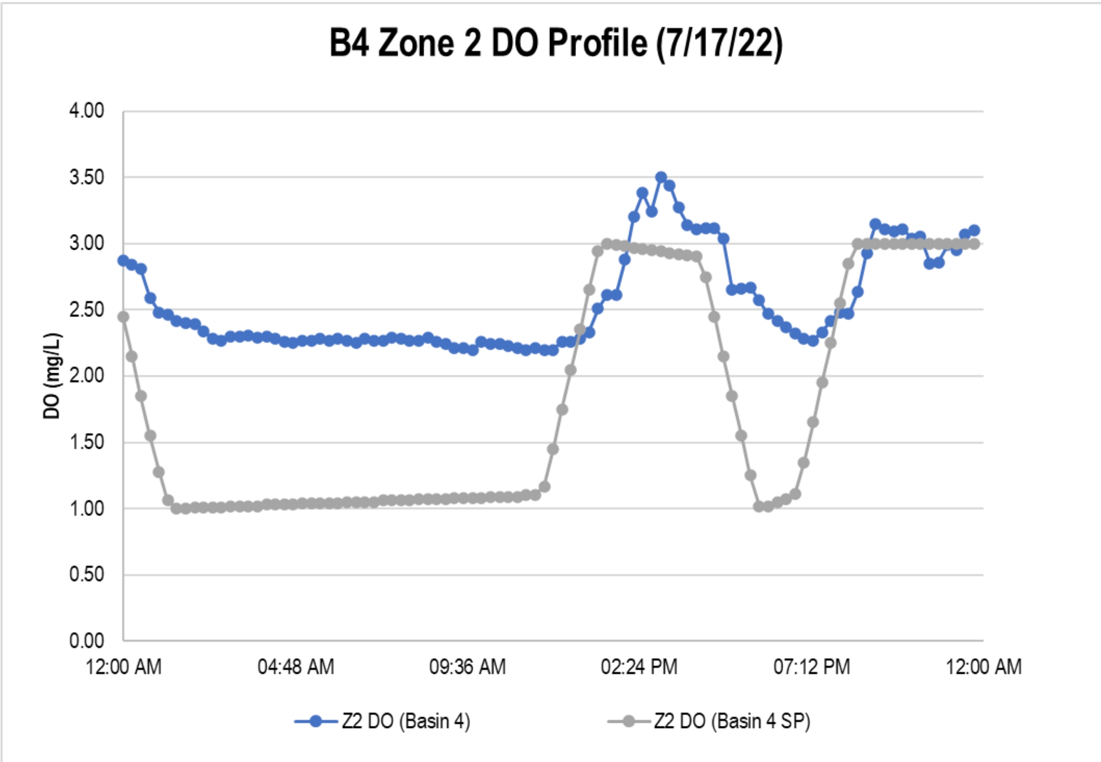


Figure 4-8. Basin 4, Zone 2 DO profile (non-centrate day)

To further illustrate the potential load distribution issue, Figure 4-9 and Figure 4-10 show the airflow demand for each online basin overlaid through the day. Basins 3 and 4 tend to track relatively closely, though the peaks and valleys of the flow profile are offset a bit. However, Basin 1 has a noticeably lower airflow profile in many instances, suggesting either a flow limitation (or potential overfeeding of air to Basins 3 and 4) or a demand discrepancy. At very low flows, it is possible that the blowers are reaching a minimum flow (approximately 1,800 scfm) even though air demands of the system are lower (as an example, Basin 4, Zone 2 DO remained higher than the set point on July 17, 2022, even though the airflow was near the minimum and similar to Basins 1 and 2).

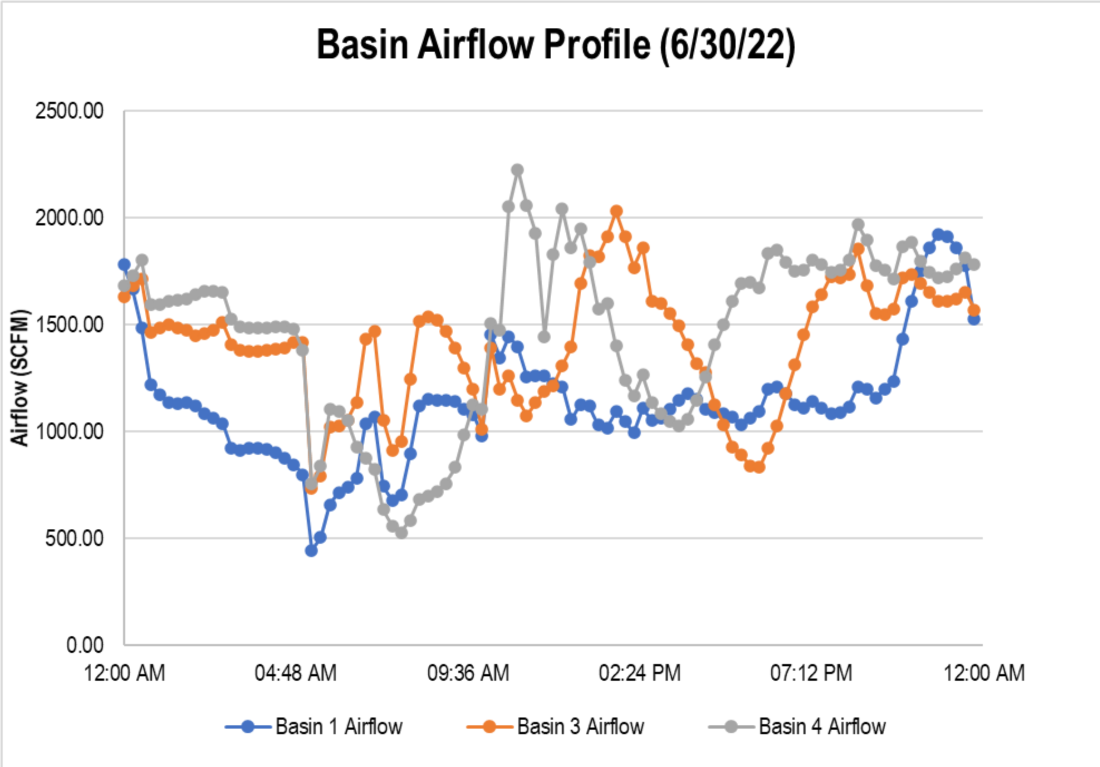


Figure 4-9. Example of basin airflow profile (centrate day)

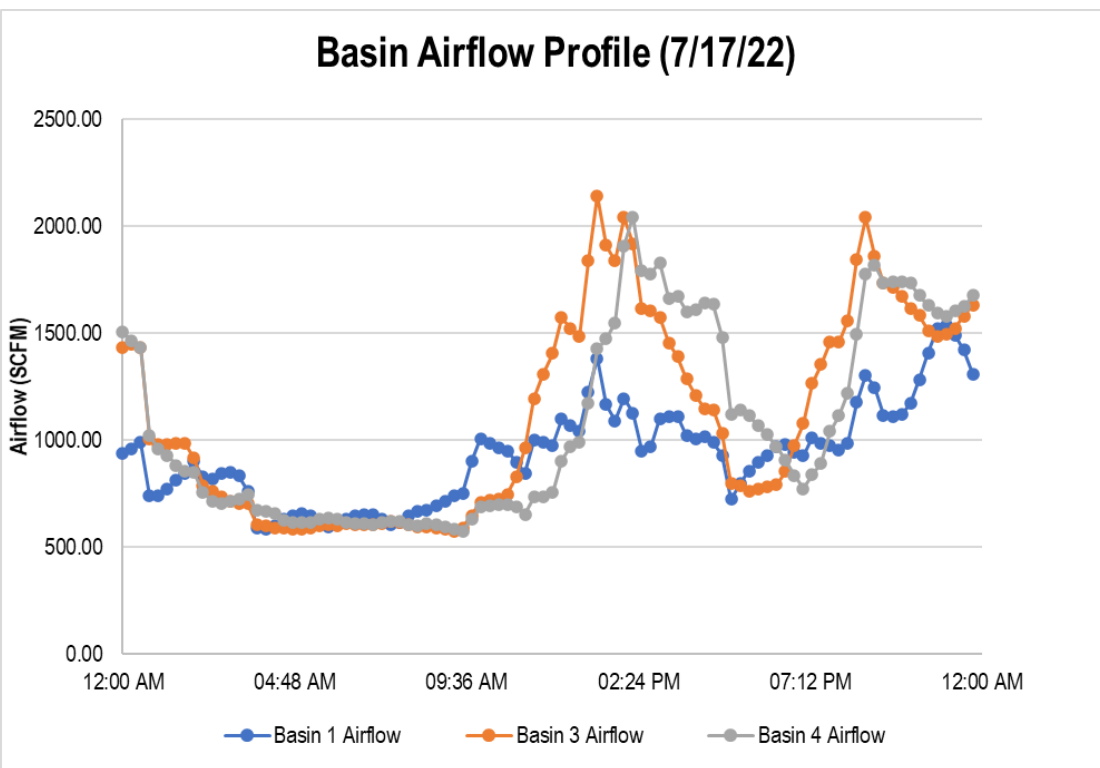


Figure 4-10. Example of basin airflow profile (non-centrate day)

Centrate and Ammonium Loading Variability

Figure 4-11, Figure 4-12, Figure 4-13 and Figure 4-14 show the ammonium profile in Zone 1 and Zone 5 of each basin for the same 2 days during ABAC operation discussed previously relative to aeration and DO patterns. The first day (June 30, 2022) included centrate loading that began in the early afternoon and also shows an initial peak that may partially be from centrate loading the previous day (June 29, 2022). The second day (July 17, 2022) shows a more general rise in ammonium related to increasing loading through the day. The centrate day has higher peak values as well as an overall higher loading because of the lack of equalization in comparison with the non-centrate day. The patterns on a given day generally hold for both Zone 1 and Zone 5.

The figures also demonstrate the potential issue with probe accuracy and with loading related to the fact that the ammonium profiles are not consistent across the basins (as would be expected with an even flow and load split). The Zone 1 ammonium graphs, for either day, shown Basin 3 with a chronically higher ammonium load compared with Basin 1 and Basin 4 (which are relatively similar). CKTP staff noticed this issue and commented on it in their field logs (Appendix D). Despite this apparent high ammonium level, by the time the flow reaches Zone 5, the ammonium levels (on either day) are very similar between Basin 3 and Basin 4, while Basin 1 tends to be much lower. As noted in the previous discussions regarding DO patterns, the Zone 5 ammonium probe is the controlling instrument for establishing DO setpoints for Zone 2 and Zone 4. Consequently, because ammonium levels in Zone 5 are relatively similar for Basin 3 and Basin 4, the pattern of DO setpoints and airflow are very similar on a given day for those basins. The Basin 1 setpoints and airflow tend to be lower as the Zone 5 ammonium tends to be lower. This is expected and follows the intent of the current control programming.

One possible explanation for this pattern could stem from an assumption that the Basin 3, Zone 1 ammonium probe is chronically inaccurate. Given the fact that the hydraulic loading of primary effluent (and centrate), as discussed previously and shown in Figure 3-8, would likely favor Basin 3 and Basin 4 over Basin 1, if the actual influent ammonium to Basin 3 was more closely aligned to Basin 4, this would explain how a similar air input and pattern of DO setpoints would lead to similar ammonium levels in Zone 5. The Basin 3, Zone 1 ammonium level could simply be inaccurate, or at least exaggerated, as a significant reason for the discrepancy.

In addition to the potential for probe inaccuracy, there remains the potential for some degree of loading imbalance or air delivery imbalance. Using the June 29, 2022 data as an example, the Basin 3, Zone 2 DO profile (Figure 4-4) compared with the Basin 4, Zone 2 DO profile (Figure 4-5), while very similar, suggests that Basin 3 may have had a somewhat higher ammonium load due to the fact that Basin 4 was unable to reduce the DO levels in Zone 2 (lower demand) while Basin 3 effectively met the lower DO setpoint with similar overall air flow (Figure 4-9). As previously discussed, the inability of Basin 4 to reduce the DO levels to the targeted setpoint could also be the result of an imbalance in air flow in which the total air to Basin 4, although similar to Basin 3, is not effectively split to Zone 2 (overaerated) compared with Zone 3 and Zone 4. Flow meters only measure total flow to a basin and flow splitting must be inferred through other variables.

Basin 1 consistently has a lower ammonium level in Zone 5 compared to the other basins, while the Zone 1 ammonia levels are similar to Basin 4. This seemingly more aggressive reduction in ammonium comes despite the fact that total aeration in Basin 1, as shown previously, tends to be lower than both Basins 3 and 4. This suggests that Basin 1 may be more lightly loaded compared with Basins 3 and 4 relative to influent flow splitting (which would include centrate recycle flows), supporting the observations noted for Figure 3-8 related to primary effluent flows favoring Basin 3 and Basin 4.

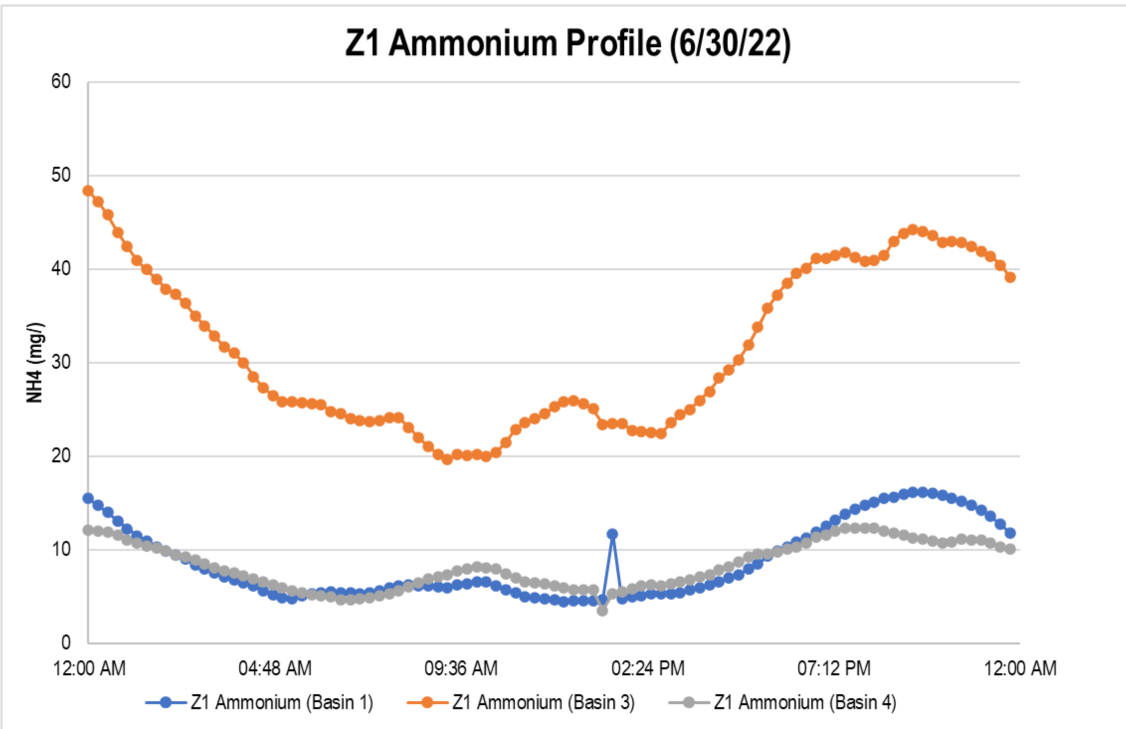


Figure 4-11. Example of Zone 1 NH_4 profile (centrate day)

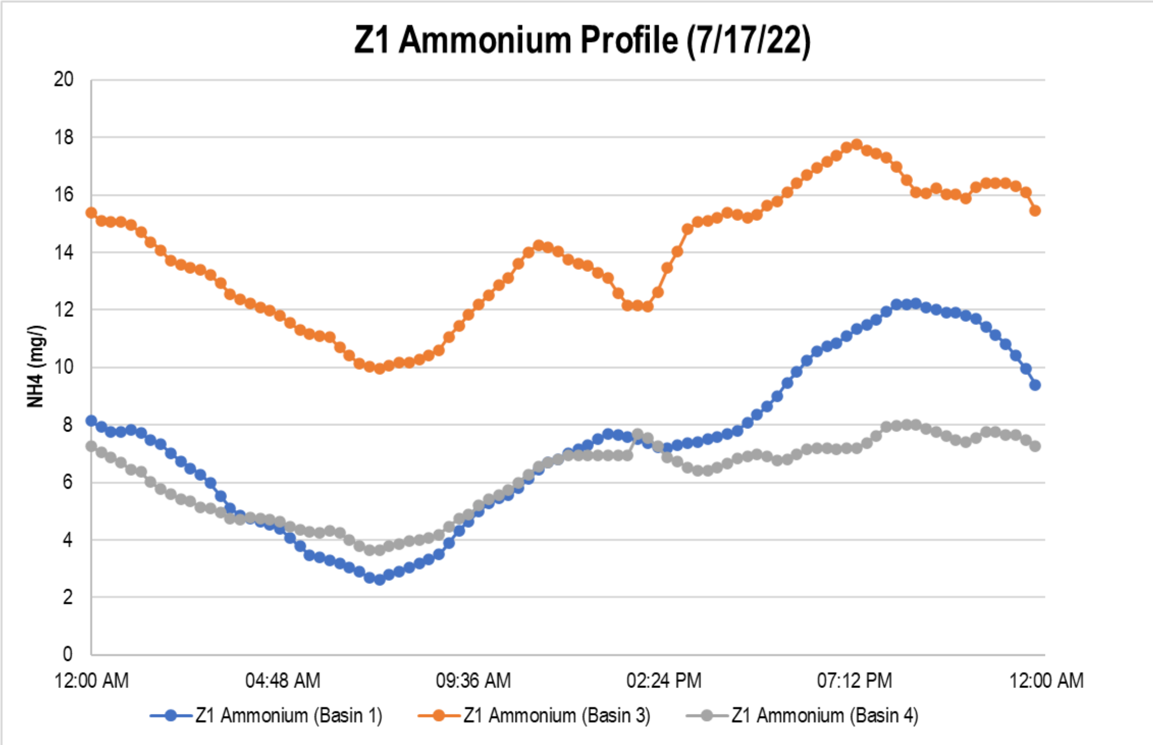


Figure 4-12. Example of Zone 1 NH_4 profile (non-centrate day)

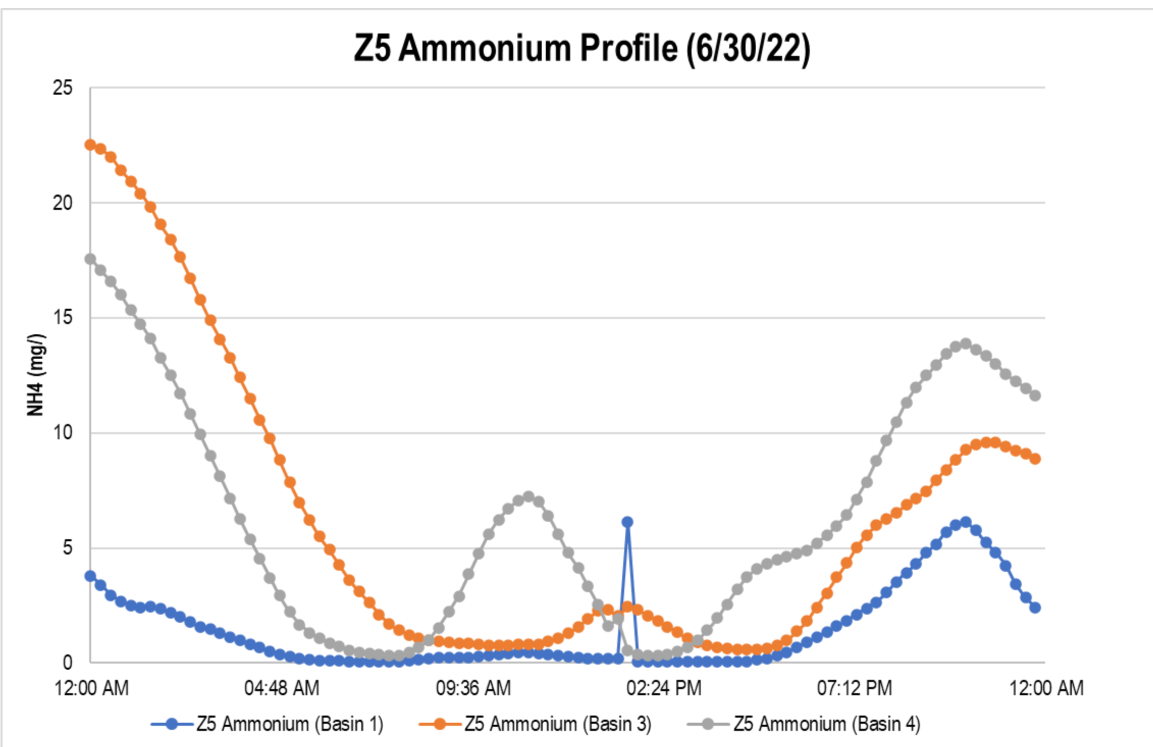


Figure 4-13. Example of Zone 5 NH_4 profile (centrate day)

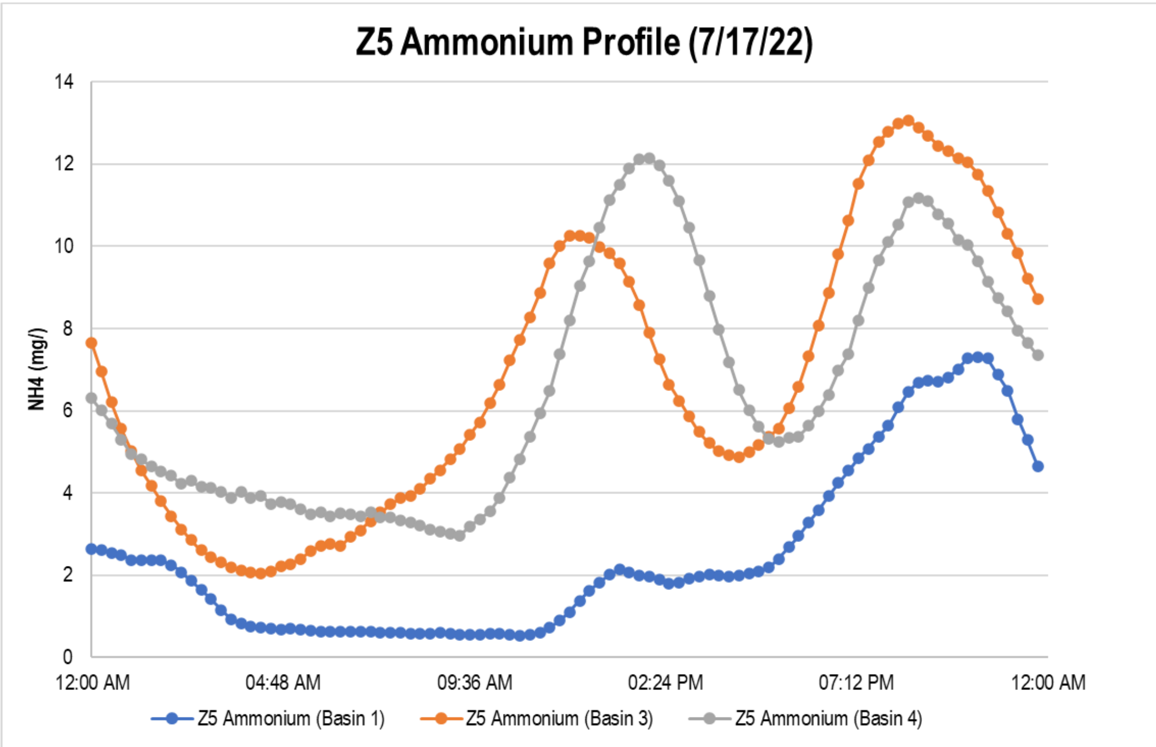


Figure 4-14. Example of Zone 5 NH_4 profile (non-centrate day)

4.3 Implications for TIN Reduction Capacity and General Permit Compliance

Given the results of the limited field testing, it is instructive to compare the performance with expectations related to the NGP AA loading limits that have been provided to CKTP by Ecology as well as general expectations for plant performance relative to potential effluent TIN concentration goals.

Table 4-3 provides a general summary of the ability of CKTP to achieve a modest TIN goal (< 10 mg/L) and a more aggressive TIN goal (< 3 mg/L), both of which are related to potential effluent limits the plant could see in the long-term. These conditions could not be fully vetted during field testing, so the summary is an engineering judgement based on the theoretical modeling performed as well as the plant response during testing at current conditions and capabilities.

For each flow/loading condition, the ability of the plant to meet the goal is judged as either Yes, No, or Possible. If the condition is listed as Possible, reference is made to the Tier optimization improvements (as outlined in Section 5.2) that would be "required" to achieve this goal (i.e. they would be judged as necessary to have a realistic chance to meet the effluent target on an AA basis). In addition, for conditions that are either Yes or Possible, optimization improvements are also listed as "recommended" that would not necessarily be required, but would likely make the effluent target easier to achieve with less risk of failure.

Table 4-3. Projected AA performance at current and projected loading for CKTP

Basis of Flow and Loading	AA (mgd)	Ability to Meet TIN < 10 mg/L	Required Modifications	Ability to Meet TIN < 3 mg/L	Required Modifications
Permitted Design Flow (~2028 design conditions)[c]	4.6	Yes	-Tier 1 improvements recommended	Possible[b]	-Tier 1 improvements required -Tier 2 improvements recommended
Build-out Conditions (2042 design conditions)	5.4	Possible	-Two additional Basins required[a] -Tier 1 improvements recommended	Possible[b]	-Tier 1 improvements required -Tier 2 improvements recommended

a. Recommended per Brown & Caldwell Basis of Design (2011).

b. If modifications implemented as noted, a TIN of < 3 mg/L for summer should be possible. Annual average should be < 5 mg/L, but may not reach < 3 mg/L.

c. Based on 2028 design conditions as similar to permitted design annual average flow.

Through previous negotiations with Ecology, the CKTP annual load limit for TIN has been set at 306,000 pounds per year (lb/yr). Table 4-4 provides a broad view of the average yearly effluent TIN concentration that would be required to meet the NGP given current CKTP flows, projected future flows, and at flows matching the field testing period for 2022 discussed in this memorandum. In general, the effluent limits, which are well above 20 mg/L, tend to reflect CKTP's historical operation as a standard secondary treatment plant with moderate levels of BNR.

Table 4-5 provides an alternatives analysis in which current and future flows are assumed to operate at AA effluent concentrations consistent with what was achieved during the BNR field testing period. What is immediately noticeable is that AA loading, even at projected 2042 conditions, is well within the allowable tolerances. Even though the BNR field testing was short-lived and has significant avenues available for future optimization, the initial efforts to test and establish new control tools and operate in a stable nitrification and denitrification arrangement produces an effluent that is significantly improved relative to effluent TIN.

Table 4-4. Projected maximum AA concentration per current NGP loading allowance for CKTP

Category	Flow (mgd)	Load (lb/yr)	Maximum AA TIN concentration (mg/L)
October 2020 sampling period	3.2	306,000	31.4
2028 projected AA flow	4.0	306,000	25.2
Current permit AA design flow	4.6	306,000	21.9
2042 projected AA flow	5.4	306,000	18.6
2022 field testing (total period)	3.7	306,000	27.3
2022 field testing (March 15–July)	3.4	306,000	29.8

Table 4-5. Projected loading contribution of CKTP under current and future flow conditions Per AA TIN concentrations measured during field testing

Design criterion	Average daily flow (mgd)	Centrate days[a]		Non-centrate days[b]	
		TIN (mg/L)[a]	Projected AA load (lb/yr)	TIN (mg/L)[b]	Projected AA load (lb/yr)
October 2020 sampling period	3.2	9.7	94,350	6.6	64,270
2028 projected AA flow	4.0	9.7	117,938	6.6	80,338
Current permit AA design flow	4.6	9.7	135,628	6.6	92,388
2042 projected AA flow	5.4	9.7	159,216	6.6	108,456
2022 field testing (total period)	3.7	9.7	108,735	6.6	74,069
2022 field testing (March 15–July)	3.4	9.7	99,370	6.6	67,690

a. Assumes AA concentration calculated during stable period of field testing (3/15/2022 through end of test period).

b. Assumes AA concentration calculated during stable period of field testing (3/15/2022 through end of test period).

Section 5 provides specific recommendations for next steps; however, in the interim the following conclusions are noted:

- Operating year-round BNR provides a great deal of effluent TIN flexibility for CKTP, even without further optimization given the results of the current field testing.
- CKTP has the capability to achieve TIN levels less than 10 mg/L and even less than 3 mg/L (at least seasonally), but further optimization projects will be required to achieve this reliably.
- At future 2042 flows, assuming implementation of recommended upgrades (Murraysmith 2021) for expansion of the RAS pumping and secondary clarifiers, basic BNR operation could allow CKTP to remain at roughly half of the annual load limit even at the 2042 AA flow conditions with four operating aeration basins.

5 Optimization Recommendations

This section provides a list of what should be considered optimization options that have been partially or completely implemented as part of the current field testing, as well as the recommended next stage of optimization projects in order of value for CKTP. This information is provided for both planning purposes and to document efforts completed to this point, both of which are necessary for reporting requirements in the current NGP.

Ultimately, CKTP is now in a position, with both staff experience and available operational tools, to operate stable BNR throughout the year. The next stage of optimization reflects ways to increase the stability and efficiency of the current operation, as well as to refine the average effluent TIN to reach values closer to the theoretical modeling (consistently less than 5 mg/L and closer to 3 mg/L as often as possible).

5.1 Summary of Completed Optimization Efforts

The following is a list of completed BNR optimization activities as part of the 2022 field testing efforts:

- Completed implementation of stable MOV aeration control and new DO probes
- Integrated new NH_4/NO_3 probes and commissioned an operational ABAC mode
- Installed new automated (NO_3-controlled) mode for IMLR pumps
- Installed new automated (NO_3-controlled) mode for methanol pumps, including fixing of methanol speed to volume controls
- Instituted partially flow-paced RAS pumping to better correlate solids inventory with nutrient loading
- Integrated new backup control loops for aeration blowers to improve reliability for BNR operation
- Identified influent hydraulic, RAS pumping, and aeration control limitations that can be integrated into future optimization efforts

5.2 Optimization Project Recommendations

Given the results of the initial modeling and the lessons learned during the field testing, the following are recommended as the next stage of optimization projects. The projects are listed in order of precedence given the potential value to further stabilize the BNR operation and further reduce effluent TIN.

Tier 1 (High Priority)

The following are Tier 1 recommendations:

- **Centrate equalization:** As noted in the early modeling efforts, and as seen in NH_4 spikes and decreased effluent quality on centrate processing days relative to non-centrate days, equalizing NH_4 flows to distribute the loads more evenly across the week would provide stability to BNR operation and improve overall average effluent TIN.

- **IMLR and methanol field testing:** Field operation of the ABAC mode using close tracking and observation of IMLR and methanol feeds at alternative set points was not completed during the original testing. Each of these control loops (methanol and IMLR) warrant more explicit full-scale testing. Refinement of these controls may help optimize BNR performance and provide field confirmation that methanol is accurately split between each online aeration basin (Zone 5). This project should be done after completion of the methanol storage upgrades noted below as another Tier 1 recommendation.
- **Full year operation:** It is recommended to continue BNR operation in warmer months and through the next winter and summer to gain additional data and operational experience for refinement of operating protocols and control programming. CKTP should continue to test optimal NH_4 and NO_3 set points to determine best operating procedures. It may be possible to reduce methanol feed rates or operate without methanol during certain periods of the year given CKTP's flexibility with regard to the NGP load allocations. This would also present an opportunity to refine the calibration of the Zone 1 and Zone 5 probes, particularly as influent hydraulics are revised and there is more confidence that flows and loads to each basin are equal.
- **Aeration basin influent hydraulic upgrades:** CKTP should conduct an engineering study (potentially with computational fluid dynamics modeling) of the aeration basin influent hydraulic box to determine modifications necessary to allow efficient mixing of RAS and PE and distribution to each basin. Correcting this imbalance, and the potential current arrangement in which PE and RAS are not equally distributed between basins, is critical to maintaining consistent effluent performance as well as efficiently integrating other optimization strategies (i.e., centrate equalization is less effective if flow cannot be accurately distributed between basins).
- **RAS flow improvements:** CKTP should implement fully automated flow pacing of the RAS pumping system (within current constraints). This can be combined with an engineering study into the value of increasing RAS capacity and potentially modifying the secondary clarifiers to lower the minimum RAS rate required for clarifier mechanism operation.
- **Methanol storage:** CKTP should add a second methanol storage tank to provide the flexibility for CKTP staff to maintain consistent methanol dosing with flexibility in scheduling methanol deliveries.

Tier 2 (Moderate Priority)

The following are Tier 2 recommendations:

- **Aeration distribution upgrades:** CKTP should conduct an engineering study to review flow meters, control valve sizing and locations, and the air distribution network to develop design improvements to the physical air distribution and control equipment.

- **Blower upgrades:** CKTP should initiate replacement of the existing centrifugal blowers with additional high-speed turbo blowers (replace a Lamson unit with at least two new Aerzen units). This will allow for additional capacity and redundancy and keep the aeration operation consistent with one type of blower. Low NH_4 set points, as staff noted, began to require high aeration loading (extensive blower runtime) from both existing high-speed turbo blowers. The blowers may be reaching a minimum flow at times and additional air is feeding zones that do not need it (consequently inhibiting denitrification to some degree). In addition, with further Aerzen units, a master control panel (MCP) can be added by Aerzen to provide central coordinated control of all turbo blowers. This is generally recommended for multi-blower systems, as it gives CKTP a single point of contact with the entire blower system and allows the blower vendor to internally make decisions regarding the speed of each blower and number of blowers that should be online to meet the process demands with maximum efficiency. Additional blowers can be added in the future and connected to the MCP as needed.
- **Nitrogen probe upgrades:** To address the challenges with low-end accuracy for NH_4/NO_3 probes, particularly for the Zone 5 and effluent locations, CKTP should upgrade to wet chemistry measurement systems, such as the Amtax / Nitratax (Hach) or ChemScan, to allow for low-level (less than 1 mg/L) monitoring and control. These systems include a centralized monitoring station that can be fed from multiple sample points and includes reagents that require periodic replacement. The units are typically higher capital cost (roughly $100,000, order of magnitude), but can be more efficient in operation and maintenance (without the expensive replacement of ISE probe caps) and can be calibrated to low range accuracy with plant specific water quality. It is recommended to solicit a proposal from each of the two vendors noted above for a single centralized unit to serve Basins 1 & 2 (Zone 5) and another unit to serve Basins 3 & 4 (Zone 5). An initial trial of a single unit for Basins 3 & 4 would also be feasible to confirm operation and accuracy.

Tier 3 (Low Priority)

The following are Tier 3 recommendations:

- **Sidestream treatment:** As shown in the initial modeling, this option may provide an excellent long-term option to reduce nitrogen loads as CKTP digestion dewatering centrate stream loads continue to increase (with septage loads, etc.). In the short term, centrate equalization and control improvements noted previously would be more critical; however, sidestream treatment could be an alternative to additional aeration basin construction or as a means of further nitrogen reduction once aeration basin capacity is at buildout conditions.
- **Step-feed field testing**: While step-feed shows potential, it is not necessary to meet near term BNR goals and would require additional capital improvements. Consequently, it is recommended to review the value of this process in the long term as the facility reaches BNR capacity and larger scale improvements are warranted. Step-feed optimization may be a lower cost alternative or means to extend the life of existing infrastructure prior to additional basin construction.

5.3 Optimization Project Costs

Table 5-1 provides a summary of the opinion of probable construction cost (OPCC) for the Tier 1, 2 and 3 projects listed in the previous section. The OPCCs are based on a Class 5 estimate (-50 percent to +100 percent) as defined by the Association for the Advancement of Cost Engineering (AACE). The actual construction costs may differ from the cost estimates developed based on different design and construction requirements and the economic climate at the time of bidding.

Details of the assumptions for each project cost are provided in Appendix E. The costs provided included the following key assumptions:

- Centrate equalization will be accomplished with a new tank (coated concrete) and will not utilize existing tankage or equipment.
- Additional field testing is assumed at a set allowance ($25,000) for the time of the engineers and integrator to continue to assist CKTP staff for the associated efforts. This applies to both Tier 1 and Tier 3 recommended field testing.
- RAS Flow Improvements are assumed to be an engineering analysis and predesign effort only with an allowance of $100,000.
- Sidestream treatment is roughly approximated as a new Annamox type system based on parametric cost estimating of a similar sized plant to CKTP.
- Hydraulic modifications to the aeration basin influent are assumed to require computational fluid dynamics (CFD) modeling as well as various baffles or additional mixers. An allowance is provided for this effort.
- Additional blowers for aeration to replace the current Lamson units are assumed to include two turbo blowers with an associated MCP to tie all the existing turbo blowers together.
- The extent of the upgraded aeration piping/valves is not currently known. The estimate assumes new control valves and flow meters for each pair of zones in each basin as a basis for a conservative cost that can be adjusted once an engineering analysis is completed.
- Nitrogen probe upgrades assume two new wet chemistry analytical units (such as ChemScan or Hach), with each unit servicing two of the four existing basins.
- Total project costs include a 25 percent allowance for engineering and administration applied to the total construction cost, and a 25 percent allowance for construction services and allied costs.
- Values shown are in current dollars and do not include escalation.

Table 5-1. OPCC for Recommended Optimization Projects

Project	Construction Cost	Project Cost
Centrate Equalization	$2,182,000	$3,274,000
IMLR and Methanol Field Testing/Full Year Operation	$20,000	$30,000
Aeration Basin Influent Hydraulic Upgrades	$592,000	$888,000
RAS Flow Improvements (Analysis)	$100,000	$150,000
Methanol Storage	$495,000	$743,000
Tier 1 Total	**$3,389,000**	**$5,085,000**
Aeration Distribution Upgrades	$822,000	$1,234,000
Blower Upgrades	$1,013,000	$1.521,000
Nitrogen Probe Upgrades	$607,000	$911,000
Tier 2 Total	**$2,442,000**	**$3,666,000**
Sidestream Treatment	$6,289,000	$9,435,000
Step-Feed Field Testing	$20,000	$30,000
Tier 3 Total	**$6,309,000**	**$9,465,000**

6 References

Brown & Caldwell

2011 *Central Kitsap Treatment Plant Reclamation and Reuse Project Volume 1: Basis of Design*. August.

Murraysmith

2020 *Central Kitsap WWTP Aeration Diffuser Emergency Replacement Basis of Design*. November.

2021 *Central Kitsap Wastewater Facility Plan and Sewer Plan Update: Chapter 6—Wastewater Treatment Facilities Existing Conditions (CKTP).* November.

Appendix A. Wastewater Characterization Testing Protocol

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Technical Memorandum – DRAFT UPDATE

To:	Barbara Zaroff, Chris Sheridan, Matt Pickering (Kitsap County)
From:	Jeffrey Zahller (HDR), Bryce Figdore (HDR), Miaomiao Zhang (Murraysmith)
Date:	9/23/2020 (UPDATE)
Subject:	Central Kitsap Treatment Plant Sampling Plan

1.0 Introduction

This memorandum outlines the proposed sampling plan at Kitsap County's (County) Central Kitsap Treatment Plant (CKTP) per Task 0100.08 of Facility/Sewer Plan Updates. The overall purpose of the sampling is to better characterize influent wastewater, other wastewater streams, and performance of unit processes at CKTP. The data will be used to develop a calibrated BioWin process model for the plant, which will subsequently be used in evaluations of biological nutrient removal (BNR) optimization scenarios.

The sampling campaign will involve daily composite and grab sampling as well as diurnal sampling to evaluate the dynamic loading pattern at CKTP. The County already collects a significant amount of analytical data for CKTP. Many parameters at locations of interest are already routinely measured at the plants. As will be shown, additional analyses proposed under this sampling plan will provide some additional enhancement to the already substantial data set.

2.0 Locations and parameters of interest

This section broadly identifies the sampling locations and wastewater parameters of interest. Specific sampling plans and details are discussed in subsequent sections.

The following locations of interest are included in the sampling campaign:

Main liquid streams:

- Influent wastewater
- Primary effluent
  - Note: For CKTP, an automated sampler will be set to measure the combined effluent from all primary clarifiers.
- Secondary effluent
  - Note: For CKTP, the current plant effluent samples represent a blend of filtered and unfiltered secondary effluent. The majority of the flow is not filtered. For this study, it is acceptable to maintain the current routine sampling point. The "true" secondary effluent can be estimated on flow and mass balance principles, with potentially extra grab samples on the filtered effluent to confirm assumptions. Such an approach is appropriate considering the current BOD-removal operation and the goals of the study.

Liquid return streams from solids handling:

- Thickening filtrate from Rotary Drum Thickener (RDT) and Gravity Thickener (GT)
- Dewatering recycle (Centrate)

Solids streams:

- Primary sludge (thickened in GT as Thickened Primary Sludge (THS))
- Waste activated sludge (thickened in RDT as Thickened Waste Activated Sludge (TWAS))
- Thickened solids (TWAS from RDT and THS from GT)
- Digested solids
- Dewatered cake
- Scum/Grease (fed directly to digesters)
- Septage (thickened in GT)
- Hauled TWAS from other Kitsap County plants (fed to digesters)

Depending on sampling location, the following parameters may be analyzed:

- Total suspended solids (TSS)
- Total solids (TS) in concentrated solids streams
- Volatile suspended solids (VSS)
- Volatile solids (VS) in concentrated solids streams
- Chemical oxygen demand (COD)
- COD, filtered at 1.2 um
- COD, flocculated and filtered at 0.45 um
- 5-day biochemical oxygen demand (BOD_5)
- Volatile fatty acids (VFA)
- Total Kjeldahl nitrogen (TKN)
- Ammonia (NH_3-N)
- Nitrite (NO_2-N)
- Nitrate (NO_3-N)
- Total phosphorus (TP)
- Orthophosphate (PO_4-P)
- Alkalinity
- pH

During the meeting held with the County on July 30th 2020, it was established that there are composite samplers currently present at the primary influent and final effluent (blended with 1 MGD of water passing through the effluent filters) locations. However, the primary effluent samples are all grab samples. The County mentioned that there is an extra composite sampler that could potentially be placed at one of the primary clarifiers' effluent location. To optimize the BNR process, centrate sampling will also be crucial to confirm recycled nitrogen loading.

In addition, though less critical to the liquid stream BNR process outside of the centrate stream, to support analysis of the volatile solids reduction (VSR) challenges in the anaerobic digesters, it will be worthwhile to perform sampling for the various digester feed streams to better understand the nature of the sludge coming from the other treatment plants in addition to CKTP. Consequently, sampling of both combined and individual solids streams are shown in Table 1, with keynote indications that sampling from individual plants need only be done on days when solids are transported.

3.0 Approach and sampling matrices

Table 1 shows matrices identifying the parameter, location, and sample type proposed for sampling campaigns at CKTP. Many of the parameters and locations are routinely sampled by CKTP staff and would be expanded over the testing period as shown. The Kitsap laboratory would be capable of running all the tests shown, but a third-party laboratory could also be employed as needed, based on workload and staff availability.

The matrix assumes the composite samplers on the influent and effluent remain in place, and the additional available composite sampler located on the effluent is relocated to a convenient effluent location on one of the primary clarifiers.

Sampling can be categorized as follows based on the sample type, objectives, and number of sampling events:

1. **Daily 24-hr composite sampling for the main liquid flow streams.** This category involves analysis of the greatest number of parameters to characterize the influent wastewater and liquid train performance. Most parameters are already routinely analyzed at the plants. Additional parameters related to nutrients and COD fractions are required for wastewater characterization. Twelve (12) sampling events are proposed for this category. Sampling days do not need to be consecutive, although having 3-4 days to represent weekends versus weekdays is useful. Near-term sampling under dry weather conditions (September/October 2020) will be optimal for initial process model development and solids estimates, even if the sampling period experiences some wet weather in October. However, additional Category 1 composite sampling under winter wet weather conditions may provide insight on seasonal differences in wastewater characteristics which may impact nutrient removal design (e.g., lower VFA concentrations in winter). The need for a second round of sampling will be evaluated after the initial data collection and model development is completed.
2. **Daily grab sampling for liquid return streams from solids handling.** This category identifies the solids and nutrient return loads to the main treatment process. Grab sampling at stable solids handling operation is acceptable, and should be done on days when the dewatering (centrate) operation is in progress. Composite sampling is also acceptable but not necessary. Six (6) sampling events are proposed for this category and should coincide with Category 1, 24-hr composite sampling when possible. Measuring RDT and GT return streams, though more routine in operation, can be done on the same days as centrate sampling.
3. **Daily grab sampling of solids streams.** This category informs solids and COD balances in the solids treatment train. Some solids concentrations are routinely analyzed at the plant, but additional sampling would help provide a full characterization of the various solids contributions to the anaerobic digesters. Grab sampling at stable solids handling operation is acceptable. Solids concentrations are routinely analyzed at the plant, but COD concentrations are not. Twelve (12) sampling events are proposed for this category and should coincide with Category 1 24-hr composite sampling. Septage and scum/grease sampling can be limited to days when flows are available.
4. **Diurnal grab sampling of influent wastewater.** This category involves sampling of the “core” influent wastewater parameters required to establish a representative 24-hr diurnal loading pattern for process modeling. Manual grab samples at 2-hr intervals are acceptable. Alternatively, a multi-bottle automated sampler can be used to obtain grab samples at 2-hr or

possibly 1-hr intervals. Two 24-hr diurnal sampling events are proposed. The days do not need to be consecutive or coincide with other sampling categories.

Table 1. Sampling Matrix for CKTP

	Liquid Streams						Solids Streams								
Parameter / **Location**	**Influent wastewater**	**Primary effluent**	**Final effluent (blended)**	**RDT Return**	**GT Return**	**Dewatering recycle (Centrate)**	**Primary sludge**	**RAS / WAS**	**RDT Thickened Solids**	**GT Thickened Solids**	**Digested solids**	**Combined TWAS (with hauled TWAS)**	**Hauled TWAS (individual from other Kitsap Plants)[e]**	**Scum/Grease**	**Septage**
TSS[a]	C,D	C	C	G	G	G	G	G	G	G	G	G	G	G	G
VSS[a]	C,D	C	C	G	G	G	G	G	G	G	G	G	G	G	G
COD, total	C,D	C	C	G	G	G	G	G	G	G	G	G	G	G	G
COD, filtered (1.2-um)	C,D	C	C	-	-	-	-	-	-	-	-	-	-	-	-
COD, flocculated+filtered (0.45-um)[b]	C	C	C	-	G	-	G[d]	-	-	G[d]	-	-	-	-	-
BOD_5	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Oxygen	D	G	-	-	-	-	-	-	-	-	-	-	-	-	-
VFA	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-
TKN	C,D	C	C	G	G	G	G[d]	G[d]	-	-	-	G[d]	-	-	-
NH_3-N	C,D	C	C	G	G	G	-	-	-	-	-	-	-	-	-
NO_2-N[c]	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-
NO_3-N[c]	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-
TP	C,D	C	C			G	-		-	-	-	-	-	-	-
PO_4-P	C,D	C	C	G	G	G	-		-	-	-	-	-	-	-
Alkalinity	C,D	C	C	-		-	-	-	-	-	G	-	-	-	-
pH	C,D	C	C	-		-	-	-	-	-	G	-	-	-	-
Sampling Events (D)	**2**	**-**	**-**	**-**			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Sampling Events (C)	**12**	**12**	**12**	**-**			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Sampling Events (G)				**6**	**6**	**6**	**12**	**12**	**12**	**12**	**12**	**12**	**12[e]**	**6[f]**	**12[g]**

Table notes:

C = 24-hr composite sampling

D = diurnal automated or manual grab sampling at 2-hr intervals

G = grab sample (composite also acceptable)

[a]TS and VS are appropriate for thickened and dewatered solids streams. For grease, dilutions can be used prior to testing to allow for easier sample handling and manipulation if the grease is not already mixed with more dilute scum prior to feeding to the digester.

[b]Filter option is discussed below; 1.2-um is also acceptable.

[c]Combination nitrate/nitrite testing is acceptable.

[d]Four grab samples for these parameters are acceptable. The purpose of measuring ffCOD on primary settled and thickened primary solids is to evaluate extent of potential fermentation. The purpose of measuring TKN on the solids streams is to characterize the nitrogen content of the sludge.

[e]Sampling of individual solids streams from Kingston, Manchester, and Suquamish plants should be done on days when a transfer takes place during the sampling events. Sampling would not occur on days when solids are not transported. The actual number of samples collected will depend on the number of the truck loads, but preferably at least two (more is preferred) samples shall be collected from each plant. Consequently, the sampling proposed is simply an extension (with COD) of the testing plant staff already perform when solids are transported.

[f] It's understood that the scum/grease and septage loads don't have a regular schedule. It is preferred that three samples are collected right after grease is dumped to the scum pit. Other samples should be just the scum in order to better determine the load increase attributed to grease. Please note the sampling condition each time.

[g] Since the plant receives 15 to 20 septage trucks, the plant staff could decide the sampling time for the daily grab to fit their schedule. The samples could be collected after screening and degritter but before combining with primary sludge.

All sampling can be done during near-term dry-weather flow conditions. Together, the sampling data and flow rates at time of sampling can be used to develop design daily composite loads and diurnal load profiles. Together with historical influent flow, BOD, and TSS data, the daily composite and diurnal loads can subsequently be used to extrapolate design conditions at wet weather flows and peak loads. Thus, additional diurnal sampling under wet weather conditions is not required for design or process modeling, per se, but can be performed if needed after the additional nutrient removal optimization review.

It is noted that the following data relevant to process modeling are available and thus not specified above as part of the sampling plan needs. These items should be monitored during the sampling period to ensure accurate information, if available either through SCADA trending or field:

- Temperature – influent, primary effluent, aeration basins, and effluent
- Flow rates:
  - Influent
  - Effluent
  - RAS
  - Centrate
  - Primary sludge
  - Waste activated sludge (WAS) from CKTP
  - Septage
  - Scum/grease
  - Solids streams (WAS) from other Kitsap plants fed to digester
- Dissolved oxygen (DO) concentrations – aeration basins
- Aeration rates (scfm) – aeration basins
- Mixed liquor solids concentrations
- SRT – target versus actual
- Aeration basins in service
- Digester volatile solids reduction
- Biosolids cake hauled

The items above are not intended to represent an inclusive list of available plant data but to confirm that appropriate additional data are available for process modeling as much as reasonably possible.

It is assumed that diurnal influent flow rates, aeration basin DO concentrations, return sludge flow rates, and process air flow rates can be obtained from SCADA.

4.0 Analytical methods and responsibility

A sampling kickoff meeting and/or call will be conducted to review this draft memorandum and confirm specific sampling locations and analytical methods currently used by County lab staff. Where possible, Standard Methods should be used to analyze parameters listed in Table 1. Alternate methods currently used or potentially used in the sampling plan should be identified.

Nearly all parameters in the sampling matrices are familiar to lab staff and can be performed in-house. The frequency of certain parameters that will be analyzed much more frequently than normal would be:

- COD, total. For solids streams, samples will require dilution prior to testing, use Hach high range COD vials. It is recommended to experiment with the dilution range to confirm the order of magnitude prior to actual testing. Once the dilution is established, it should remain relatively consistent for the testing period.
- COD, filtered at 1.2 um. Filtrate from TSS measurement can be used. A small sample volume of only a few mL is required for COD analysis. The resulting COD corresponds to the sum of true soluble plus colloidal COD.
- COD, flocculated and filtered at 0.45 um. Raw wastewater (or other sample) is flocculated to remove colloids using either a) zinc sulfate with pH adjustment or b) aluminum sulfate without pH adjustment. Flocculant is added under rapid mixing, then followed by slower mixing for several minutes during the flocculation period. The sample is allowed to settle. Supernatant is filtered and analyzed for COD. The resulting COD corresponds to the true soluble COD. Literature and experience has shown that filtration at 1.2 um after flocculation gives similar results as filtration at 0.45 um (Wentzel et al., 2000, "Evaluation of A Modified Flocculation Filtration Method to Determine Wastewater Readily Biodegradable COD"). Accordingly, a 1.2 um glass fibre filter can be used to reduce the cost of the test procedure or if 0.45-um filters are not readily available. Additional details on the method can be provided separately.
- Volatile fatty acids. Measured by distillation method and completed by County staff.
- TKN. Required to quantify the influent organic nitrogen fraction (and thus total nitrogen load).

All samples will be collected by the CKTP staff. An outside lab can be used to reduce the demand on lab staff if desired. A final sampling plan will be memorialized based on input from the County.

5.0 Schedule

The sampling campaign can be initiated as soon as the sampling plan is finalized based on County's input. Because the plan is not reliant on wet weather sampling, per se, all samples can be collected and analyzed during dry weather conditions. Ideally, the sampling campaigns can be completed in September, and the resulting data can be used for model calibration at what are anticipated to be relatively stable flows and loads.

CKTP Biowin Sampling Type and Location

Parameter	Liquid Stream							Solid Stream										
	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS	C	C	C	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
VSS	C	C	C	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Total COD	C	C	C	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Filtered COD (fCOD)	C	C	C															
Flocculated-Filtered COD (ffCOD)	C	C	C		G	G		G			G	G						
BOD	C	C	C															
DO	C	C																
VA	C	C																
Total Kjeldahl Nitrogen (TKN)	C	C	C	G	G	G	G	G	G						G			
Ammonia-Nitrogen (NH3)	C	C	C	G	G	G	G											
Nitrate+Nitrite Nitrogen (NO3+NO2)	C	C	C															
Total Phosphorus (TP)	C	C	C				G											
Orthophosphate (Ortho-P)	C	C	C	G	G	G	G											
Alkalinity	C	C	C										G	G				
pH	C	C	C										G	G				

Note: C = Composite G = Grab

CKTP Biowin Sampling Results (10/6/20)

	Liquid Stream							Solid Stream											
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT MN	STT SQ	Scum / Grease	Septage Effluent
TSS mg/L	284	83.3	5.02	84	182	207	G		3417										
VSS mg/L	263	70.8	4.01	71	163	183	G		2883										
TS %								0.55%	0.34%	6.31%	5.08%	4.39%	2.33%	2.34%	5.82%	6.18%	5.88%	G	2.11%
TVS %								87.2%	75.0%	82.1%	88.2%	87.2%	78.0%	77.0%	82.3%	86.6%	87.0%	G	80.2%
Total COD mg/L	610	340	34	55	699	682	G	2050	3737	77400	70700	50400	28000	28000	67100	71000	68500	G	52200
Filtered COD (fCOD) mg/L	258	233	23																
Flocculated-Filtered COD (ffCOD) mg/L	162	101	20		230	173		315			4300	3500							
BOD mg/L	335	196	6.70																
DO mg/L	2.2	3.3																	
VA mg/L	82.1	69.0																	
Total Kjeldahl Nitrogen (TKN) mg/L	57.6	49.5	16.1	25.5	63.6	72.3	G	272	368						183				
Ammonia-Nitrogen (NH3) mg/L	38.4	41.0	14.6	21.6	41.3	47.1	G												
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	3.33																
Total Phosphorus (TP) mg/L	7.06	7.70	3.27				G												
Orthophosphate (Ortho-P) mg/L	4.03	4.66	2.06	4.41	10.5	9.57	G												
Alkalinity mg/L	290	276	184										4238	4090					
pH SU	7.53	7.47	7.74										7.32	7.28					

Note: C = Composite G = Grab

WEATHER: Dry

CKTP Biowin Sampling Results (10/7/20)

	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Grease	Septage Effluent
TSS mg/L	268	76.8	4.58	127	229	207	G		3428									
VSS mg/L	245	63.6	3.75	106	198	178	G		2869									
TS %								0.76%	0.35%	5.79%	5.98%	4.40%	2.39%	2.36%	6.02%	G	0.22%	2.17%
TVS %								86.9%	75.0%	82.8%	87.2%	84.4%	77.9%	79.2%	81.3%	G	86.2%	79.1%
Total COD mg/L	618	361	32	25	657	482	G	10450	3879	66000	134300	61400	20500	41000	61000	G	5550	27150
Filtered COD (fCOD) mg/L	220	203	29															
Flocculated-Filtered COD (ffCOD) mg/L	133	141	28		213	120		265			3200	4000						
BOD mg/L	324	188	6.76															
DO mg/L	2.3	0.8																
VA mg/L	62.6	66.4																
Total Kjeldahl Nitrogen (TKN) mg/L	57.9	49.4	9.25	22.2	59.7	50.5	G	352	506						192			
Ammonia-Nitrogen (NH3) mg/L	42.6	39.8	7.63	10.8	39.1	33.9	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	3.54															
Total Phosphorus (TP) mg/L	6.86	6.40	0.66				G											
Orthophosphate (Ortho-P) mg/L	3.62	4.16	0.33	2.52	10.9	7.89	G											
Alkalinity mg/L	290	280	156										4200	4000				
pH SU	7.56	7.55	7.72										7.24	7.21				

Note: C = Composite G = Grab

East, West Thickener ffCOD corrected on 10/19. MCP

WEATHER: Dry

CKTP Biowin Sampling Results (10/9/20)

Inlfuent composite sample not valid	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	282	84.1	6.02	91	247	242	194		3100									
VSS mg/L	264	75.0	4.82	77	2117	212	142		2593									
TS %								0.71%	0.31%	5.90%	4.76%	3.85%	2.39%	2.31%	5.63%	G	G	1.47%
TVS %								85.3%	78.3%	81.2%	87.4%	85.1%	77.7%	77.9%	80.9%	G	G	74.7%
Total COD mg/L	709	397	40	98	742	621	499	18700	3481	75300	63000	50700	28800	27000	70300	G	G	12700
Filtered COD (fCOD) mg/L	285	255	36															
Flocculated-Filtered COD (ffCOD) mg/L	181	165	36		261	176		692			4600	3400						
BOD mg/L	334	199	7.72															
DO mg/L	2.5	0.9																
VA mg/L	74.0	60.0																
Total Kjeldahl Nitrogen (TKN) mg/L	54.4	69.5	15.2	9.80	59.8	49.4	1010	390	312						187			
Ammonia-Nitrogen (NH3) mg/L	39.4	57.8	13.9	4.26	37.9	33.9	982											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	4.21															
Total Phosphorus (TP) mg/L	7.62	12.9	3.21				252											
Orthophosphate (Ortho-P) mg/L	3.17	9.25	2.83	0.62	10.7	8.41	476											
Alkalinity mg/L	273	C	178										4320	4186				
pH SU	7.73	7.65	7.73										7.29	7.28				

Note: C = Composite G = Grab

Influent composite sample line removed from channel and not replaced. Only 7 of 24 samples during the day collected. MCI

WEATHER: Rain started at 2000

CKTP Biowin Sampling Results (10/10/20)

	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum	Septage Effluent
TSS mg/L	262	70.7	5.74	121	304	260	G		3350									
VSS mg/L	242	38.3	4.83	106	277	225	G		2850									
TS %								0.68%	0.34%	5.88%	4.92%	4.33%	2.34%	2.29%	5.64%	G	0.66%	G
TVS %								88.9%	91.7%	81.7%	89.0%	86.8%	79.4%	78.7%	81.2%	G	92.6%	G
Total COD mg/L	650	358	38	160	1004	931	G	11900	4100	69900	68500	76800	26300	26400	61200	G	20050	G
Filtered COD (fCOD) mg/L	221	230	35															
Flocculated-Filtered COD (ffCOD) mg/L	155	140	36		402	299		304			5000	5700						
BOD mg/L	301	170	9.26															
DO mg/L	2.8	0.8																
VA mg/L	62.6	62.6																
Total Kjeldahl Nitrogen (TKN) mg/L	48.2	43.1	17.8	29.4	63.4	59.6	G	644	382						138			
Ammonia-Nitrogen (NH3) mg/L	36.5	34.6	17.2	22.4	38.3	37.3	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	1.86															
Total Phosphorus (TP) mg/L	5.84	6.08	2.06				G											
Orthophosphate (Ortho-P) mg/L	2.87	3.64	1.63	4.80	14.1	12.0	G											
Alkalinity mg/L	260	252	190										4396	4118				
pH SU	7.54	7.58	7.79										7.51	7.44				

Note: C = Composite G = Grab

WEATHER: Rain overnight. Stopped at 0800.

CKTP Biowin Sampling Results (10/11/20)

Parameter	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	279	68.2	5.99	84	162	186	G		2733									
VSS mg/L	255	59.1	5.39	73	155	167	G		2280									
TS %								0.31%	0.29%	5.86%	5.36%	4.37%	2.42%	2.35%	5.59%	G	G	G
TVS %								93.3%	76.9%	82.3%	89.4%	87.2%	78.6%	78.0%	81.8%	G	G	G
Total COD mg/L	927	368	42	119	822	688	G	34750	3568	69900	63200	132800	28800	28800	69500	G	G	G
Filtered COD (fCOD) mg/L	251	231	33															
Flocculated-Filtered COD (ffCOD) mg/L	147	141	37		427	327		179			5100	3500						
BOD mg/L	401	174	9.54															
DO mg/L	2.4	1.2																
VA mg/L	64.0	72.0																
Total Kjeldahl Nitrogen (TKN) mg/L	46.8	39.8	13.0	16.3	46.0	40.6	G	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	34.8	32	11.6	10.7	26.4	24.5	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	1.38															
Total Phosphorus (TP) mg/L	6.22	5.51	1.49				G											
Orthophosphate (Ortho-P) mg/L	2.99	3.16	1.10	1.46	11.3	9.43	G											
Alkalinity mg/L	250	240	176										4280	4110				
pH SU	7.45	7.52	7.72										7.31	7.36				

Note: C = Composite G = Grab

RDT Filtrate corrected 10/19. MCP

WEATHER: Dry AM. Rain started at 1000 continued overnight

CKTP Biowin Sampling Results (10/13/20)

	Liquid Stream							Solid Stream											
				RDT	East Thickener	West Thickener	12-Oct	Primary	RAS	RDT	East Thickened	West Thickened	East	West	Blending	STT	Scum	Grease	Septage
Parameter	Influent	PCE	Effluent	Filtrate	Effluent	Effluent	Centrate	Sludge		Solids	Sludge	Sludge	Digester	Digester	Tank	M,S,K			Effluent
TSS mg/L	250	77.6	5.05	129	281	245	699		4157										
VSS mg/L	225	67.3	4.73	111	256	218	523		3457										
TS %								0.76%	0.36%	5.85%	5.27%	5.07%	2.40%	2.33%	5.49%	G	0.32%	2.30%	1.28%
TVS %								90.4%	80.0%	81.5%	90.1%	89.0%	78.0%	77.5%	81.9%	G	85.9%	92.5%	78.9%
Total COD mg/L	585	342	36	73	1000	917	525	41800	4756	74500	71700	84300	21600	29000	64700	G	4250	55250	25600
Filtered COD (fCOD) mg/L	216	78	31																
Flocculated-Filtered COD (ffCOD) mg/L	126	68	34		464	439		889			4300	4700							
BOD mg/L	285	155	10.2																
DO mg/L	3.4	3.1																	
VA mg/L	57.0	57.0																	
Total Kjeldahl Nitrogen (TKN) mg/L	50.1	43.9	18.2	36.1	62.9	55.0	1050	351	553						162				
Ammonia-Nitrogen (NH3) mg/L	33.0	32.7	15.5	22.4	33.5	29.5	983												
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	2.80																
Total Phosphorus (TP) mg/L	5.7	5.71	0.49				276												
Orthophosphate (Ortho-P) mg/L	2.68	3.37	0.19	2.06	11.6	9.49	237												
Alkalinity mg/L	244	248	176										4304	4088					
pH SU	749	7.54	7.79										7.34	7.27					

Note: C = Composite G = Grab

NOTICE: Centrate is dated 10/12. MCP

WEATHER: Rain overnight. Dry at 1000

CKTP Biowin Sampling Results (10/14/20)

	Liquid Stream							Solid Stream											
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum	Grease	Septage Effluent
TSS mg/L	285	82.2	5.52	111	302	318	549		3525										
VSS mg/L	265	73.3	5.19	100	285	290	415		2950										
TS %								0.71%	0.36%	5.51%	5.58%	5.36%	2.42%	2.34%	5.43%	G	0.10%	2.90%	1.94%
TVS %								90.8%	80.0%	81.2%	88.9%	88.1%	78.1%	78.8%	81.1%	G	76.8%	94.1%	78.7%
Total COD mg/L	599	341	33	269	1004	1008	888	8400	4280	59500	73400	82400	29500	28500	69200	G	1500	24500	28050
Filtered COD (fCOD) mg/L	227	185	31																
Flocculated-Filtered COD (ffCOD) mg/L	134	124	38		388	404		394			4600	1000							
BOD mg/L	337	153	9.78																
DO mg/L	2.5	1.4																	
VA mg/L	64.2	51.3																	
Total Kjeldahl Nitrogen (TKN) mg/L	54.6	58.1	12.5	22.7	68.9	67.1	1050	G	G						G				
Ammonia-Nitrogen (NH3) mg/L	38.3	45.5	10.7	9.59	38.4	35.8	971												
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	5.06																
Total Phosphorus (TP) mg/L	6.49	8.9	0.52				283												
Orthophosphate (Ortho-P) mg/L	3.19	7.08	0.2	1.48	0.06	0.06	237												
Alkalinity mg/L	268	292	152										4304	4082					
pH SU	7.50	7.72	7.73										7.34	7.26					

Note: C = Composite G = Grab

East, West Thickener Effluent OP possible Lab error. MCP

WEATHER: Dry

CKTP Biowin Sampling Results (10/15/20)

Parameter	Liquid Stream							Solid Stream										
	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT SQ	Scum / Grease	Septage Effluent
TSS mg/L	311	70.6	7.54	229	242	229	G		2426									
VSS mg/L	286	64.7	6.89	189	220	205	G		1994									
TS %								0.55%	0.26%	6.10%	5.00%	5.21%	2.41%	2.35%	5.39%	5.28%	G	3.48%
TVS %								88.9%	72.2%	79.7%	88.5%	88.2%	77.5%	77.1%	79.9%	87.6%	G	76.3%
Total COD mg/L	811	375	39	662	797	759	G	7000	2660	70000	59900	93300	34000	26700	67200	74000	G	34450
Filtered COD (fCOD) mg/L	237	207	33															
Flocculated-Filtered COD (ffCOD) mg/L	139	134	29		329	571		401			3700	4800						
BOD mg/L	373	179	11.5															
DO mg/L	2.5	1.5																
VA mg/L	51.6	48.4																
Total Kjeldahl Nitrogen (TKN) mg/L	54.8	52.7	11.8	42.7	73.7	66.1	G	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	38.8	41.0	10.5	13.9	47.0	40.6	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	9.82															
Total Phosphorus (TP) mg/L	6.53	7.51	1.38				G											
Orthophosphate (Ortho-P) mg/L	3.4	5.71	0.95	1.36	11.3	G	G											
Alkalinity mg/L	270	278	142										4244	4044				
pH SU	7.57	7.61	7.63										7.33	7.31				

Note: C = Composite G = Grab

SEE diurnal results to the right. MCP

WEATHER: Dry

Diurnal Results

15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	16-Oct	16-Oct	16-Oct
700	900	1100	1300	1500	1700	1900	2100	2300	100	300	500
183	164	196	368	223	340	514	249	218	174	164	133
178	155	182	336	205	319	468	236	24	165	150	129
726	740	503	879	535	776	1046	698	687	634	645	503
316	286	201	197	214	283	292	285	303	292	305	292
49.3	51.0	48.0	62.2	67.1	66.2	63.6	55.9	56.7	51.9	50.8	51.9
34.6	37.7	34.7	43.7	48	45.8	44.1	42.0	38.4	36.7	36.4	37.6
5.55	5.85	5.28	7.98	7.1	7.27	7.41	6.61	6.13	5.32	5.28	5.52
3.15	3.57	2.72	4.48	4.55	4.65	4.1	3.88	3.55	3.02	3.03	3.33
250	260	252	280	300	306	292	270	280	268	280	270
7.31	7.25	7.46	7.51	7.68	7.58	7.41	7.45	7.42	7.40	7.39	7.37

CKTP Biowin Sampling Results (10/16/20)

	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	287	85.7	7.44	55.3	257	225	839		2491									
VSS mg/L	263	76.9	6.55	50.6	235	205	669		2085									
TS %								0.80%	0.26%	6.14%	5.72%	5.54%	2.40%	2.33%	5.73%	G	G	2.30%
TVS %								91.0%	80.0%	80.4%	87.9%	87.9%	78.0%	78.9%	79.0%	G	G	73.7%
Total COD mg/L	644	335	52	219	744	847	1391	31900	3814	64100	91800	88600	12300	11700	75100	G	G	29050
Filtered COD (fCOD) mg/L	243	188	36															
Flocculated-Filtered COD (ffCOD) mg/L	140	110	38		208	218		322			800	1500						
BOD mg/L	309	138	12.1															
DO mg/L	3.00	2.3																
VA mg/L	63.4	33.7																
Total Kjeldahl Nitrogen (TKN) mg/L	55.4	65.1	11.3	12.3	63.8	55.5	1080	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	38.7	52.6	10	7.65	35.5	32.1	973											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	11.9															
Total Phosphorus (TP) mg/L	6.27	10.8	4.73				292											
Orthophosphate (Ortho-P) mg/L	3.47	9.02	4.33	2.69	9.05	8.75	234											
Alkalinity mg/L	280	325	128										G	G				
pH SU	7.46	7.68	7.49										G	G				

Note: C = Composite G = Grab

WEATHER: Dry

CKTP Biowin Sampling Results (10/18/20)

Parameter	Liquid Stream							Solid Stream										
	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	258	61.2	6.85	286	227	161	G		2067									
VSS mg/L	239	51.8	5.82	249	207	143	G		1767									
TS %								0.21%	0.22%	6.26%	4.94%	4.48%	2.33%	2.35%	5.96%	G	G	G
TVS %								75.0%	87.5%	81.9%	89.8%	88.7%	77.8%	78.2%	80.9%	G	G	G
Total COD mg/L	676	351	41	117	664	561	G	2750	2538	73600	125800	54500	28900	29200	72400	G	G	G
Filtered COD (fCOD) mg/L	256	225	34															
Flocculated-Filtered COD (ffCOD) mg/L	167	133	34		204	195		188			5000	6800						
BOD mg/L	361	158	8.11															
DO mg/L	5.1	2.6																
VA mg/L	78.7	60.5																
Total Kjeldahl Nitrogen (TKN) mg/L	54.5	42.9	3.99	16.6	53.8	46.3	G	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	38.6	33.2	1.77	2.88	31.5	27.7	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	9.15															
Total Phosphorus (TP) mg/L	6.44	5.79	4.25				G											
Orthophosphate (Ortho-P) mg/L	3.43	3.98	4.02	7.65	6.33	9.29	G											
Alkalinity mg/L	276	256	112										G	G				
pH SU	7.49	7.54	7.52										G	G				

Note: C = Composite G = Grab

WEATHER: Light rain overnight and during day

CKTP Biowin Sampling Results (10/19/20)

Parameter	Liquid Stream							Solid Stream										
	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	246	67.4	7.59	1380	159	162	G		2250									
VSS mg/L	231	58.7	5.94	1113	140	142	G		1894									
TS %								0.27%	0.26%	6.02%	4.57%	4.23%	2.37%	2.37%	5.81%	G	G	1.28%
TVS %								91.7%	70.0%	84.6%	91.2%	91.1%	78.8%	79.3%	82.4%	G	G	84.0%
Total COD mg/L	627	340	41	370	517	420	1212	4350	2602	75900	63400	64600	28900	31700	75900	G	G	35800
Filtered COD (fCOD) mg/L	239	204	36															
Flocculated-Filtered COD (ffCOD) mg/L	144	133	36		163	135		204			4800	3200						
BOD mg/L	321	166	10.7															
DO mg/L	4.1	3.3																
VA mg/L	71.4	49.6																
Total Kjeldahl Nitrogen (TKN) mg/L	55.2	65.6	10.0	22.0	40.5	32.3	1130	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	38.3	52.6	7.8	1.29	23.0	18.4	1050											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	5.18															
Total Phosphorus (TP) mg/L	6.39	11.3	5.15				280											
Orthophosphate (Ortho-P) mg/L	3.54	9.57	4.78	6.85	8.50	6.98	267											
Alkalinity mg/L	286	320	144										G	G				
pH SU	7.54	7.67	7.58										G	G				

Note: C = Composite G = Grab

WEATHER: mostly dry

CKTP Biowin Sampling Results (10/21/20)

	Liquid Stream							Solid Stream										
Parameter	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT M,S,K	Scum / Grease	Septage Effluent
TSS mg/L	267	67.4	7.99	495	264	280	341		2239									
VSS mg/L	244	58.7	6.71	423	228	166	246		1890									
TS %								0.29%	0.24%	6.25%	4.48%	4.60%	2.35%	2.33%	5.78%	G	G	1.01%
TVS %								84.6%	85.0%	83.9%	88.3%	88.1%	77.6%	78.9%	82.8%	G	G	87.2%
Total COD mg/L	671	349	43	232	828	683	1181	3775	2676	77700	59100	75400	31700	30500	72000	G	G	30100
Filtered COD (fCOD) mg/L	250	209	36															
Flocculated-Filtered COD (ffCOD) mg/L	144	135	36		252	209		199			2500	3200						
BOD mg/L	317	165	12.2															
DO mg/L	5	3.8																
VA mg/L	64.8	59.3																
Total Kjeldahl Nitrogen (TKN) mg/L	59.2	69.4	10.7	34.9	77.8	69.0	G	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	40.7	55.00	8.34	3.78	49.4	44.3	1030											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	9.55															
Total Phosphorus (TP) mg/L	6.72	11.3	5.61				264											
Orthophosphate (Ortho-P) mg/L	1.60	8.95	4.96	4.60	13.1	10.8	92.4											
Alkalinity mg/L	276	320	130										G	G				
pH SU	7.56	7.72	7.52										G	G				

Note: C = Composite G = Grab

Centrate TKN : Lab Error. May try to reanalyze, time allowing. MCF

WEATHER: Rain overnight. T-Storms in AM

Diurnal Results											
21-Oct	21-Oct	21-Oct	21-Oct	21-Oct	21-Oct	21-Oct	21-Oct	21-Oct	22-Oct	22-Oct	22-Oct
700	900	1100	1300	1500	1700	1900	2100	2300	100	300	500
204	167	209	257	291	309	298	238	250	178	108	174
187	154	191	235	265	278	264	221	221	161	100	157
620	547	565	620	662	749	802	705	659	584	508	620
294	291	229	220	248	301	326	314	296	303	305	308
49.6	49.3	47.6	56.0	63.5	63.9	64.9	57.5	52.6	48.2	45.6	46.3
38.6	37.8	39.00	43.6	49.7	47.8	49.7	44.5	39.6	38.3	36.4	37.1
5.98	6.03	5.91	7.01	7.86	8.07	7.96	6.88	6.26	5.8	5.27	5.73
3.37	3.31	3.59	4.33	4.71	4.8	4.82	4.18	3.21	3.00	3.02	3.44
266	260	254	276	290	286	304	280	294	284	270	258
7.36	7.32	7.40	7.52	7.58	7.47	7.51	7.43	7.64	7.56	7.47	7.34

CKTP Biowin Sampling Results (10/22/20)

Parameter	Liquid Stream							Solid Stream										
	Influent	PCE	Effluent	RDT Filtrate	East Thickener Effluent	West Thickener Effluent	Centrate	Primary Sludge	RAS	RDT Solids	East Thickened Sludge	West Thickened Sludge	East Digester	West Digester	Blending Tank	STT (23rd) SQ	Scum / Grease	Septage Effluent
TSS mg/L	962	88.4	8.51	75.9	231	195	G		2138									
VSS mg/L	843	75.8	7.09	69.6	169	108	G		1819									
TS %								0.65%	0.24%	6.40%	5.13%	4.11%	2.43%	2.31%	6.06%	5.02%	G	1.65%
TVS %								88.7%	76.2%	84.3%	88.6%	87.6%	78.1%	78.7%	83.9%	G	G	84.0%
Total COD mg/L	1055	354	48	170	802	614	G	8800	2611	75400	69400	46400	28900	28000	68700	66000	G	43000
Filtered COD (fCOD) mg/L	220	204	41															
Flocculated-Filtered COD (ffCOD) mg/L	137	119	45		222	165		342			3600	2700						
BOD mg/L	468	172	13.7															
DO mg/L	3.6	6.2																
VA mg/L	65.6	47.4																
Total Kjeldahl Nitrogen (TKN) mg/L	66.000	50.9	10.4	25.7	73.9	61.4	G	G	G						G			
Ammonia-Nitrogen (NH3) mg/L	39.0	37.6	15.4	17.00	48.7	41.8	G											
Nitrate+Nitrite Nitrogen (NO3+NO2) mg/L	<0.05	<0.05	5.85															
Total Phosphorus (TP) mg/L	7.26	6.37	6.08				G											
Orthophosphate (Ortho-P) mg/L	3.82	4.32	5.51	7.55	12.9	11.1	G											
Alkalinity mg/L	266	260	164										G	G				
pH SU	7.49	7.61	7.60										G	G				

Note: C = Composite G = Grab

Influent composite sample impacted by significant loading from random discharge. Influent sample black in color. We occassionally receive loads like this which we believe are from Navy discharges. We see this type of discharge at our Navy LS-17 frequently

WEATHER: Mostly Dry

Appendix B. Biological Nutrient Removal Field Testing Protocol

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Technical Memorandum – DRAFT

To:	Chris Sheridan (Kitsap County), Matt Pickering (Kitsap County), Miaomiao Zhang (Murraysmith)
From:	Jeffrey Zahller (HDR), Bryce Figdore (HDR)
Date:	12/15/2021
Subject:	Central Kitsap Treatment Plant Biological Nutrient Removal Field Testing Protocol

1.0 Introduction

This memorandum outlines the proposed biological nutrient removal (BNR) field testing protocol at Kitsap County's (County) Central Kitsap Treatment Plant (CKTP) per Task 0100.08 of Facility/Sewer Plan Updates. The overall purpose of the field testing is to accomplish the following:

- Demonstrate and document full-scale application of various modes of BNR operation, including:
    - Application of dissolved oxygen (DO) control under most-open-valve (MOV) aeration system operation
    - Application of ammonia-based aeration control (ABAC), utilizing new ammonia and nitrate probes, for the following:
        - Control of aeration via ammonium setpoints
        - Control of the Internal Mixed Liquor Recycle (IMLR) Pumps via nitrate setpoints
        - Control of methanol supplemental carbon feed via nitrate setpoints
- Determine the level of BNR that various modes are capable of achieving for current and future optimization in conjunction with requirements of the Department of Ecology (DOE) Nutrient General Permit (NGP).
- Determine capability of plant to achieve low TIN levels (< 3 mg/L) throughout the year or seasonally, and potential impacts on capacity.

This memorandum will outline three primary aspects of the testing plan for purpose of logistical coordination and to provide a standard operating procedure (SOP) for plant staff:

- Section 2 – Field Testing Scenarios
    - A description of each testing period, including the control variable(s) and initial setpoints required for operation – this will be the basis for the standard operating procedures during each test
- Section 3 – Sampling and Data Collection

    - A description of the composite and grab sample data that should be collected during each testing period, as well as SCADA data that should be downloaded, along with additional templates for data reporting

- Section 4 – Testing Schedule and Meetings
    - A short description of the current schedule and plan for team meetings and data evaluation

The ultimate goal of the BNR field testing is to establish an efficient series of optimization strategies for CKTP to implement as part of the NGP requirements, as well as provide real operational experience and data to allow the County to make more informed decisions regarding future capital project investments.

2.0 Field Testing Scenarios

The CKTP biological process is divided into four (4) Basins (trains) that operate in parallel, each of which includes six (6) Zones (Passes). A schematic example of a Basin is shown in **Figure 1**. Zone 1 and Zone 5 may be operated aerobically (with air) or as an anoxic zone (without air). Zone 4 includes the IMLR pump, which directs recirculation flow back to Zone 1.

Over the past year, the following key system improvements have been implemented, each of which are essential prerequisites for nutrient removal testing:

- The existing aeration diffusers (Aerostrip) have been replaced with Sanitaire disc diffusers, eliminating damaged diffusers and course air patches within the basins.
- DO probes have been installed and tested in Zone 2, Zone 4, and Zone 6.
- MOV control has been implemented for the butterfly control valves that regulate air to each Basin. One valve controls air to two zones: Zones 1 & 2, Zones 3 & 4, and Zones 5 & 6. A total of three control valves per Basin.
- The DO probes, in conjunction with the MOV operation, have been implemented at full-scale to allow operators to effectively control the system via a matrix of DO setpoints.
- New ammonium (NH_4)/nitrate (NO_3) probes have been installed in Zone 1 and Zone 5. These probes are required for the more advanced BNR applications.
- TSS sensors are located in Zone 5 of each Basin.

As of 12/15/21, two of the Hach SC200 controllers are not fully optimized (located in Basin 2, Zone2 and Zone 6). This impacts two DO probes (B2 Z2, B2 Z6), one ammonium/nitrate probe (B2 Z1) and one TSS meter (B2, Z5). These issues should be address by late January, which will allow for a local calibration to update the factory calibration. In addition, Hach field calibration for ammonium sensors was conducted prior to solids dewatering, when ammonium levels where low. They will repeat the process in early January with higher ammonium levels. At this point, the probes are trending and CKTP staff have confirmed that the factory calibrations are very accurate.

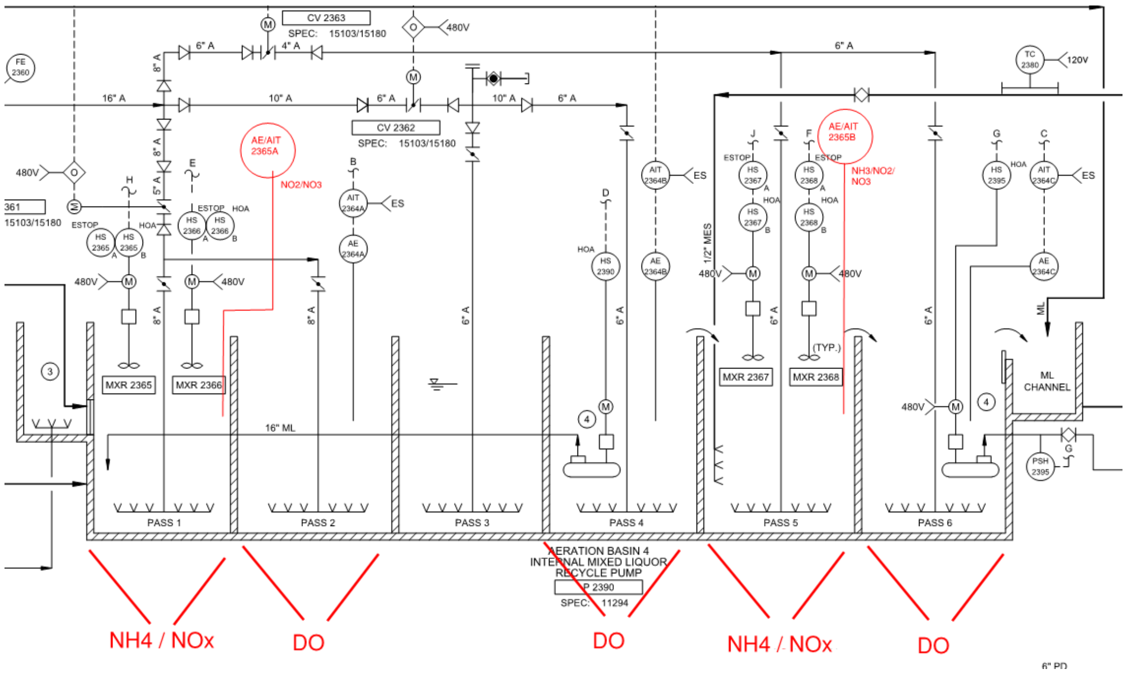

Figure 1 – Dissolved Oxygen and Nutrient Probe Locations

References to the Basins and Zones will follow the current CKTP nomenclature as described below in **Table 1** and shown in **Figure 2**.

Table 1 – Basin and Zone Nomenclature for CKTP Biological Process

Basin	Zone	Abbreviated Name	DO Probe	NH_4/NO_3 Probe	TSS Probe
1	1	B1 Z1		X	
	2	B1 Z2	X		
	3	B1 Z3			
	4	B1 Z4	X		
	5	B1 Z5		X	X
	6	B1 Z6	X		
2	1	B2 Z1		X	
	2	B2 Z2	X		
	3	B2 Z3			
	4	B2 Z4	X		
	5	B2 Z5		X	X
	6	B2 Z6	X		
3	1	B3 Z1		X	
	2	B3 Z2	X		
	3	B3 Z3			
	4	B3 Z4	X		

Basin	Zone	Abbreviated Name	DO Probe	NH_4/NO_3 Probe	TSS Probe
	5	B3 Z5		X	X
	6	B3 Z6	X		
4	1	B4 Z1		X	
	2	B4 Z2	X		
	3	B4 Z3			
	4	B4 Z4	X		
	5	B4 Z5		X	X
	6	B4 Z6	X		

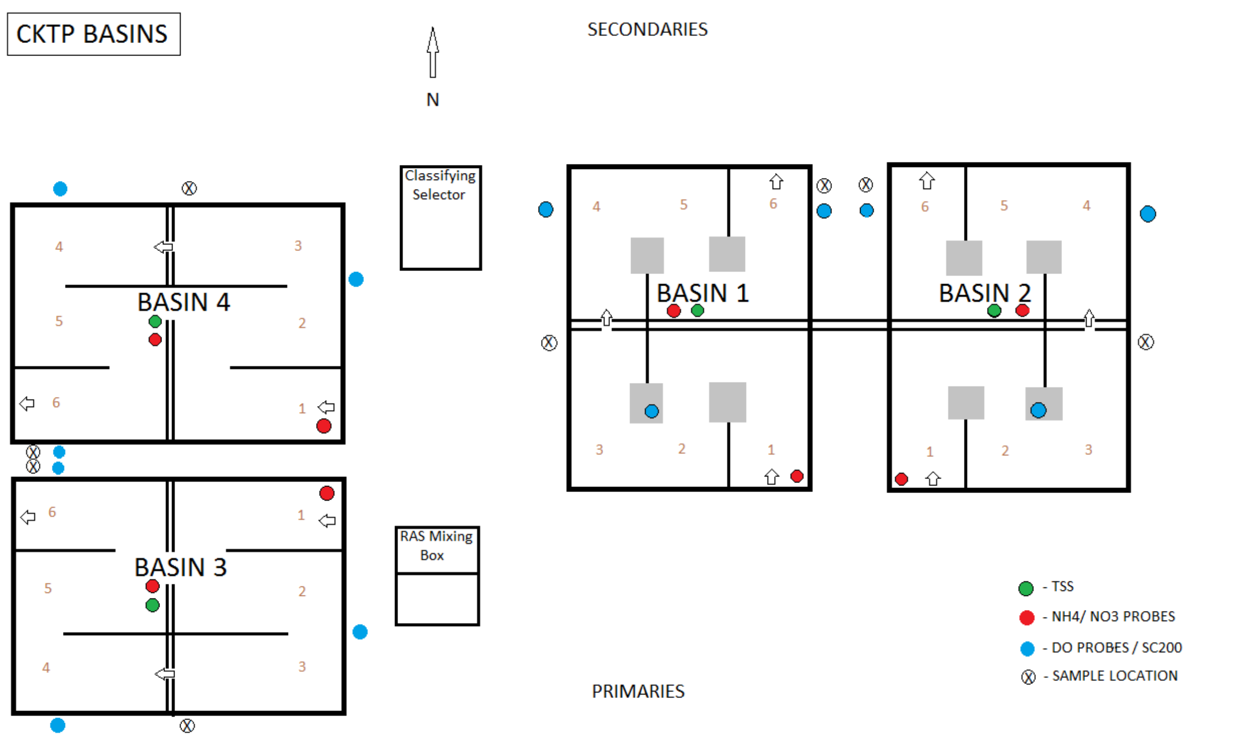

Figure 2 – CKTP Basin Configuration and Probe Location

The actual BNR testing will be divided into six (6) Periods of operation (A through F), as outlined in **Figure 3** below. This matrix table will serve as the backbone for the testing protocol, highlighting the mode of operation, key variables for control, and initial setpoints. However, it is not intended to be an inflexible sequence of events. While each Period of testing may start as shown in the table, the testing team will have the freedom to modify operation as data becomes available and the situation warrants. The Periods are intended to provide a logical sequence in which to test the effect of each unique aspect of the proposed ABAC operation. Control of the methanol pumps, IMLR, and aeration using the new ammonium/nitrate probes are introduced in successive Periods to allow for a clear understanding of the effects of each one as well as minimize the number of variables in play at a given time.

A short summary of the intent of each testing Period is provided below. The description and data provided assumes that the plant is operating all four (4) of the Basins in parallel. This is generally recommended as the preferred approach, as it allows for characterization of each individual Basin and a better determination of the “unique” operation that may arise when utilizing the full capacity of the plant. If necessary, the testing can be easily modified for a three Basin configuration.

Period A – Baseline Nitrification

The purpose of Period A is to establish full nitrification, under standard DO control, to prepare the plant biologically for more advanced BNR testing. In this Period, the plant inventory (mixed liquor suspended solids [MLSS] and solids retention time [SRT]) are adjusted to allow for complete nitrification. Based on previous modeling, the MLSS will need to exceed 2,000 mg/L to achieve this state, and full nitrification is an essential prerequisite for any substantive BNR that would follow. In this mode of operation, DO control, with particular attention to the aerobic SRT (see Section 3 of this memorandum for further discussion) are the basis of the standard operating procedure. IMLR and methanol feeds are maintained as indicated, and can be adjusted, if necessary, based on field observation by staff.

The plant is currently working on increasing solids inventory and is anticipating the necessary MLSS will be achieved by early January, 2022.

Period B – Introduce Nitrate Control of Methanol

The purpose of Period B is to continue operation exactly as established in Period A, but allow for automated control of the methanol via the newly installed ammonium/nitrate probe in Zone 5. As the nitrate increases, the methanol will increase to provide a carbon source for denitrification.

Period C – Introduce Nitrate Control of IMLR

The purpose of Period C is to continue operation exactly as established in Period B, but add the additional variable of NO_x/nitrate control for the IMLR pumps. In this case, the controlling variable is the Zone 1 NO_x/nitrate levels. As the nitrate level decreases below the setpoint, indicating denitrification capacity is available, the pumps can increase flow. If the level rises above the setpoint, indicating additional denitrification is not available, the pumps will slow down.

Period D – Introduce ABAC

The purpose of Period D is to build off Period B and Period C by adding full control of the aeration system via the ammonium/nitrate probe in Zone 5. MOV valve control and DO operation will still be in place, however, the Zone 2 and Zone 4 DO setpoints will be automatically adjusted up or down to achieve a particular ammonium level at the outlet of the basin. In this case, the aeration air is limited to produce only the level of nitrification necessary to meet the setpoint, with the added benefit of limiting recirculated oxygen from the IMLR pump and improving Zone 1 denitrification. Once Period D has been completed, all the major BNR variables will have had an opportunity for operation at full-scale.

Period E – Optimize for low Total Inorganic Nitrogen (TIN) with Methanol

The purpose of Period E is to build off Period D and begin to operate the system to achieve as low an effluent TIN as possible. In this case, the only operational change compared with Period D is to now set the methanol feed control to go to 1 mg/L of nitrate in Zone 5. Consequently, the system will be targeting both very low ammonium (~ 1 mg/L) as well as very low nitrate (~1 mg/L). This will be the opportunity to see how low the plant could go, assuming all other variables are not limiting. In reality, the plant is not expected to be able to maintain this level of methanol feed given current storage limitations, so this will be a short-term testing period. However, this information will prove critical for County staff to know the ultimate limits of the plant (for future optimization) as well as for the purposes of planning any form of capital improvements to the methanol storage and feed system.

Period F – Optimize without Methanol

The purpose of Period F is essentially the same as Period E, but with the additional methanol feed removed. In this case, methanol is either taken off-line completely, or kept at a very low dose, to determine the best-case effluent TIN without significant supplemental carbon. This information is not only helpful to provide an idea of optimal plant operation if methanol supply was interrupted, but provides a foundation for showing the potential to optimize (perhaps seasonally) while saving money on reduced methanol usage. Ultimately, this data could be used as a basis to determine if an annual operation with Period E in the summer (best TIN possible, lower flows) and Period F in the winter (reduce methanol use, but operate efficient ABAC) could be helpful to the County to balance process efficiency and cost in meeting the NGP.

Schedule

As shown in Figure 2, the timing for each Period is not yet determined and will need to be evaluated in real time as the testing proceeds (see Section 4 of this memorandum). The intent would be to operate at each Period until stable operation is achieved and reliable data can be taken, prior to moving to the next Period.

Period	Dates	Process Config.	Primary Goal(s)	SRT Target & ABs online	RAS control	Aeration / DO control	IMLR control	Methanol
A	1/5/2022 – XX/XX/22	4-Stage	Establish near-complete nitrification	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L (may need to adjust wasting / SRT / MCRT control and calc)	Per current practice: Constant flow rate (may be adjusted pending initial results)	DO setpoint control DO = 2 mg/L Zone 1, 2, 3	Flow-paced Initial Setpoint 2.5Q May be adjusted (at 4Q now, 12/15/21)	Per current practice: Manual setpoint near 10 gph. Modify as needed to manage pH, alkalinity, sludge blankets. (Methanol at 10-11 gph now, 12/15/21)
B	TBD	4-Stage	Implement / Test NOx-based methanol control	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L	Per current practice: Constant flow rate	DO setpoint control DO = 2 mg/L Zone 1, 2, 3	Flow-paced as per above	NOx-based Nitrate setpoint TBD per discussion with Kitsap based on Period A performance, methanol delivery demand, etc. Zone 5
C	TBD	4-Stage	Implement / Test NOx-based IMLR control	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L	Per current practice: Constant flow rate	DO setpoint control DO = 2 mg/L Zone 1, 2, 3	NOx-based Setpoint = 2 mg/L NO_3 in Zone 1	NOx-based Maintain prior setpoint Zone 5
D	TBD	4-Stage	Implement / Test ABAC	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N setpoint = 1 mg/L May be adjusted over time Zone 1	NOx-based Setpoint = 2 mg/L NO_3 in Zone 1	NOx-based Maintain prior setpoint Zone 5
E	TBD	4-Stage	Implement / Test “Optimized Low TIN”	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N setpoint ~1 mg/L Zone 1	NOx-based Setpoint = 2 mg/L NO_3 in Zone 1	NOx-based Setpoint ~1 mg/L nitrate for low TIN Zone 5
F	TBD	4-Stage	Implement / Test “Optimized no (or low) methanol”	9d Aerobic 14d Total 4 ABs MLSS ~2,000-2,500 mg/L	Per current practice: Constant flow rate	ABAC NH_4-N setpoint ~1 mg/L (may be increased to limit NOx production) Zone 1	NOx-based Setpoint = 2 mg/L NO_3 in Zone 1	Methanol OFF (or low dose as needed to maintain alk, pH, blanket, background methanol-degrader population)

Figure 3 – Biological Nutrient Removal Testing Periods and Associated Control Variables (4 Basins Online) – Ammonia based control noted in Red.

3.0 Sampling and Data Collection

During operation of each of the Periods outlined in the previous section, data will be collected by CKTP staff for analysis by HDR and Murraysmith and discussion with the overall team. The collected data will fall into three primary categories, as outlined below.

- Data Category 1 – General Daily Spreadsheet
- Data Category 2 – Laboratory Data
- Data Category 3 – SCADA Trending

Each category is discussed in further detail below. Included in each discussion is an initial expectation of when data should be taken and how often a set of compiled results should be supplied to the team.

- *Tracking Time*: how often data is taken
- *Reporting Time*: how often data is collated and reported to the Team
- *Reporting Format*: method of reporting (Excel, Word, etc.).

Data Category 1 – General Daily Spreadsheet

Plant staff will maintain their normal daily spreadsheet data tracking, but with modified columns for tracking additional information useful for BNR analysis (such as aerobic SRT). **Attachment A**, provided with this memorandum, provides an example template (from October, 2021) that shows the modified data fields in red relative to the plant standard sheet.

Typical monthly discharge monitoring reports (DMRs) data tables would also be preserved, as per normal plant protocol, and can be used for logging typical daily numbers in addition to **Attachment A**. The Category 1 tracking and reporting times are shown below. Daily data in this category would be reported to the team on a weekly basis.

Tracking Time: Daily

Reporting Time: Weekly

Reporting Format: Excel spreadsheet (modified per **Attachment A**)

Data Category 2 – Laboratory Data

For physical data collection (composite sampling and grab sampling), the process during BNR testing will be very similar to the normal plant data collection approach. CKTP staff should maintain normal data collection typically used for both DMRs and the current plant optimization driven data collection approach. BNR testing will simply require a few moderate modifications to the optimization driven data collection already in place. **Table 2** provides the summary table of the current optimization data sampling, with specific highlights for the modifications requested for BNR testing. The key BNR testing additions are as follows:

- Effluent ammonia and NOx testing at 3/week instead of 2/week
- Primary effluent composite testing (Ammonia) at 3/week instead of 1/week
- Add primary effluent composite testing for CBOD at 3/week
- Centrate ammonia testing at 1/week instead of 2/month
- Basin temperature spot checked twice per day
- Basin pH spot checked twice per day

This data can be provided in/with the plant's standard DMR monthly reports, and does not need to be "accredited" for the purpose of this testing. It is also understood that primary effluent sampling will be from one of the primary clarifiers (either is feasible), as a sample point for a true composite is not possible.

Tracking Time: Per standard practice, with modifications as noted above and in **Table 2**
Reporting Time: Data updated every week, with one week delay in reporting a given testing week
Reporting Format: Excel spreadsheet (normal monthly DMR summary spreadsheet)

Table 2 – Field Sampling Requirements (Based on Current Optimization Testing Protocol)

Parameter	Frequency	DO Probe
Influent		
Flow	Continuous	
CBOD	2/week	Composite
Total Ammonia	3/week	Composite
Nitrate plus Nitrite Nitrogen	1/month	Composite
Total Kjeldahl Nitrogen	2/week	Composite
Total Organic Carbon	2/week	Composite
Effluent		
Flow	Continuous	
CBOD	2/week	Composite
Total Ammonia	3/week	Composite
Nitrate plus Nitrite Nitrogen	3/week	Composite
Total Kjeldahl Nitrogen	2/week	Composite
Total Organic Carbon	2/week	Composite
Alkalinity	3/week	Grab (Composite preferred)
Process		
Total Ammonia	3/week	Primary Effluent - Composite
Nitrate plus Nitrite Nitrogen	1/week	Primary Effluent - Composite
CBOD	3/week	Primary Effluent - Composite
Total Organic Carbon	1/week	Primary Effluent - Composite
Alkalinity	3/week	Primary Effluent – Grab (Composite preferred)
Total Ammonia	1/week	Centrate - Grab
Nitrate plus Nitrite Nitrogen	2/month	Centrate - Grab
Total Organic Carbon	2/month	Centrate - Grab
Total Ammonia	1/quarter	In-Plant Pump Station - Grab
Nitrate plus Nitrite Nitrogen	1/quarter	In-Plant Pump Station - Grab
Total Organic Carbon	1/quarter	In-Plant Pump Station - Grab
Temperature	2/day	Basins 1 through 4 - Grab
pH	2/day	Basins 1 through 4 - Grab

Data Category 3 – SCADA Trending

Electronic data trending will be critical for evaluation of the BNR data, as control will be primarily from new online probes and the associated flow monitoring of the air and pumping systems connected to those controls. The following list provides the key data that should be downloaded by CKTP staff and saved during each day of testing, with the initial recommended interval for sampling for each data type.

- NH_4/NO_3 in each Bain, both Zone 1 and Zone 5
  - Maximum of 16 data sets per day (4 per Basin with 4 Basins online)
  - Sampling interval: 15 minutes
- Dissolved oxygen (DO) in each Basin in Zone 2, Zone 4 and Zone 6
  - Maximum of 12 data sets per day (3 per Basin with 4 Basins online)
  - Sampling interval: 10 minutes
- IMLR Pump Flow (via speed feedback and PLC lookup table)
  - Maximum of 4 data sets per day (1 pump per Basin with 4 Basins online)
  - Sampling interval: 10 minutes
- RAS Pump Flow
  - Maximum of 1 data set per day (1 composite flow rate)
  - Sampling interval: 10 minutes
- Methanol Pump Flow (FIT-2411B / 2421B)
  - Maximum of 1 data set per day (1 composite flow rate or pump speed, whichever is available)
  - Sampling interval: 10 minutes
- Centrate Flow and Timing
  - Maximum of 1 data set per day (1 composite flow rate when operating)
  - Sampling interval: 10 minutes
- Influent Flow
  - Maximum of 1 data set per day (1 composite flow)
  - Sampling interval: 10 minutes

Tracking Time: As noted above
Reporting Time: Weekly
Reporting Format: Excel spreadsheet (individual tab or sheet for each variable above)

4.0 Testing Schedule and Meetings

The actual implementation of the testing schedule, as outlined in **Figure 3**, will occur once the facility has reached the appropriate solids inventory and is operating with full nitrification. This is expected in early January, 2022. Once Period A is underway, the stop time for that Period, and the associated start and stop times for each additional Period, will be evaluated as the process progresses and data can be evaluated. The transition from one Period to another is not based on a set time interval, but on reaching a steady-state for that period in which reasonable data can be obtained and the process documented. Once that is achieved, the next Period can begin.

The process team (County, HDR, Murraysmith) will need to evaluate the data on a regular basis and meet to discuss current process issues, data trends, and determine next steps.

It is recommended that, once testing starts, the team meet every two weeks (twice per month) as a baseline minimum. Additional meetings can be schedule, as needed, if issues arise in the field or immediate attention is required. Meetings will occur on the second and fourth Thursday of each month and will include the following base agenda:

- Observations of current operation and questions (Rich Neal and Matt Pickering)
- Review of current data trends (Bryce Figdore and Jeff Zahller)
- Proposed operational approach for next two-week period (Bryce Figdore)
- General Q&A and discussion

Attendees to the meeting would be the following (at minimum) and can be modified as needed when issues arise.

- Kitsap County: Chris Sheridan, Rich Neal, Matt Pickering
- QCC: Ben Dearden (as needed)
- HDR: Jeff Zahller, Bryce Figdore, Bruce Johnston (as needed), Ben McConkey (when available), Jeff Hansen (when available)
- Murraysmith: Miaomiao Zhang

HDR will provide summary minutes from each meeting. Once all testing Periods are complete, a final summary memorandum will be compiled and submitted to the County to document the results of each testing Period.

Appendix C. Updated Process Control Strategies

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CKTP-2111: Aeration Basins 1 through 4 Aeration Control Valves

A. Process overview:

1. Each aeration basin is divided into six passes. Three aeration control valves are installed for each aeration basin, with one valve controlling aeration airflow to each successive pair of passes (zone) in the basin. Dissolved oxygen (DO) sensors provide monitoring of DO for the three aeration zones as follows:
   i. Zone 1: Pass 2 DO sensor.
   ii. Zone 2: Pass 4 DO sensor.
   iii. Zone 3: Pass 6 DO sensor.
2. The aeration control valves for aeration basins 1 through 4 control the flow of air produced by the aeration blowers to their respective aeration zones. Under normal operating conditions, the aeration control valves modulate to maintain operator-entered DO set points within the aeration zones.
3. A combination ammonia and nitrate sensor located in pass 5 of the aeration basinsprovides monitoring of ammonia-nitrogen (NH_3-N) and nitrate-nitrogen (NO_3-N) within the pass. As an alternative control mode, operators may select ammonia-based aeration control (ABAC) for the aeration zones in any of the aeration basins. Under the ABAC control mode, the aeration control valve in zone 3 modulates to maintain an operator-entered DO set point within pass 6, while the DO set points for zone 1 and/or zone 2 are adjusted incrementally to maintain a NH_3-N set point within pass 5.
4. Mixed liquor suspended solids (MLSS) is also monitored in pass 5 of the aeration basins, but these measurements are not involved in SCADA control.

B. Relevant HMI screen(s):

1. Aeration basin 1, aeration basin 2, aeration basin 3, and aeration basin 4.

C. Relevant P&ID(s):

Drawing number	Drawing description	Project	Record drawing year
P-210	Aeration basin 1	Resource recovery	2016
P-211	Aeration basin 2	Resource recovery	2016
P-230	Aeration basin 3	Resource recovery	2016
P-231	Aeration basin 4	Resource recovery	2016

D. Relevant control strategies:

Control strategy number	Control strategy title
CKTP-2003	Aeration blowers 3 and 4

E. Motorized equipment:

Equipment tag	Equipment description	Motor HP	Motor controller
CV 2111	Aeration basin 1, pass 1 and 2 aeration control valve		Actuator - modulating
CV 2112	Aeration basin 1, pass 3 and 4 aeration control valve		Actuator - modulating
CV 2113	Aeration basin 1, pass 5 and 6 aeration control valve		Actuator - modulating
CV 2161	Aeration basin 2, pass 1 and 2 aeration control valve		Actuator - modulating
CV 2162	Aeration basin 2, pass 3 and 4 aeration control valve		Actuator - modulating
CV 2163	Aeration basin 2, pass 5 and 6 aeration control valve		Actuator - modulating
CV 2311	Aeration basin 3, pass 1 and 2 aeration control valve		Actuator - modulating
CV 2312	Aeration basin 3, pass 3 and 4 aeration control valve		Actuator - modulating
CV 2313	Aeration basin 3, pass 5 and 6 aeration control valve		Actuator - modulating
CV 2361	Aeration basin 4, pass 1 and 2 aeration control valve		Actuator - modulating
CV 2362	Aeration basin 4, pass 3 and 4 aeration control valve		Actuator - modulating
CV 2363	Aeration basin 4, pass 5 and 6 aeration control valve		Actuator - modulating

F. Instrumentation:

Instrument tag	Instrument description	Calibrated range, min / actuation set point[1]	Calibrated range, max / deactuation set point[1]	Engineering units
AE/AIT 2114A	Aeration basin 1, pass 2 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2114B	Aeration basin 1, pass 4 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2114C	Aeration basin 1, pass 6 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2115B	Aeration basin 1, pass 5 ammonia and nitrate sensor/transmitter	0.2 0.2	20.0 20.0	mg/L NH_3-N mg/L NO_3-N
AE/AIT 2115C	Aeration basin 1, pass 5 total suspended solids (TSS) sensor/transmitter	0.001	5.000	g/L
AE/AIT 2164A	Aeration basin 2, pass 2 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2164B	Aeration basin 2, pass 4 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2164C	Aeration basin 2, pass 6 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2165B	Aeration basin 2, pass 5 ammonia and nitrate sensor/transmitter	0.2 0.2	20.0 20.0	mg/L NH_3-N mg/L NO_3-N
AE/AIT 2165C	Aeration basin 2, pass 5 TSS sensor/transmitter	0.001	5.000	g/L
AE/AIT 2314A	Aeration basin 3, pass 2 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2314B	Aeration basin 3, pass 4 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2314C	Aeration basin 3, pass 6 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2315B	Aeration basin 3, pass 5 ammonia and nitrate sensor/transmitter	0.2 0.2	20.0 20.0	mg/L NH_3-N mg/L NO_3-N
AE/AIT 2315C	Aeration basin 3, pass 5 TSS sensor/transmitter	0.001	5.000	g/L
AE/AIT 2364A	Aeration basin 4, pass 2 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2364B	Aeration basin 4, pass 4 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2364C	Aeration basin 4, pass 6 DO sensor/transmitter	0.00	10.00	mg/L
AE/AIT 2365B	Aeration basin 4, pass 5 ammonia and nitrate sensor/transmitter	0.2 0.2	20.0 20.0	mg/L NH_3-N mg/L NO_3-N
AE/AIT 2365C	Aeration basin 4, pass 5 TSS sensor/transmitter	0.001	5.000	g/L

1. Some calibrated ranges for existing instruments are based on ISA data sheets from resource recovery project. QCC to confirm calibrated ranges in field.

G. Control panels:

Panel tag	Panel description	Building / process area	Room / location
PNL 2920	Power/blower building control panel	Power/blower building	Blower room
PNL 2939	Aeration basins electrical building control panel	Aeration basins electrical building	Electrical room

H. Local control:

1. Each electrically actuated valve may be controlled locally via the control interface integral to the actuator. The control interface consists of a local-stop-remote selector switch (LSR), an open-close selector switch (OC), and an LCD display for indicating actuator position, status, and alarms.
   i. When the LSR is placed in local, the operator may use the OC to open or close the valve.
   ii. When the LSR is placed in stop, the valve is stopped in its current position and prevented from changing position.
   iii. When the LSR is placed in remote, SCADA control of the actuator is enabled.
   iv. **Under normal operating conditions, the LSR is placed in remote.**

I. SCADA control:

1. DO moving average calculation:
   i. Measurements from each DO sensor are sampled every 5 seconds.
   ii. A non-weighted moving average is calculated from the most recent samples based on an operator-entered averaging time, resulting in moving averages for each DO sensor.
      a) Current averaging time set point: 2 minutes.
      b) Averaging time set point range: 30 seconds to 15 minutes.
   iii. Moving averages for each DO sensor are displayed at the HMI.
2. NH_3-N moving average calculation:
   i. Measurements from each ammonia sensor are sampled every 5 seconds.
   ii. A non-weighted moving average is calculated from the most recent samples based on an operator-entered averaging time, resulting in moving averages for each ammonia sensor.
      a) Current averaging time set point: 30 seconds.
      b) Averaging time set point range: 30 seconds to 15 minutes.
   iii. Moving averages for each ammonia sensor are displayed at the HMI.
3. NO_3-N moving average calculation:
   i. Measurements from each nitrate sensor are sampled every 5 seconds.
   ii. A non-weighted moving average is calculated from the most recent samples based on an operator-entered averaging time, resulting in moving averages for each nitrate sensor.
      c) Current averaging time set point: 30 seconds.
      d) Averaging time set point range: 30 seconds to 15 minutes.
   iii. Moving averages for each nitrate sensor are displayed at the HMI.
4. MLSS moving average calculation:
   i. Measurements from each TSS sensor are sampled every 5 seconds.

ii. A non-weighted moving average is calculated from the most recent samples based on an operator-entered averaging time, resulting in moving averages for each TSS sensor.
    e) Current averaging time set point: 30 seconds.
    f) Averaging time set point range: 30 seconds to 15 minutes.
iii. Moving averages for each TSS sensor are displayed at the HMI.

5. With the actuator LSR set to remote, the operator may determine the SCADA control method for the actuator by selecting between manual (SCADA Manual) and auto (SCADA Automatic) for the actuator at the HMI.

6. SCADA Manual:
   i. When in SCADA Manual, the aeration control valve may be commanded to an operator entered position set point.

7. SCADA Automatic:
   i. When in SCADA Automatic, the aeration control valve is automatically positioned as follows:
      a) If the aeration control valve belongs to an aeration basin that has been set to out-of-service at the HMI, the valve is commanded to an operator-entered out-of-service position set point.
         1) Current out-of-service valve position set point: 25% open.
      b) DO control mode:
         1) If the aeration control valve belongs to an aeration basin that has been set to in-service at the HMI and the blowers stable status is active (see control strategy CKTP-2003 for blowers stable status conditions), the valve is modulated to maintain an operator-entered zone DO set point ($DO_{Set\ Point}$) by means of an aeration control valve control loop that executes at an operator-entered interval.
            i) Current aeration control valve control loop execution interval: 2 minutes.
            ii) Countdown until next control valve control loop execution is displayed at HMI.
         2) To achieve more stable aeration header pressures by avoiding scenarios where multiple aeration control valves are changing positions at once, the aeration control valve control loops are staggered evenly throughout the control loop execution interval:
            i) The amount of time to stagger the control loop execution is determined by dividing the control loop execution interval by the number of aeration control valves set to SCADA Automatic control and located in aeration basins that have been set to in-service at the HMI.
         3) Each aeration control valve control loop executes as follows:
            i) The current DO moving average value for the zone ($DO_{Measured}$) is taken as an input to the control loop.
            ii) The difference between the measured DO value and DO set point is then calculated:

$$Error_{DO} = DO_{Set\ Point} - DO_{Measure}$$

            iii) The rate of change for the DO measurement is then calculated:

$$Rate\ of\ change_{DO} = \left|\frac{\Delta DO_{Measured}}{\Delta t}\right|$$

            iv) The change in position for the aeration control valve is then calculated:
               (a) If the error falls within an operator-entered deadband:

$$\Delta\%Open = 0$$

(b) Otherwise, if the rate of change exceeds an operator-entered minimum rate of change set point and the error has been reduced without changing sign:

$$\Delta\%Open = 0$$

This is meant to reduce hunting oscillations and overcorrection when the process is responding as desired.

(c) Otherwise, if the measured DO value is below the DO set point:

$$\Delta\%Open = Error_{DO} \times Gain_{DO}$$

(d) Otherwise, if the measured DO value is above the DO set point:

$$\Delta\%Open = Damping\ Coefficient_{DO} \times Error_{DO} \times Gain_{DO}$$

v) The new valve position is then calculated based on the calculated change in position:

$$\%Open_{New} = \%Open_{Current} + \Delta\%Open$$

vi) Finally, the new valve position is compared with minimum and maximum position set points for the valve and limited to those boundary conditions:

(a) If the new valve position falls below the minimum valve position set point:

$$\%Open_{New} = \%Open_{Position\ Minimum\ SP}$$

(b) Otherwise, if the new valve position rises above the maximum valve position set point:

$$\%Open_{New} = \%Open_{Position\ Maximum\ SP}$$

(c) Otherwise, the calculated new valve position remains unchanged.

4) General:

i) The DO set point, minimum rate of change, deadband, gain, damping coefficient, valve minimum open, and valve maximum open values used in the aeration control valve control loop calculations are operator-entered and are unique for each aeration control valve control loop. These values are displayed at the HMI and recorded in the historian (on change) to support control loop performance monitoring and optimization. Current values for these parameters are listed in the table below.

Aeration zone	DO set point	DO minimum rate of change	DO deadband	DO gain	DO damping coefficient	Valve % open, min	Valve % open, max
Aeration basin 1 zone 1	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 1 zone 2	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 1 zone 3	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 2 zone 1	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 2 zone 2	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 2 zone 3	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 3 zone 1	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 3 zone 2	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 3 zone 3	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 4 zone 1	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 4 zone 2	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70
Aeration basin 4 zone 3	2.00 mg/L	0.05 mg/L/minute	+/- 0.15 mg/L	10	0. 90	30	70

ii) The damping coefficient is set between 0 and 1 so that the change in valve position when the basin is overaerated is less than the change in these values when the basin is underaerated, which will reduce hunting oscillations with a bias favoring overaeration versus underaeration.

c) ABAC control mode:

1) As an optional control mode for the aeration zones in any aeration basin, the operator may select ABAC control mode instead of DO control mode. To select this control mode, the following requirements must be met:
   i) All three aeration control valves in the aeration basin are in SCADA Automatic and have no active alarms.
   ii) Loss of signal alarms for DO and NH_3-N transmitters in the basin are not active.
2) Under ABAC control mode, the aeration control valve control loops remain the same and execute at the same interval as the DO control mode control loops with the following exceptions:
   i) The operator-entered DO set points for zones 1 and/or 2 are substituted with set points that are automatically adjusted to maintain an operator-entered NH_3-N concentration set point in pass 5 ($NH3_{Set\ Point}$).
   ii) The DO set point for zone 3 is substituted for an operator-entered ABAC control mode DO set point.

3) Prior to each iteration of the aeration control valve control loops, the DO set points for zone 1 and zone 2 aeration control valves set to ABAC control mode are updated as follows:
   i) The current NH_3-N moving average value for pass 5 ($NH3_{Measured}$) is taken as an input to the control loop.
   ii) The difference between the measured NH_3-N value and NH_3-N set point is then calculated:
   $Error_{NH3} = NH3_{Measured} - NH3_{Set\ Point}$
   iii) The rate of change for the NH_3-N measurement is then calculated:
   $$Rate\ of\ change_{NH3} = \left|\frac{\Delta \mathrm{NH3}_{Measured}}{\Delta \mathrm{t}}\right|$$
   iv) The change in DO set point for the zone is then calculated:
      (a) If the NH_3-N error falls within an operator-entered deadband:
      $$\Delta DO_{Set\ Point} = 0$$
      (b) Otherwise, if the rate of change exceeds an operator-entered minimum rate of change set point and the error has been reduced without changing sign:
      $$\Delta DO_{Set\ Point} = 0$$
      This is meant to reduce hunting oscillations and overcorrection when the process is responding as desired.
      (c) Otherwise, if the measured NH_3-N value is below the NH_3-N set point:
      $$\Delta DO_{Set\ Point} = DO_{Set\ Point\ Negative\ Adjustment}$$
      (d) Otherwise, if the measured NH_3-N value is above the NH_3-N set point:
      $$\Delta DO_{Set\ Point} = DO_{Set\ Point\ Positive\ Adjustment}$$
      (a) The DO set point is then adjusted:
      $$DO_{Set\ Point} = DO_{Set\ Point} + \Delta DO_{Set\ Point}$$
   v) General:
      (a) The NH_3-N set point, minimum rate of change, deadband, and DO set point adjustment set points used in the ABAC control loop calculations are operator-entered and are unique for each aeration train. These values are displayed at the HMI and recorded in the historian (on change) to support control loop performance monitoring and optimization. Current values for these parameters are listed in the table below.

Aeration zone	NH_3-N set point	NH_3-N minimum rate of change	NH_3-N deadband	DO set point positive adjustment	DO set point negative adjustment	Initial DO set point
Aeration basin 1 zone 1	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 1 zone 2	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 1 zone 3	1.0 mg/L	0.1 mg/L/minute	+/- 0.2 mg/L	N/A	N/A	2.00 mg/L
Aeration basin 2 zone 1	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 2 zone 2	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 2 zone 3	1.0 mg/L	0.1 mg/L/minute	+/- 0.2 mg/L	N/A	N/A	2.00 mg/L
Aeration basin 3 zone 1	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 3 zone 2	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 3 zone 3	1.0 mg/L	0.1 mg/L/minute	+/- 0.2 mg/L	N/A	N/A	2.00 mg/L
Aeration basin 4 zone 1	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 4 zone 2	N/A	N/A	N/A	0.10 mg/L	-0.10 mg/L	2.00 mg/L
Aeration basin 4 zone 3	1.0 mg/L	0.1 mg/L/minute	+/- 0.2 mg/L	N/A	N/A	2.00 mg/L

d) Whether in DO control mode or ABAC control mode, if the aeration control valve belongs to an aeration basin that has been set to in-service at the HMI and the blowers stable status is not active (see control strategy CKTP-2003 for blowers stable status conditions), the current valve position is maintained until the blowers stable status returns to active. This effectively prevents aeration control valves from changing positions while blowers are transitioning between operating states.

8. MOV position calculation:

   i. The position of the MOV out of all aeration control valves in SCADA Automatic is continuously communicated to PLC 2920 for use in controlling blowers 3 and 4 (see control strategy CKTP-2003 for MOV control description).

9. Flex sequence for out-of-service aeration basins:

   i. Each day at an operator-entered time, a flex sequence is initiated to temporarily set the aeration control valves belonging to out-of-service aeration basins to an operator-entered fixed position.

      a) Current flex sequence initiation time: 12:00pm.

      b) Current flex fixed position set point: 40% open.

ii. The flex sequence starts with the lowest aeration basin number of all aeration basins that are set as out-of-service at the HMI.

a) Starting with the first zone (passes 1 and 2), the flex sequence commands the aeration control valve associated with that zone to the flex fixed position. Once the valve reaches the flex fixed position, the flex sequence waits for an operator-entered flex sequence delay.

1) Current flex sequence delay: 5 minutes.

b) The same steps are then repeated for the aeration control valve associated with the second zone (passes 3 and 4) in the same out-of-service aeration basin.

c) The same steps are then repeated for the aeration control valve associated with the third zone (passes 5 and 6) in the same out-of-service aeration basin.

iii. Then flex sequence then repeats the steps for the next out-of-service aeration basin(s), until all out-of-service aeration basin aeration control valves have been set to the flex fixed position.

iv. After each aeration control valve in out-of-service aeration basins reaches the flex fixed position, the valves are then released from the sequence to operate based on SCADA Automatic controls described above.

J. Interlocks:

1. Refer to the actuator O&M documentation for a complete listing of events that will result in actuator failure via software and hardwired interlocks within the actuator.

2. The following PLC software interlocks are active when the control valve is set to SCADA Automatic control:

i. If a DO loss of signal alarm is active for the DO transmitter associated with the control valve's DO or ABAC control mode, the valve maintains its current position. Once the signal returns for 5 seconds, the control valve reverts back to its previous control mode.

ii. If a NH_3-N loss of signal alarm is active for the NH_3-N transmitter associated with a basin's ABAC control mode, the last good NH_3-N value received is maintained. Once the signal returns for 5 seconds, real-time NH_3-N values are again used for the basin's ABAC control mode.

K. Hardwired I/O:

I/O description	I/O type	I/O panel	Scale factor	Scaled range	Eng. Units	Used in PLC logic	Displayed at HMI	Included in historian
AB 1, pass 2 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 4 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 5 NH_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 5 NO_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 5 MLSS	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 6 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 1, pass 1 and 2 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 1, pass 1 and 2 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 1, pass 1 and 2 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 1, pass 3 and 4 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 1, pass 3 and 4 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 1, pass 3 and 4 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 1, pass 5 and 6 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 1, pass 5 and 6 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 1, pass 5 and 6 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 2 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 2, pass 4 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 2, pass 5 NH_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 2, pass 5 NO_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 2, pass 5 MLSS	AI	PLC-2939			mg/L	✓	✓	✓

I/O description	I/O type	I/O panel	Scale factor	Scaled range	Eng. Units	Used in PLC logic	Displayed at HMI	Included in historian
AB 2, pass 6 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 2, pass 1 and 2 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 2, pass 1 and 2 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 1 and 2 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 3 and 4 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 2, pass 3 and 4 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 3 and 4 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 5 and 6 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 2, pass 5 and 6 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 2, pass 5 and 6 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 2 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 4 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 5 NH_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 5 NO_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 5 MLSS	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 6 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 3, pass 1 and 2 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	
AB 3, pass 1 and 2 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 1 and 2 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 3 and 4 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓

I/O description	I/O type	I/O panel	Scale factor	Scaled range	Eng. Units	Used in PLC logic	Displayed at HMI	Included in historian
AB 3, pass 3 and 4 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 3 and 4 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 5 and 6 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 3, pass 5 and 6 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 3, pass 5 and 6 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 4, pass 2 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 4 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 5 NH_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 5 NO_3-N	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 5 MLSS	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 6 DO	AI	PLC-2939			mg/L	✓	✓	✓
AB 4, pass 1 and 2 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 4, pass 1 and 2 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 4, pass 1 and 2 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 4, pass 3 and 4 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 4, pass 3 and 4 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓
AB 4, pass 3 and 4 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓
AB 4, pass 5 and 6 aeration control valve in remote	DI	PLC-2939	---	---	---	✓	✓	✓
AB 4, pass 5 and 6 aeration control valve position feedback	AI	PLC-2939		0 - 100	% open	✓	✓	✓

I/O description	I/O type	I/O panel	Scale factor	Scaled range	Eng. Units	Used in PLC logic	Displayed at HMI	Included in historian
AB 4, pass 5 and 6 aeration control valve position command	AO	PLC-2939		0 - 100	% open	✓	✓	✓

L. Network data exchange: None.

M. Alarms:

Tag	Alarm description	Set point	Priority	Call out[1]
AIT2114A_HiAlm	AB 1, pass 2 high DO		1	
AIT2114A_LoAlm	AB 1, pass 2 low DO		1	
AIT2114A_LossOfSignal	AB 1, pass 2 DO loss of signal	N/A	1	
AIT2114B_HiAlm	AB 1, pass 4 high DO		1	
AIT2114B_LoAlm	AB 1, pass 4 low DO		1	
AIT2114B_LossOfSignal	AB 1, pass 4 DO loss of signal	N/A	1	
AIT2114C_HiAlm	AB 1, pass 6 high DO		1	
AIT2114C_LoAlm	AB 1, pass 6 low DO		1	
AIT2114C_LossOfSignal	AB 1, pass 6 DO loss of signal	N/A	1	
AIT2115BA_HiAlm	AB 1, pass 5 high NH_3-N		1	
AIT2115BA_LoAlm	AB 1, pass 5 low NH_3-N		1	
AIT2115BA_LossOfSignal	AB 1, pass 5 NH_3-N loss of signal	N/A	1	
AIT2115BB_HiAlm	AB 1, pass 5 high NO_3-N		1	
AIT2115BB_LoAlm	AB 1, pass 5 low NO_3-N		1	
AIT2115BB_LossOfSignal	AB 1, pass 5 NO_3-N loss of signal	N/A	1	
CV2111_Fail	AB 1, pass 1 and 2 aeration control valve fail to respond	60 seconds	1	
CV2112_Fail	AB 1, pass 3 and 4 aeration control valve fail to respond	60 seconds	1	
CV2113_Fail	AB 1, pass 5 and 6 aeration control valve fail to respond	60 seconds	1	
AIT2164A_HiAlm	AB 2, pass 2 high DO		1	
AIT2164A_LoAlm	AB 2, pass 2 low DO		1	

Tag	Alarm description	Set point	Priority	Call out[1]
AIT2164A_LossOfSignal	AB 2, pass 2 DO loss of signal	N/A	1	
AIT2164B_HiAlm	AB 2, pass 4 high DO		1	
AIT2164B_LoAlm	AB 2, pass 4 low DO		1	
AIT2164B_LossOfSignal	AB 2, pass 4 DO loss of signal	N/A	1	
AIT2164C_HiAlm	AB 2, pass 6 high DO		1	
AIT2164C_LoAlm	AB 2, pass 6 low DO		1	
AIT2164C_LossOfSignal	AB 2, pass 6 DO loss of signal	N/A	1	
AIT2165BA_HiAlm	AB 2, pass 5 high NH_3-N		1	
AIT2165BA_LoAlm	AB 2, pass 5 low NH_3-N		1	
AIT2165BA_LossOfSignal	AB 2, pass 5 NH_3-N loss of signal	N/A	1	
AIT2165BB_HiAlm	AB 2, pass 5 high NO_3-N		1	
AIT2165BB_LoAlm	AB 2, pass 5 low NO_3-N		1	
AIT2165BB_LossOfSignal	AB 2, pass 5 NO_3-N loss of signal	N/A	1	
CV2161_Fail	AB 2, pass 1 and 2 aeration control valve fail to respond	60 seconds	1	
CV2162_Fail	AB 2, pass 3 and 4 aeration control valve fail to respond	60 seconds	1	
CV2163_Fail	AB 2, pass 5 and 6 aeration control valve fail to respond	60 seconds	1	
AIT2314A_HiAlm	AB 3, pass 2 high DO		1	
AIT2314A_LoAlm	AB 3, pass 2 low DO		1	
AIT2314A_LossOfSignal	AB 3, pass 2 DO loss of signal	N/A	1	
AIT2314B_HiAlm	AB 3, pass 4 high DO		1	
AIT2314B_LoAlm	AB 3, pass 4 low DO		1	
AIT2314B_LossOfSignal	AB 3, pass 4 DO loss of signal	N/A	1	
AIT2314C_HiAlm	AB 3, pass 6 high DO		1	
AIT2314C_LoAlm	AB 3, pass 6 low DO		1	
AIT2314C_LossOfSignal	AB 3, pass 6 DO loss of signal	N/A	1	
AIT2315BA_HiAlm	AB 3, pass 5 high NH_3-N		1	

Tag	Alarm description	Set point	Priority	Call out[1]
AIT2315BA_LoAlm	AB 3, pass 5 low NH_3-N		1	
AIT2315BA_LossOfSignal	AB 3, pass 5 NH_3-N loss of signal	N/A	1	
AIT2315BB_HiAlm	AB 3, pass 5 high NO_3-N		1	
AIT2315BB_LoAlm	AB 3, pass 5 low NO_3-N		1	
AIT2315BB_LossOfSignal	AB 3, pass 5 NO_3-N loss of signal	N/A	1	
CV2311_Fail	AB 3, pass 1 and 2 aeration control valve fail to respond	60 seconds	1	
CV2312_Fail	AB 3, pass 3 and 4 aeration control valve fail to respond	60 seconds	1	
CV2313_Fail	AB 3, pass 5 and 6 aeration control valve fail to respond	60 seconds	1	
AIT2364A_HiAlm	AB 4, pass 2 high DO		1	
AIT2364A_LoAlm	AB 4, pass 2 low DO		1	
AIT2364A_LossOfSignal	AB 4, pass 2 DO loss of signal	N/A	1	
AIT2364B_HiAlm	AB 4, pass 4 high DO		1	
AIT2364B_LoAlm	AB 4, pass 4 low DO		1	
AIT2364B_LossOfSignal	AB 4, pass 4 DO loss of signal	N/A	1	
AIT2364C_HiAlm	AB 4, pass 6 high DO		1	
AIT2364C_LoAlm	AB 4, pass 6 low DO		1	
AIT2364C_LossOfSignal	AB 4, pass 6 DO loss of signal	N/A	1	
AIT2365BA_HiAlm	AB 4, pass 5 high NH_3-N		1	
AIT2365BA_LoAlm	AB 4, pass 5 low NH_3-N		1	
AIT2365BA_LossOfSignal	AB 4, pass 5 NH_3-N loss of signal	N/A	1	
AIT2365BB_HiAlm	AB 4, pass 5 high NO_3-N		1	
AIT2365BB_LoAlm	AB 4, pass 5 low NO_3-N		1	
AIT2365BB_LossOfSignal	AB 4, pass 5 NO_3-N loss of signal	N/A	1	
CV2361_Fail	AB 4, pass 1 and 2 aeration control valve fail to respond	60 seconds	1	
CV2362_Fail	AB 4, pass 3 and 4 aeration control valve fail to respond	60 seconds	1	
CV2363_Fail	AB 4, pass 5 and 6 aeration control valve fail to respond	60 seconds	1	

1. HDR did not obtain WIN-911 alarm call out list. Check marks to be added for alarms that send alarm notification to remote and/or on-call staff.

***** End of Control Strategy *****

Document revision history:

Date	Author	Description of Revision(s)
2020-12-01	John Thomas (HDR)	Document creation based on as-implemented PLC programming.
2021-02-12	John Thomas (HDR)	Modified per BNR optimization work.

Appendix D. Compiled Log of Field Testing Notes (January–July 2022)

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BNR LOG Comments

Key Items to Note Highlighted Below

1 MOV was online at beginning of year
2 Changes in RAS flow started on 3/18, with more formal programming on 4/19
3 Programming of ABAC mode on 4/19
4 Basin 1 in ABAC mode on 4/27 (pulled back on 5/17, then back on 5/23)
5 Basin 1, 3, 4 in ABAC on 6/1
6 IMLR in nitrate mode on 6/28
7 Field Study Stopped on 7/27
8 Methanol programming set up on 8/2

Compiled Log

- 1/25/22 - Removed AB 2 from service. Higher MLSS concentration in AB 1 and 2 versus AB 3 and 4.
- 2/2/22 - Still have higher MLSS concentration in AB1 compared to 3 and 4. Throttling back on AB1 RAS/PE flow at SG2221. Approximately 20/40/40 flow split between basin.
- 2/7/22 - Begin composite sampling at PE1
- 2/8/22 - Turned Mixer 2210 off in RAS/PE mix box. Still have higher MLSS concentration in AB1. Hydraulics in splitter box appears to keep contents well mixed.
- 2/9/22 - Performed calibration checks of Ammonia probes. Possible issue with correction factor for both ammonia probes in AB3. Consider data to be invalid.
- 2/10/22 - Stopped throttling flow to AB1. Mixer 2210 still off.
- 2/11/22 - Calibration check for Nitrate readings. AB3 probes appear to be out of cal. Removed matrix correction on AB3 Ammonia / Nitrate-Nitrite. Consider all data prior to 2/11 invalid.
- 2/15/22 - Programming Lamson Blowers as lag to turbo blowers. Reprogrammed range of methanol pumps to better track gallons per hour.
- 2/16/22 - Closed slide gate SLG2220 to decouple (isolate) RAS from PE. RAS Split open to AB1, 3 and 4. PE Split open to AB1, 3 and 4
- 2/18/22 - Methanol tank filled to 10.8 feet.
- 2/21/22 - Begin only reading basin zone 4 temp, online DO and portable DO.
- 2/22/22 - Changed methanol pump tubing. Previous weeks flow rate 10 GPH at 17.5 Hz. SOUR / RR increasing.
- 2/22/22 - Begin adjusting RAS flow to #3 AB in attempt even concentration of MLSS between all 3 operating basins.
- 2/27/22 - AB4 Internal Recycle Pump failed. OOS
- 2/28/22 - Lowered internal recycle to 200% due to heavy rains/flows yesterday. AB 4 recycle pump back on line.
- 3/2/22 - Nitrate analysis of Centrate consistently non-detect <0.10
- 3/7/22 - Increased IMLR rate to 250%
- 3/7/22 - Increased DO setpoints at Z2 and Z4 all basins from 2.0 to 2.5. Z6 remains at 2.0 mg/L
- 3/8/22 - Noticed with increase in DO setpoints second blower started, but did not drop off line during low flows and high DO readings. Disabled MOV control at 10:30 AM temporarily to all blower 3 to shutdown. Returned MOV control to engage.
- 3/9/22 - Process Target Adjustment - increase Aerobic SRT from 9 to 10-days (MCRT to 15 days).
- 3/15/22 - Basin 3 Ammonia and Nitrate readings not reliable. HACH service visit schedule for week of 3/21
- 3/15/22 - Lowered methanol pump speed to 16.1 Hz or about 10 gph. Methanol delivery delayed until Thursday 3/24.
- 3/18/22 - Began to manipulate RAS flow rate as follows

  Monday – Friday
  6:00 AM
  4 mgd
  1400 gpm per pump

  5:00 PM
  2.8 mgd
  1000 gpm per pump

  End of Swing Shift (varies)
  2.0 mgd
  700 gpm per pump

  Sat – Sun
  6:00 AM
  4 mgd

  2:00 PM
  2.8 mgd
- 3/21/22 - Septage deliveries shutdown. Grease and portable toilets only.
- 3/21/22 - West Gravity Thickener shutdown
- 3/23/22 - Methanol tank fill
- 3/23/22 - DO set points all basins Z2 - 2.5 mg/L, Z4 - 2.5 mg/L, Z6 - 2.0 mg/L
- 3/24/22 - Noticed beginning of floating solids on basin surfaces
- 3/25/22 - Operator notes header pressure at 7.6 psi with setpoint at 7.0 psi and CV at 76% open. Operator temporarily sets setpoint higher than actual pressure before loop starts to react.
- 3/25/22 - Calibrated TSS meters and placed on-line. 15-minute data reporting starts 3/26/22.
- 3/28/22 - RAS adjusted to 1400 gpm per pump until swing shift ends 10 pm to 11 pm then RAS set to 700 gpm per pump.
- 3/30/22 - Lowered methanol setpoint to 10 gph due earliest next delivery April 22nd. RAS Pump 5 back on VFD

- 3/31/22 - Opened RAS to AB3 to even out MLSS
- 3/31/22 - Operator noticing increased floating solids at AB and secondary clarifier surfaces.
- 4/1/22 - West Gravity Thickener back in service.
- 4/4/22 - Septage receiving open
- 4/6/22 - Adjusted RAS to AB3 to balance mixed liquor concentration
- 4/7/22 - Operator noticing decreased floating solids on aeration basin surface.
- 4/11/22 - Lowered Methanol feed rate to 9.0 gpd to observe and document settleability impacts when process not denitrifying
- 4/12/22 - Recalibrated AB3 TSS probe.
- 4/12/22 - Lowered methanol feed rate setpoint to 8 gpd.
- 4/13/22 - Some visual signs of nitrification on secondary clarifier surface
- 4/13/22 - Adjusted RAS to AB3 to balance mixed liquor concentration
- 4/13/22 - Decreased methanol flow rate setpoint to 7 gph
- 4/14/22 - Decreased methanol flow rate setpoint to 6 gph
- 4/15/22 - Settlemeters rise in 165 minutes. Some straggler floc at secondary effluent. Floating solids building B3Z1 surface.
- 4/19/22 - QCC/HDR programming ABAC and manual RAS time table.
- 4/20/22 - Methanol delivered.
- 4/21/22 - Aligned RAS and PE to common mix box with mixer off to verify if ML concentrations will equalize between basins.
- 4/22/22 - RAS in "Auto Scheduled" mode. From 0600 to 2200 RAS total setpoint 2800 gpm. 2200 to 0600 setpoint 1400 gpm.
- 4/25/22 - East Primary Clarifier off-line for annual PM.
- 4/25/22 - Separated RAS / PE. MLSS concentrations did not equalize between basins. See 4/22 entry.
- 4/26/22 - Increased DO setpoints at Z2 all basins to 2.5 mg/L
- 4/27/22 - Enabled ABAC control at Basin 1
- 4/27/22 - Sett and SVI increasing (510-175)
- 5/2/22 - West Primary Clarifier off-line for annual PM
- 5/2/22 - Moved Primary Effluent Composite Sampler to PE Split Box. Now sampling both clarifier effluents when on-line
- 5/3/22 - Significant solids buildup on anoxic zone 1 each basin. Some solids buildup in zone 5.
- 5/4/22 - West Primary Clarifier offline for PM's
- 5/5/22 - West Primary Clarifier back in service at 1300
- 5/9/22 - Basin and Core TSS analysis frequency changed to Mon, Wed, Fri, Sat, Sun only
- 5/10/22 - West Secondary Clarifier off-line with RAS pumps for approximately 4.5 hours
- 5/17/22 - Removed Basin 1 from ABAC mode. HACH service tech replacing caps on Ammonia probes and calibrating TSS probes.
- 5/18/22 - All Basin ISE probes in HOLD status for calibration and run-in
- 5/18/22 - Portable DO meter out of service. Ordered new. ETA 21-days
- 5/19/22 - At 1400 all ISE probes removed from HOLD status and in-service
- 5/19/22 - No centrifuges in operation. Centrate flow from backup in system and not centrate.
- 5/20/22 - Implemented correction factor for B1Z6 TSS probe 2500 local / 2705 lab
- 5/20/22 - Implemented correction factor for B1Z1 Nitrate and B4Z1 Ammonia
- 5/20/22 - Increased methanol feed rate to 10.5 gph to make room for next delivery
- 5/23/22 - Placed Basin 1 in ABAC mode around 9 AM.
- 5/27/22 - Lab cal checks of Ammonia and Nitrate on-line readings appear to be satisfactory. B4Z1 Ammonia reading 19.2 with actual at 11.9. Adjusted correction factor.
- 6/1/22 - Placed all 3 operating basins in ABAC. Blower controls went full throttle due to incorrect Max DO settings on B3 and B4.
- 6/2/22 - Placed B1 and B3 on ABAC with proper setpoints in the morning. Placed B4 on ABAC in the afternoon. Second blower called to ops but appears to be tracking correctly.
- 6/3/22 - Noticed second blower called to off as Ammonia decreased during the night.
- 6/4/22 - Power outage on generator from 12:15 to 20:05. Blower 3 fault. Once blower ops until early AM on 6/6.
- 6/13/22 - Portable DO meter back in service. Performing DO cal checks.
- 6/15/22 - During NO3 Lab calibration sampling, Zones 1 and 5 in all basins were aerated during maintenance to flex membranes.
- 6/15/22 - Cleaned all probes (DO and ISE)
- 6/15/22 - New A-SRT target is 7 days
- 6/22/22 - QCC programming IMLR Nitrate loop. Not enabled.
- 6/23/22 - Received full load of Methanol. Increased methanol feed rate to 19 Hz or approximately 12 gph
- 6/24/22 - Rotated mixer 90 degrees at PE splitter box
- 6/28/22 - IMLR Pump in Nitrate Mode. Targeting 2.0 mg/L
- 6/28/22 - Aligned RAS to PE mix box for combined flow
- 6/29/22 - Separated RAS and PE mix boxes. Combined flow not successful
- 6/30/22 - Decreased methanol dose to 10 gph mid-day due to tank level
- 6/30/22 - Check Basin on-line DO meter calibrations. Adjusted DO probes at B3Z6, B4Z4 and B4Z6
- 7/12/22- Noticed 2-blowers in operation for 17 plus hours. B1 ABAC setpoint at 1 mg/L. B3 and 4 at 3 mg/L. Set all ABAC setpoints to 5 mg/L to observe effect to blower run hours.
- 7/13/22 - ABAC setpoint to 7 mg/L. 2-blowers running from 10:30 am to 2:30 am. High pinfloc at clarifiers and cloudy settlemeters.
- 7/14/22 - B4Z5 ammonia reading higher than B4Z1. Chronic issue with high ammonia reading B3Z1 compared to all basins. 2x higher.
- 7/15/22 - West secondary clarifier off-line today for cleaning
- 7/18/22 - Dropped ABAC setpoint to 5 mg/L all basins from 7 mg/L to quantify blower capacity
- 7/20/22 - Low MLSS inventory due to RAS misaligned to off-line basin 2. Corrected by end of day.
- 7/21/22 - Lowered ABAC setpoint all basins to 3 mg/L at 9 am
- 7/25/22 - East secondary clarifier off-line this week for cleaning.
- 7/27/22 - Septage shutdown for digester repairs. Field study suspended.
- 8/2/22 - QCC programming methanol dose control. Status not complete at this time.

Appendix E. Optimization Projects OPCC

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 1 Improvements - Centrate EQ					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 1 - General Requirements						**$ 39,100**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	4	Week	$ 2,500		$ 10,000
01 73 20	Openings & Penetrations	1	LS	$ 7,500		$ 7,500
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	10	DAYS	$ 960		$ 9,600
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 2 - Existing Conditions						**$ 10,000**
02 41 00	Demolition	1	LS	$ 10,000		$ 10,000
Division 3 - Concrete						**$ 312,500**
03 00 05	New Centrate Storage Tank	2,500	SF	$ 50	$ 75	$ 312,500
Division 5 - Metals						**$ 25,000**
05 50 00	Misc Metals	1	LS	$ 25,000		$ 25,000
Division 09 - High Industrial Coating						**$ 130,000**
09 96 00	Tank Coating	2,400	SF	$ 25	$ 25	$ 120,000
09 96 00	Misc Metals Coating	1	LS	$ 10,000		$ 10,000
Division 26 - Electrical						**$ -**
	See Multiplier Below					
Division 31 - Earthwork						**$ 29,500**
31 23 10	Excavation (structure and piping)	1,000	CY	$ -	$ 25	$ 25,000
31 23 10	Backfill (utility)	100	CY	$ 35	$ 10	$ 4,500
Division 40 - Process Interconnections						**$ 187,381**
40 05 07	Pipe Supports	1	LS	$ 5,000	$ 5,000	$ 10,000
40 05 19	4" Ductile Iron Piping	250	LF	$ 62	$ 7	$ 17,250
40 05 00	4" Ductile Iron 90-Elbow	25	EA	$ 232	$ 63	$ 7,375
40 05 52	Valve Allowance	12	EA	$ 5,000	$ 63	$ 60,756
40 05 59	Fabricated Stainless Steel Slide Gates	1	EA	$ 20,000	$ 10,000	$ 30,000
40 05 64	18" Gate Valve, Buried	2	EA	$ 30,000	$ 1,000	$ 62,000
Division 43 - Process Gas and Liquid Handling, Purification and Storage Equipment						**$ 57,500**
43 23 14	Centrifugal Pumps (Centrate)	2	EA	$ 25,000	$ 3,750	$ 57,500
Division 46 - Water and Wastewater Equipment						**$ 275,000**
46 13 13	Aluminum Covers (Centrate Tank)	2,500	SF	$ 85	$ 25	$ 275,000
				Mech/Structural Direct Cost Subtotal:		**$ 1,065,981**
				Electrical, Instrumentation & Controls	25%	$ 266,000
				Subtotal Direct Cost:		**$ 1,331,981**
				GC Mobilization/Demobilization:	10%	$ 133,000
				General Contractor Home Office Overhead:	8%	$ 107,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 160,000
				Bond & All Risk Insurance:	2.5%	$ 33,000
				Contingency	17.5%	$ 233,000
				Subtotal:		**$ 1,998,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 184,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 2,182,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 2,182,000**
				Project Engineering and Administration	25.0%	$ 546,000
				Construction Services and Allied Costs	25.0%	$ 546,000
				Total Project Cost:		**$ 3,274,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 1,637,000
				High	100%	$ 6,548,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 1 Improvements - IMLR and Methanol Field Testing/Full Year Operation					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 40 - Process Interconnections						**$ 20,000**
40 61 96	Allowance for Extra Testing (Integrator)	1	LS	$ 20,000	$ -	$ 20,000
				Mech/Structural Direct Cost Subtotal:		**$ 20,000**
				Electrical, Instrumentation & Controls	0%	$ -
				Subtotal Direct Cost:		**$ 20,000**
				GC Mobilization/Demobilization:	0%	$ -
				General Contractor Home Office Overhead:	0%	$ -
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	0%	$ -
				Bond & All Risk Insurance:	0.0%	$ -
				Contingency	0.0%	$ -
				Subtotal:		**$ 20,000**
				Washington State Sales Tax (Poulsbo, WA):	0.0%	$ -
				Contingency:	0.0%	$ -
				Subtotal:		**$ 20,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 20,000**
				Project Engineering and Administration	25.0%	$ 5,000
				Construction Services and Allied Costs	25.0%	$ 5,000
				Total Project Cost:		**$ 30,000**
Class 5 Accuracy Range per AACE 18R-97			Low		-50%	$ 15,000
			High		100%	$ 60,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 1 Improvements - Aeration Basin Influent Hydraulic Upgrades					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 1 - General Requirements						**$ 34,100**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	2	Week	$ 2,500		$ 5,000
01 73 20	Openings & Penetrations	1	LS	$ 7,500		$ 7,500
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	10	DAYS	$ 960		$ 9,600
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 2 - Existing Conditions						**$ 10,000**
02 41 00	Demolition	1	LS	$ 10,000		$ 10,000
Division 5 - Metals						**$ 25,000**
05 50 00	Misc Metals	1	LS	$ 25,000		$ 25,000
Division 09 - High Industrial Coating						**$ 10,000**
09 96 00	Misc Metals Coating	1	LS	$ 10,000		$ 10,000
Division 10 - Specialties						**$ 750**
10 14 00	Identification Tags	10	LS	$ 50	$ 25	$ 750
Division 26 - Electrical						**$ -**
	See Multiplier Below					
Division 40 - Process Interconnections						**$ 60,000**
40 05 59	Fabricated Stainless Steel Slide Gates	2	EA	$ 20,000	$ 10,000	$ 60,000
Division 46 - Water and Wastewater Equipment						**$ 150,000**
46 41 00	Influent Box Mechanical Allowance (Baffles, CFD, Additional Mixers)	1	LS	$ 100,000	$ 50,000	$ 150,000
					Mech/Structural Direct Cost Subtotal:	**$ 289,850**
				Electrical, Instrumentation & Controls	25%	$ 72,000
				Subtotal Direct Cost:		**$ 361,850**
				GC Mobilization/Demobilization:	10%	$ 36,000
				General Contractor Home Office Overhead:	8%	$ 29,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 43,000
				Bond & All Risk Insurance:	2.5%	$ 9,000
				Contingency	17.5%	$ 63,000
				Subtotal:		**$ 542,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 50,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 592,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 592,000**
				Project Engineering and Administration	25.0%	$ 148,000
				Construction Services and Allied Costs	25.0%	$ 148,000
					Total Project Cost:	**$ 888,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 444,000
				High	100%	$ 1,776,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 1 Improvements - RAS Flow Improvements (Analysis)					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 40 - Process Interconnections						**$ 100,000**
40 61 96	Allowance for RAS Engineering Analysis	1	LS	$ 100,000	$ -	$ 100,000
					Mech/Structural Direct Cost Subtotal:	**$ 100,000**
				Electrical, Instrumentation & Controls	0%	$ -
				Subtotal Direct Cost:		**$ 100,000**
				GC Mobilization/Demobilization:	0%	$ -
				General Contractor Home Office Overhead:	0%	$ -
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	0%	$ -
				Bond & All Risk Insurance:	0.0%	$ -
				Contingency	0.0%	$ -
				Subtotal:		**$ 100,000**
				Washington State Sales Tax (Poulsbo, WA):	0.0%	$ -
				Contingency:	0.0%	$ -
				Subtotal:		**$ 100,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 100,000**
				Project Engineering and Administration	25.0%	$ 25,000
				Construction Services and Allied Costs	25.0%	$ 25,000
					Total Project Cost:	**$ 150,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 75,000
				High	100%	$ 300,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 1 Improvements - Methanol Storage					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 1 - General Requirements						**$ 26,800**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	1	Week	$ 2,500		$ 2,500
01 73 20	Openings & Penetrations	1	LS	$ 7,500		$ 7,500
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	5	DAYS	$ 960		$ 4,800
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 2 - Existing Conditions						**$ 10,000**
02 41 00	Demolition	1	LS	$ 10,000		$ 10,000
Division 5 - Metals						**$ 25,000**
05 50 00	Misc Metals	1	LS	$ 25,000		$ 25,000
Division 09 - High Industrial Coating						**$ 5,000**
09 96 00	Misc Metals Coating	1	LS	$ 5,000		$ 5,000
Division 10 - Specialties						**$ 750**
10 14 00	Identification Tags	10	LS	$ 50	$ 25	$ 750
Division 26 - Electrical						**$ -**
	See Multiplier Below					
Division 40 - Process Interconnections						**$ 76,458**
40 05 07	Pipe Supports	1	LS	$ 5,000	$ 5,000	$ 10,000
40 05 23	1" Stainless Steel Piping	100	LF	$ 47	$ 10	$ 5,702
40 05 52	Valve Allowance	12	EA	$ 5,000	$ 63	$ 60,756
Division 43 - Process Gas and Liquid Handling, Purification and Storage Equipment						**$ 97,500**
43 41 13.33	Methanol Storage Tank (10,000 gal)	1	LS	$ 75,000	$ 22,500	$ 97,500
				Mech/Structural Direct Cost Subtotal:		**$ 241,508**
				Electrical, Instrumentation & Controls	25%	$ 60,000
				Subtotal Direct Cost:		**$ 301,508**
				GC Mobilization/Demobilization:	10%	$ 30,000
				General Contractor Home Office Overhead:	8%	$ 24,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 36,000
				Bond & All Risk Insurance:	2.5%	$ 8,000
				Contingency	17.5%	$ 53,000
				Subtotal:		**$ 453,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 42,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 495,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 495,000**
				Project Engineering and Administration	25.0%	$ 124,000
				Construction Services and Allied Costs	25.0%	$ 124,000
				Total Project Cost:		**$ 743,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 372,000
				High	100%	$ 1,486,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 2 Improvements - Aeration Distribution Upgrades					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 1 - General Requirements						**$ 26,600**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	2	Week	$ 2,500		$ 5,000
01 73 20	Openings & Penetrations	-	LS	$ 7,500		$ -
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	10	DAYS	$ 960		$ 9,600
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 2 - Existing Conditions						**$ 10,000**
02 41 00	Demolition	1	LS	$ 10,000		$ 10,000
Division 3 - Concrete						**$ 2,000**
03 00 05	Minor Equipment Pads	1	LS	$ 2,000		$ 2,000
Division 5 - Metals						**$ 15,000**
05 50 00	Misc Metals	1	LS	$ 15,000		$ 15,000
Division 09 - High Industrial Coating						**$ 5,000**
09 96 00	Misc Metals Coating	1	LS	$ 5,000		$ 5,000
Division 10 - Specialties						**$ 1,800**
10 14 00	Identification Tags	24	LS	$ 50	$ 25	$ 1,800
Division 26 - Electrical						**$ -**
	See Multiplier Below					
Division 40 - Process Interconnections						**$ 340,000**
40 05 07	Pipe Supports	1	LS	$ 5,000	$ 5,000	$ 10,000
40 05 00	Misc Piping Allowance	1	LS	$ 30,000		$ 30,000
40 05 52	Additional Control Valve Allowance	12	EA	$ 15,000	$ 3,750	$ 225,000
40 71 00	New Flow Meters	12	EA	$ 5,000	$ 1,250	$ 75,000
					Mech/Structural Direct Cost Subtotal:	**$ 400,400**
				Electrical, Instrumentation & Controls	25%	$ 100,000
				Subtotal Direct Cost:		**$ 500,400**
				GC Mobilization/Demobilization:	10%	$ 50,000
				General Contractor Home Office Overhead:	8%	$ 40,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 60,000
				Bond & All Risk Insurance:	2.5%	$ 13,000
				Contingency	17.5%	$ 88,000
				Subtotal:		**$ 752,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 70,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 822,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 822,000**
				Project Engineering and Administration	25.0%	$ 206,000
				Construction Services and Allied Costs	25.0%	$ 206,000
					Total Project Cost:	**$ 1,234,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 617,000
				High	100%	$ 2,468,000

Notes:

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Opinion of Probable Construction Cost (OPCC)

Project Stage: 10% Design
Client: Kitsap County
Project: BNR Optimization - Tier 2 Improvements - Blower Upgrades

Section	Description	Quantity	Unit	Unit Price	Install	Amount
Division 1 - General Requirements						**$ 24,100**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	1	Week	$ 2,500		$ 2,500
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	10	DAYS	$ 960		$ 9,600
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 2 - Existing Conditions						**$ 10,000**
02 41 00	Demolition	1	LS	$ 10,000		$ 10,000
Division 3 - Concrete						**$ 2,000**
03 00 05	Minor Equipment Pads	1	LS	$ 2,000		$ 2,000
Division 5 - Metals						**$ 25,000**
05 50 00	Misc Metals	1	LS	$ 25,000		$ 25,000
Division 09 - High Industrial Coating						**$ 5,000**
09 96 00	Misc Metals Coating	1	LS	$ 5,000		$ 5,000
Division 10 - Specialties						**$ 900**
10 14 00	Identification Tags	12	LS	$ 50	$ 25	$ 900
Division 26 - Electrical						**$ -**
	See Multiplier Below					
Division 40 - Process Interconnections						**$ 37,500**
40 05 07	Pipe Supports	1	LS	$ 2,500	$ 2,500	$ 5,000
40 05 23	Blower Stainless Steel Piping Allowance	1	LS	$ 20,000		$ 20,000
40 05 64	Air Service Manual Butterfly Valves	2	EA	$ 5,000	$ 1,250	$ 12,500
Division 43 - Process Gas and Liquid Handling, Purification and Storage Equipment						**$ 390,000**
43 11 50	Blowers and Main Control Panel Allowance	1	LS	$ 300,000	$ 90,000	$ 390,000
					Mech/Structural Direct Cost Subtotal:	**$ 494,500**
				Electrical, Instrumentation & Controls	25%	$ 124,000
				Subtotal Direct Cost:		**$ 618,500**
				GC Mobilization/Demobilization:	10%	$ 62,000
				General Contractor Home Office Overhead:	8%	$ 49,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 74,000
				Bond & All Risk Insurance:	2.5%	$ 15,000
				Contingency	17.5%	$ 108,000
				Subtotal:		**$ 927,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 86,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 1,013,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 1,013,000**
				Project Engineering and Administration	25.0%	$ 254,000
				Construction Services and Allied Costs	25.0%	$ 254,000
					Total Project Cost:	**$ 1,521,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 761,000
				High	100%	$ 3,042,000

Notes:

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Opinion of Probable Construction Cost (OPCC)							
Project Stage:	10% Design						
Client:	Kitsap County						
Project:	BNR Optimization - Tier 2 Improvements - Nitrogen Probe Upgrades						
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**		**Amount**
Division 1 - General Requirements						**$**	**21,600**
01 41 24	Permits & Fees	1	LS	$ 2,000		$	2,000
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$	5,000
01 91 00	Startup	10	DAYS	$ 960		$	9,600
01 78 39	Record Drawings	1	LS	$ 5,000		$	5,000
Division 2 - Existing Conditions						**$**	**2,000**
02 41 00	Demolition	1	LS	$ 2,000		$	2,000
Division 3 - Concrete						**$**	**2,000**
03 00 05	Minor Equipment Pads	1	LS	$ 2,000		$	2,000
Division 5 - Metals						**$**	**2,000**
05 50 00	Misc Metals	1	LS	$ 2,000		$	2,000
Division 09 - High Industrial Coating						**$**	**2,000**
09 96 00	Misc Metals Coating	1	LS	$ 2,000		$	2,000
Division 10 - Specialties						**$**	**900**
10 14 00	Identification Tags	12	LS	$ 50	$ 25	$	900
Division 26 - Electrical						**$**	**-**
	See Multiplier Below						
Division 40 - Process Interconnections						**$**	**265,000**
40 05 07	Pipe Supports	1	LS	$ 2,500	$ 2,500	$	5,000
40 05 00	Misc Piping and Valve Allowance	1	LS	$ 10,000		$	10,000
40 61 96	New Wet Chemistry Probe Units	2	EA	$ 100,000	$ 25,000	$	250,000
				Mech/Structural Direct Cost Subtotal:		**$**	**295,500**
				Electrical, Instrumentation & Controls	25%	$	74,000
				Subtotal Direct Cost:		**$**	**369,500**
				GC Mobilization/Demobilization:	10%	$	37,000
				General Contractor Home Office Overhead:	8%	$	30,000
				General Contractor General Conditions:	0%	$	-
				General Contractor Profit:	12%	$	44,000
				Bond & All Risk Insurance:	2.5%	$	9,000
				Contingency	17.5%	$	65,000
				Subtotal:		**$**	**555,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$	52,000
				Contingency:	0.0%	$	-
				Subtotal:		**$**	**607,000**
				Escalation to Mid-Point:	0.0%	$	-
				Total Construction Cost:		**$**	**607,000**
				Project Engineering and Administration	25.0%	$	152,000
				Construction Services and Allied Costs	25.0%	$	152,000
					Total Project Cost:	**$**	**911,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$	456,000
				High	100%	$	1,822,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 3 Improvements - Sidestream Treatment					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 1 - General Requirements						**$ 70,800**
01 41 24	Permits & Fees	1	LS	$ 2,000		$ 2,000
01 14 19	Crane Rental	4	Week	$ 2,500		$ 10,000
01 73 20	Openings & Penetrations	1	LS	$ 20,000		$ 20,000
01 78 23	Shop Drawings / O&M Manual	1	LS	$ 5,000		$ 5,000
01 91 00	Startup	30	DAYS	$ 960		$ 28,800
01 78 39	Record Drawings	1	LS	$ 5,000		$ 5,000
Division 46 - Water and Wastewater Equipment						**$ 3,000,000**
46 00 00	Sidestream Treatment System	1	LS	$ 3,000,000	$ -	$ 3,000,000
				Mech/Structural Direct Cost Subtotal:		**$ 3,070,800**
				Electrical, Instrumentation & Controls	25%	$ 768,000
				Subtotal Direct Cost:		**$ 3,838,800**
				GC Mobilization/Demobilization:	10%	$ 384,000
				General Contractor Home Office Overhead:	8%	$ 307,000
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	12%	$ 461,000
				Bond & All Risk Insurance:	2.5%	$ 96,000
				Contingency	17.5%	$ 672,000
				Subtotal:		**$ 5,759,000**
				Washington State Sales Tax (Poulsbo, WA):	9.2%	$ 530,000
				Contingency:	0.0%	$ -
				Subtotal:		**$ 6,289,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 6,289,000**
				Project Engineering and Administration	25.0%	$ 1,573,000
				Construction Services and Allied Costs	25.0%	$ 1,573,000
				Total Project Cost:		**$ 9,435,000**
Class 5 Accuracy Range per AACE 18R-97				Low	-50%	$ 4,718,000
				High	100%	$ 18,870,000

Notes:

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Opinion of Probable Construction Cost (OPCC)						
Project Stage:	10% Design					
Client:	Kitsap County					
Project:	BNR Optimization - Tier 3 Improvements - Step-Feed Field Testing					
Section	**Description**	**Quantity**	**Unit**	**Unit Price**	**Install**	**Amount**
Division 40 - Process Interconnections						**$ 20,000**
40 61 96	Allowance for Extra Testing (Integrator)	1	LS	$ 20,000	$ -	$ 20,000
				Mech/Structural Direct Cost Subtotal:		**$ 20,000**
				Electrical, Instrumentation & Controls	0%	$ -
				Subtotal Direct Cost:		**$ 20,000**
				GC Mobilization/Demobilization:	0%	$ -
				General Contractor Home Office Overhead:	0%	$ -
				General Contractor General Conditions:	0%	$ -
				General Contractor Profit:	0%	$ -
				Bond & All Risk Insurance:	0.0%	$ -
				Contingency	0.0%	$ -
				Subtotal:		**$ 20,000**
				Washington State Sales Tax (Poulsbo, WA):	0.0%	$ -
				Contingency:	0.0%	$ -
				Subtotal:		**$ 20,000**
				Escalation to Mid-Point:	0.0%	$ -
				Total Construction Cost:		**$ 20,000**
				Project Engineering and Administration	25.0%	$ 5,000
				Construction Services and Allied Costs	25.0%	$ 5,000
				Total Project Cost:		**$ 30,000**
Class 5 Accuracy Range per AACE 18R-97			Low	-50%		$ 15,000
			High	100%		$ 60,000

Notes:

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consor

APPENDIX L
VISUAL HYDRAULICS MODEL

Visual Hydraulics Summary Report - Hydraulic Analysis

Project: **Central Kitsap WWTP - Existing_All On Line.vhf**
Company: **Consor**
Date: **10/14/2024**

Current flow conditions

Forward Flow =	21.6 mgd
Return I Flow =	5.4 mgd
Return II Flow =	-----
Return III Flow =	-----

Section Description	Water Surface Elevation
Starting water surface elevation	**0**
Eff Pipe 2	**1.39**

Pipe shape = Circular
Diameter = 36 in
Length = 500 ft
Flow = 21.6 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 0.4
Pipe area = 7.07 ft^2
Pipe hydraulic radius = 0.75
Age factor = 1
Solids factor = 1
Velocity = 4.73 ft/s
Friction loss = 1.25 ft
Fitting loss = 0.14 ft
Total loss = 1.39 ft

MH_B — **1.6**

Manhole config. = one pipe in, one pipe out
Angle between pipes = 100 degrees
Diameter of pipe into manhole = 72 in
Diameter of pipe out of manhole = 36 in
Flow through manhole = 21.6 mgd
Velocity of pipe out of manhole = 4.73 ft/s
Manhole configuration K value = 0.6
Overall head loss = 0.21 ft

Section Description	Water Surface Elevation
Eff Pipe 1	**1.63**

Pipe shape = Circular
Diameter = 72 in
Length = 45 ft
Flow = 21.6 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 1.5
Pipe area = 28.27 ft²
Pipe hydraulic radius = 1.5
Age factor = 1
Solids factor = 1
Velocity = 1.18 ft/s
Friction loss = 0 ft
Fitting loss = 0.03 ft
Total loss = 0.04 ft

Eff_Weir — **140.08**

Weir invert (top of weir) = 139
Weir length = 9 ft
Weir 'C' coefficient = 3.33
Flow over weir = 21.6 mgd
Weir submergence = unsubmerged
Head over weir = 1.08 ft

Effluent Channel — **140.08**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 20 ft
Channel width/diameter = 9 ft
Flow = 21.6 mgd
Downstream channel invert = 130
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 90.68 ft^2
Hydraulic radius = 3.111
Normal depth = infinite
Critical depth = 0.75 ft
Depth downstream = 10.08 ft
Bend loss = 0 ft
Depth upstream = 10.08 ft
Velocity = 0.37 ft/s
Flow profile = Horizontal

UV1 Control Weir — **140.62**

Constant elevation = 140.62

Section Description	Water Surface Elevation
UV2 Control Weir	**140.62**

Constant elevation = 140.62

UV2 Eff Channel — **140.62**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 12.67 ft
Channel width/diameter = 5.33 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 28.2 ft^2
Hydraulic radius = 1.772
Normal depth = infinite
Critical depth = 0.67 ft
Depth downstream = 5.29 ft
Bend loss = 0 ft
Depth upstream = 5.29 ft
Velocity = 0.59 ft/s
Flow profile = Horizontal

PC2 Launder — **140.62**

Flow through transition = 10.8 mgd
Transition invert = 135.33
Contraction width = 3.65 ft
Expansion width = 5.33 ft
Downtream velocity = 0.59 ft/s
Upstream velocity = 0.86 ft/s
Units on-line = 0
Total flow, all units = 0 mgd
Downstream depth = 5.29 ft
Upstream depth = 5.29 ft

UV2 Bank Channel — **140.62**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 21.33 ft
Channel width/diameter = 3.65 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 19.31 ft^2
Hydraulic radius = 1.357
Normal depth = infinite
Critical depth = 0.87 ft
Depth downstream = 5.29 ft

Section Description	Water Surface Elevation

Bend loss = 0 ft
Depth upstream = 5.29 ft
Velocity = 0.87 ft/s
Flow profile = Horizontal

PC2 Launder **140.62**

Flow through transition = 10.8 mgd
Transition invert = 135.33
Contraction width = 3.65 ft
Expansion width = 5.33 ft
Downtream velocity = 0.86 ft/s
Upstream velocity = 0.59 ft/s
Units on-line = 0
Total flow, all units = 0 mgd
Downstream depth = 5.29 ft
Upstream depth = 5.29 ft

UV2 Inf Channel **140.63**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 2 ft
Channel width/diameter = 5.33 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 28.22 ft^2
Hydraulic radius = 1.773
Normal depth = infinite
Critical depth = 0.67 ft
Depth downstream = 5.29 ft
Bend loss = 0 ft
Depth upstream = 5.3 ft
Velocity = 0.59 ft/s
Flow profile = Horizontal

UV2 Gate **140.67**

Opening type = rectangular gate
Opening diameter/width = 48 in
Gate height = 48 in
Invert = 135.22
Number of gates = 1
Flow through gate(s) = 10.8 mgd
Total area of opening(s) = 16 ft^2
Velocity through gate(s) = 1.04 ft/s
Flow behavior = orifice, downstream control
Gate loss = 0.04 ft
Downstream water level = 140.63

Section Description	Water Surface Elevation

Upstream water level = 140.67

UV1 Eff Channel **140.62**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 12.67 ft
Channel width/diameter = 5.33 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 28.2 ft^2
Hydraulic radius = 1.772
Normal depth = infinite
Critical depth = 0.67 ft
Depth downstream = 5.29 ft
Bend loss = 0 ft
Depth upstream = 5.29 ft
Velocity = 0.59 ft/s
Flow profile = Horizontal

PC2 Launder **140.62**

Flow through transition = 10.8 mgd
Transition invert = 135.33
Contraction width = 3.65 ft
Expansion width = 5.33 ft
Downtream velocity = 0.59 ft/s
Upstream velocity = 0.86 ft/s
Units on-line = 0
Total flow, all units = 0 mgd
Downstream depth = 5.29 ft
Upstream depth = 5.29 ft

UV1 Bank Channel **140.62**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 21.33 ft
Channel width/diameter = 3.65 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 19.31 ft^2
Hydraulic radius = 1.357
Normal depth = infinite
Critical depth = 0.87 ft
Depth downstream = 5.29 ft
Bend loss = 0 ft

Section Description	Water Surface Elevation

Depth upstream = 5.29 ft
Velocity = 0.87 ft/s
Flow profile = Horizontal

PC2 Launder — **140.62**

Flow through transition = 10.8 mgd
Transition invert = 135.33
Contraction width = 3.65 ft
Expansion width = 5.33 ft
Downtream velocity = 0.86 ft/s
Upstream velocity = 0.59 ft/s
Units on-line = 0
Total flow, all units = 0 mgd
Downstream depth = 5.29 ft
Upstream depth = 5.29 ft

UV1 Inf Channel — **140.63**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 2 ft
Channel width/diameter = 5.33 ft
Flow = 10.8 mgd
Downstream channel invert = 135.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 28.22 ft^2
Hydraulic radius = 1.773
Normal depth = infinite
Critical depth = 0.67 ft
Depth downstream = 5.29 ft
Bend loss = 0 ft
Depth upstream = 5.3 ft
Velocity = 0.59 ft/s
Flow profile = Horizontal

UV1 Gate — **140.67**

Opening type = rectangular gate
Opening diameter/width = 48 in
Gate height = 48 in
Invert = 135.22
Number of gates = 1
Flow through gate(s) = 10.8 mgd
Total area of opening(s) = 16 ft^2
Velocity through gate(s) = 1.04 ft/s
Flow behavior = orifice, downstream control
Gate loss = 0.04 ft
Downstream water level = 140.63
Upstream water level = 140.67

Section Description	Water Surface Elevation

UV Split **140.67**

User defined loss for flow split = 0 ft
Total flow through flow split = 21.6 mgd

UV Common Influent Channel **140.67**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 34 ft
Channel width/diameter = 7 ft
Flow = 21.6 mgd
Downstream channel invert = 132
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 60.69 ft^2
Hydraulic radius = 2.493
Normal depth = infinite
Critical depth = 0.89 ft
Depth downstream = 8.67 ft
Bend loss = 0 ft
Depth upstream = 8.67 ft
Velocity = 0.55 ft/s
Flow profile = Horizontal

SE2 Pipe **140.82**

Pipe shape = Circular
Diameter = 36 in
Length = 23 ft
Flow = 10.8 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 1.5
Pipe area = 7.07 ft^2
Pipe hydraulic radius = 0.75
Age factor = 1
Solids factor = 1
Velocity = 2.36 ft/s
Friction loss = 0.01 ft
Fitting loss = 0.13 ft
Total loss = 0.14 ft

SE2 Gate **141.03**

Opening type = rectangular gate
Opening diameter/width = 36 in
Gate height = 36 in
Invert = 140
Number of gates = 1

Section Description	Water Surface Elevation
Flow through gate(s) = 10.8 mgd Total area of opening(s) = 9 ft^2 Velocity through gate(s) = 1.86 ft/s Flow behavior = weir control Gate loss = 1.03 ft Downstream water level = 140.82 Upstream water level = 141.03	
PC2 Launder	**143.2**
Flow through transition = 10.8 mgd Transition invert = 141 Contraction width = 3 ft Expansion width = 6 ft Downtream velocity = 8.95 ft/s Upstream velocity = 1.27 ft/s Units on-line = 0 Total flow, all units = 0 mgd Downstream depth = 0.62 ft Upstream depth = 2.2 ft	
SE2 Slide	**143.05**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 12.5 ft Channel width/diameter = 3 ft Flow = 10.8 mgd Downstream channel invert = 140 Channel slope = 0.12 ft/ft Channel side slope = not applicable Area of flow = 7.12 ft^2 Hydraulic radius = 0.919 Normal depth = 0.34 ft Critical depth = 0.99 ft Depth downstream = 3.2 ft Bend loss = 0 ft Depth upstream = 1.55 ft Velocity = 1.74 ft/s Flow profile = Steep	
Secondary Clarifier 1 Launder	**143.41**
Launder invert = 141.5 Launder length = 132 ft Launder width = 3 ft Launder slope = 0 ft/ft Flow through launder = 10.8 mgd Critical depth = 0.99 ft Downstream depth = 1.55 ft Upstream depth = 1.91 ft	

Section Description	Water Surface Elevation
Secondary Clarifier 1 Weir	**144.17**

Invert of notch = 143.9
Width of notch = 1.25 in
Number of notches = 352
Total flow over weir = 10.8 mgd
Weir submergence = unsubmerged
Head over weir = 0.27 ft

ML Sec Clarifier1 — **145.17**

Pipe shape = Circular
Diameter = 30 in
Length = 170 ft
Flow = 13.5 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2
Pipe area = 4.91 ft^2
Pipe hydraulic radius = 0.625
Age factor = 1
Solids factor = 1
Velocity = 4.25 ft/s
Friction loss = 0.44 ft
Fitting loss = 0.56 ft
Total loss = 1 ft

ML Eff Box 1 — **145.17**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 4 ft
Channel width/diameter = 4 ft
Flow = 13.5 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 16.67 ft^2
Hydraulic radius = 1.351
Normal depth = infinite
Critical depth = 0.95 ft
Depth downstream = 4.17 ft
Bend loss = 0 ft
Depth upstream = 4.17 ft
Velocity = 1.25 ft/s
Flow profile = Horizontal

ML Flume 1 — **145.89**

Flume invert = 144
Flume length = 5.5 ft

Section Description	Water Surface Elevation
Flume throat width = 2 ft	
Flow through flume = 13.5 mgd	
Flume submergence = unsubmerged	
Head through flume = 1.89 ft	
Sec Clarifier Gate 1	**145.99**
Opening type = rectangular gate	
Opening diameter/width = 36 in	
Gate height = 42 in	
Invert = 144	
Number of gates = 1	
Flow through gate(s) = 13.5 mgd	
Total area of opening(s) = 5.66 ft^2	
Velocity through gate(s) = 3.69 ft/s	
Flow behavior = orifice, downstream control	
Gate loss = 0.11 ft	
Downstream water level = 145.89	
Upstream water level = 145.99	
SE1 Pipe	**140.73**
Pipe shape = Circular	
Diameter = 48 in	
Length = 166 ft	
Flow = 10.8 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 1.3	
Pipe area = 12.57 ft²	
Pipe hydraulic radius = 1	
Age factor = 1	
Solids factor = 1	
Velocity = 1.33 ft/s	
Friction loss = 0.02 ft	
Fitting loss = 0.04 ft	
Total loss = 0.06 ft	
MH A	**140.75**
Manhole config. = one pipe in, one pipe out	
Angle between pipes = 135 degrees	
Diameter of pipe into manhole = 36 in	
Diameter of pipe out of manhole = 48 in	
Flow through manhole = 10.8 mgd	
Velocity of pipe out of manhole = 1.33 ft/s	
Manhole configuration K value = 0.6	
Overall head loss = 0.02 ft	
SE1 Pipe1	**140.82**
Pipe shape = Circular	

Section Description	Water Surface Elevation
Diameter = 36 in Length = 38 ft Flow = 10.8 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 0.5 Pipe area = 7.07 ft² Pipe hydraulic radius = 0.75 Age factor = 1 Solids factor = 1 Velocity = 2.36 ft/s Friction loss = 0.02 ft Fitting loss = 0.04 ft Total loss = 0.07 ft	
SE1 Gate	**141.03**
Opening type = rectangular gate Opening diameter/width = 36 in Gate height = 36 in Invert = 140 Number of gates = 1 Flow through gate(s) = 10.8 mgd Total area of opening(s) = 9 ft^2 Velocity through gate(s) = 1.86 ft/s Flow behavior = weir control Gate loss = 1.03 ft Downstream water level = 140.82 Upstream water level = 141.03	
PC2 Launder	**143.2**
Flow through transition = 10.8 mgd Transition invert = 141 Contraction width = 3 ft Expansion width = 6 ft Downtream velocity = 8.95 ft/s Upstream velocity = 1.27 ft/s Units on-line = 0 Total flow, all units = 0 mgd Downstream depth = 0.62 ft Upstream depth = 2.2 ft	
SE1 Slide	**143.05**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 12.5 ft Channel width/diameter = 3 ft Flow = 10.8 mgd Downstream channel invert = 140	

Section Description	Water Surface Elevation
Channel slope = 0.12 ft/ft	
Channel side slope = not applicable	
Area of flow = 7.12 ft^2	
Hydraulic radius = 0.919	
Normal depth = 0.34 ft	
Critical depth = 0.99 ft	
Depth downstream = 3.2 ft	
Bend loss = 0 ft	
Depth upstream = 1.55 ft	
Velocity = 1.74 ft/s	
Flow profile = Steep	
Secondary Clarifier 2 Launder	**143.41**
Launder invert = 141.5	
Launder length = 132 ft	
Launder width = 3 ft	
Launder slope = 0 ft/ft	
Flow through launder = 10.8 mgd	
Critical depth = 0.99 ft	
Downstream depth = 1.55 ft	
Upstream depth = 1.91 ft	
Secondary Clarifier 2 Weir	**144.17**
Invert of notch = 143.9	
Width of notch = 1.25 in	
Number of notches = 352	
Total flow over weir = 10.8 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.27 ft	
ML Sec Clarifier2	**145.17**
Pipe shape = Circular	
Diameter = 30 in	
Length = 170 ft	
Flow = 13.5 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2	
Pipe area = 4.91 ft^2	
Pipe hydraulic radius = 0.625	
Age factor = 1	
Solids factor = 1	
Velocity = 4.25 ft/s	
Friction loss = 0.44 ft	
Fitting loss = 0.56 ft	
Total loss = 1 ft	
ML Eff Box 2	**145.17**

Section Description	Water Surface Elevation

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 4 ft
Channel width/diameter = 4 ft
Flow = 13.5 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 16.67 ft^2
Hydraulic radius = 1.351
Normal depth = infinite
Critical depth = 0.95 ft
Depth downstream = 4.17 ft
Bend loss = 0 ft
Depth upstream = 4.17 ft
Velocity = 1.25 ft/s
Flow profile = Horizontal

ML Flume 2 — **145.89**

Flume invert = 144
Flume length = 5.5 ft
Flume throat width = 2 ft
Flow through flume = 13.5 mgd
Flume submergence = unsubmerged
Head through flume = 1.89 ft

Sec Clarifier Gate 2 — **145.99**

Opening type = rectangular gate
Opening diameter/width = 36 in
Gate height = 42 in
Invert = 144
Number of gates = 1
Flow through gate(s) = 13.5 mgd
Total area of opening(s) = 5.66 ft^2
Velocity through gate(s) = 3.69 ft/s
Flow behavior = orifice, downstream control
Gate loss = 0.11 ft
Downstream water level = 145.89
Upstream water level = 145.99

ML Split — **145.99**

User defined loss for flow split = 0 ft
Total flow through flow split = 27 mgd

New ML Chnnl A — **146.01**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 30 ft

Section Description	Water Surface Elevation

Channel width/diameter = 6 ft
Flow = 27 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 29.96 ft^2
Hydraulic radius = 1.874
Normal depth = infinite
Critical depth = 1.15 ft
Depth downstream = 4.99 ft
Bend loss = 0.01 ft
Depth upstream = 5.01 ft
Velocity = 1.39 ft/s
Flow profile = Horizontal

New ML Chnnl B **146.02**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 16 ft
Channel width/diameter = 6 ft
Flow = 27 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 30.05 ft^2
Hydraulic radius = 1.876
Normal depth = infinite
Critical depth = 1.15 ft
Depth downstream = 5.01 ft
Bend loss = 0.01 ft
Depth upstream = 5.02 ft
Velocity = 1.39 ft/s
Flow profile = Horizontal

New ML Chnnl C **146.04**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 15 ft
Channel width/diameter = 6 ft
Flow = 27 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 30.13 ft^2
Hydraulic radius = 1.878
Normal depth = infinite
Critical depth = 1.15 ft
Depth downstream = 5.02 ft

Section Description	Water Surface Elevation
Bend loss = 0.01 ft Depth upstream = 5.04 ft Velocity = 1.39 ft/s Flow profile = Horizontal	
AB2 Channel	**146.06**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 36 ft Channel width/diameter = 2.5 ft Flow = 6.75 mgd Downstream channel invert = 143.17 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 7.17 ft^2 Hydraulic radius = 0.871 Normal depth = infinite Critical depth = 0.82 ft Depth downstream = 2.87 ft Bend loss = 0.01 ft Depth upstream = 2.89 ft Velocity = 1.46 ft/s Flow profile = Horizontal	
AB 1 Eff Weir	**148.1**
Weir invert (top of weir) = 147.83 Weir length = 22 ft Weir 'C' coefficient = 3.33 Flow over weir = 6.75 mgd Weir submergence = unsubmerged Head over weir = 0.27 ft	
AB 1, Zone 6	**148.1**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 45 ft Channel width/diameter = 24 ft Flow = 6.75 mgd Downstream channel invert = 132.33 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 378.56 ft^2 Hydraulic radius = 6.815 Normal depth = infinite Critical depth = 0.18 ft Depth downstream = 15.77 ft Bend loss = 0 ft	

Section Description	Water Surface Elevation
Depth upstream = 15.77 ft Velocity = 0.03 ft/s Flow profile = Horizontal	
AB 1.5 Weir	**148.12**
Weir invert (top of weir) = 145 Weir length = 10 ft Weir 'C' coefficient = 3.33 Flow over weir = 6.75 mgd Weir submergence = fully submerged Head over weir = 3.12 ft	
AB 1, Zone 5	**148.13**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 45 ft Channel width/diameter = 24 ft Flow = 6.75 mgd Downstream channel invert = 132.33 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 379.08 ft^2 Hydraulic radius = 6.819 Normal depth = infinite Critical depth = 0.18 ft Depth downstream = 15.79 ft Bend loss = 0 ft Depth upstream = 15.8 ft Velocity = 0.03 ft/s Flow profile = Horizontal	
AB 1.4 Weir	**148.15**
Weir invert (top of weir) = 145 Weir length = 10 ft Weir 'C' coefficient = 3.33 Flow over weir = 6.75 mgd Weir submergence = fully submerged Head over weir = 3.15 ft	
AB 1, Zone 4	**148.15**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 45 ft Channel width/diameter = 24 ft Flow = 6.75 mgd Downstream channel invert = 132.33 Channel slope = 0 ft/ft Channel side slope = not applicable	

Section Description	Water Surface Elevation

Area of flow = 379.61 ft^2
Hydraulic radius = 6.823
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.82 ft
Bend loss = 0 ft
Depth upstream = 15.82 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 1.3 Weir — **148.15**

Weir invert (top of weir) = 144.17
Weir length = 8 ft
Weir height = 10.34 ft
Flow over weir = 6.75 mgd
Submergence = submerged
Head over weir = 3.98 ft

AB 1, Zone 3 — **148.15**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 379.66 ft^2
Hydraulic radius = 6.824
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.82 ft
Bend loss = 0 ft
Depth upstream = 15.82 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 1.2 Weir — **148.17**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.17 ft

AB 1, Zone 2 — **148.17**

Channel shape = Rectangular
Manning's 'n' = 0.013

Section Description	Water Surface Elevation

Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 380.19 ft^2
Hydraulic radius = 6.828
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.84 ft
Bend loss = 0 ft
Depth upstream = 15.84 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 1.1 Weir — **148.19**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.19 ft

AB 1, Zone 1 — **148.19**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 380.72 ft^2
Hydraulic radius = 6.832
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.86 ft
Bend loss = 0 ft
Depth upstream = 15.86 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB1 Upper Inf Gate — **148.2**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 24 in

Section Description	Water Surface Elevation
Invert = 147.17 Number of openings = 1 Flow through opening(s) = 1.35 mgd Total area of opening(s) = 4.1 ft^2 Velocity through opening(s) = 0.51 ft/s Flow behavior = orifice, downstream control Orifice loss = 0 ft Downstream water level = 148.19 Upstream water level = 148.2	
AB1 Lower Inf Gates	**148.2**
Opening type = rectangular orifice Opening diameter/width = 48 in Opening height = 48 in Invert = 143.75 Number of openings = 2 Flow through opening(s) = 5.4 mgd Total area of opening(s) = 32 ft^2 Velocity through opening(s) = 0.26 ft/s Flow behavior = orifice, downstream control Orifice loss = 0 ft Downstream water level = 148.19 Upstream water level = 148.2	
AB1 Inf Split	**148.2**
User defined loss for flow split = 0 ft Total flow through flow split = 6.75 mgd	
AB1 Inf Channel	**148.2**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 16 ft Channel width/diameter = 2.5 ft Flow = 6.75 mgd Downstream channel invert = 143.17 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 12.57 ft^2 Hydraulic radius = 1.001 Normal depth = infinite Critical depth = 0.82 ft Depth downstream = 5.03 ft Bend loss = 0 ft Depth upstream = 5.03 ft Velocity = 0.83 ft/s Flow profile = Horizontal	
AB1 ML Pipe	**148.79**

Section Description	Water Surface Elevation
Pipe shape = Circular Diameter = 24 in Length = 115 ft Flow = 6.75 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 2 Pipe area = 3.14 ft² Pipe hydraulic radius = 0.5 Age factor = 1 Solids factor = 1 Velocity = 3.32 ft/s Friction loss = 0.24 ft Fitting loss = 0.34 ft Total loss = 0.59 ft	
ML1 Box	**148.79**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 4 ft Channel width/diameter = 4 ft Flow = 6.75 mgd Downstream channel invert = 144.25 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 18.16 ft^2 Hydraulic radius = 1.388 Normal depth = infinite Critical depth = 0.6 ft Depth downstream = 4.54 ft Bend loss = 0 ft Depth upstream = 4.54 ft Velocity = 0.57 ft/s Flow profile = Horizontal	
ML1 Flume	**148.79**
Flume invert = 148 Flume length = 4.5 ft Flume throat width = 24 ft Flow through flume = 6.75 mgd Flume submergence = submerged Head through flume = 0.79 ft	
AB1 Gate	**148.94**
Opening type = rectangular orifice Opening diameter/width = 36 in Opening height = 36 in Invert = 148	

Section Description	Water Surface Elevation

Number of openings = 1
Flow through opening(s) = 6.75 mgd
Total area of opening(s) = 2.38 ft^2
Velocity through opening(s) = 4.39 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0.15 ft
Downstream water level = 148.79
Upstream water level = 148.94

AB 3-4 Old Channel — **146.05**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 74 ft
Channel width/diameter = 4 ft
Flow = 13.5 mgd
Downstream channel invert = 143.17
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 11.49 ft^2
Hydraulic radius = 1.179
Normal depth = infinite
Critical depth = 0.95 ft
Depth downstream = 2.87 ft
Bend loss = 0 ft
Depth upstream = 2.88 ft
Velocity = 1.82 ft/s
Flow profile = Horizontal

AB 3-4 Eff Pipe — **146.39**

Pipe shape = Circular
Diameter = 36 in
Length = 100 ft
Flow = 13.5 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 1.75
Pipe area = 7.07 ft^2
Pipe hydraulic radius = 0.75
Age factor = 1
Solids factor = 1
Velocity = 2.95 ft/s
Friction loss = 0.1 ft
Fitting loss = 0.24 ft
Total loss = 0.33 ft

AB 3-4 New Channel — **146.53**

Channel shape = Rectangular
Manning's 'n' = 0.013

Section Description	Water Surface Elevation

Channel length = 170 ft
Channel width/diameter = 2.5 ft
Flow = 13.5 mgd
Downstream channel invert = 143.17
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 8.17 ft^2
Hydraulic radius = 0.904
Normal depth = infinite
Critical depth = 1.29 ft
Depth downstream = 3.22 ft
Bend loss = 0.04 ft
Depth upstream = 3.36 ft
Velocity = 2.6 ft/s
Flow profile = Horizontal

AB 3 Channel **146.57**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 170 ft
Channel width/diameter = 2.5 ft
Flow = 6.75 mgd
Downstream channel invert = 143.17
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 8.44 ft^2
Hydraulic radius = 0.912
Normal depth = infinite
Critical depth = 0.82 ft
Depth downstream = 3.36 ft
Bend loss = 0.01 ft
Depth upstream = 3.4 ft
Velocity = 1.24 ft/s
Flow profile = Horizontal

AB 3 Eff Weir **148.09**

Weir invert (top of weir) = 147.83
Weir length = 24 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = unsubmerged
Head over weir = 0.26 ft

AB 3, Zone 6 **148.09**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft

Section Description	Water Surface Elevation

Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 378.19 ft^2
Hydraulic radius = 6.812
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.76 ft
Bend loss = 0 ft
Depth upstream = 15.76 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 3.5 Weir **148.11**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.11 ft

AB 3, Zone 5 **148.11**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 378.72 ft^2
Hydraulic radius = 6.816
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.78 ft
Bend loss = 0 ft
Depth upstream = 15.78 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 3.4 Weir **148.13**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged

Section Description	Water Surface Elevation
Head over weir = 3.13 ft	
AB 3, Zone 4	**148.13**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 379.24 ft^2	
Hydraulic radius = 6.82	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.8 ft	
Bend loss = 0 ft	
Depth upstream = 15.8 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 3.3 Weir	**148.13**
Weir invert (top of weir) = 144.17	
Weir length = 8 ft	
Weir height = 10.34 ft	
Flow over weir = 6.75 mgd	
Submergence = submerged	
Head over weir = 3.96 ft	
AB 3, Zone 3	**148.14**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 379.29 ft^2	
Hydraulic radius = 6.821	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.8 ft	
Bend loss = 0 ft	
Depth upstream = 15.81 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	

Section Description	**Water Surface Elevation**
AB 3.2 Weir	**148.16**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.16 ft

AB 3, Zone 2 — **148.16**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 379.82 ft^2
Hydraulic radius = 6.825
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.83 ft
Bend loss = 0 ft
Depth upstream = 15.83 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 3.1 Weir — **148.18**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.18 ft

AB 3, Zone 1 — **148.18**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 380.35 ft^2
Hydraulic radius = 6.829
Normal depth = infinite
Critical depth = 0.18 ft

Section Description	Water Surface Elevation

Depth downstream = 15.85 ft
Bend loss = 0 ft
Depth upstream = 15.85 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB3 Lower Inf Gates **148.18**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 48 in
Invert = 143.75
Number of openings = 2
Flow through opening(s) = 5.4 mgd
Total area of opening(s) = 32 ft^2
Velocity through opening(s) = 0.26 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft
Downstream water level = 148.18
Upstream water level = 148.18

AB3 Upper Inf Gate **148.18**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 24 in
Invert = 147.17
Number of openings = 1
Flow through opening(s) = 1.35 mgd
Total area of opening(s) = 4.04 ft^2
Velocity through opening(s) = 0.52 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft
Downstream water level = 148.18
Upstream water level = 148.18

AB 3 Inf Split **148.18**

User defined loss for flow split = 0 ft
Total flow through flow split = 6.75 mgd

AB3 Inf Channel **148.19**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 16 ft
Channel width/diameter = 2.5 ft
Flow = 6.75 mgd
Downstream channel invert = 143.17
Channel slope = 0 ft/ft
Channel side slope = not applicable

Section Description	Water Surface Elevation

Area of flow = 12.53 ft^2
Hydraulic radius = 1.001
Normal depth = infinite
Critical depth = 0.82 ft
Depth downstream = 5.01 ft
Bend loss = 0 ft
Depth upstream = 5.02 ft
Velocity = 0.83 ft/s
Flow profile = Horizontal

AB3 ML Pipe **148.59**

Pipe shape = Circular
Diameter = 24 in
Length = 26.5 ft
Flow = 6.75 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2
Pipe area = 3.14 ft²
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 3.32 ft/s
Friction loss = 0.06 ft
Fitting loss = 0.34 ft
Total loss = 0.4 ft

ML3 Box **148.59**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 4 ft
Channel width/diameter = 4 ft
Flow = 6.75 mgd
Downstream channel invert = 144.25
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 17.35 ft^2
Hydraulic radius = 1.369
Normal depth = infinite
Critical depth = 0.6 ft
Depth downstream = 4.34 ft
Bend loss = 0 ft
Depth upstream = 4.34 ft
Velocity = 0.6 ft/s
Flow profile = Horizontal

ML3 Flume **148.59**

Flume invert = 148

Section Description	**Water Surface Elevation**
Flume length = 4.5 ft	
Flume throat width = 24 ft	
Flow through flume = 6.75 mgd	
Flume submergence = submerged	
Head through flume = 0.59 ft	
AB3 Gate	**148.75**
Opening type = rectangular orifice	
Opening diameter/width = 36 in	
Opening height = 36 in	
Invert = 148	
Number of openings = 1	
Flow through opening(s) = 6.75 mgd	
Total area of opening(s) = 9 ft^2	
Velocity through opening(s) = 1.16 ft/s	
Flow behavior = weir control	
Orifice loss = 0.75 ft	
Downstream water level = 148.59	
Upstream water level = 148.75	
AB 4 Eff Weir	**148.09**
Weir invert (top of weir) = 147.83	
Weir length = 24 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.26 ft	
AB 4, Zone 6	**148.09**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 378.19 ft^2	
Hydraulic radius = 6.812	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.76 ft	
Bend loss = 0 ft	
Depth upstream = 15.76 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 4.5 Weir	**148.11**

Section Description	Water Surface Elevation

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.11 ft

AB 4, Zone 5 — **148.11**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 378.72 ft^2
Hydraulic radius = 6.816
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.78 ft
Bend loss = 0 ft
Depth upstream = 15.78 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB 4.4 Weir — **148.13**

Weir invert (top of weir) = 145
Weir length = 10 ft
Weir 'C' coefficient = 3.33
Flow over weir = 6.75 mgd
Weir submergence = fully submerged
Head over weir = 3.13 ft

AB 4, Zone 4 — **148.13**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 379.24 ft^2
Hydraulic radius = 6.82
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.8 ft

Section Description	**Water Surface Elevation**
Bend loss = 0 ft	
Depth upstream = 15.8 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 4.3 Weir	**148.13**
Weir invert (top of weir) = 144.17	
Weir length = 8 ft	
Weir height = 10.34 ft	
Flow over weir = 6.75 mgd	
Submergence = submerged	
Head over weir = 3.96 ft	
AB 4, Zone 3	**148.14**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 379.29 ft^2	
Hydraulic radius = 6.821	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.8 ft	
Bend loss = 0 ft	
Depth upstream = 15.81 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 4.2 Weir	**148.16**
Weir invert (top of weir) = 145	
Weir length = 10 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	
Weir submergence = fully submerged	
Head over weir = 3.16 ft	
AB 4, Zone 2	**148.16**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	

Section Description	**Water Surface Elevation**
Channel side slope = not applicable	
Area of flow = 379.82 ft^2	
Hydraulic radius = 6.825	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.83 ft	
Bend loss = 0 ft	
Depth upstream = 15.83 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 4.1 Weir	**148.18**
Weir invert (top of weir) = 145	
Weir length = 10 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	
Weir submergence = fully submerged	
Head over weir = 3.18 ft	
AB 4, Zone 1	**148.18**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 380.35 ft^2	
Hydraulic radius = 6.829	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.85 ft	
Bend loss = 0 ft	
Depth upstream = 15.85 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB4 Upper Inf Gate	**148.18**
Opening type = rectangular orifice	
Opening diameter/width = 48 in	
Opening height = 24 in	
Invert = 147.17	
Number of openings = 1	
Flow through opening(s) = 1.35 mgd	
Total area of opening(s) = 4.04 ft^2	
Velocity through opening(s) = 0.52 ft/s	

Section Description	Water Surface Elevation
Flow behavior = orifice, downstream control	
Orifice loss = 0 ft	
Downstream water level = 148.18	
Upstream water level = 148.18	
AB4 Lower Inf Gates	**148.18**
Opening type = rectangular orifice	
Opening diameter/width = 48 in	
Opening height = 48 in	
Invert = 143.75	
Number of openings = 2	
Flow through opening(s) = 5.4 mgd	
Total area of opening(s) = 32 ft^2	
Velocity through opening(s) = 0.26 ft/s	
Flow behavior = orifice, downstream control	
Orifice loss = 0 ft	
Downstream water level = 148.18	
Upstream water level = 148.18	
AB4 Inf Split	**148.18**
User defined loss for flow split = 0 ft	
Total flow through flow split = 6.75 mgd	
AB4 Inf Channel	**148.19**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 16 ft	
Channel width/diameter = 2.5 ft	
Flow = 6.75 mgd	
Downstream channel invert = 143.17	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 12.53 ft^2	
Hydraulic radius = 1.001	
Normal depth = infinite	
Critical depth = 0.82 ft	
Depth downstream = 5.01 ft	
Bend loss = 0 ft	
Depth upstream = 5.02 ft	
Velocity = 0.83 ft/s	
Flow profile = Horizontal	
AB4 ML Pipe	**148.59**
Pipe shape = Circular	
Diameter = 24 in	
Length = 28 ft	
Flow = 6.75 mgd	
Friction method = Manning's Equation	

Section Description	Water Surface Elevation
Friction factor = 0.013	
Total fitting K value = 2	
Pipe area = 3.14 ft²	
Pipe hydraulic radius = 0.5	
Age factor = 1	
Solids factor = 1	
Velocity = 3.32 ft/s	
Friction loss = 0.06 ft	
Fitting loss = 0.34 ft	
Total loss = 0.4 ft	
ML4 Box	**148.59**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 4 ft	
Channel width/diameter = 4 ft	
Flow = 6.75 mgd	
Downstream channel invert = 144.25	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 17.37 ft^2	
Hydraulic radius = 1.369	
Normal depth = infinite	
Critical depth = 0.6 ft	
Depth downstream = 4.34 ft	
Bend loss = 0 ft	
Depth upstream = 4.34 ft	
Velocity = 0.6 ft/s	
Flow profile = Horizontal	
ML4 Flume	**148.59**
Flume invert = 148	
Flume length = 4.5 ft	
Flume throat width = 24 ft	
Flow through flume = 6.75 mgd	
Flume submergence = submerged	
Head through flume = 0.59 ft	
AB4 Gate	**148.75**
Opening type = rectangular orifice	
Opening diameter/width = 36 in	
Opening height = 36 in	
Invert = 148	
Number of openings = 1	
Flow through opening(s) = 6.75 mgd	
Total area of opening(s) = 9 ft^2	
Velocity through opening(s) = 1.16 ft/s	
Flow behavior = weir control	

Section Description	Water Surface Elevation
Orifice loss = 0.75 ft Downstream water level = 148.59 Upstream water level = 148.75	
AB 2 Eff Weir	**148.1**
Weir invert (top of weir) = 147.83 Weir length = 22 ft Weir 'C' coefficient = 3.33 Flow over weir = 6.75 mgd Weir submergence = unsubmerged Head over weir = 0.27 ft	
AB 2, Zone 6	**148.1**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 45 ft Channel width/diameter = 24 ft Flow = 6.75 mgd Downstream channel invert = 132.33 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 378.56 ft^2 Hydraulic radius = 6.815 Normal depth = infinite Critical depth = 0.18 ft Depth downstream = 15.77 ft Bend loss = 0 ft Depth upstream = 15.77 ft Velocity = 0.03 ft/s Flow profile = Horizontal	
AB 2.5 Weir	**148.12**
Weir invert (top of weir) = 145 Weir length = 10 ft Weir 'C' coefficient = 3.33 Flow over weir = 6.75 mgd Weir submergence = fully submerged Head over weir = 3.12 ft	
AB 2, Zone 5	**148.13**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 45 ft Channel width/diameter = 24 ft Flow = 6.75 mgd Downstream channel invert = 132.33 Channel slope = 0 ft/ft Channel side slope = not applicable	

Section Description	Water Surface Elevation
Area of flow = 379.08 ft^2	
Hydraulic radius = 6.819	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.79 ft	
Bend loss = 0 ft	
Depth upstream = 15.8 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 2.4 Weir	**148.15**
Weir invert (top of weir) = 145	
Weir length = 10 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	
Weir submergence = fully submerged	
Head over weir = 3.15 ft	
AB 2, Zone 4	**148.15**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 379.61 ft^2	
Hydraulic radius = 6.823	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.82 ft	
Bend loss = 0 ft	
Depth upstream = 15.82 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 2.3 Weir	**148.15**
Weir invert (top of weir) = 144.17	
Weir length = 8 ft	
Weir height = 10.34 ft	
Flow over weir = 6.75 mgd	
Submergence = submerged	
Head over weir = 3.98 ft	
AB 2, Zone 3	**148.15**
Channel shape = Rectangular	
Manning's 'n' = 0.013	

Section Description	Water Surface Elevation
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 379.66 ft^2	
Hydraulic radius = 6.824	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.82 ft	
Bend loss = 0 ft	
Depth upstream = 15.82 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 2.2 Weir	**148.17**
Weir invert (top of weir) = 145	
Weir length = 10 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	
Weir submergence = fully submerged	
Head over weir = 3.17 ft	
AB 2, Zone 2	**148.17**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 45 ft	
Channel width/diameter = 24 ft	
Flow = 6.75 mgd	
Downstream channel invert = 132.33	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 380.19 ft^2	
Hydraulic radius = 6.828	
Normal depth = infinite	
Critical depth = 0.18 ft	
Depth downstream = 15.84 ft	
Bend loss = 0 ft	
Depth upstream = 15.84 ft	
Velocity = 0.03 ft/s	
Flow profile = Horizontal	
AB 2.1 Weir	**148.19**
Weir invert (top of weir) = 145	
Weir length = 10 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 6.75 mgd	

Section Description	Water Surface Elevation

Weir submergence = fully submerged
Head over weir = 3.19 ft

AB 2, Zone 1 — **148.19**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 45 ft
Channel width/diameter = 24 ft
Flow = 6.75 mgd
Downstream channel invert = 132.33
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 380.72 ft^2
Hydraulic radius = 6.832
Normal depth = infinite
Critical depth = 0.18 ft
Depth downstream = 15.86 ft
Bend loss = 0 ft
Depth upstream = 15.86 ft
Velocity = 0.03 ft/s
Flow profile = Horizontal

AB2 Lower Inf Gates — **148.2**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 48 in
Invert = 143.75
Number of openings = 2
Flow through opening(s) = 5.4 mgd
Total area of opening(s) = 32 ft^2
Velocity through opening(s) = 0.26 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft
Downstream water level = 148.19
Upstream water level = 148.2

AB2 Upper Inf Gate — **148.2**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 24 in
Invert = 147.17
Number of openings = 1
Flow through opening(s) = 1.35 mgd
Total area of opening(s) = 4.1 ft^2
Velocity through opening(s) = 0.51 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft

Section Description	Water Surface Elevation

Downstream water level = 148.19
Upstream water level = 148.2

AB2 Inf Split **148.2**

User defined loss for flow split = 0 ft
Total flow through flow split = 6.75 mgd

AB2 Inf Channel **148.2**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 16 ft
Channel width/diameter = 2.5 ft
Flow = 6.75 mgd
Downstream channel invert = 143.17
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 12.57 ft^2
Hydraulic radius = 1.001
Normal depth = infinite
Critical depth = 0.82 ft
Depth downstream = 5.03 ft
Bend loss = 0 ft
Depth upstream = 5.03 ft
Velocity = 0.83 ft/s
Flow profile = Horizontal

AB2 ML Pipe **148.83**

Pipe shape = Circular
Diameter = 24 in
Length = 135 ft
Flow = 6.75 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2
Pipe area = 3.14 ft^2
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 3.32 ft/s
Friction loss = 0.29 ft
Fitting loss = 0.34 ft
Total loss = 0.63 ft

ML2 Box **148.84**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 4 ft
Channel width/diameter = 4 ft

Section Description	Water Surface Elevation
Flow = 6.75 mgd Downstream channel invert = 144.25 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 18.33 ft^2 Hydraulic radius = 1.392 Normal depth = infinite Critical depth = 0.6 ft Depth downstream = 4.58 ft Bend loss = 0 ft Depth upstream = 4.59 ft Velocity = 0.57 ft/s Flow profile = Horizontal	
ML2 Flume	**148.84**
Flume invert = 148 Flume length = 4.5 ft Flume throat width = 24 ft Flow through flume = 6.75 mgd Flume submergence = submerged Head through flume = 0.84 ft	
AB2 Gate	**148.97**
Opening type = rectangular orifice Opening diameter/width = 36 in Opening height = 36 in Invert = 148 Number of openings = 1 Flow through opening(s) = 6.75 mgd Total area of opening(s) = 2.51 ft^2 Velocity through opening(s) = 4.17 ft/s Flow behavior = orifice, downstream control Orifice loss = 0.13 ft Downstream water level = 148.84 Upstream water level = 148.97	
RAS Box Split	**148.97**
User defined loss for flow split = 0 ft Total flow through flow split = 27 mgd	
RAS Mix	**148.97**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 20 ft Channel width/diameter = 9.16 ft Flow = 27 mgd Downstream channel invert = 143.5 Channel slope = 0 ft/ft	

Section Description	Water Surface Elevation
Channel side slope = not applicable	
Area of flow = 50.11 ft^2	
Hydraulic radius = 2.493	
Normal depth = infinite	
Critical depth = 0.86 ft	
Depth downstream = 5.47 ft	
Bend loss = 0 ft	
Depth upstream = 5.47 ft	
Velocity = 0.83 ft/s	
Flow profile = Horizontal	
PE RAS Gates	**149.05**
Opening type = rectangular orifice	
Opening diameter/width = 36 in	
Opening height = 48 in	
Invert = 143.5	
Number of openings = 2	
Flow through opening(s) = 21.6 mgd	
Total area of opening(s) = 24 ft^2	
Velocity through opening(s) = 1.39 ft/s	
Flow behavior = orifice, downstream control	
Orifice loss = 0.08 ft	
Downstream water level = 148.97	
Upstream water level = 149.05	
PE1 Box	**149.05**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 9.5 ft	
Channel width/diameter = 9 ft	
Flow = 21.6 mgd	
Downstream channel invert = 143.08	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 53.74 ft^2	
Hydraulic radius = 2.566	
Normal depth = infinite	
Critical depth = 0.75 ft	
Depth downstream = 5.97 ft	
Bend loss = 0 ft	
Depth upstream = 5.97 ft	
Velocity = 0.62 ft/s	
Flow profile = Horizontal	
PE1 RAS Box	**149.62**
Pipe shape = Circular	
Diameter = 24 in	

Section Description	Water Surface Elevation

Length = 24 ft
Flow = 10.8 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 1
Pipe area = 3.14 ft²
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 5.32 ft/s
Friction loss = 0.13 ft
Fitting loss = 0.44 ft
Total loss = 0.57 ft

PE2 RAS Box — **150.07**

Pipe shape = Circular
Diameter = 24 in
Length = 26 ft
Flow = 10.8 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2
Pipe area = 3.14 ft²
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 5.32 ft/s
Friction loss = 0.14 ft
Fitting loss = 0.88 ft
Total loss = 1.02 ft

PE Pipe Split — **150.07**

User defined loss for flow split = 0 ft
Total flow through flow split = 21.6 mgd

PE Common Pipe — **150.17**

Pipe shape = Circular
Diameter = 36 in
Length = 38 ft
Flow = 21.6 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 0
Pipe area = 7.07 ft²
Pipe hydraulic radius = 0.75
Age factor = 1
Solids factor = 1
Velocity = 4.73 ft/s

Section Description	Water Surface Elevation
Friction loss = 0.09 ft Fitting loss = 0 ft Total loss = 0.09 ft	
PE1 Pipe	**151.04**
Pipe shape = Circular Diameter = 24 in Length = 20 ft Flow = 10.8 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 1.75 Pipe area = 3.14 ft² Pipe hydraulic radius = 0.5 Age factor = 1 Solids factor = 1 Velocity = 5.32 ft/s Friction loss = 0.11 ft Fitting loss = 0.77 ft Total loss = 0.88 ft	
PC1 Launder	**151.18**
Launder invert = 147.75 Launder length = 106 ft Launder width = 2.5 ft Launder slope = 0.01 ft/ft Flow through launder = 10.8 mgd Critical depth = 1.12 ft Downstream depth = 3.29 ft Upstream depth = 2.37 ft	
PC1 Weir	**151.19**
Invert of V notch = 150.49 Angle of V notch = 90 degrees Number of notches = 384 Total flow over weir = 10.8 mgd Weir submergence = fully submerged Head over weir = 0.7 ft	
RS1 Pipe	**153.28**
Pipe shape = Circular Diameter = 24 in Length = 190 ft Flow = 10.8 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 2.4	

Section Description	Water Surface Elevation

Pipe area = 3.14 ft²
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 5.32 ft/s
Friction loss = 1.03 ft
Fitting loss = 1.05 ft
Total loss = 2.09 ft

RS1 Box — **153.28**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 6 ft
Channel width/diameter = 4 ft
Flow = 10.8 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 49.12 ft^2
Hydraulic radius = 1.72
Normal depth = infinite
Critical depth = 0.82 ft
Depth downstream = 12.28 ft
Bend loss = 0 ft
Depth upstream = 12.28 ft
Velocity = 0.34 ft/s
Flow profile = Horizontal

PE2 Pipe — **151.37**

Pipe shape = Circular
Diameter = 24 in
Length = 85 ft
Flow = 10.8 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 1.7
Pipe area = 3.14 ft²
Pipe hydraulic radius = 0.5
Age factor = 1
Solids factor = 1
Velocity = 5.32 ft/s
Friction loss = 0.46 ft
Fitting loss = 0.75 ft
Total loss = 1.21 ft

PC2 Launder — **151.49**

Launder invert = 147.75
Launder length = 106 ft

Section Description	Water Surface Elevation
Launder width = 2.5 ft	
Launder slope = 0.01 ft/ft	
Flow through launder = 10.8 mgd	
Critical depth = 1.12 ft	
Downstream depth = 3.62 ft	
Upstream depth = 2.68 ft	
PC2 Weir	**151.5**
Invert of V notch = 150.49	
Angle of V notch = 90 degrees	
Number of notches = 384	
Total flow over weir = 10.8 mgd	
Weir submergence = fully submerged	
Head over weir = 1.01 ft	
RS2 Pipe	**153.23**
Pipe shape = Circular	
Diameter = 24 in	
Length = 125 ft	
Flow = 10.8 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2.4	
Pipe area = 3.14 ft^2	
Pipe hydraulic radius = 0.5	
Age factor = 1	
Solids factor = 1	
Velocity = 5.32 ft/s	
Friction loss = 0.68 ft	
Fitting loss = 1.05 ft	
Total loss = 1.73 ft	
RS2 Box	**153.23**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 4 ft	
Channel width/diameter = 6 ft	
Flow = 10.8 mgd	
Downstream channel invert = 141	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 73.39 ft^2	
Hydraulic radius = 2.409	
Normal depth = infinite	
Critical depth = 0.62 ft	
Depth downstream = 12.23 ft	
Bend loss = 0 ft	
Depth upstream = 12.23 ft	

Section Description	Water Surface Elevation

Velocity = 0.23 ft/s
Flow profile = Horizontal

RS Split — **154.1**

Weir invert (top of weir) = 152.25
Weir length = 5 ft
Weir 'C' coefficient = 3.33
Total flow through flow split = 21.6 mgd
Weir submergence = partially submerged
Head over weir = 1.85 ft

RS Common Box — **154.1**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 6 ft
Channel width/diameter = 6 ft
Flow = 10.8 mgd
Downstream channel invert = 141
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 78.61 ft^2
Hydraulic radius = 2.441
Normal depth = infinite
Critical depth = 0.62 ft
Depth downstream = 13.1 ft
Bend loss = 0 ft
Depth upstream = 13.1 ft
Velocity = 0.21 ft/s
Flow profile = Horizontal

Common RS Pipe — **156.33**

Pipe shape = Circular
Diameter = 36 in
Length = 365 ft
Flow = 21.6 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 3.8
Pipe area = 7.07 ft^2
Pipe hydraulic radius = 0.75
Age factor = 1
Solids factor = 1
Velocity = 4.73 ft/s
Friction loss = 0.91 ft
Fitting loss = 1.32 ft
Total loss = 2.23 ft

Section Description	Water Surface Elevation
Grit2 Effluent	**156.34**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 32 ft
Channel width/diameter = 5.25 ft
Flow = 10.8 mgd
Downstream channel invert = 151.25
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 26.69 ft^2
Hydraulic radius = 1.731
Normal depth = infinite
Critical depth = 0.68 ft
Depth downstream = 5.08 ft
Bend loss = 0 ft
Depth upstream = 5.09 ft
Velocity = 0.63 ft/s
Flow profile = Horizontal

Grit2 Eff Weir — **156.42**

Weir invert (top of weir) = 155.35
Weir length = 12 ft
Weir 'C' coefficient = 3.33
Flow over weir = 10.8 mgd
Weir submergence = fully submerged
Head over weir = 1.07 ft

Grit2 Stage2 — **156.42**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 13 ft
Channel width/diameter = 25 ft
Flow = 10.8 mgd
Downstream channel invert = 144.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 297.97 ft^2
Hydraulic radius = 6.101
Normal depth = infinite
Critical depth = 0.24 ft
Depth downstream = 11.92 ft
Bend loss = 0 ft
Depth upstream = 11.92 ft
Velocity = 0.06 ft/s
Flow profile = Horizontal

Grit2 Baffle — **156.42**

Opening type = rectangular orifice

Section Description	Water Surface Elevation

Opening diameter/width = 300 in
Opening height = 6 in
Invert = 144.5
Number of openings = 8
Flow through opening(s) = 10.8 mgd
Total area of opening(s) = 100 ft^2
Velocity through opening(s) = 0.17 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft
Downstream water level = 156.42
Upstream water level = 156.42

Grit2 Stage1 **156.42**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 13 ft
Channel width/diameter = 25 ft
Flow = 10.8 mgd
Downstream channel invert = 144.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 298.04 ft^2
Hydraulic radius = 6.102
Normal depth = infinite
Critical depth = 0.24 ft
Depth downstream = 11.92 ft
Bend loss = 0 ft
Depth upstream = 11.92 ft
Velocity = 0.06 ft/s
Flow profile = Horizontal

Grit2 Influent Gate **156.47**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 48 in
Invert = 152.3
Number of openings = 1
Flow through opening(s) = 10.8 mgd
Total area of opening(s) = 16 ft^2
Velocity through opening(s) = 1.04 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0.04 ft
Downstream water level = 156.42
Upstream water level = 156.47

Grit2 EffluentB **156.34**

Channel shape = Rectangular
Manning's 'n' = 0.013

Section Description	Water Surface Elevation
Channel length = 68 ft	
Channel width/diameter = 6 ft	
Flow = 10.8 mgd	
Downstream channel invert = 151.25	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 30.51 ft^2	
Hydraulic radius = 1.887	
Normal depth = infinite	
Critical depth = 0.62 ft	
Depth downstream = 5.08 ft	
Bend loss = 0 ft	
Depth upstream = 5.09 ft	
Velocity = 0.55 ft/s	
Flow profile = Horizontal	
Grit1 EffluentA	**156.34**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 32 ft	
Channel width/diameter = 5.25 ft	
Flow = 10.8 mgd	
Downstream channel invert = 151.25	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 26.7 ft^2	
Hydraulic radius = 1.731	
Normal depth = infinite	
Critical depth = 0.68 ft	
Depth downstream = 5.09 ft	
Bend loss = 0 ft	
Depth upstream = 5.09 ft	
Velocity = 0.63 ft/s	
Flow profile = Horizontal	
Grit1 Eff Weir	**156.42**
Weir invert (top of weir) = 155.35	
Weir length = 12 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 10.8 mgd	
Weir submergence = fully submerged	
Head over weir = 1.07 ft	
Grit1 Stage2	**156.42**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 13 ft	
Channel width/diameter = 25 ft	

Section Description	Water Surface Elevation

Flow = 10.8 mgd
Downstream channel invert = 144.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 298.02 ft^2
Hydraulic radius = 6.102
Normal depth = infinite
Critical depth = 0.24 ft
Depth downstream = 11.92 ft
Bend loss = 0 ft
Depth upstream = 11.92 ft
Velocity = 0.06 ft/s
Flow profile = Horizontal

Grit1 Baffle **156.42**

Opening type = rectangular orifice
Opening diameter/width = 300 in
Opening height = 6 in
Invert = 144.5
Number of openings = 8
Flow through opening(s) = 10.8 mgd
Total area of opening(s) = 100 ft^2
Velocity through opening(s) = 0.17 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0 ft
Downstream water level = 156.42
Upstream water level = 156.42

Grit1 Stage1 **156.43**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 13 ft
Channel width/diameter = 25 ft
Flow = 10.8 mgd
Downstream channel invert = 144.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 298.09 ft^2
Hydraulic radius = 6.103
Normal depth = infinite
Critical depth = 0.24 ft
Depth downstream = 11.92 ft
Bend loss = 0 ft
Depth upstream = 11.93 ft
Velocity = 0.06 ft/s
Flow profile = Horizontal

Grit1 Influent Gate **156.47**

Section Description	**Water Surface Elevation**

Opening type = rectangular orifice
Opening diameter/width = 48 in
Opening height = 48 in
Invert = 152.3
Number of openings = 1
Flow through opening(s) = 10.8 mgd
Total area of opening(s) = 16 ft^2
Velocity through opening(s) = 1.04 ft/s
Flow behavior = orifice, downstream control
Orifice loss = 0.04 ft
Downstream water level = 156.43
Upstream water level = 156.47

Grit Split — **156.47**

User defined loss for flow split = 0 ft
Total flow through flow split = 21.6 mgd

Grit InfluentB — **156.47**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 30 ft
Channel width/diameter = 5 ft
Flow = 21.6 mgd
Downstream channel invert = 152.3
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 20.86 ft^2
Hydraulic radius = 1.563
Normal depth = infinite
Critical depth = 1.12 ft
Depth downstream = 4.17 ft
Bend loss = 0 ft
Depth upstream = 4.17 ft
Velocity = 1.6 ft/s
Flow profile = Horizontal

Grit InfluentA — **156.49**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 6 ft
Channel width/diameter = 6 ft
Flow = 21.6 mgd
Downstream channel invert = 152.3
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 25.05 ft^2
Hydraulic radius = 1.746
Normal depth = infinite

Section Description	Water Surface Elevation

Critical depth = 0.99 ft
Depth downstream = 4.17 ft
Bend loss = 0.01 ft
Depth upstream = 4.19 ft
Velocity = 1.33 ft/s
Flow profile = Horizontal

Flume 1 Effluent — **156.53**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 2.5 ft
Channel width/diameter = 4.5 ft
Flow = 10.8 mgd
Downstream channel invert = 155
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 6.7 ft^2
Hydraulic radius = 0.896
Normal depth = infinite
Critical depth = 0.75 ft
Depth downstream = 1.49 ft
Bend loss = 0.04 ft
Depth upstream = 1.53 ft
Velocity = 2.5 ft/s
Flow profile = Horizontal

Flume1 — **157.2**

Flume invert = 155.25
Flume throat width = 1.5 ft
Flow through flume = 10.8 mgd
Flume 'm' value = 6
Flume 'e' value = 1.538
Head through flume = 1.95 ft

MechScreen1 Effluent — **157.2**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 12 ft
Channel width/diameter = 4.5 ft
Flow = 10.8 mgd
Downstream channel invert = 155
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 9.89 ft^2
Hydraulic radius = 1.112
Normal depth = infinite
Critical depth = 0.75 ft

Section Description	Water Surface Elevation
Depth downstream = 2.2 ft Bend loss = 0 ft Depth upstream = 2.2 ft Velocity = 1.69 ft/s Flow profile = Horizontal	
MechScreen1	**157.35**
Theory used = Kirschmer Rack/screen invert = 155 Rack/screen width = 4.5 ft Flow through rack = 10.8 mgd Bar width = 0.18 in Bar spacing = 0.24 in Bar shape = Rectangular Angle of inclination = 75 degrees Downstream depth = 2.2 ft Approach velocity = 1.58 ft/s Rack/screen head loss = 0.15 ft	
MechScreen1 Influent	**157.36**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 5 ft Channel width/diameter = 4.5 ft Flow = 10.8 mgd Downstream channel invert = 155 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 10.6 ft^2 Hydraulic radius = 1.151 Normal depth = infinite Critical depth = 0.75 ft Depth downstream = 2.35 ft Bend loss = 0 ft Depth upstream = 2.36 ft Velocity = 1.58 ft/s Flow profile = Horizontal	
Screen1 Gate	**157.38**
Opening type = rectangular gate Opening diameter/width = 52 in Gate height = 48 in Invert = 155 Number of gates = 1 Flow through gate(s) = 10.8 mgd Total area of opening(s) = 10.21 ft^2 Velocity through gate(s) = 1.64 ft/s Flow behavior = orifice, downstream control	

Section Description	Water Surface Elevation
Gate loss = 0.02 ft Downstream water level = 157.36 Upstream water level = 157.38	
Flume 2 Effluent	**156.53**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 2.5 ft Channel width/diameter = 4.5 ft Flow = 10.8 mgd Downstream channel invert = 155 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 6.7 ft^2 Hydraulic radius = 0.896 Normal depth = infinite Critical depth = 0.75 ft Depth downstream = 1.49 ft Bend loss = 0.04 ft Depth upstream = 1.53 ft Velocity = 2.5 ft/s Flow profile = Horizontal	
Flume2	**157.2**
Flume invert = 155.25 Flume throat width = 1.5 ft Flow through flume = 10.8 mgd Flume 'm' value = 6 Flume 'e' value = 1.538 Head through flume = 1.95 ft	
ManualScreen Effluent	**157.2**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 12 ft Channel width/diameter = 4.5 ft Flow = 10.8 mgd Downstream channel invert = 155 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 9.89 ft^2 Hydraulic radius = 1.112 Normal depth = infinite Critical depth = 0.75 ft Depth downstream = 2.2 ft Bend loss = 0 ft Depth upstream = 2.2 ft Velocity = 1.69 ft/s	

Section Description	Water Surface Elevation
Flow profile = Horizontal	
MechScreen1	**157.24**
Theory used = Kirschmer	
Rack/screen invert = 155	
Rack/screen width = 4.5 ft	
Flow through rack = 10.8 mgd	
Bar width = 0.38 in	
Bar spacing = 1.12 in	
Bar shape = Rectangular	
Angle of inclination = 45 degrees	
Downstream depth = 2.2 ft	
Approach velocity = 1.66 ft/s	
Rack/screen head loss = 0.04 ft	
ManualScreen2 Influent	**157.24**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 5 ft	
Channel width/diameter = 4.5 ft	
Flow = 10.8 mgd	
Downstream channel invert = 155	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 10.09 ft^2	
Hydraulic radius = 1.123	
Normal depth = infinite	
Critical depth = 0.75 ft	
Depth downstream = 2.24 ft	
Bend loss = 0 ft	
Depth upstream = 2.24 ft	
Velocity = 1.66 ft/s	
Flow profile = Horizontal	
Screen2 Gate	**157.27**
Opening type = rectangular gate	
Opening diameter/width = 52 in	
Gate height = 48 in	
Invert = 155	
Number of gates = 1	
Flow through gate(s) = 10.8 mgd	
Total area of opening(s) = 9.73 ft^2	
Velocity through gate(s) = 1.72 ft/s	
Flow behavior = orifice, downstream control	
Gate loss = 0.02 ft	
Downstream water level = 157.24	
Upstream water level = 157.27	

Section Description	Water Surface Elevation
Flume 3 Effluent	**156.53**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 2.5 ft
Channel width/diameter = 4.5 ft
Flow = 10.8 mgd
Downstream channel invert = 155
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 6.7 ft^2
Hydraulic radius = 0.896
Normal depth = infinite
Critical depth = 0.75 ft
Depth downstream = 1.49 ft
Bend loss = 0.04 ft
Depth upstream = 1.53 ft
Velocity = 2.5 ft/s
Flow profile = Horizontal

Flume3 — **157.2**

Flume invert = 155.25
Flume throat width = 1.5 ft
Flow through flume = 10.8 mgd
Flume 'm' value = 6
Flume 'e' value = 1.538
Head through flume = 1.95 ft

MechScreen3 Effluent — **157.2**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 12 ft
Channel width/diameter = 4.5 ft
Flow = 10.8 mgd
Downstream channel invert = 155
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 9.89 ft^2
Hydraulic radius = 1.112
Normal depth = infinite
Critical depth = 0.75 ft
Depth downstream = 2.2 ft
Bend loss = 0 ft
Depth upstream = 2.2 ft
Velocity = 1.69 ft/s
Flow profile = Horizontal

MechScreen1 — **157.35**

Theory used = Kirschmer

Section Description	Water Surface Elevation

Rack/screen invert = 155
Rack/screen width = 4.5 ft
Flow through rack = 10.8 mgd
Bar width = 0.18 in
Bar spacing = 0.24 in
Bar shape = Rectangular
Angle of inclination = 75 degrees
Downstream depth = 2.2 ft
Approach velocity = 1.58 ft/s
Rack/screen head loss = 0.15 ft

MechScreen3 Influent — **157.36**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 5 ft
Channel width/diameter = 4.5 ft
Flow = 10.8 mgd
Downstream channel invert = 155
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 10.6 ft^2
Hydraulic radius = 1.151
Normal depth = infinite
Critical depth = 0.75 ft
Depth downstream = 2.35 ft
Bend loss = 0 ft
Depth upstream = 2.36 ft
Velocity = 1.58 ft/s
Flow profile = Horizontal

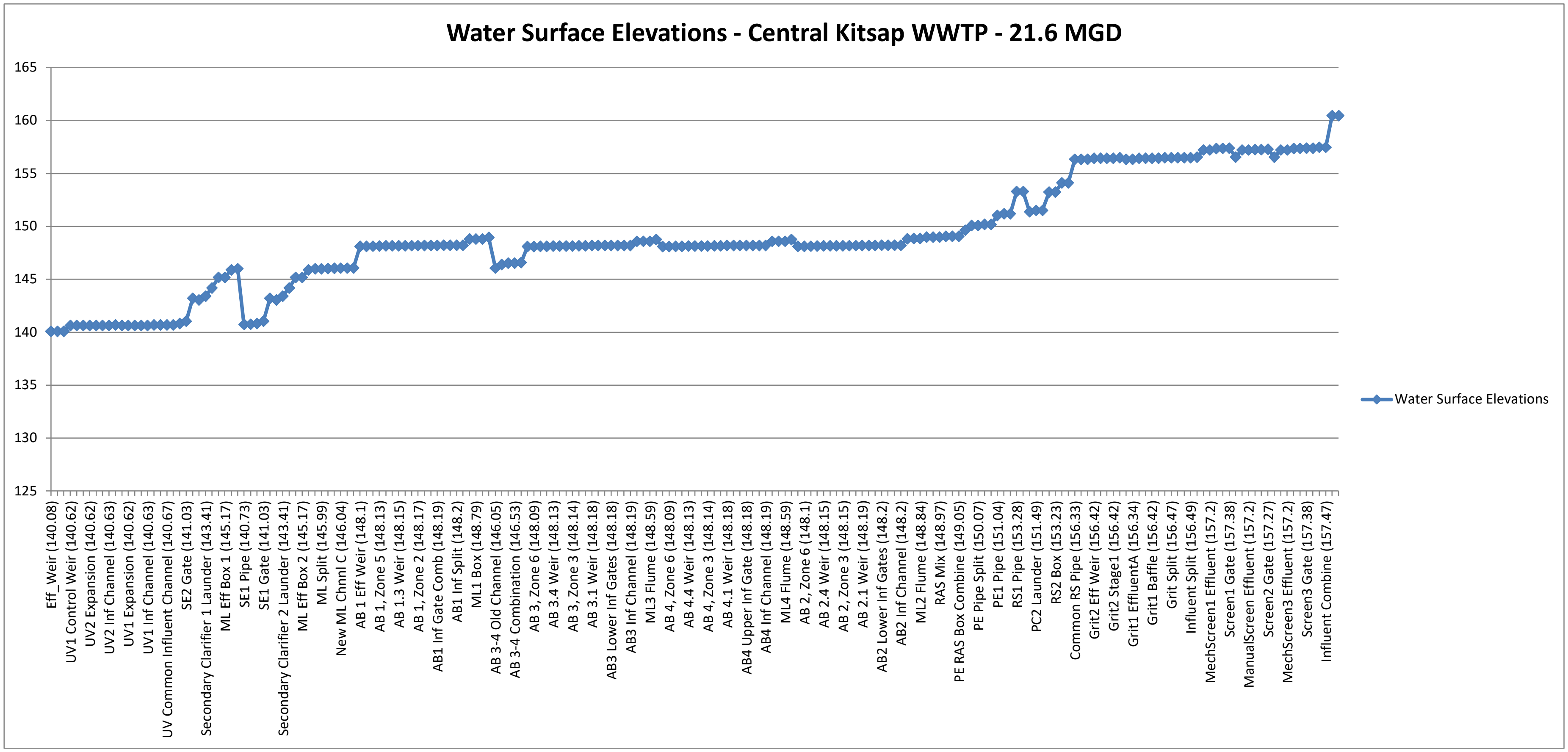
Screen3 Gate — **157.38**

Opening type = rectangular gate
Opening diameter/width = 52 in
Gate height = 48 in
Invert = 155
Number of gates = 1
Flow through gate(s) = 10.8 mgd
Total area of opening(s) = 10.21 ft^2
Velocity through gate(s) = 1.64 ft/s
Flow behavior = orifice, downstream control
Gate loss = 0.02 ft
Downstream water level = 157.36
Upstream water level = 157.38

Screen Split — **157.38**

User defined loss for flow split = 0 ft
Total flow through flow split = 32.4 mgd

Section Description	Water Surface Elevation
Common Influent	**157.47**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 10 ft	
Channel width/diameter = 4 ft	
Flow = 21.6 mgd	
Downstream channel invert = 155	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 9.53 ft^2	
Hydraulic radius = 1.087	
Normal depth = infinite	
Critical depth = 1.29 ft	
Depth downstream = 2.38 ft	
Bend loss = 0.08 ft	
Depth upstream = 2.47 ft	
Velocity = 3.51 ft/s	
Flow profile = Horizontal	
North FM Weir	**160.44**
Weir invert (top of weir) = 159.5	
Weir length = 5.5 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 10.8 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.94 ft	
South FM Weir	**160.44**
Weir invert (top of weir) = 159.5	
Weir length = 5.5 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 10.8 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.94 ft	



Water Surface Elevations - Central Kitsap WWTP - 21.6 MGD
165
160
155
150
145
140
135
130
125
Water Surface Elevations
Eff_Weir (140.08)
UV1 Control Weir (140.62)
UV2 Expansion (140.62)
UV2 Inf Channel (140.63)
UV1 Expansion (140.62)
UV1 Inf Channel (140.63)
UV Common Influent Channel (140.67)
SE2 Gate (141.03)
Secondary Clarifier 1 Launder (143.41)
ML Eff Box 1 (145.17)
SE1 Pipe (140.73)
SE1 Gate (141.03)
Secondary Clarifier 2 Launder (143.41)
ML Eff Box 2 (145.17)
ML Split (145.99)
New ML Chnnl C (146.04)
AB 1 Eff Weir (148.1)
AB 1, Zone 5 (148.13)
AB 1.3 Weir (148.15)
AB 1, Zone 2 (148.17)
AB1 Inf Gate Comb (148.19)
AB1 Inf Split (148.2)
ML1 Box (148.79)
AB 3-4 Old Channel (146.05)
AB 3-4 Combination (146.53)
AB 3, Zone 6 (148.09)
AB 3.4 Weir (148.13)
AB 3, Zone 3 (148.14)
AB 3.1 Weir (148.18)
AB3 Lower Inf Gates (148.18)
AB3 Inf Channel (148.19)
ML3 Flume (148.59)
AB 4, Zone 6 (148.09)
AB 4.4 Weir (148.13)
AB 4, Zone 3 (148.14)
AB 4.1 Weir (148.18)
AB4 Upper Inf Gate (148.18)
AB4 Inf Channel (148.19)
ML4 Flume (148.59)
AB 2, Zone 6 (148.1)
AB 2.4 Weir (148.15)
AB 2, Zone 3 (148.15)
AB 2.1 Weir (148.19)
AB2 Lower Inf Gates (148.2)
AB2 Inf Channel (148.2)
ML2 Flume (148.84)
RAS Mix (148.97)
PE RAS Box Combine (149.05)
PE Pipe Split (150.07)
PE1 Pipe (151.04)
RS1 Pipe (153.28)
PC2 Launder (151.49)
RS2 Box (153.23)
Common RS Pipe (156.33)
Grit2 Eff Weir (156.42)
Grit2 Stage1 (156.42)
Grit1 EffluentA (156.34)
Grit1 Baffle (156.42)
Grit Split (156.47)
Influent Split (156.49)
MechScreen1 Effluent (157.2)
Screen1 Gate (157.38)
ManualScreen Effluent (157.2)
Screen2 Gate (157.27)
MechScreen3 Effluent (157.2)
Screen3 Gate (157.38)
Influent Combine (157.47)

APPENDIX M
COLLECTION AND CONVEYANCE SYSTEM MODEL REVIEW/COORDINATION, MURRAYSMITH, 2021

consor

Technical Memorandum

Date:	May 12, 2021
Project:	Kitsap County Wastewater Facility Plan and Sewer Plan Updates
To:	Barbara Zaroff, PE, PMP
From:	Kevin Cook, PE; Peter Cunningham, PE
Reviewed By:	Andrew Henson, PE, PMP; Erika Schuyler, PE, PMP
Re:	Central Kitsap Collection and Conveyance System Model Review/Coordination

Introduction

Kitsap County (County) is updating their Central Kitsap Treatment Wastewater Facility Plan and corresponding collection and conveyance system Sewer Plan. Summarized in this memorandum is a review the existing hydrologic and hydraulic (H/H) model of the Central Kitsap basin in support of the planning efforts and recommendations for future modeling in the Central Kitsap, Kingston, and Suquamish sewer basins.

Background and Model History

The Central Kitsap Service area is the largest system in Kitsap County and includes the Navy facilities at Bangor and Keyport, the City of Poulsbo, and the Silverdale and Central Kitsap Urban Growth Areas (UGAs). The collection system contains approximately 44 lift stations and over 145 miles of gravity mains and force mains. The collection system is conveyed to the Central Kitsap Wastewater Treatment Plant (CKWWTP) where treated effluent is discharged in Port Orchard Bay in the Puget Sound.

The County's modeling consultant, BHC Consultants (BHC), last updated the H/H model as part of the 2019 Hydraulic Model Update (BHC Consultants, 2019) using the MIKE URBAN modeling software. This effort assessed pumping capacities for peak flow conditions for current and future population forecasts, zoning changes, calibration to 2016 flow monitoring data at the CKWWTP, and development of capital improvement projects (CIPs) in the model.

Modeling scenarios were based on three different planning horizons based on population and zoning changes. Hydraulic capacity of the system was assessed by analyzing the existing system as well as modeled CIPs. A total of five scenarios were modeled, and the corresponding model file name and description of each scenario are shown in Table 1.

Table 1: Model Files and Scenario

Model Name	Pop. Estimate Year	Hydraulic System
2017_KitsapCo_FINAL.mdb	2017	Existing
2038_KitsapCo_FINAL.mdb	2038	Existing
2038CIP_KitsapCo_FINAL.mdb	2038	Existing with modeled CIPs
Buildout_KitsapCo_FINAL.mdb	Buildout*	Existing
BuildoutCIP_KitsapCo_FINAL.mdb	Buildout*	Existing with modeled CIPs

*Buildout conditions are reflective of full zoning capacity utilized.

Several data sources were used by BHC to characterize population and flow estimates for existing and future conditions. The Kitsap County GMA Remand study (BHC Consultants, 2012) was used as the basis for the methodology. Parcel based population data, in coordination with data from the Puget Sound Regional Council (PSRC) was used to estimate populations and assign approximate load points based on parcel location. Population estimates for residential and commercial population were analyzed, in coordination with flow data at the CKWWTP. This yielded an estimate usage of roughly 70 gallons per capita per day (gpcd). The UGAs in Silverdale and Central Kitsap were supplemented with data from the Traffic Analysis Zones (TAZ).

Additional flows from the Bangor and Keyport naval facilities were developed based on projections to the County for the Central Kitsap service area. Flows from the Poulsbo service area were derived from the 2016 City of Poulsbo Comprehensive Sewer Plan.

This data was used to develop and update flows for each of the planning scenarios in the model. Additional information regarding assumptions specific to the data sources and planning scenarios are discussed in the 2019 Hydraulic Model Update (BHC Consultants, 2019).

Model Set Up

The following section describes the approaches and assumptions used by BHC to develop modeling inputs for the H/H model files.

Collection System

The Central Kitsap H/H model includes gravity mains and force mains ranging from 3-inches to 36-inches. As part of CIP development and buildout scenarios, pipes were added and upsized as necessary for planning level analysis. The collection system discharges at the CKWWTP, which is represented by two modeled outfalls, where flows are separated by northern and southern influent lines.

Boundary Items

Boundary items were used to simulate flows into the conveyance system. These can represent inflows to a single point within the system, or as an aggregation of multiple load allocations for the purposes of global application of parameters. Boundary item inflows can have diurnal patterns to represent varying peak hourly demands, as well as applied scaling factors to simulate additional wet-weather response.

The boundary items as they appear in each model file a brief description of their application is listed below:

- Poulsbo Loading – Single point load from Poulsbo, with Poulsbo diurnal pattern applied
- Navy Keyport Loading – Single point load from Navy and Keyport with peak day pattern applied
- Bangor Loading – Single point load from Bangor with peak day pattern applied
- 2017_Peak – Aggregation of load allocation from all system inflows based on demand with peak day pattern applied. Note that 2017_Peak was renamed for each planning scenario as appropriate e.g., Buildout_Peak

For each planning scenario, the point and aggregate loads were adjusted for population and development. Wet weather scaling factors were also adjusted for each planning horizon. The scale factor represents an approximation of wet-weather influence to the system based on the relative age of the system and its susceptibility to wet weather influence. Scale factors applied as part of the 2019 Hydraulic Model Update for each planning scenario are:

- Existing – Scale factor of 1.17 applied to diurnal pattern to simulate wet weather response
- Future - Scale factor of 1.09 applied to diurnal pattern to simulate wet weather response
- Buildout - Scale factor of 1.09 applied to diurnal pattern to simulate wet weather response

Calibration

Model calibration for the existing conditions scenario utilized flow data at the treatment plant. The maximum daily inflow from the period between 2012 and 2016 was used to identify the maximum inflow data for wet weather calibration. The maximum daily inflow occurred during a wet weather event on January 21, 2016, which correlated to roughly a 25-year, 24-hour rainfall event based on isopluvial maps in the Department of Ecology's Stormwater Management Manual for Western Washington. Inflow data for the calibration event was used to determine the peaking factor for peak daily flow to peak hourly flow.

Hydrologic Parameters/Rainfall

Rainfall and hydrologic data were not incorporated as part of this model development beyond calibration and establishment of scale factors and peak diurnal patterns. Inflow and infiltration (I/I) were accounted for in the model using peaking factors.

Hydraulic Simulation Criteria

An Additional Parameter file (*.ADP) file was used to increase stability in the model. The *slot_width.adp* was used for all hydraulic model simulations. The corresponding DHIAPP.INI file used to define additional hydraulic parameters was also modified to account for use of the .ADP file. These were used with the MOUSE engine for hydraulic simulation.

Model Validation

The model received from BHC was validated by assessing peak flow estimates for observed data. This validation was completed by assessing model peak flow simulated results versus estimates of observed peak influent to the CKWWTP. Rainfall data from the Kingston and Suquamish rain gauges were used to characterize the December 21, 2020 storm. This rainfall event yielded approximately 2.1 inches of rainfall over 24-hours. Using Intensity Duration Frequency (IDF) curves from the Unites States Geological Survey (USGS) State of Washington Water Research Center Annual Technical Report FY 2015 for Kitsap County, several different rainfall durations from 30-minutes to 24-hours were analyzed to compute the highest rainfall return period. This storm equated to roughly a 10-year recurrence. Correspondence with County staff indicated approximately 16-MGD peak influent flow was observed at the CKWWPT. The peak simulated model flows to the CKWWTP for the 2017 and 2038 planning scenarios were 13.2 MGD and 20.1 MGD, respectively. The observed influent peak of 16 MGD for 2020 is between these peak simulated flows. While this does not indicate a linear trend of increases in peak flow in the system, it does show that methodology applied provides a sufficient estimate for planning level purposes based on the data used to update the model.

Recommendations for Use

Review of the H/H model for the Central Kitsap service area related to model set-up as well as validation indicate that the model is acceptable in assessing the hydraulic capacity of the system for existing and future conditions. Updates to population and land use assumptions for different planning horizons should follow the previously developed methodology to update the model. No new modeling needs to be completed to establish existing hydraulic capacity of the system. Changes related to CIP development other than those identified as part of previous modeling analysis will require new model runs to confirm their efficacy in improving the hydraulic capacity of the model.

Limitations and Sources of Uncertainty

Discussions with the County's modeling consultant indicated that the model was developed only for peak wet weather conditions in the conveyance system and not for average dry weather conditions. The patterns and scaling factors used to calibrate the model to data at the CKWWTP were specific to the calibration event. This limits the ability to evaluate the conveyance system performance with different design storms, for example a 5-year 24-hour storm, or a 10-year 24-hour storm.

Calibration resolution was limited to flow data at the CKWWTP. The distribution of flows across the system is dependent on the assumptions used in developing flows based on population and land use. In addition, the peaked diurnal pattern and scaling factors assumes a consistent wet-weather response across the service area. Lack of monitoring data and application of this methodology limits the ability to identify areas that have potential high inflow and infiltration (I/I) rates. The global scale factor applied to the inflows also limits the ability to assess impact of any I/I reduction methodology in an efficient manner. As new monitoring data becomes available within the basin, the model should be updated to reflect the more recently available data.

Recommendations for Future Central Kitsap Model Development

Although the model is useful for the purposes of this Plan, several improvements are recommended in the future. Dry weather flows and wet weather flows should be input separately in the model. This will allow for better geographic distribution and reflect varying rates of I/I throughout the system. Additional flow monitoring should be performed throughout the system to confirm dry weather flow distribution, improve wet weather flow distribution, and to better determine wet weather flow response. This will allow a more accurate analysis of conveyance system capacity, determination of a reasonable level of service for different storm events, and potential for improved analysis of I/I reduction. Flow monitoring locations should be informed by availability and age of existing monitoring data, cost of installation and monitoring, as well as intended use of data. A figure showing approximate locations of flow monitoring is appended to the end of this memorandum. The monitoring locations assume that SCADA improvements will allow for better access to data from existing pump station flow meters, and installation of four additional flow meters in the gravity system.

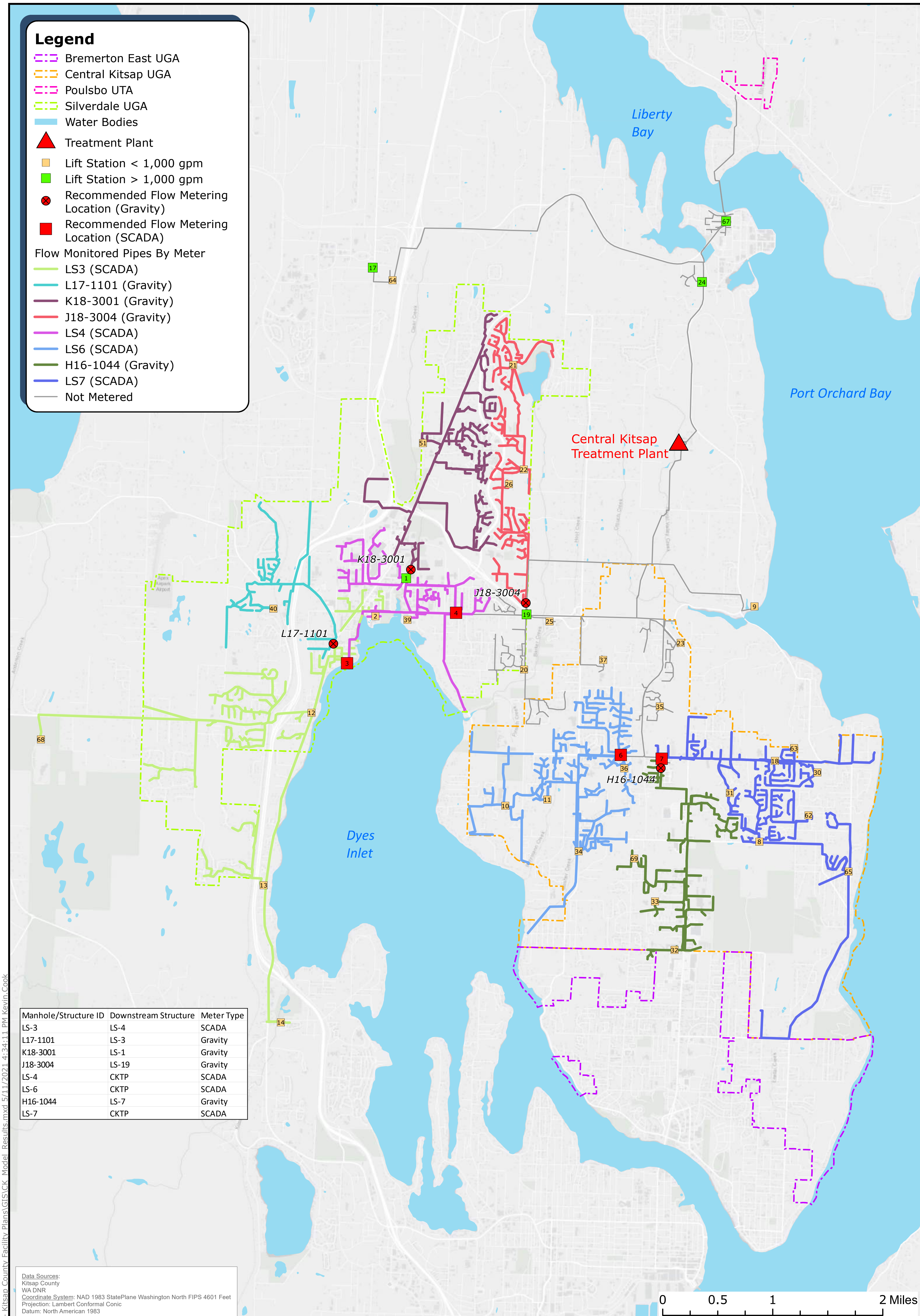
Recommendations for Kingston and Suquamish Model Development

H/H models are being developed for the Kingston and Suquamish sewer basins for Kitsap County. Review of available data sources used as part of the Central Kitsap model development as well as understanding of current and potential future needs for the County yield the following recommendations for future model development.

It is recommended that the models be set up with a dry-weather flow component in conjunction with hydrologic parameters to account for wet weather system response. Additional flow monitoring data within the basin should be used to verify and adjust wastewater usage estimates based on existing population and employment data as well as data collected at the treatment plant and water consumption data. These data sets will be used to verify assumptions used in developing future projected wastewater flows, as well as confirm assumptions regarding consumption and adjust distribution of flows within the basin if necessary. Flow monitoring data will also be used to establish diurnal patterns specific to each basin area average dry weather flow estimates. The recommendations for flow monitoring data for the Central Kitsap basin with respect to needs for additional flow monitoring are consistent with any future monitoring in the Kingston and Suquamish basins.

Model calibration should incorporate MIKE URBAN hydrologic parameters. This will be used to evaluate I/I within the system as well as system response to rainfall as well as any baseflow amounts identified within the monitoring period. The addition of the hydrologic component allows for validation, analysis to future rainfall events, and varying levels of service.

It is also recommended that the models for these two basins be developed using the same software platform, however DHI (the developer of MIKE URBAN) has discontinued new releases of the program in favor of a new release, MIKE+. Changes to the platform and software indicate that continued support of the current MOUSE engine is not supported in MIKE+ which uses the MIKE1D engine (note that the latest releases of MIKE URBAN do support the use of the MIKE1D engine). Modeling for the Kingston and Suquamish basins will use MIKE+.



Manhole/Structure ID	Downstream Structure	Meter Type
LS-3	LS-4	SCADA
L17-1101	LS-3	Gravity
K18-3001	LS-1	Gravity
J18-3004	LS-19	Gravity
LS-4	CKTP	SCADA
LS-6	CKTP	SCADA
H16-1044	LS-7	Gravity
LS-7	CKTP	SCADA

Data Sources:
Kitsap County
WA DNR
Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

murraysmith

KITSAP COUNTY WASHINGTON

Kitsap County Wastewater Facility Plan and Sewer Plan Updates

Figure 1
Flow Monitoring Recommendations

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APPENDIX N
CENTRAL KITSAP WWTP SOLIDS
HANDLING IMPROVEMENT
RECOMMENDATIONS,
MURRAYSMITH, 2022

Technical Memorandum

Date:	October 19, 2022
Project:	Wastewater General Sewer Plan Update
To:	Barbara Zaroff, PE, PMP Christopher Sheridan Kitsap County, WA
From:	Miaomiao Zhang, PE, PMP Jefferson Moss, PE Xinyi Xu, EIT
Reviewed By:	Erika Schuyler, PE, PMP
Re:	Central Kitsap WWTP Solids Handling Improvement Recommendations

1. Introduction and Background

Kitsap County embarked the General Sewer Plan update on its Central Kitsap Wastewater Treatment Plant (WWTP) and associated sewer basin in 2020. Recognizing the age and condition of the existing solids handling processes at the Central Kitsap WWTP, the County has made assessing and improving the solids processes one of the top priorities during the General Sewer planning effort and hopes to implement the identified improvement in a timely manner to ensure the reliable operation and performance of the solids handling processes.

Over the last two years several tasks focusing on the plant's solids handling processes have been completed to meet the County's goal, including:

- Existing system condition assessment
- Anaerobic digester emergency response and interim operation plan
- Digester rehabilitation
- Liquid hauled waste study
- Class A biosolids evaluation

The purpose of this technical memorandum (TM) is to summarize the previous work, document the evolvement of the process from identifying the needs and evaluating alternatives to determining the best solutions and prioritizing capital improvement projects, and make recommendations on the solids handling improvement strategy with implementation timeline (near-term and long-term).

2. Summary of Previous Work

2.1 Existing Condition Assessment and Deficiency

In September 2020, the Murraysmith team conducted a 3-day field visit to assess the condition and performance of the unit processes at Central Kitsap WWTP. Following the condition assessment, the team evaluated the hydraulic and treatment capacity, as well as treatment performance of all the unit processes and documented the findings and recommendations in Section 6 Wastewater Treatment Facilities Existing Conditions of the Central Kitsap General Sewer Plan (Murraysmith). Each unit process was assigned a condition rating ranging from very good to very poor.

Table 1 below summarizes the findings and improvement recommendations related to the solids handling processes based on this condition assessment and deficiency evaluation. To focus on the purpose of this TM, only solids handling unit processes with a poor to very poor condition or with a capacity or performance issue are listed in Table 1. Only recommendations requiring significant capital investment are listed in Table 1.

Table 1
Solids Handling Process Condition, Capacity and Recommendations

Unit Process	Physical Condition	Capacity/ Performance	Improvement Recommendations
Gravity Thickener	Poor. Over 45 years old. Both mechanical components and concrete are severely corroded	Oversized resulting in potential sludge fermentation	1. Replace the control structure. 2. Replace gravity thickeners with other thickening technology
Anaerobic Digester	Poor. Over 45 years old. Leaking pressure vacuum relief valves (PVRVs) and annular seal	No redundancy. Having challenge of meeting the volatile solids reduction (VSR) requirement in Federal Regulation 503	1. Repair digester annular seal, PVRVs, and any failed coating. 2. Provide additional digester capacity in the near term for redundancy and reliability 3. Replace failing manual valves. Establish a preventative maintenance program to exercise major valves annually
Digester Gas Treatment and Cogeneration	Good	System is down due to the past operational challenges associated with insufficient biogas quantities and pressure	1. Improve digester gas supply and quality 2. Conduct necessary maintenance and improvement before restart the system

Unit Process	Physical Condition	Capacity/ Performance	Improvement Recommendations
In-plant Pump Station	Poor. Both mechanical components and concrete are severely corroded	No pump redundancy. High flows at septage receiving overwhelm station capacity	Replace in-plant pump station with new higher capacity pump station
Fats, Oils and Grease (FOG) Receiving	FOG is dumped to primary clarifier scum pit which is in poor condition	No dedicated FOG receiving and pre-treatment	Construct a dedicated FOG receiving station
Septage Receiving	Good	No redundancy	Construct a redundant septage receiving station
Septage pumps	Poor. Over 45 years old.	Have enough capacity and redundancy	Replace septage pumps
Septage cyclone and classifier	Poor. Over 45 years old.	No redundancy. Limited access to equipment	Replace septage cyclone and classifier

2.2 Anaerobic Digester Emergency Response and Interim Operation

Based on the condition assessment and the plant staff's input, the existing digesters which were placed into service in 1977 have many failing components, including:

- The PVRV and three-way valve upstream of the PVRV are failing, resulting in digester gas leaks, and posing health risks to the plant personnel
- The deteriorating annular seals had failed in the past resulting in sludge leaking
- Digester mixing pump suction pipes had been removed, which may reduce mixing effectiveness
- Coating on the digester cover and skirt was observed to be deteriorated
- The digesters have failed to meet the VSR requirement during high septage receiving periods. The land application site has reported vector attraction of the biosolids from Central Kitsap WWTP.

In November 2021, Murraysmith developed a TM entitled *Central Kitsap WWTP Anaerobic Digester Emergency Response Plan and Interim Operation Plan* (Murraysmith, November 2021) to establish the plans for the County in the event of digester failure and determine the digester interim improvements to prevent the digester failure, as discussed below.

2.2.1 Emergency Response Plan

The Emergency Response Plan includes temporary backup, treatment hauling, and disposal options. It evaluates three sludge management alternatives during emergency situations:

- Alternative 1 - Single digester operation

- Alternative 2 - Sludge processing by other wastewater treatment plants
- Alternative 3 - Landfill disposal of sludge

Alternative 1 - Single digester operation

Although in theory the hydraulic retention time (HRT) of one duty digester at the current sludge loading meets the requirement for pathogen reduction, treating the entire amount of sludge with one digester will likely fail the vector reduction requirement and increase risk of upsetting the digestion process during the real operation, given the VSR challenge that the plant currently experiences with two operational digesters. Therefore, single digester operation is only recommended for short-term (less than six weeks) emergency response when septage receiving is shut down at the plant. Long-term shutdown of septage receiving has a significant impact to County residents who own septic tanks for sewage treatment and also results in an estimated $724,000 per year revenue loss for the sewer utility.

Alternative 2 - Sludge processing by other wastewater treatment plants

Several wastewater treatment utilities were contacted regarding their excess sludge handling capacity and interest of receiving and treating sludge from Kitsap County during emergency, both on a short-term (less than six weeks) or long-term (multiple years) basis. This exercise identified a few potential accepting utilities including the City of Bremerton, West Sound utility District, Lakehaven Water and Sewer District, Pierce County, and the City of Tacoma. This alternative is technically feasible since the combined backup capacity of the accepting utilities exceeds the total volume of sludge treated at Central Kitsap WWTP, although the costs would be high (estimated at $3.8 million per year), and the coordination with and trucking arrangement to various receiving plants would be complicated. Due to the high cost and complexity, this alternative is not recommended.

Alternative 3 – Landfill disposal of sludge

Waste Management was contacted regarding the feasibility of transporting the undigested and dewatered sludge to the landfill for disposal. The regulatory requirement, logistics and operational requirements have been discussed in the TM. Landfill disposal under an emergency or interim situation will likely be approved by the Washington Department of Ecology if the County can provide the approval from the disposal company and the health department with the jurisdiction of the landfill and demonstrate the intent of emergency or short-term operation. The existing digester configuration requires sludge to be sent to one or both digesters and be pumped from there to dewatering process before being loaded to the truck for landfill disposal. New bypass piping is recommended to allow both digesters to be completely bypassed during the landfill disposal. This alternative allows the County to continue accepting septage and is substantially less expensive than Alternative 2. The estimated cost for landfill hauling and disposal is $1 million per year. Therefore, it is a preferred alternative to handle the County's sludge during a long-term emergency digester shutdown. The County is currently in the process of installing the new digester bypass piping in the digester rehabilitation project.

2.2.2 *Interim Operation Plan*

The Interim Operation Plan includes capital improvements and operational adjustments recommendations to improve digester performance and extend service life of the existing digesters, specifically,

- Annular seal and roof repairs
- Preventative maintenance, spare parts, and backup equipment
- Digester mixing improvements

2.3 Digester Rehabilitation

Due to the increasing concern of the deteriorating digesters, the County has decided to implement a digester rehabilitation and modification project to address some of the immediate needs identified during digester emergency response and interim operation plans. The rehabilitation and modification design was completed in April 2022 and the construction was scheduled to complete by summer 2022. However, the County had to reduce the scope of construction after they received only one bid with a price much higher than expected. The reduced scope includes:

- Nitrogen purging of digester during digester shutdown, startup and sludge transfer
- Annular seal repair on East Digester
- PVRV and three-way valve replacement on both digesters
- Existing manual valve replacement and digester bypass piping installation

The County's decision on this reduced scope of construction was made in the context that the rest of solids handling improvements will need to be accelerated in order to maintain the reliable and successful operation of the solids handling processes. Construction started in late July 2022. The first three work items (above) are scheduled to be completed by mid-September 2022 to minimize the impact on septage receiving and digester operation. The last work item will be completed by February 2023 due to the long lead time of the pipe and valves.

2.4 Liquid Hauled Waste Study

The County currently receives and treats over 23,000 gallons per day of liquid hauled waste (LHW) at its Central Kitsap WWTP. LHW mainly consists of septage, thickened waste activated sludge (TWAS) from the County's other liquids treatment plants, and FOG from restaurants and residential grease traps. The entire LHW load contributes approximately one third of the sludge loading to the digester feed. Since septage is normally fairly stabilized and some of the portable toilet waste contains unknown chemicals, it is believed that LHW is one of the reasons for the observed low digester VSR at Central Kitsap WWTP.

Despite the challenges associated with the septage treatment at Central Kitsap WWTP, the Kitsap Board of County Commissioners (BOCC) is committed to providing continuous septage receiving service to the residents and businesses within the County, including outside of the Urban Growth Area (UGA). The purpose of the Liquid Hauled Waste Study (Murraysmith, July 2022) is to project the LHW quantities and evaluate the solids handling alternatives focusing on improving LHW treatment as well as solving the other related near-term needs. The study indicated the LHW is anticipated to increase at a rate of approximately 4 percent in the next 20 years. Five alternatives to handle the LHW, specifically septage, have been evaluated from the perspectives of regulatory requirements, technology, equipment design, layout, site plan, cost, and O&M requirements. They are:

Alternative 1 – Treat Septage with Other Solids Streams
Alternative 2 – Separated Septage Treatment with Anaerobic Digestion
Alternative 3 – Separated Septage Treatment with Lime Stabilization
Alternative 4 – Entire Solids Treatment with Sedron Varcor System
Alternative 5 – Separated Septage Treatment with Wetland and Composting

Alternative 4 was determined not feasible due to the limitation of the technology. Table 2 summarizes the comparison of the remaining four alternatives. Table 3 provides a comprehensive comparison of these four alternatives and the baseline (do nothing), from both the non-monetary and monetary perspectives, and a recommendation.

Table 2
Existing Class B Solids Handling Improvement Alternative Evaluation

Alternative	Capital Cost[1]	O&M 20-year Net Present Cost	20-yr Lifecycle Cost	Advantages	Disadvantages
1 – Treat septage with other solids streams	$43M	$7.7M	$50M	• Lowest cost • Familiar technology • No changes from current biosolids management practice • Simple O&M	• Risk of not meeting VSR requirement for vector attraction reduction, although the risk is very low since additional digester will significantly increase digestion HRT and new thickening system will minimize any VSR prior to digestion
2 – Separated septage treatment with anaerobic digestion	$46M	$7.9M	$54M	• Relatively low cost • Familiar technology • Minimal changes from current biosolids management practice • Separating septage eliminates any undesirable impact from septage on the main solids stream • Separating septage allows flexible and customized septage treatment	• More complex O&M • Risk of septage not meeting VSR requirement for vector attraction reduction, although the risk is very low since the dedicated digester with a redundant unit will significantly increase digestion HRT and new thickening system will minimize any VSR prior to digestion

Alternative	Capital Cost[1]	O&M 20-year Net Present Cost	20-yr Lifecycle Cost	Advantages	Disadvantages
3 – Separated septage treatment with lime stabilization	$49M	$16M	$65M	• Separating septage eliminates any undesirable impact from septage on the main solids stream • Lime stabilization provides a reliable method to convert septage to Class A or Class B biosolids	• High cost • Complex O&M • Unfamiliar technology • Lime stabilization could generate higher dust and odor • Removing septage from digestion may reduce biogas production thus cogeneration operation
4 – Entire solids treatment with Sedron Varcor system	N/A	N/A	N/A	• N/A	• Not feasible. Technology not currently available at appropriate scale
5 – Separated septage treatment with wetland and composting	$51M	$5M	$56M	• Separating septage eliminates any undesirable impact from septage on the main solids stream • Provides opportunity to integrate with main solids stream composting for Class A • Relatively simple O&M	• High cost • Large land requirement • Unfamiliar technology • Removing septage from digestion may reduce biogas production thus cogeneration operation

Notes:

1. M = million
2. N/A = Not applicable

Table 3
Existing Class B Solids Handling Improvement Alternative Comparison

Alternative	Comply with regulations	Handle future loads with redundancy	Compatible with existing processes	Improved operation and process control	Easy O&M	Reasonable O&M and capital costs	Recommended
Baseline - Do nothing	✓	✕	✓	✕	✓	✓	N
1 – Treat septage with other solids streams	✓	✓	✓	✕	✓	✓	N
2 – Separated septage treatment with anaerobic digestion	✓	✓	✓	✓	✓	✓	Y
3 – Separated septage treatment with lime stabilization	✓	✓	✓	✓	✕	✕	N
4 – Entire solids treatment with Sedron Varcor system	N/A	N/A	N/A	N/A	N/A	N/A	N
5 – Separated septage treatment with wetland and composting	✓	✓	✕	✓	✕	✕	N

The study recommended Alternative 2 because it provides a more reliable septage treatment with relatively low cost. Other advantages of Alternative 2 include that it proposes familiar technologies to the plant staff, and provides flexibility, redundancy, and ability to customize treatment of septage and other WWTP sludge streams independently.

Alternative 2 includes the following improvements:

- A third, 1.3-MG anaerobic digester will be constructed for thickened sludge and FOG treatment. One of the existing digesters will be used for septage treatment.
- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone will be replaced with a new grit removal system.
- A new FOG receiving station and associated sump and pump will be constructed.
- Septage will be thickened separately by new thickening equipment.
- The existing gravity thickeners will be replaced with a new thickening process.

2.5 Class A Biosolids Evaluation

Class A biosolids options were evaluated in a TM entitled "Central Kitsap WWTP Class A Biosolids Evaluation" (Murraysmith, July 2022) in the context of a long-term and holistic biosolids management strategy.

After a preliminary Class A biosolids technology screening, two post-digestion Class A technologies remained for a detailed comparison as they are established technologies, appropriate for the size of Central Kitsap WWTP, are compatible with the existing process, and have reasonable O&M and capital costs. These technologies are Class A composting and heat drying. The conceptual design, product reuse potential and capital, O&M and life cycle costs were developed and evaluated against the existing Class B biosolids operation. Table 4 summarizes the comparison of the alternatives.

Table 4
Class A Solids Handling Improvement Alternative Evaluation

Alternative	Capital Cost[1]	O&M 20-year Net Present Cost	20-year Lifecycle Cost	Advantages	Disadvantages
Existing Class B	$0	$9.3 – 12.0M[2]	$9.3 – 12.0M[2]	• Lowest cost • No changes from current biosolids management practice • Simplest infrastructure and operation	• Limited options for Class B biosolids reuse • High Class B biosolids hauling and land application costs
Class A Composting	$10.6M	(1.1M) – 16.0M (best estimate: $6.7M)[3]	$9.5 – 26.6M (best estimate: 17.2M)[3]	• Relatively low capital cost • Low energy use • Promising market and revenue • Sustainable approach to reduce carbon emission and promote green waste recycle	• High labor demand • Large footprint • Requires time and effort to establish market for compost product
Class A Drying	$16.4M	$10.6M	$27.1M	• Relatively lower labor attention • Relatively smaller footprint • Sustainable approach to reduce carbon emission	• Highest capital and lifecycle costs • High energy (fuel and electricity) use • Less certain market and revenue for dried pellets

Notes:
1. Capital costs do not include cost required to improve performance or capacity of the existing Class B processes, since that cost is the same for all alternatives.
2. The range is based on the Class B biosolids hauling and disposal prices from the County's current and historical contracts.
3. The range is based on the conservative and optimal assumptions on the O&M effort and revenue from compost sales. The best estimate is based on the most likely assumptions on these items.

The conclusions of the Class A biosolids evaluation are:

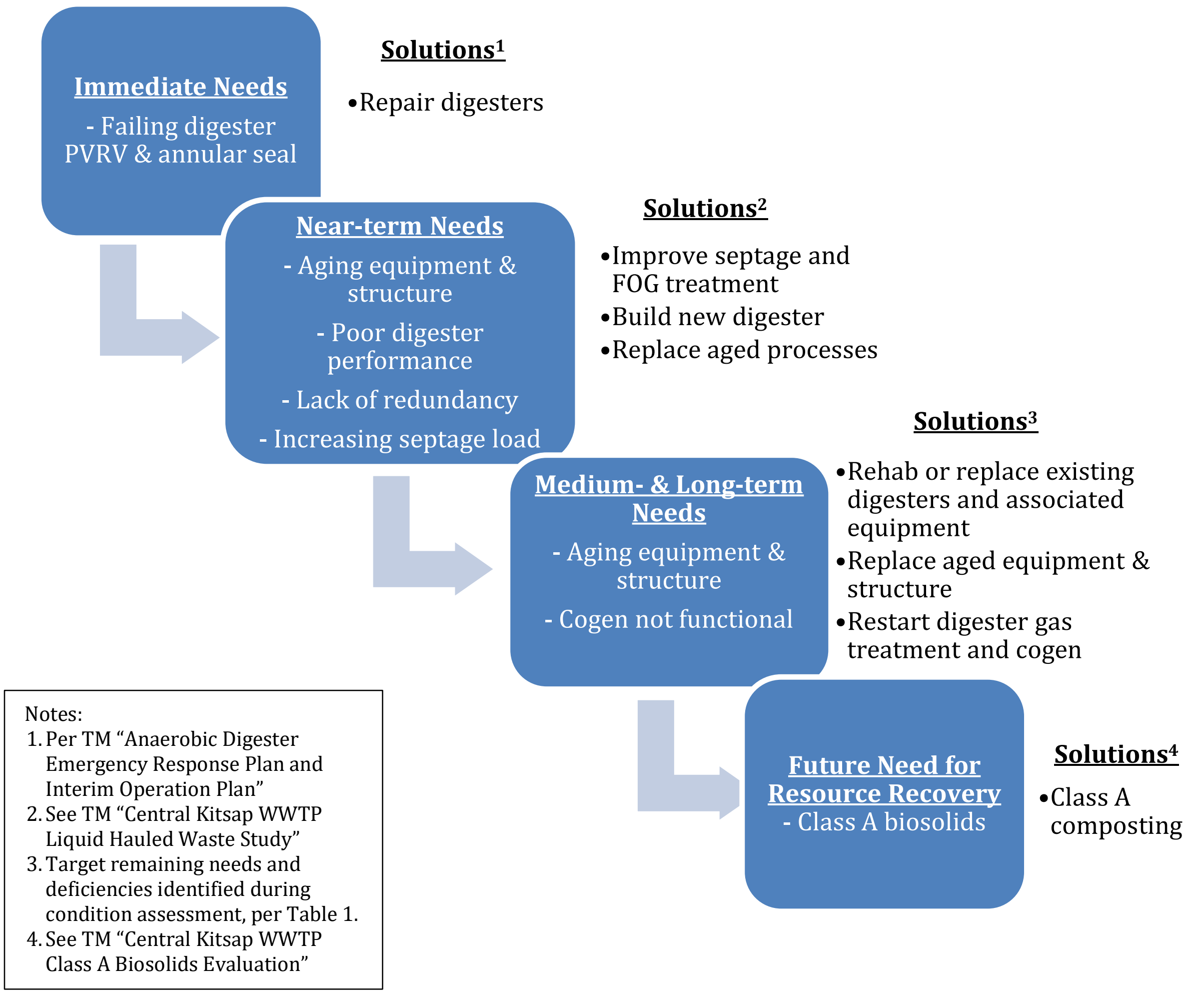
- Continuing the existing Class B process is the lowest cost option, with simplest infrastructure and operation.
- The life-cycle cost of the Class A composting will likely be higher than the existing Class B program, but lower than the heat drying alternative. Because the labor and the revenue from compost product are two main factors impacting the cost analysis and they could significantly vary case by case, effort to optimize labor and develop strong market is critical to a financially successful program.
- Composting also provides a lot of non-financial benefits, such as reducing carbon footprint associated with Class B biosolids hauling to eastern Washington, reducing risk of relying on limited land application sites for Class B product disposal, providing a valuable soil amendment to the local community and home growers, and providing a convenient location for the public to recycle green waste. These non-financial considerations make composting an attractive alternative.
- There is not an immediate need or financial incentive to upgrade the solids handling process to produce Class A biosolids, but there are numerous benefits to constructing and operating a composting process. Other parts of Central Kitsap WWTP need refurbishment or replacement sooner. Therefore, it is recommended to reserve land area for the composting site as other improvements are considered, but delay implementation of the composting until other more critical improvements are addressed or the financial outlook becomes more favorable.

3. Solids Handling Improvements Recommendations

3.1 Solids Handling Improvement Considerations

The previous work collected abundance of information, laid out alternatives, and presented solutions for the County to develop a phased solids handling improvement strategy. Figure 1 illustrates the evolution of the process.

Figure 1
Solids Handling Improvement Strategy Development Process



Besides replacing the aging infrastructure and equipment when they reach their useful life, as identified in the condition assessment, the most important considerations on solids process improvements includes 1) when and how the plant should improve the existing Class B biosolids process including septage treatment; 2) whether, when, and how the plant should implement Class A biosolids process.

3.2 Solids Handling Improvement Recommendations

Based on all the previous work the following phased solids handling capital improvement projects are recommended.

Immediate Improvements (ongoing)

The purpose of the immediate improvements is to repair the failing digester PVRV and annual seal to protect the plant staff's health and safety. The work is being done currently in the digester rehabilitation project. Due to the urgent need for the repair of these critical components and the fact that neither of the digesters cannot be taken offline for an extended duration, the goal of this project is to temporarily address the immediate needs and allow for the design and construction of longer-term improvements that will address other needs related to the entire solids handling processes.

Near-term Improvements (next 5 years)

These improvements address the near-term needs associated with the existing Class B biosolids process.

- Installing a new FOG receiving station with new pump
- Replacing existing septage pumps
- Replacing existing septage grit cyclone and classifier
- Thicken septage separately with new thickening equipment
- Replacing existing gravity thickeners with a new thickening process
- Constructing a new 1.3-MG anaerobic digester for thickened sludge and FOG treatment.
- The existing shop and equipment maintenance building will need to be demolished and relocated to make space for this new digester.
- Replacing existing in-plant pump station
- Replacing hot water system associated with the existing digesters, including new hot water pumps and new boilers.

Most of these items are described in detail in the TM *Central Kitsap WWTP Liquid Hauled Waste Study* (Murraysmith, July 2022). The last two items are determined based on the condition of the equipment.

The existing in-plant pump station was installed in 2011. It consists of a 6-ft diameter wetwell constructed with a reinforced concrete pipe, and two submersible pumps. The two 4-inch pump discharges go through a precast concrete valve vault before getting combined and routed to upstream of the aerated grit tanks. The pump station is severely corroded and under-sized for all the flows received at the pump station. A new submersible pump station with new pumps will be installed to completely replace the existing station.

The existing hot water system is located on the ground level of the digester control building. It includes two boilers; two expansion tanks and four hot water recirculation pumps, all of which were installed in 1977. They are reaching their end of the life. A new hot water system will be installed in the new digester control building to supply the heat demand from both the existing and new digesters and other process areas. The existing boilers use diesel as fuel and propane for the pilot. A more advanced and sustainable boiler technology using biogas and natural gas should be considered as a replacement option. Cascade Natural Gas Corporation (CNGC) has been contacted to discuss the possibility of extending their natural gas pipeline to serve the CK WWTP. According to CNGC's preliminary analysis, an approximately 1.2-mile-long new natural gas pipeline will need to be extended from Greywolf PL and Old Military Rd to the plant. The County will be responsible for approximately $260,000 for the pipeline extension. Further investigation on boiler technology and the need for natural gas will be done in the next phase of the engineering study.

Medium-term Improvements (next 5 to 10 years)

These improvements address the medium-term needs associated with the existing Class B biosolids processes. They are all determined based on the condition of the equipment.

- Improving or replacing existing anaerobic digesters, including structure, equipment and electrical panels, after the new digester is in operation and the existing ones can be taken offline
- Expanding septage receiving station to provide redundancy
- Replacing existing scum grinder and pumps
- Replacing centrifuge sludge feed grinders
- Restarting the biogas treatment and cogeneration system

After the new digester is constructed and put into operation at the end of near-term improvements, the existing digesters could be taken offline for a thorough inspection and rehabilitation to extend their useful life. The equipment associated with the existing digester construction, such as mixing pumps, sludge recirculation pumps, heat exchangers, and motor control center will be replaced. The structural components, such as digesters vessel, covers, control building, will be inspected and evaluated for repair or replacement.

The biogas treatment and cogeneration system are fairly new but have not been successfully operational in the recent years. The biogas production and pressure are expected to improve after the near-term improvements, which will benefit the successful re-commissioning of the biogas treatment and cogeneration system. The need for the biogas storage to improve the cogeneration operation shall be evaluated during this phase.

Long-Term Improvements (next 10 to 20 years)

The long-term improvements would be primarily replacing equipment i.e. those installed in 1999, as they approach the end of their useful life. The equipment includes:

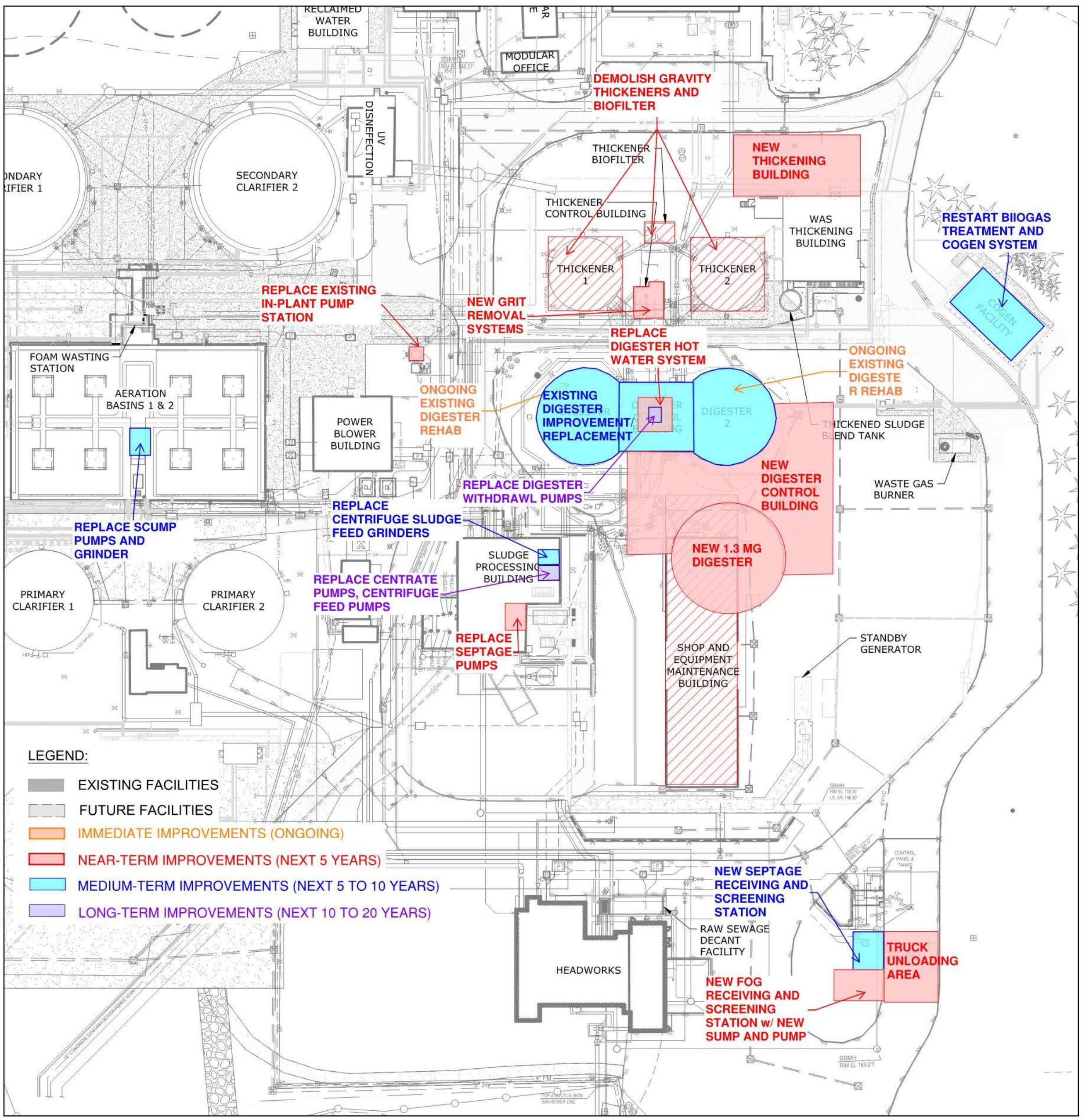
- Centrate pumps
- Centrifuge feed pumps
- Digester withdrawal pumps

Future Considerations

Class A composting should be considered after the more urgent improvements on the existing Class B biosolids processes are completed, as evaluated and recommended in the TM *Central Kitsap WWTP Class A Biosolids Evaluation* (Murraysmith, July 2022).

Figure 2 is a site plan showing the recommended improvements at Central Kitsap WWTP in different phases.

Figure 2
Recommended Phased Solids Handling Improvements at Central Kitsap WWTP



3.3 Cost Estimate

The probable costs are developed for each recommended improvement using the same methods in this General Sewer Plan update effort. All costs were developed based on the preliminary concept, equipment quote and system layout in 2022 dollars should be escalated with the future CCI for use in project budgeting.

This Class 5 cost estimates were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE), for planning-level evaluations with a range of -50 percent to +100 percent, based on the *AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries - TCM Framework: 7.3 - Cost Estimating and Budgeting*.

Table 5 summarizes the Class 5 cost estimate for these recommended improvements for the near-term, medium-term, and long-term improvement projects. Construction costs include the estimated cost of construction work plus markups for mobilization, general contractor markups, overhead, and profit, taxes, and a construction contingency. The capital costs include an additional markup of 25 percent for engineering, legal, and administration costs associated with project delivery. The detailed estimates for each improvement are included in Appendix A.

Table 5
Cost Estimates of Recommended Solids Handling Improvements

Improvements	Construction Cost	Capital Cost
Near-term	$41 M	$51 M
Medium-term	$11 M	$14 M
Long-term	$1.1 M	$1.4 M
Future	$7.9 M	$10.6 M

Table 6 shows the cost breakdown of each of the major components of the near-term improvement work.

Table 6
Cost Breakdown of Recommended Near-term Solids Handling Improvements

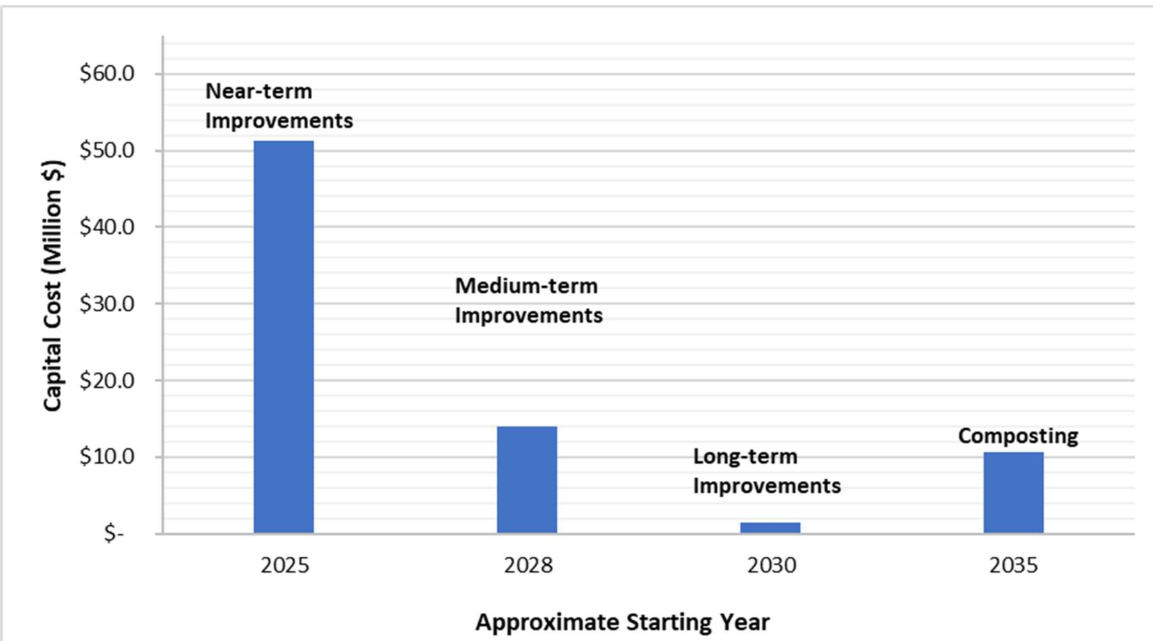
Near-Term Improvements	Construction Cost	Capital Cost
New FOG receiving station	$1.2 M	$1.5 M
New septage pumps and grit cyclone and classifier	$0.9 M	$1.1 M
New septage thickening	$5.8 M	$7.3 M
New primary sludge thickening	$5.6 M	$7.0 M
New digester and building	$20.3 M	$25.4 M

Near-Term Improvements	Construction Cost	Capital Cost
New in-plant pump station	$0.6 M	$0.7 M
New hot water system[1]	$2.3 M	$3.3 M
O&M shop relocation	$4.0 M	$5.0 M
Total	$40.8 M	$51.3 M

1. Cost of constructing natural gas pipeline by Cascade Natural Gas to serve the plant's new boilers is included in the new hot water system.

Figure 3 illustrates the anticipated capital expenditure (in 2022 dollars) and approximate timeline for the above projects.

Figure 3
Solids Handling Improvement CIPs and Approximate Timeline



Appendices

Appendix A – Detailed Cost Estimates

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APPENDIX A

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

Horizon	Items	Construction Cost	Capital Cost
Near-Term	New FOG Receiving Station	$1,157,000	$1,447,000
	New Septage Pumps and Grit Cyclone and Classifier	$910,000	$1,137,000
	New Septage Thickening	$5,823,000	$7,279,000
	New Primary Sludge Thickening	$5,620,000	$7,025,000
	New Digester and Building	$20,346,000	$25,433,000
	New In-plant Pump Station	$557,000	$696,000
	New Hot Water System	$2,328,000	$3,244,000
	Shop and Equipment Maintenance Building Relocation	$4,026,000	$5,033,000
	NEAR-TERM TOTAL	$40,767,000	$51,294,000
Medium-Term	Existing Digesters Improvements and Replacements	$9,917,000	$12,396,000
	New Septage Receiving Station	$776,000	$970,000
	Existing Scum Grinder and Pumps Replacement and Centrifuge Sludge Feed Grinders Replacement	$511,000	$638,000
	MEDIUM-TERM TOTAL	$11,204,000	$14,004,000
Long-Term	Centrate Pumps Replacement, Centrifuge Feed Pumps Replacement, Withdrawal Pumps Replacement	$1,121,000	$1,401,000
	LONG-TERM TOTAL	$1,121,000	$1,401,000

Murraysmith's construction cost estimate ("estimate") is in 2022 dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development. Final costs will depend on
•actual field conditions.
•actual material and labor costs.
•market conditions for construction.
•regulatory factors.
•final project scope.
•method of implementation.
•schedule, and
•other variables.

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Murraysmith has no control over, nor can it forecast variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means, and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Murraysmith neither warrants nor guarantees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New FOG Receiving Station

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Excavation	CY	33	$	60.00	$1,973.33
	Backfill	CY	5	$ 45.00	$ 18.00	$310.80
	FOG Yard Piping (4'')	LF	500	$ 100.00	$ 30.00	$65,000.00
	Subtotal					**$67,284.13**
Structural						
	FOG Sump	SF	50	$400.00		$20,000.00
	Subtotal					**$20,000.00**
Mechanical						
	FOG Receiving and Screening Station	LS	1	$ 273,840.00	$ 82,152.00	$355,992.00
	FOG Pump	EA	2	$ 40,000.00	$ 12,000.00	$104,000.00
	Subtotal					**$459,992.00**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$91,998.40		$91,998.40
	Subtotal					**$91,998.40**
Construction Material & Labor Subtotal:						**$639,274.53**

Markups	
Mobilization (10%)	$ 63,927.45
General Conditions (8%)	$ 51,141.96
Contractor O&P (12%)	$ 76,712.94
Subtotal	**$ 831,056.89**
Tax (9.2%)	$ 76,457.23
Construction Contingency (30%)	$ 249,317.07
Total Construction Cost	**$ 1,156,831.20**
Engineering, Legal, and Administration (25%)	$ 289,207.80
Total Project Cost	**$ 1,446,038.99**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Septage Pumps and Grit Cyclone and Classifier

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Excavation	CY	106	$	60.00	$6,378.67
	Backfill	CY	16	$ 45.00	$ 18.00	$1,004.64
	Demolition of septage pumps	LS	1	$	5,000.00	$5,000.00
	Demolition of grit cyclone	LS	1	$	5,000.00	$5,000.00
	Subtotal					**$17,383.31**
Structural						
	Equipment support modification	LS	1	$	100,000.00	$100,000.00
	Subtotal					**$100,000.00**
Mechanical						
	Septage Pumps	LS	2	$ 50,000.00	$ 15,000.00	$130,000.00
	Septage Grit Removal System	LS	1	$ 146,880.00	$ 44,064.00	$190,944.00
	Subtotal					**$320,944.00**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$64,188.80		$64,188.80
	Subtotal					**$64,188.80**
Construction Material & Labor Subtotal:						**$502,516.11**

Markups	
Mobilization (10%)	$ 50,251.61
General Conditions (8%)	$ 40,201.29
Contractor O&P (12%)	$ 60,301.93
Subtotal	**$ 653,270.94**
Tax (9.2%)	$ 60,100.93
Construction Contingency (30%)	$ 195,981.28
Total Construction Cost	**$ 909,353.15**
Engineering, Legal, and Administration (25%)	$ 227,338.29
Total Project Cost	**$ 1,136,691.43**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Septage Thickening

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Excavation	CY	400	$ 60.00		$24,000.00
	Backfill	CY	60	$ 45.00	$ 18.00	$3,780.00
	RDT Yard Piping (6")	LF	200	$ 125.00	$ 37.50	$32,500.00
	Subtotal					**$60,280.00**
Structural						
	Thickener Building	SF	2250	$ 400.00		$900,000.00
	Subtotal					**$900,000.00**
Mechanical						
	Septage RDT	LS	1	$ 374,136.00	$ 112,240.80	$486,376.80
	Septage Thickening Ancillary Equipment	LS	1	$ 673,000.00	$ 201,900.00	$874,900.00
	Odor Control	LS	1	$ 400,000.00	$ 120,000.00	$520,000.00
	Subtotal					**$1,881,276.80**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$376,255.36		$376,255.36
	Subtotal					**$376,255.36**
Construction Material & Labor Subtotal:						**$3,217,812.16**

Markups	
Mobilization (10%)	$ 321,781.22
General Conditions (8%)	$ 257,424.97
Contractor O&P (12%)	$ 386,137.46
Subtotal	**$ 4,183,155.81**
Tax (9.2%)	$ 384,850.33
Construction Contingency (30%)	$ 1,254,946.74
Total Construction Cost	**$ 5,822,952.88**
Engineering, Legal, and Administration (25%)	$ 1,455,738.22
Total Project Cost	**$ 7,278,691.11**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Primary Sludge Thickening

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Excavation	CY	400	$	60.00	$24,000.00
	Backfill	CY	60	$ 45.00	$ 18.00	$3,780.00
	Demolition	LS	1	$	30,000.00	$30,000.00
	RDT Yard Piping (6")	LF	300	$ 125.00	$ 37.50	$48,750.00
	Subtotal					**$106,530.00**
Structural						
	Thickener Building	SF	2250	$	400.00	$900,000.00
	Subtotal					**$900,000.00**
Mechanical						
	Primary Sludge RDT	LS	1	$ 297,936.00	$ 89,380.80	$387,316.80
	Primary Sludge Thickening Ancillary Equipment	LS	1	$ 647,500.00	$ 194,250.00	$841,750.00
	Odor Control	LS	1	$ 400,000.00	$ 120,000.00	$520,000.00
	Subtotal					**$1,749,066.80**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$349,813.36		$349,813.36
	Subtotal					**$349,813.36**
Construction Material & Labor Subtotal:						**$3,105,410.16**

Markups	
Mobilization (10%)	$ 310,541.02
General Conditions (8%)	$ 248,432.81
Contractor O&P (12%)	$ 372,649.22
Subtotal	**$ 4,037,033.21**
Tax (9.2%)	$ 371,407.06
Construction Contingency (30%)	$ 1,211,109.96
Total Construction Cost	**$ 5,619,550.23**
Engineering, Legal, and Administration (25%)	$ 1,404,887.56
Total Project Cost	**$ 7,024,437.78**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Digester and Building

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Site Grubbing and Clearing	SF	18000		$0.50	$9,000.00
	Excavation	CY	5909		$60.00	$354,540.00
	Dewatering & Dewatered GW Treatment	LS	1		$500,000.00	$500,000.00
	Backfill	CY	886	$45.00	$18.00	$55,840.05
	Digester Yard Piping (4")	LF	500	$100.00	$30.00	$65,000.00
	Subtotal					**$984,380.05**
Structural						
	RC - Slab on Grade	CY	1288	$500.00	$150.00	$837,287.21
	RC - Elevated Slab	CY	370	$600.00	$180.00	$288,888.89
	RC - Walls	CY	1491	$900.00	$180.00	$1,610,641.52
	Steel Fixed Cover	EA	1	$990,000.00	$297,000.00	$1,287,000.00
	Digester Wall Painting and Coating	SF	8671	$80.00		$693,663.66
	Equipment Pad	CY	10	$500.00	$150.00	$6,500.00
	Subtotal					**$4,723,981.28**
Mechanical						
	Mixing Pumps	EA	2	$124,994.35	$37,498.31	$324,985.31
	Recirculation Pumps	EA	2	$25,000.00	$7,500.00	$65,000.00
	Withdrawl Pumps	EA	2	$100,000.00	$30,000.00	$260,000.00
	Heat Exchangers	EA	2	$81,000.00	$24,300.00	$210,600.00
	Cover Insulation	EA	1	$15,000.00	$4,500.00	$19,500.00
	Mixing Piping - 16" HDPE	LS	1	$500,000.00		$500,000.00
	Mechanical Piping - 16" DI (DS mixing)	LF	100	$700.00	$210.00	$91,000.00
	Mechanical Piping - 6" DI (DS heating)	LF	100	$200.00	$60.00	$26,000.00
	Mechanical Piping - 6" DI (THS)	LF	200	$200.00	$60.00	$52,000.00
	Mechanical Piping - 6" DI (DS)	LF	200	$200.00	$60.00	$52,000.00
	Fittings	LB	2763	$4.50	$4.50	$24,862.50
	Mechanical Valves	LS	1	$300,000.00	$90,000.00	$390,000.00
	Digester Gas Safety Equipment	EA	1	$400,000.00	$120,000.00	$520,000.00
	Digester Gas Sediment Trap	EA	1	$100,000.00	$30,000.00	$130,000.00
	Digester Gas Piping - 4" SST (DG)	LF	200	$60.00	$60.00	$24,000.00
	Building HVAC	LS	1	$500,000.00		$500,000.00
	Building Plumbing and Lighting	LS	1	$500,000.00		$500,000.00
	Subtotal					**$3,689,947.81**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$1,844,974		$1,844,973.91
	Subtotal					**$1,844,973.91**
Construction Material & Labor Subtotal:						**$11,243,283.04**

Markups		
Mobilization (10%)	$	1,124,328.30
General Conditions (8%)	$	899,462.64
Contractor O&P (12%)	$	1,349,193.96
Subtotal	**$**	**14,616,267.95**
Tax (9.2%)	$	1,344,696.65
Construction Contingency (30%)	$	4,384,880.39
Total Construction Cost	**$**	**20,345,844.99**
Engineering, Legal, and Administration (25%)	$	5,086,461.25
Total Project Cost	**$**	**25,432,306.24**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New In-plant Pump Station

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Existing Wetwell Dewatering	EA	1		$100,000.00	$100,000.00
	Existing Wetwell Cleaning	EA	1		$1,280.00	$1,280.00
	Existing Wetwell Demolition	LS	1		$5,000.00	$5,000.00
	New Wetwell and Valve Vault Excavation	CY	132	$25.00	$60.00	$11,184.39
	New Wetwell and Valve Vault Backfill	CY	26	$ 45.00	$ 18.00	$1,657.92
	Subtotal					**$119,122.32**
Structural						
	RC-Slab on Grade - New Wetwell & valve vault	CY	4.2	$500.00	$150.00	$2,726.76
	RC - Wall - New Wetwell & valve vault	CY	14	$600.00	$180.00	$10,864.58
	Subtotal					**$13,591.34**
Mechanical						
	New Sump Pump	EA	1	$33,220.14	$9,966.04	$43,186.18
	Associated Piping and Valves	LS	1	$20,000.00	$6,000.00	$26,000.00
	Subtotal					**$69,186.18**
Electrical, Instrumentation, and Controls						
	Pump Disconnect Panel	EA	1	$8,000.00	$2,400.00	$10,400.00
	Control Panel (PNL-1067)	EA	1	$50,000.00	$15,000.00	$65,000.00
	Yard electrical	LS	1	$30,000.00		$30,000.00
	Subtotal					**$105,400.00**
Construction Material & Labor Subtotal:						**$307,299.84**

Markups		
Mobilization (10%)		$ 30,729.98
General Conditions (8%)		$ 24,583.99
Contractor O&P (12%)		$ 36,875.98
	Subtotal	**$ 399,489.80**
Tax (9.2%)		$ 36,753.06
Construction Contingency (30%)		$ 119,846.94
	Total Construction Cost	**$ 556,089.80**
Engineering, Legal, and Administration (25%)		$ 139,022.45
	Total Project Cost	**$ 695,112.25**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Hot Water System

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Subtotal					**$0.00**
Structural						
	Subtotal					**$0.00**
Mechanical						
	Existing Demolition	EA	3		$5,000.00	$15,000.00
	New Boilers (Replace Existing)	EA	2	$ 320,000.00	$ 96,000.00	$832,000.00
	New Boiler Stack (SS)	LS	1	$ 20,000.00	$ 6,000.00	$26,000.00
	New Hot Water Recirculation Pumps	EA	4	$ 6,150.00	$ 1,845.00	$31,980.00
	New Expansion Tanks	EA	2	$ 15,000.00	$ 4,500.00	$39,000.00
	Hot water piping - 5''	LS	1	$ 12,000.00	$ 3,600.00	$15,600.00
	Natural Gas Piping and Connection	LS	1	$ 30,000.00		$30,000.00
	Subtotal					**$989,580.00**
Electrical, Instrumentation, and Controls						
	EI&C	LS	1	$296,874.00		$296,874.00
	Subtotal					**$296,874.00**
Construction Material & Labor Subtotal:						**$1,286,454.00**

Markups		
Mobilization (10%)		$ 128,645.40
General Conditions (8%)		$ 102,916.32
Contractor O&P (12%)		$ 154,374.48
	Subtotal	**$ 1,672,390.20**
Tax (9.2%)		$ 153,859.90
Construction Contingency (30%)		$ 501,717.06
	Total Construction Cost	**$ 2,327,967.16**
Engineering, Legal, and Administration (25%)		$ 581,991.79
Natural Gas Pipeline Extension by Cascade Natural Gas		$ 333,075.60
	Total Project Cost	**$ 3,243,034.55**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

Shop and Equipment Maintenance Building Relocation

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Existing Shop Demolition	LS	1		$50,000.00	$50,000.00
	Yard Piping Modification	LS	1		$50,000.00	$50,000.00
	Subtotal					**$100,000.00**
Structural						
	New Shop and Equipment Maintenance Building	SF	10324	$200.00		$2,064,800.00
	Subtotal					**$2,064,800.00**
Mechanical						
	Equipment Relocation	LS	1	$30,000.00		$30,000.00
	Subtotal					**$30,000.00**
Electrical, Instrumentation, and Controls						
	EI&C Relocation	LS	1	$30,000.00		$30,000.00
	Subtotal					**$30,000.00**
Construction Material & Labor Subtotal:						**$2,224,800.00**
	Markups					
Mobilization (10%)						$ 222,480.00
General Conditions (8%)						$ 177,984.00
Contractor O&P (12%)						$ 266,976.00
					Subtotal	**$ 2,892,240.00**
Tax (9.2%)						$ 266,086.08
Construction Contingency (30%)						$ 867,672.00
					Total Construction Cost	**$ 4,025,998.08**
Engineering, Legal, and Administration (25%)						$ 1,006,499.52
					Total Project Cost	**$ 5,032,497.60**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

Existing Digesters Improvements and Replacements

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Dewatering & Dewatered GW Treatment	LS	1	$500,000.00		$500,000.00
	Digester Gas Purge	EA	4	$13,000.00		$52,000.00
	Digester Drainage, Cleaning & Inspection	EA	2	$325,000.00		$650,000.00
	Subtotal					**$1,202,000.00**
Structural						
	Equipment Pad	CY	4	$500.00	$150.00	$2,600.00
	Structural & Coating Repair	SF	12252	$80.00		$980,177
	Cover and Skirt Repair or Replace	EA	2	$660,000.00	$198,000.00	$1,716,000
	Subtotal					**$2,698,776.91**
Mechanical						
	Demolition	LS	1	$20,000.00		$20,000.00
	Mixing Pumps Replace	EA	2	$124,994.35	$37,498.31	$324,985.31
	Mixing Piping - 16'' HDPE	LS	1	$500,000.00		$500,000.00
	Heat Exchangers Replace	EA	2	$81,000.00	$16,200.00	$194,400.00
	Recirculation Pumps Replace	EA	2	$25,000.00	$5,000.00	$60,000.00
	Subtotal					**$1,099,385.31**
Electrical, Instrumentation, and Controls						
	MCC Replacement	EA	1	$200,000.00	$60,000.00	$260,000.00
	EI&C Lump Sum	LS	1	$219,877		$219,877.06
	Subtotal					**$479,877.06**
Construction Material & Labor Subtotal:						**$5,480,039.28**

Markups		
Mobilization (10%)	$	548,003.93
General Conditions (8%)	$	438,403.14
Contractor O&P (12%)	$	657,604.71
Subtotal	**$**	**7,124,051.06**
Tax (9.2%)	$	655,412.70
Construction Contingency (30%)	$	2,137,215.32
Total Construction Cost	**$**	**9,916,679.08**
Engineering, Legal, and Administration (25%)	$	2,479,169.77
Total Project Cost	**$**	**12,395,848.85**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

New Septage Receiving Station

Item No.	Item	Unit	QTY	Unit Price Materials & Equipment	Unit Price Labor	Total
Civil Site Prep/Earthwork						
	Excavation	CY	20	$	60.00	$1,173.33
	Backfill	CY	3	$ 45.00	$ 18.00	$184.80
	Subtotal					**$1,358.13**
Structural						
	Subtotal					**$0.00**
Mechanical						
	Septage Acceptance Plant	LS	1	$ 273,840.00	$ 82,152.00	$355,992.00
	Subtotal					**$355,992.00**
Electrical, Instrumentation, and Controls						
	EI&C	EA	1	$71,198.40		$71,198.40
	Subtotal					**$71,198.40**
Construction Material & Labor Subtotal:						**$428,548.53**

Markups	
Mobilization (10%)	$ 42,854.85
General Conditions (8%)	$ 34,283.88
Contractor O&P (12%)	$ 51,425.82
Subtotal	**$ 557,113.09**
Tax (9.2%)	$ 51,254.40
Construction Contingency (30%)	$ 167,133.93
Total Construction Cost	**$ 775,501.43**
Engineering, Legal, and Administration (25%)	$ 193,875.36
Total Project Cost	**$ 969,376.78**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

Existing Scum Grinder and Pumps Replacement and Centrifuge Sludge Feed Grinders Replacement

Item No. Item	Unit	QTY	Materials & Equipment	Labor	Total
Civil Site Prep/Earthwork					
					$0.00
					$0.00
					$0.00
Subtotal					**$0.00**
Structural					
Equipment Pad	CY	5	$ 600.00	$150.00	$3,750.00
Subtotal					**$3,750.00**
Mechanical					
Existing Scum Grinder and Pumps Demolition	LS	3		$ 5,000.00	$15,000.00
New Scum Pumps	EA	2	$ 30,058.00	$ 9,017.40	$78,150.80
New Scum Grinder	LS	1	$ 28,000.00	$ 8,400.00	$36,400.00
Pump Seal Water Assembly	LS	3	$ 2,000.00	$ 600.00	$7,800.00
Mechanical Piping and Fittings	LS	1	$ 5,000.00	$ 1,500.00	$6,500.00
Existing Centrifuge Sludge Feed Grinders Demolition	EA	2		$ 5,000.00	$10,000.00
New Centrifuge Sludge Feed Grinders	EA	2	$ 27,500.00	$ 8,250.00	$71,500.00
Centrifuge Mechanical Piping and Fittings	LS	1	$ 5,000.00	$ 1,500.00	$6,500.00
Subtotal					**$231,850.80**
Electrical, Instrumentation, and Controls					
EI&C Replacement	EA	1	$46,370.16		$46,370.16
Subtotal					**$46,370.16**
Construction Material & Labor Subtotal:					**$281,970.96**

Markups	
Mobilization (10%)	$ 28,197.10
General Conditions (8%)	$ 22,557.68
Contractor O&P (12%)	$ 33,836.52
Subtotal	**$ 366,562.25**
Tax (9.2%)	$ 33,723.73
Construction Contingency (30%)	$ 109,968.67
Total Construction Cost	**$ 510,254.65**
Engineering, Legal, and Administration (25%)	$ 127,563.66
Total Project Cost	**$ 637,818.31**

Project: Central Kitsap Facility Plan Update Solids Handling Improvement Recommendations
Client: Kitsap County
Project No.: 20-2840.00. 0100.09
Date: 10/18/2022

Class 5 Estimate

Centrate Pumps Replacement, Centrifuge Feed Pumps Replacement, Withdrawal Pumps Replacement

Item No. Item	Unit	QTY	Materials & Equipment	Labor	Total
Civil Site Prep/Earthwork					
					$0.00
					$0.00
					$0.00
					$0.00
Subtotal					**$0.00**
Structural					
Equipment Pad	CY	5	$ 600.00	$150.00	$3,750.00
					$0.00
Subtotal					**$3,750.00**
Mechanical					
Existing Centrate Pumps Demolition	EA	2		$ 5,000.00	$10,000.00
New Centrate Pumps	EA	2	$ 6,150.00	$ 1,845.00	$15,990.00
Mechanical Piping and Fittings	LS	1	$ 10,000.00	$ 3,000.00	$13,000.00
Existing Centrifuge Feed Pumps Demolition	EA	2		$ 5,000.00	$10,000.00
New Centrifuge Feed Pumps	LS	2	$ 49,400.00	$ 14,820.00	$128,440.00
Mechanical Piping and Fittings	LS	1	$ 10,000.00	$ 3,000.00	$13,000.00
Existing Digester Withdrawl Pumps Demolition	EA	2		$ 5,000.00	$10,000.00
New Digester Withdrawl Pumps	LS	2	$ 100,000.00	$ 30,000.00	$260,000.00
Mechanical Piping and Fittings	LS	1	$ 10,000.00	$ 3,000.00	$13,000.00
Subtotal					**$473,430.00**
Electrical, Instrumentation, and Controls					
EI&C Replacement	LS	1	$142,029.00		$142,029.00
Subtotal					**$142,029.00**
Construction Material & Labor Subtotal:					**$619,209.00**

Markups	
Mobilization (10%)	$ 61,920.90
General Conditions (8%)	$ 49,536.72
Contractor O&P (12%)	$ 74,305.08
Subtotal	**$ 804,971.70**
Tax (9.2%)	$ 74,057.40
Construction Contingency (30%)	$ 241,491.51
Total Construction Cost	**$ 1,120,520.61**
Engineering, Legal, and Administration (25%)	$ 280,130.15
Total Project Cost	**$ 1,400,650.76**

APPENDIX O

LIQUID HAULED WASTE STUDY,

MURRAYSMITH, 2022

Technical Memorandum

Date:	July 22, 2022
Project:	Wastewater General Sewer Plan
To:	Barbara Zaroff, PE, PMP Christopher Sheridan Kitsap County, WA
From:	Jefferson Moss, PE Xinyi Xu, EIT
Reviewed By:	Miaomiao Zhang, PE, PMP Erika Schuyler, PE, PMP
Re:	Central Kitsap WWTP Liquid Hauled Waste Study

1. Introduction

This technical memorandum (TM) establishes the basis of planning for the County's liquid hauled waste (LHW) flows and loads for a 6- and 20-year planning period. The TM also evaluates alternatives for LHW treatment for the 20-year planning period with consideration of the effects on other solids treatment processes at Central Kitsap Wastewater Treatment Plant (WWTP).

2. Background

LHW at Central Kitsap WWTP consists of thickened waste activated sludge (TWAS) from the County's Kingston, Manchester, and Suquamish WWTPs, septage, and fats, oils and grease (FOG). Septage includes waste from septic tanks, portable toilets, and other sources. FOG loads are self-identified by septage haulers as being obtained from sources that have high FOG such as restaurants, grease traps, etc.

The County provides septage and FOG disposal services to ensure that rural residents and businesses in the region have a safe and sanitary means of disposal in areas where sewer systems have not been constructed. The County is committed to continuing this critical public service in the future to those residents outside of the Urban Growth Area (UGA).

The following tasks were developed:

- Study Area Characterization and Growth Projection: Review current septage and FOG disposal sites in the Kitsap County to establish a study area. Determine land use designations, establish land development assumptions, and develop a growth curve for the next 20 years.
- Flow and Load Projection: Prepare LHW flow and load projections for the 6- and 20-year planning periods.
- Alternatives Analysis: Develop and evaluate LHW receiving and treatment process alternatives to provide treatment for the near-term as well as 20-year planning periods. Alternatives include options to treat septage and FOG with existing Central Kitsap WWTP processes and as a separate process at Central Kitsap WWTP.

3. Study Area Characterization and Growth Projection

3.1 Study Area Characterization

Central Kitsap WWTP is the only facility that receives LHW in Kitsap County. The County Council is committed to providing LHW receiving service to the residents and businesses within the County but outside of the UGA. The study area is defined as unsewered areas within Kitsap County, so sewered areas within the County were identified and removed from consideration. Removed areas include the County's collection system, areas within UGA boundaries of other agencies or municipalities, and military bases.

The unsewered study area was provided to the Puget Sound Regional Council (PSRC) to obtain the population forecasts corresponding to LHW production. The PSRC is led by a group of representatives from the counties, cities, towns, Tribes, port districts and transit agencies in the Puget Sound region. It develops policies and coordinates decisions related to regional growth and transportation and economic planning within Kitsap, King, Pierce, and Snohomish counties. It provides a leading source of data and forecasting for regional and local planning in the Puget Sound area.

The PSRC's population projection is based on their Land Use Vision (LUV) forecast. The LUV dataset reflects the VISION 2040 Regional growth strategy, local policies, and each county's adopted growth targets. The PSRC's Regional Macroeconomic Forecast is apportioned to cities and unincorporated areas using the VISION 2040 Regional Growth Strategy and local growth targets to create annual control totals. The PSRC's land use model, UrbanSim, then uses the annual control totals to determine projected population growth.

For planning purposes, it is assumed that all of the unsewered study area identified will remain unsewered by the end of the 20-year planning horizon.

3.2 Growth Curve Development

The PSRC projections for residential population are defined by household population and group quarters population. Household population includes both single-family and multi-family units. Group quarters are places where people live or stay in a group living arrangement such as group homes, nursing facilities, federal and state prisons, or military quarters. PSRC provided population in 2014 and population forecast in 2030 and 2040. The population was then interpolated to 2028 and extrapolated to 2042. Table 1 presents the projected growth for the unsewered population based on PSRC projections. This projection shows a 11.7 percent growth between 2021 and 2042, which is an annual growth rate of 0.53 percent.

Table 1. Central Kitsap Unsewered Area Population Projection

Year	Household	Group Quarters	Total
2014	89,290	318	89,608
2021[1]	96,051	340	96,391
2028[1]	102,812	362	103,174
2030	104,744	368	105,112
2040	106,889	390	107,279
2042[2]	107,38	394	107,712

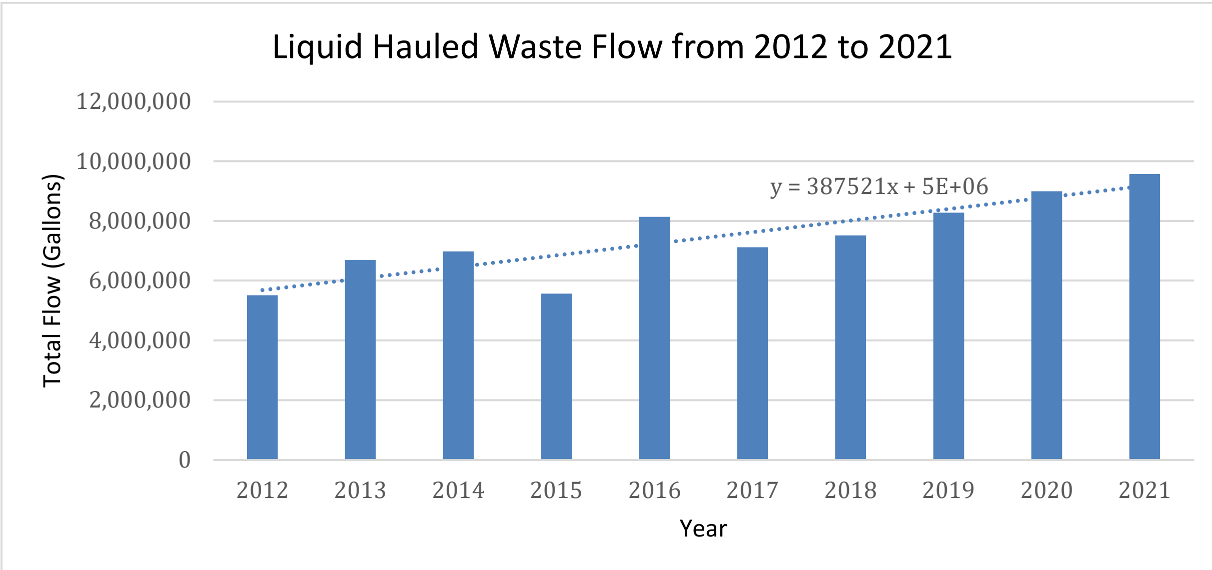
1. PSRC Projections, interpolated between 2014 and 2030
2. PSRC Projections, extrapolated based on yearly growth between 2030 and 2040

4. Flow and Load Projection

4.1 Current Flows

The County tracks LHW disposal at Central Kitsap WWTP. Figure 1 shows the total flow and linear trend line of LHW received at the WWTP from 2012 to 2021. The data show an average annual growth rate of 4.1 percent or 387,521 gallons per year. LHW disposal increases steadily over the nine years of data and does not show a substantial deviation from the trend during the COIVD-19 shutdowns and increased working from home in 2020 and 2021. Note that in the fall of 2015 the anaerobic digesters were taken off-line for cleaning and septage receiving was shut down for several weeks. This may contribute to the relatively low flow received in 2015 and high flow received in 2016.

Figure 1. Liquid Hauled Waste Flow and Growth Rate from 2012 to 2021



More recent data from Central Kitsap WWTP includes greater detail on the source of individual loads of LHW. For data from 2016 to 2021, the septage and FOG components of LHW was extracted to remove the effect of TWAS hauled from other WWTPs. In 2021, septage and FOG represented 94 percent of LHW. Figure 2 shows the total flow and linear trend line of septage and FOG from 2016 to 2021. The observed annual growth rate is 4.5 percent or 397,760 gallons per year.

Figure 2. Septage and FOG Flow and Growth Rates from 2016 to 2021

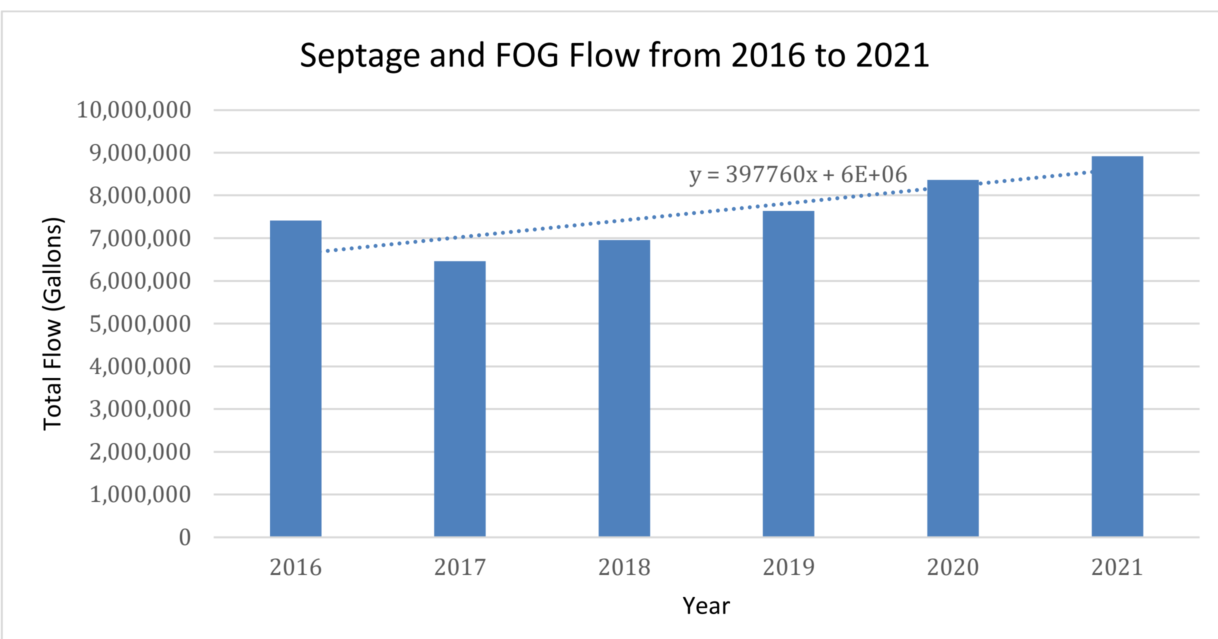
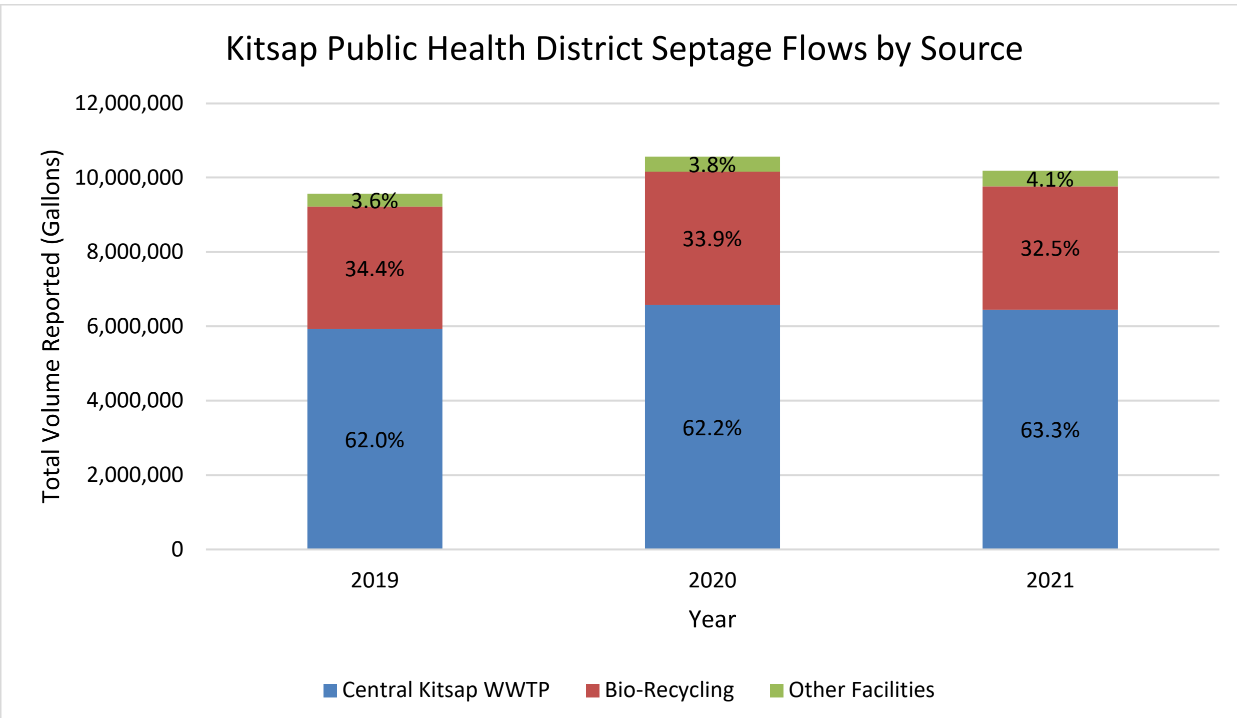


Figure 3 summarizes the total annual septage volume and percentage of septage loads in Kitsap County that different septage treatment service groups received in 2019, 2020 and 2021 per Kitsap Public Health District (KPHD) records. The septage volumes and dump locations are self-reported to KPHD by septage haulers, so the volumes are not as accurate as the volumes calculated at the WWTP, but the data shows that Central Kitsap WWTP consistently receives approximately two third of the septage collected within Kitsap County, with most of the remaining third going to Bio-recycling in neighboring Mason County. Although there is some variability in the reported septage hauling, the KPHD record also shows a clear trend of increase in loading from sources within the County to Central Kitsap WWTP at an annual increase rate of approximately 4.4 percent from 2019 to 2021.

Figure 3. Septage Loads by Source in Kitsap County



Daily septage and FOG receiving flow data from Central Kitsap WWTP were evaluated using septage receiving reports from January 2019 through December 2021 and are shown in Figure 4. Some seasonality is observed with slightly lower flows in the winter compared to the rest of the year and a general increase in flows over time is observable, consistent with the annual data. Septage receiving was halted for two weeks in the fall of 2021, which resulted in a significant decrease in the 30-day running average.

Figure 4. Septage and FOG Daily Flowrates from Jan 2019 to Dec 2021

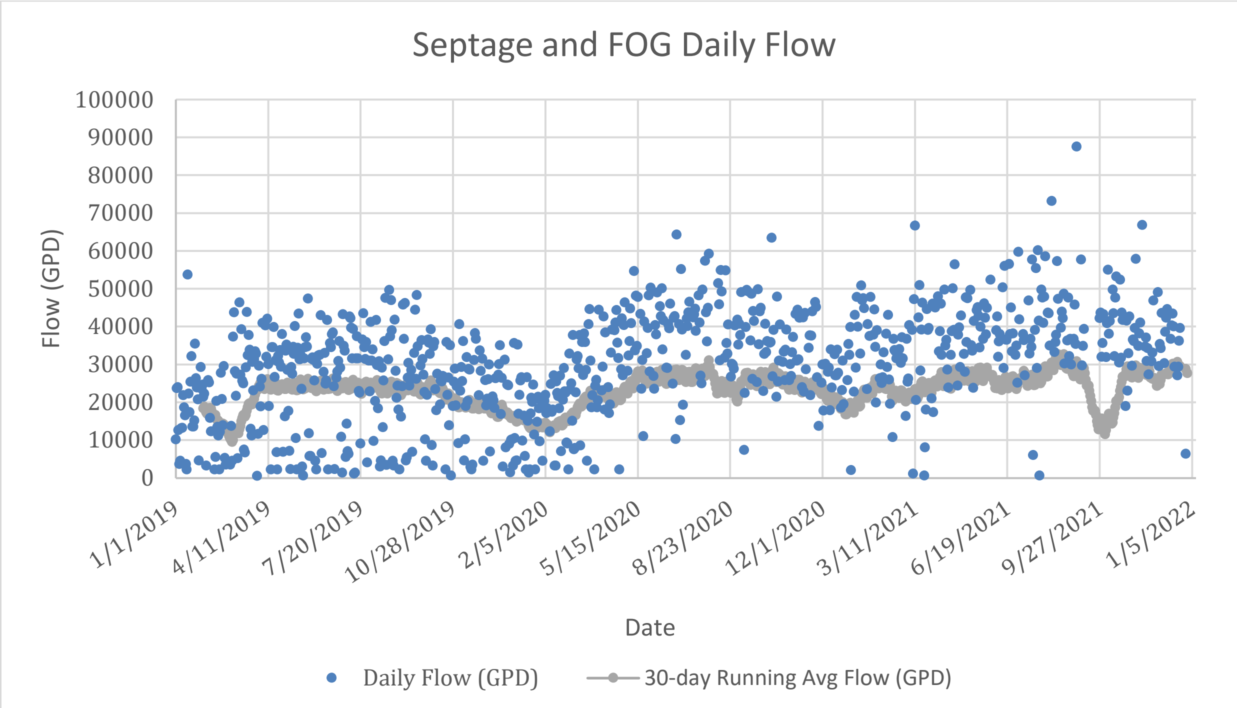


Table 2 summarizes the annual average flow (AAF), maximum month flow (MMF), and peak day flow (PDF) based on the daily septage receiving data 2019-2021. Table 2 also lists the corresponding peaking factors and per capita flow based on the estimated un-sewered population of 96,391 in 2021 reported in Table 1. Assuming a median household size of 2.5 persons and a typical septic tank size of 1,000 gallons (per Washington Administrative Code (WAC)), the septage receiving data indicates the average household's septic tank cleaning frequency is every 4.6 years, which is consistent with EPA recommendations and indicates that the observed septage data is generally consistent with the expected septage loading based on unsewered area population.

Table 2. 2019-2021 Septage Receiving Flows

Flow Event	Flow (GPD[1])	Peaking Factor	Per Capita Flow (gpcpd[2])
AAF	23,004		0.24
MMF	32,681	1.42	0.34
PDF	87,600	3.81	0.91

1. GPD = gallons per day
2. gpcpd = gallons per capita per day

Table 3 summarizes the AAF, MMF and PDF of the FOG flows received in 2019 to 2021 and corresponding peaking factors. FOG loading is very intermittent and highly variable which results in higher peaking factors. Per capita flow was not analyzed for FOG because of the variability and indirect correlation between FOG and population.

Table 3. 2019-2021 FOG Receiving Flows

	Flow (GPD)	Peaking Factor
AAF	1,543	
MMF	4,825	3.13
PDF	19,200	12.4

4.2 Current Loads

LHW loads to Central Kitsap WWTP are used to evaluate different treatment alternatives and to determine the required treatment capacities. Septage data from 2019 through 2021 show an average of 2.1 percent of total solids (TS) and 5,780 mg/L of Biological Oxygen Demand (BOD). Current septage TS and BOD daily mass loads were derived for AAF and MMF conditions as shown in Table 4.

Table 4. 2021 Septage TS and BOD Load

Parameter	Annual Average Load (ppd[1])	Max Month Load (ppd[1])
TS	4,042	5,743
BOD	1,109	1,575

1. ppd = pounds per day

Current FOG TS and BOD daily mass loads and per capita plant loading rates were derived for AAF and MMF conditions as shown in Table 5. Although FOG is not normally sampled at the plant, sampling tests that were done in October 2020 had an average TS of 1.81 percent. It is assumed that the TS and BOD content of grease are similar to those of septage.

Table 5. 2021 FOG TS and BOD Load

Parameter	Annual Average Load (ppd)	Max Month Load (ppd)
TS	271	848
BOD	74	233

4.3 Projected Flows and Loads

The unsewered population growth rate projection from the PSRC forecast of 0.53 percent per year is substantially lower than the observed septage receiving growth rate of 4.5 percent per year. It is difficult to determine a conclusive reason for such a dramatic difference in growth rates. However, it is believed the septage receiving growth rate is more accurate for flow projections because it comes directly from the County's septage flow data and the growth has been consistent for the last six years, while the unsewered population is indirectly correlated with the septage production. The septage data and population forecasts were discussed with the County and an estimated septage and FOG growth rate of 4 percent was selected to be used for future flow and load projections. This value is close to, but slightly below, the septage receiving growth rate and was selected because it accurately captures the current trends while also accounting for the lower expected population growth forecast developed from the PSRC data. It should be noted that due to the large difference in growth rates from the PSRC forecast and septage data there is considerable uncertainty regarding the rate of increase of septage that will actually occur.

Table 6 summarizes the projected flows of LHW in 2028 and 2042. The growth rate of septage and FOG received at Central Kitsap WWTP is assumed to be 4 percent per for the next 20 years. The TWAS hauled from the County's other WWTPs were developed in the General Sewer Plan of corresponding WWTP and are reported here to capture all LHW sources.

Table 6. Projected Liquid Hauled Waste Flows in 2028 and 2042

LHW Component	2028			2042		
	AAF	MMF	PDF	AAF	MMF	PDF
Septage Flow (GPD)	30,272	43,006	115,276	52,421	74,472	199,620
FOG Flow (GPD)	2,030	6,349		3,516	10,995	
TWAS Flow from Other WWTPs (GPD)	2,079	3,261		2,937	4,685	
Total LHW Flow (GPD)	**34,381**	**52,616**		**58,874**	**90,152**	

Table 7 and Table 8 summarize the projected TS and BOD loads from LHW in 2028 and 2042. It is assumed that the TS and BOD content of septage and FOG will remain consistent with current observations at 2.11 percent and 5,780 mg/L, respectively. The TWAS loads hauled from the County's other WWTPs were developed in the applicable Population, Flow, and Load Projection Section of the General Sewer Plan of corresponding WWTP and are reported here to capture all LHW sources.

Table 7. Projected Liquid Hauled Waste TS Loads in 2028 and 2042

LHW Component	2028		2042	
	Annual Average	Max. Month	Annual Average	Max. Month
Septage TS Load (ppd)	5,319	7,557	9,212	13,087
FOG TS Load (ppd)	357	1,117	619	1,935
TWAS TS Load from Other WWTPs (ppd)	933	1,463	1,318	2,102
Total LHW TS Load (ppd)	**6,609**	**10,137**	**11,149**	**17,124**

Table 8. Projected Liquid Hauled Waste BOD Loads in 2028 and 2042

LHW Component	2028		2042	
	Annual Average	Max. Month	Annual Average	Max. Month
Septage BOD Load (ppd)	1,459	2,073	2,527	3,589
FOG BOD Load (ppd)	98	306	169	530
TWAS BOD Load from Other WWTPs (ppd)	100	157	142	226
Total LHW BOD Load (ppd)	1,657	2,536	2,838	4,345

5. Existing Solids and Septage Treatment

Central Kitsap WWTP receives and treats sewage, sewage sludge, septage and FOG. According to the latest Statewide General Permit for Biosolids Management issued on June 15, 2022, "when a facility mixes septage, sewage sludge or biosolids together in any combination, the mixture must be treated to the same standards for biosolids produced from the treatment of sewage in a wastewater treatment plant". Consistent with this requirement, Central Kitsap WWTP currently handles septage as "septage managed as biosolids originating from sewage sludge" as defined in WAC 173-308-080. This means the septage treatment at Central Kitsap WWTP will need to meet the sampling requirement in WAC 173-308-140, monitoring requirement in WAC 173-308-150, the pollutant limits in WAC 173-308-160, the pathogen reduction requirements in WAC 173-308-170, and the vector attraction reduction requirements in WAC 173-308-180. Although WAC 173-308-270 allows an alternative which applies septage to the land with less stringent treatment requirement, this alternative is not feasible to the County since it has very particular requirements on site management and access restriction, application rate, and monitoring. It is not possible for the County to identify any land application site near the WWTP that can meet all the requirements. And it is not economical for the County to haul liquid septage to the eastern Washington for land application.

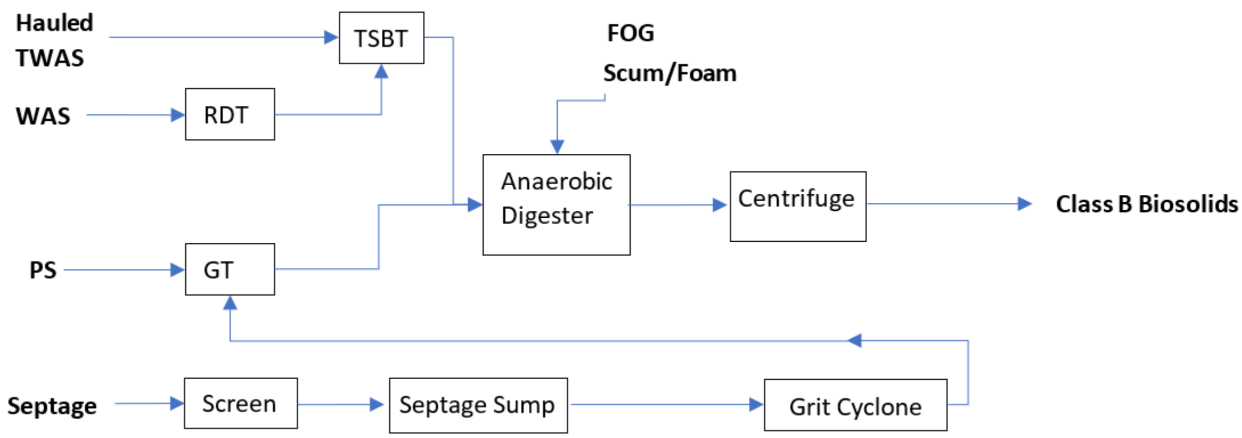
The existing solids and septage handling process diagram at Central Kitsap WWTP is shown in Figure 5. Waste activated sludge (WAS) from Central Kitsap WWTP is thickened in a rotary drum thickener (RDT) and then stored in the thickened sludge blending tank (TSBT), which also receives the TWAS hauled from other WWTPs. Blended sludge from the TSBT is fed into the two anaerobic digesters.

Septage is unloaded from trucks at the septage receiving station. After flowing through a rotary drum fine screen, the screened septage flows by gravity to the septage sump in the solids processing building and is diluted with process water. The diluted septage is pumped by two septage pumps to a grit cyclone and then flows into the gravity thickeners (GTs), which also receive primary sludge (PS). Thickened sludge from the GTs can be pumped either to the TSBT or directly into the anaerobic digesters.

FOG is dumped into the secondary clarifier scum pit and the mixed scum and FOG is pumped directly into the anaerobic digesters. The aeration basin foam wasting station is not normally operated but also pumps into the anaerobic digesters if it is in use.

All the sludge is stabilized in the anaerobic digesters to Class B biosolids. Biosolids from the anaerobic digesters are then dewatered with a centrifuge and loaded to a truck for hauling and land application.

Figure 5. Existing Solids and Septage Handling Process Diagram



As discussed in the General Sewer Plan, the challenges associated with the existing solids and septage handling process include:

- Existing septage receiving and screening station does not have redundancy to allow for maintenance and it will become increasingly difficult for septage haulers to unload without delay as septage hauling increases.
- Existing septage pumps are 45 years old and have exceeded their typical lifespan of 25 to 30 years.
- Existing septage grit cyclone and classifier are 45 years old and have exceeded their typical lifespan of 25 to 30 years.
- There is no dedicated FOG receiving and treatment station. FOG is dumped to the secondary clarifier scum sump. Existing scum sump and piping are 45 years old.
- Existing GTs are over 45 years old and experience severe corrosion on the roof structure and mechanism. Most of the major equipment associated with the GTs is reaching the end of its expected lifespan.
- Existing GTs are over-sized for thickening purpose thus become the potential cause of sludge fermentation within the GTs and reduced volatile solids reduction (VSR) within anaerobic digesters.
- Existing anaerobic digesters are over 45 years old. Some major equipment associated with the digestion is reaching the end of its expected lifespan. In addition, the two existing digesters do not provide redundancy at current loading rates and do not consistently meet

VSR requirements for vector attraction reduction using the historic VSR calculation methods.

6. Alternatives Analysis

The five alternatives presented below were developed to address the challenges identified for the existing process and identify a more reliable LHW and biosolids management strategy for the County to meet all the regulatory requirements.

Alternative 1 – Treat Septage with Other Solids Streams

Alternative 2 – Separated Septage Treatment with Anaerobic Digestion

Alternative 3 – Separated Septage Treatment with Lime Stabilization

Alternative 4 – Entire Solids Treatment with Sedron Varcor System

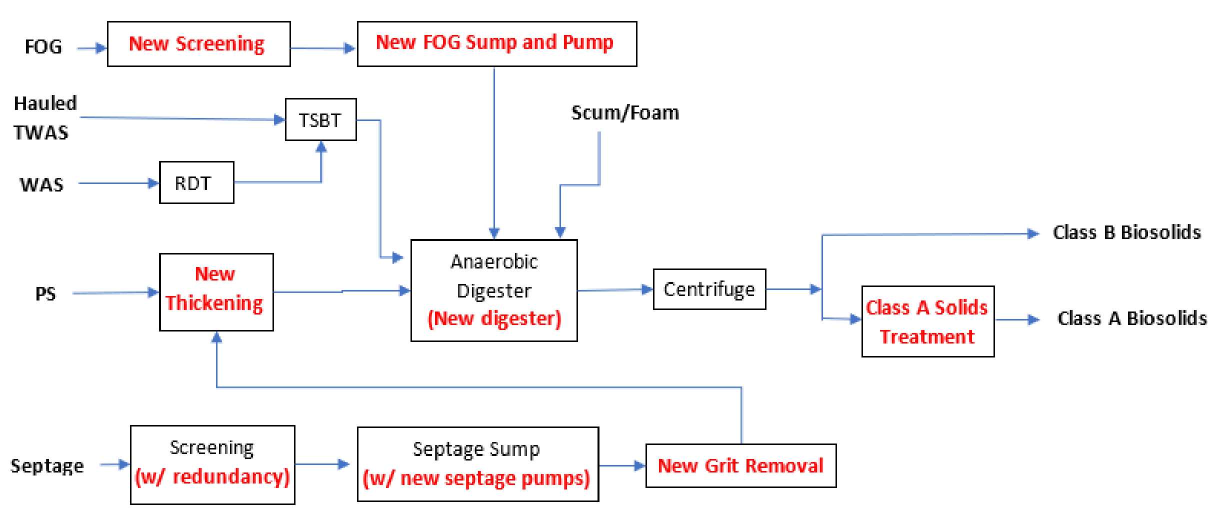
Alternative 5 – Separated Septage Treatment with Wetland and Composting

Each of the alternative is discussed in more detail in the following sections.

6.1 Alternative 1 – Treat Septage with Other Solids Streams

Alternative 1 continues the current approach of mixing septage with other solids streams and treating it using the existing processes by improving the capacity, redundancy, and performance of these processes. Figure 6 shows the process flow diagram of Alternative 1, with new or modified components indicated in red text.

Figure 6. Alternative 1 Flow Process Diagram

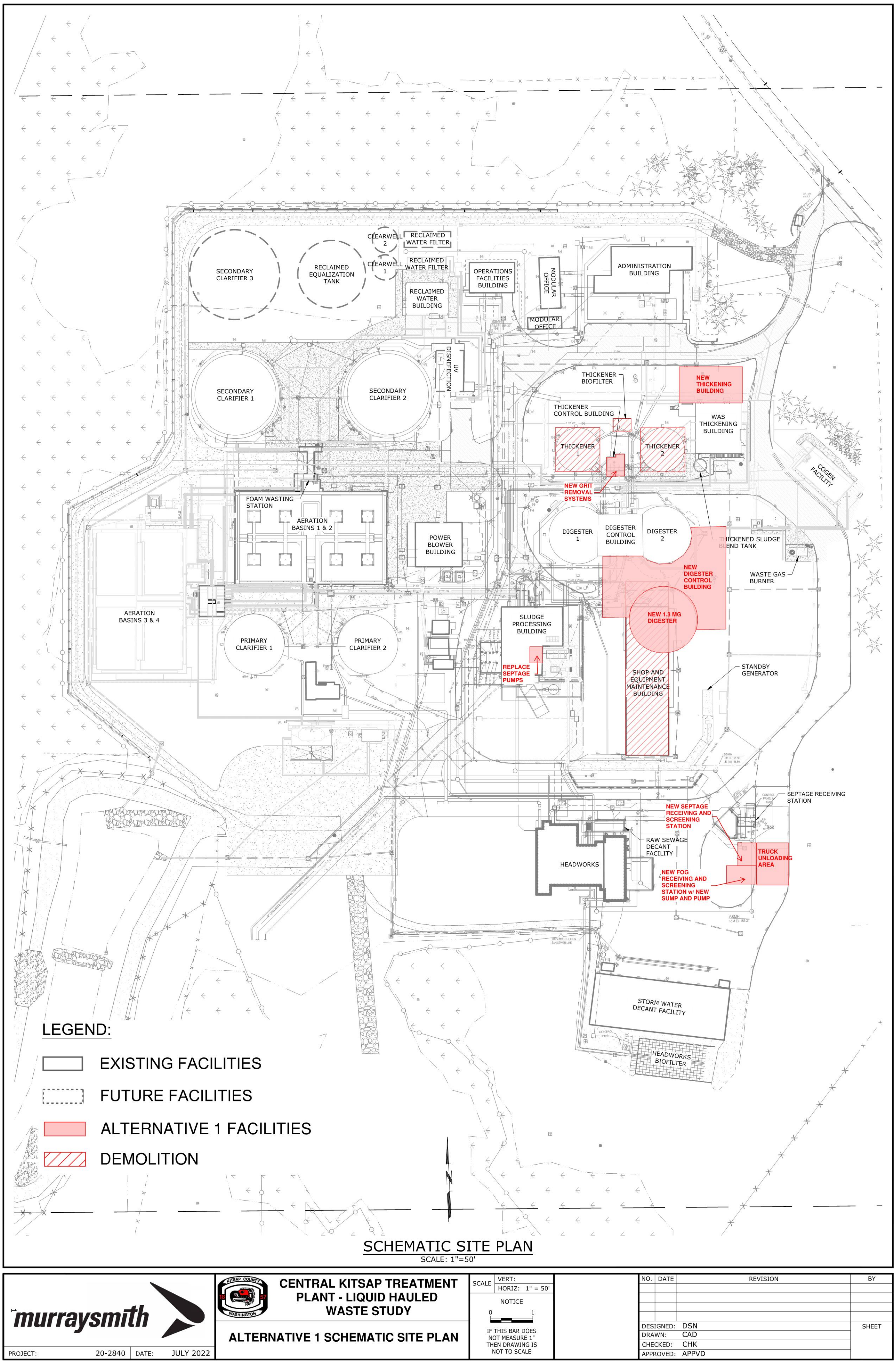


The proposed improvements include:

- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone will be replaced with a new grit removal system.
- A new FOG receiving station and associated sump and pump will be constructed.
- The existing GTs will be replaced with a new thickening process.
- A third, 1.3-million-gallon (MG) anaerobic digester will be constructed to add digestion capacity for mixed thickened sludge, septage, and FOG.
- All other existing solids treatment components are sufficient to continue operating through 2042.

The proposed site layout of Alternative 1 is shown in Figure 7.

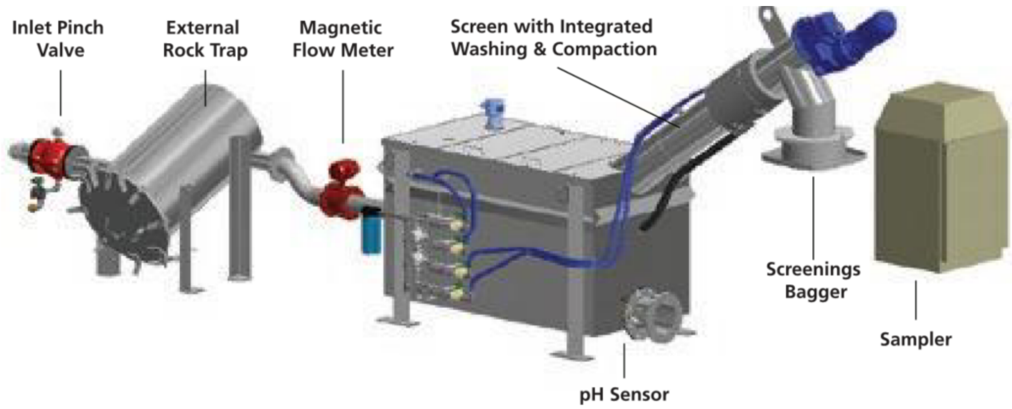
Figure 7. Site Layout of Alternative 1



Receiving and Pretreatment

A new septage screening station will be added and the existing grit removal system will be replaced with two new grit removal systems to provide higher capacity and redundancy for these processes. The new septage screening station will match the existing septage screening station and consists of a rock trap and screening equipment to separate coarse and heavy material from septage and FOG, as shown in Figure 8. The presence of a rock trap helps to capture and remove large debris. As septage goes into the screening trough the unwanted solids are captured and removed. The screened septage flows by gravity to the existing septage sump in the solids handling building and is diluted with process water.

Figure 8. New Septage Screening Station



The diluted septage is pumped by two new septage pumps to two new grit removal systems, which are a combination of cyclone and classifier, as shown in Figure 9. Grit slurry is introduced into the cyclone and a centrifugal force is established to spin the grit into the wall of the cyclone, forcing solids to discharge through the underflow apex orifice, along with some liquid. The remaining liquid and lighter particles are discharged through the overflow pipe.

Figure 9. Grit Cyclone-Classifier

FOG loads will be received separately from the septage to avoid clogging the septage pipes. A new FOG screening station that is similar to the above septage screening station will be constructed at the septage receiving area to specifically screen the hauled FOG. Then the screened FOG will drain to a new sump in the screening station area and a new grinder pump will be installed to pump the FOG to the digesters.

The existing unloading station for hauled sludge from the County's other WWTPs is in good condition and will continue to be used without modification.

Primary Sludge and Septage Thickening

The existing GTs will be replaced with new RDTs. Two 400-GPM RDTs, one duty and one standby, each with one 540-gallon flocculation tank will be installed in a new building to thicken the combined primary sludge and diluted septage stream. A polymer feed system will be constructed to improve the thickening performance. Approximately 15 to 30 pounds (lbs) of active polymer per dry ton solids will be added. Each unit requires one thickener feed pump to provide the screened septage and one thickened sludge pump to discharge the thickened septage to the digester.

Thickening using RDTs is a familiar process for the plant operation and maintenance (O&M) staff. Compared to GTs, RDTs provides many advantages, including improved performance, easier process control, reduced footprint, and less potential for sludge fermentation and odor generation.

Although the existing WAS building reserves some space for an additional RDT, it is not enough for two additional units. Therefore, a new 3,750-square-foot building will be constructed to house the two new RDTs, ancillary equipment, and associated pumps.

Table 9 summarizes the design criteria of new primary sludge and diluted septage thickeners in 2028 and 2042.

Table 9. Alternative 1 Thickening Design Criteria

Parameter	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Primary Sludge and Septage Flow (GPD)	226,000	297,200	358,900	474,400
Primary Sludge and Septage Solids (ppd)	11,400	14,600	17,500	22,400
No. of RDTs	1 Operating + 1 Standby			
Capacity of Each RDT	400 GPM			
Operating Time with one RDT (hrs/week)	66	87	105	140
Solids Capture (%)	>92%			
Thickened Solids Content (%)	6 to 8			
Polymer Dosage (lb active/dry ton solids)	15 to 30			

Digestion

A new 1.3-MG digester will be constructed to provide improved digestion performance and higher capacity for the combined thickened sludge stream. This digester volume is equal to the combined capacity of both existing digesters. Under normal operating conditions, the digester feed would be split between one existing digester and the new larger digester, and the other existing digester would provide redundancy. Table 10 summarizes the design conditions of the new and existing anaerobic digesters under normal operating conditions.

Table 10. Alternative 1 Digester Design Criteria

Parameter	Combined Digesters (1.3 MG & 645,000 gal)			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Flow (GPD)	34,100	47,600	51,000	72,100
Solids (ppd)	16,000	21,200	23,900	31,824
No. of Digesters	1 new + 1 existing + 1 existing (standby)			
Total Vol. of Duty Digesters (MG)	1.945			
Residence Time (days)	57	41	38	27
Solids Loading Rate (lb/ft^3/day)	0.05	0.06	0.07	0.09

If the new digester needs to be taken off-line for cleaning, during this temporary maintenance period, the two existing digesters with a combined capacity of approximately 1.3 MG can be used to provide treatment and would still have an average residence time of 25.3 days and a maximum month residence time of 17.9 days. This is a significant improvement comparing to the current condition since the plant will have difficulty to treat the entire solids if one of the existing digesters is off-line.

Dewatering

No change to the dewatering process is required. The existing centrifuges have sufficient capacity to treat all the biosolids from the anaerobic digesters in 2042.

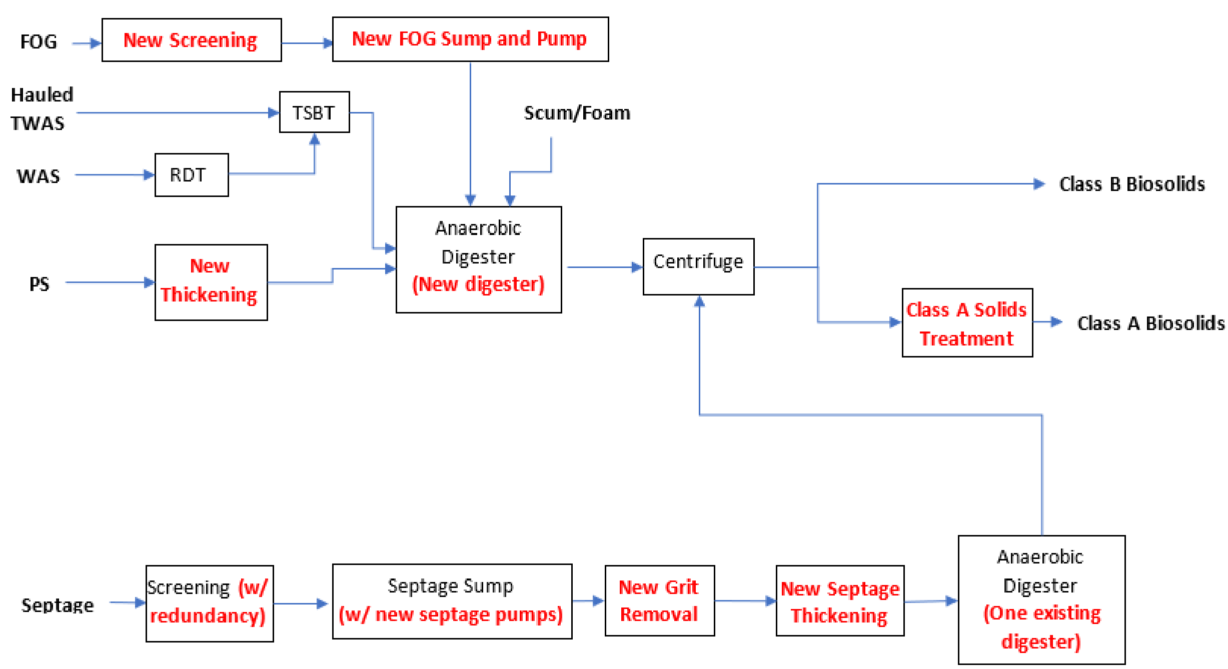
Disposal

No change to the disposal process is required. The dewatered Class B biosolids can be hauled for land disposal or further treated to Class A requirements if desired.

6.2 Alternative 2 – Separated Septage Treatment with Anaerobic Digestion

Alternative 2 separates the septage out from the existing solids treatment processes and treats the septage with a dedicated anaerobic digester to Class B biosolids standards. Improvements are made to the capacity and performance of the main solids stream by updating select processes. Separating the septage treatment allows for the septage and WWTP sludge processes to be optimized independently and provides greater flexibility and control. Figure 10 shows the process flow diagram of Alternative 2, with new or modified components indicated in red text.

Figure 10. Alternative 2 Flow Process Diagram

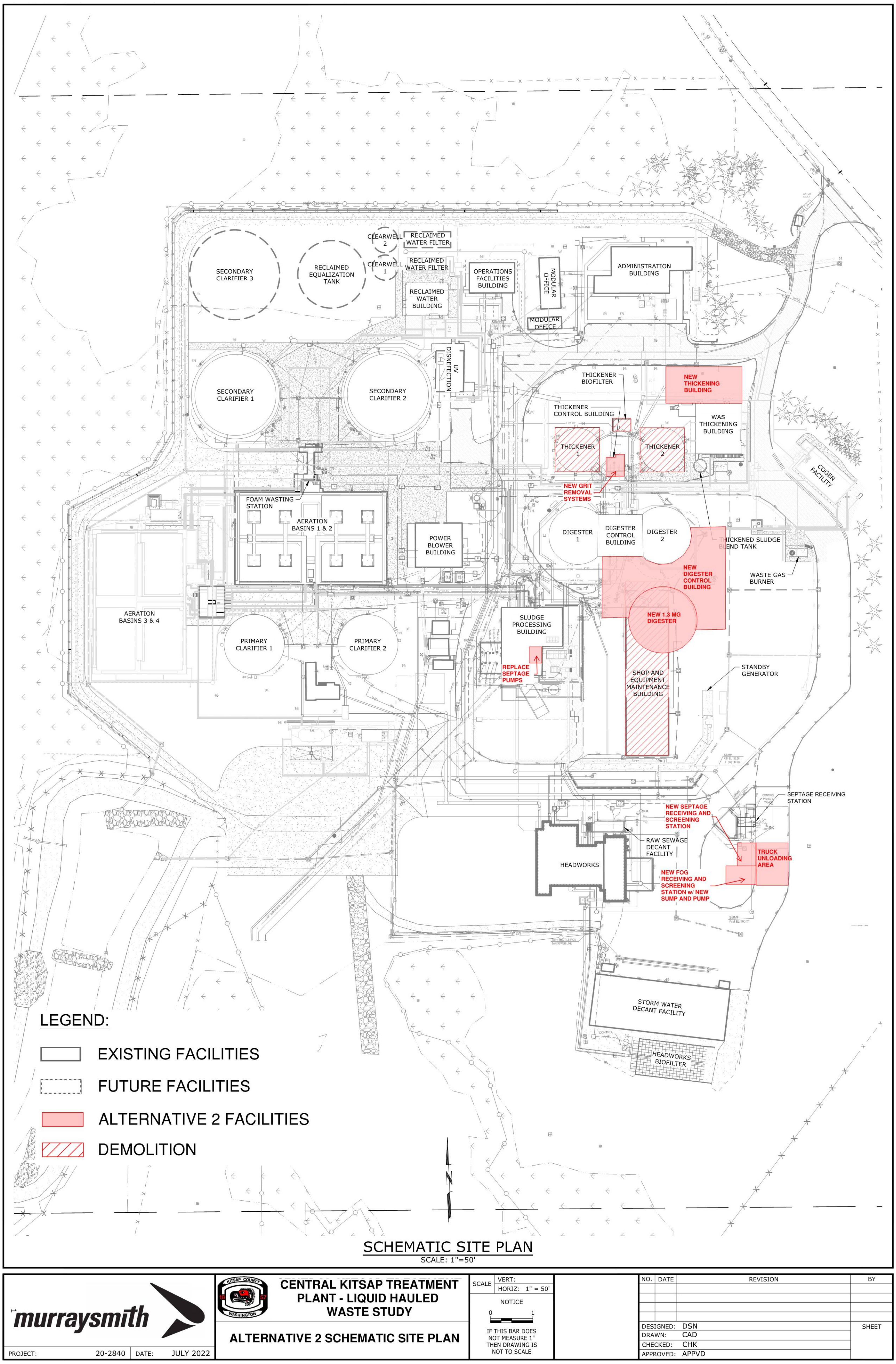


The proposed improvements include:

- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone will be replaced with a new grit removal system.
- A new FOG receiving station and associated sump and pump will be constructed.
- Septage will be thickened separately by new thickening equipment.
- The existing GTs will be replaced with a new thickening process.
- A third, 1.3-MG anaerobic digester will be constructed for thickened sludge and FOG treatment. One of the existing digesters will be used for septage treatment.
- All other existing solids treatment components are sufficient to continue operating through 2042.

The proposed site layout of Alternative 2 is shown in Figure 11.

Figure 11. Site Layout of Alternative 2



Receiving and Pretreatment

A new septage receiving and screening station and grit removal system will provide higher capacity and redundancy for these processes. A new FOG receiving and screening station will avoid clogging the septage pipe. The septage receiving station, grit removal system, and FOG receiving station are the same as options discussed in Alternative 1.

Primary Sludge and Septage Thickening

The existing GTs will be replaced with new thickening equipment. Separate RDTs will be used for the septage and primary sludge to allow for optimized operation and flexibility.

One 250-GPM RDT with 540-gallon flocculation tank will be installed to thicken the diluted septage. A polymer feed system will be constructed to improve the thickening performance. Approximately 20 to 40 lbs of active polymer per dry ton solids will be added.

One 200-GPM RDT with 540-gallon flocculation tank will be installed to thicken the primary sludge. A polymer feed system will be constructed to improve the thickening performance. Approximately 10 to 20 lbs of active polymer per dry ton solids will be added.

One additional 250-GPM RDT with 540-gallon flocculation tank will be installed as a standby unit to thicken either diluted septage or primary sludge when one of the above two RDTs is offline. The redundant RDT can also be used as a standby for the WAS thickening RDT as the 250-GPM capacity is slightly higher than the existing WAS RDT.

Each RDT requires one thickener feed pump to feed the unit and one thickened sludge pump to pump the thickened solids to the digester. Therefore, a new 4,500-square-foot building will be constructed to house three RDTs, ancillary equipment, and associated pumps.

Table 11 and Table 12 summarizes the performance of new primary sludge thickeners and diluted septage thickeners in 2028 and 2042.

Table 11. Alternative 2 Diluted Septage Thickener Design Criteria

Parameter	Diluted Septage Thickener			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Diluted Septage Flow (GPD)	138,900	197,300	240,400	341,600
Diluted Septage Solids (ppd)	5,300	7,600	9,200	13,100
No. of Units	1 Operating + 1 Shared Standby			
Capacity of Each RDT (GPM)	250			
Operating Time (hrs/week)	65	92	112	161
Solids Capture (%)	>90%			
Thickened Solids Content (%)	6 to 8			
Polymer Dosage (lb active/dry ton solids)	20 to 40			

Table 12. Alternative 2 Primary Sludge Thickener Design Criteria

Parameter	Primary Sludge Thickener			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Primary Sludge Flow (GPD)	87,100	99,900	118,500	132,800
Primary Sludge Solids (ppd)	6,100	7,000	8,300	9,300
No. of Units	1 Operating + 1 Shared Standby			
Capacity of Each RDT (GPM)	200			
Operating Time (hrs/week)	51	58	70	77
Solids Capture (%)	>95%			
Thickened Solids Content (%)	6 to 8			
Polymer Dosage (lb active/dry ton solids)	10 to 20			

Digestion

A new 1.3-MG digester will be added to provide better digestion performance and higher capacity for both the septage digestion and WWTP sludge digestion. Under normal operating conditions, the mix of thickened primary sludge, TWAS, and FOG would be treated in the new digester, while the thickened septage will be sent to one of the existing digesters. The other existing digester would provide redundancy. Table 13 and Table 14 summarizes the design conditions of the new and existing anaerobic digesters under normal operating conditions.

Table 13. Alternative 2 Thickened Septage Digester Design Criteria

Parameter	Thickened Septage Digester			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Flow (GPD)	10,600	15,100	18,400	26,200
Solids (ppd)	5,300	7,600	9,200	13,100
No. of Digesters	1 existing + 1 existing (shared standby)			
Total Vol. of Duty Digesters (MG)	0.645			
Residence Time (days)	61	43	35	25
Solids Loading Rate ($lb/ft^3/day$)	0.05	0.07	0.08	0.12

Table 14. Alternative 2 Thickened Sludge Digester Design Criteria

Parameter	Thickened Sludge Digesters			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Flow (GPD)	23,500	32,500	32,600	46,000
Solids (ppd)	10,700	13,700	14,600	18,700
No. of Digesters	1 new + 1 existing (shared standby)			
Total Vol. of Duty Digesters (MG)	1.3			
Residence Time (days)	55	40	40	28
Solids Loading Rate ($lb/ft^3/day$)	0.05	0.06	0.07	0.08

If the new digester needs to be taken off-line for maintenance, the thickened septage will be mixed with other sludge and sent to the remaining digesters. The remaining digesters have a combined capacity of approximately 1.3 MG and would have an average residence time of 38 days and the maximum month residence time of 27 days in 2028 and an average residence time of 25 days and the maximum month residence time of 18 days in 2042.

Dewatering

No change to the dewatering process is required. The existing centrifuges have sufficient capacity to treat all the biosolids from the anaerobic digesters in 2042.

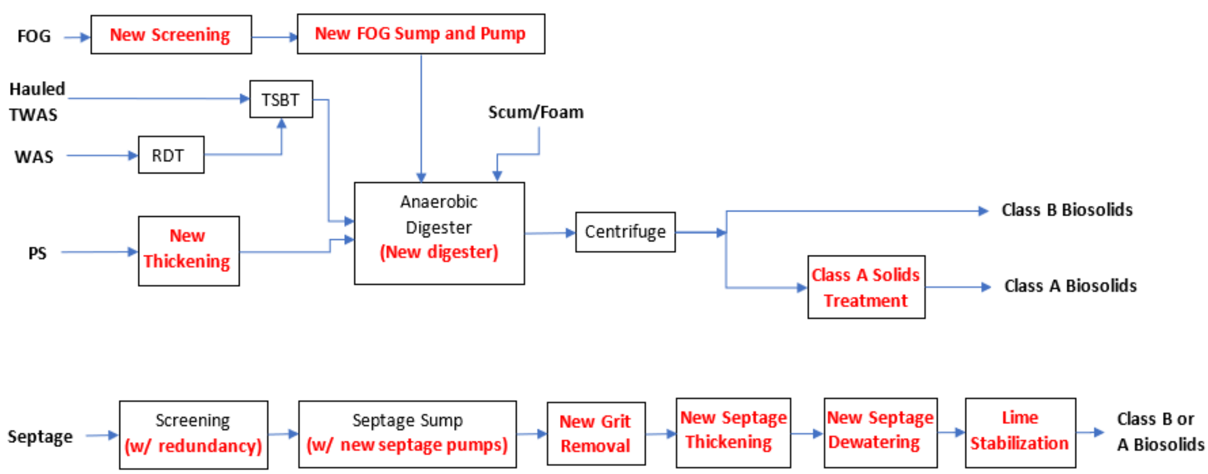
Disposal

No change to the disposal process is required. The dewatered Class B biosolids can be hauled for land disposal or further treated to Class A requirements if desired.

6.3 Alternative 3 – Separated Septage Treatment with Lime Stabilization

Alternative 3 separates the septage out from the existing solids treatment processes and treats the septage with pasteurization and lime stabilization. Improvements are made to the capacity and performance of the main solids stream by updating select processes. Separating the septage treatment allows for the septage and WWTP sludge processes to be optimized independently and provides greater flexibility and control. Septage treatment with lime stabilization is a reliable chemical process that eliminates the challenge of digesting partially stabilized septage solids. Figure 12 shows the process flow diagram of Alternative 3, with new or modified components indicated in red text.

Figure 12. Alternative 3 Flow Process Diagram

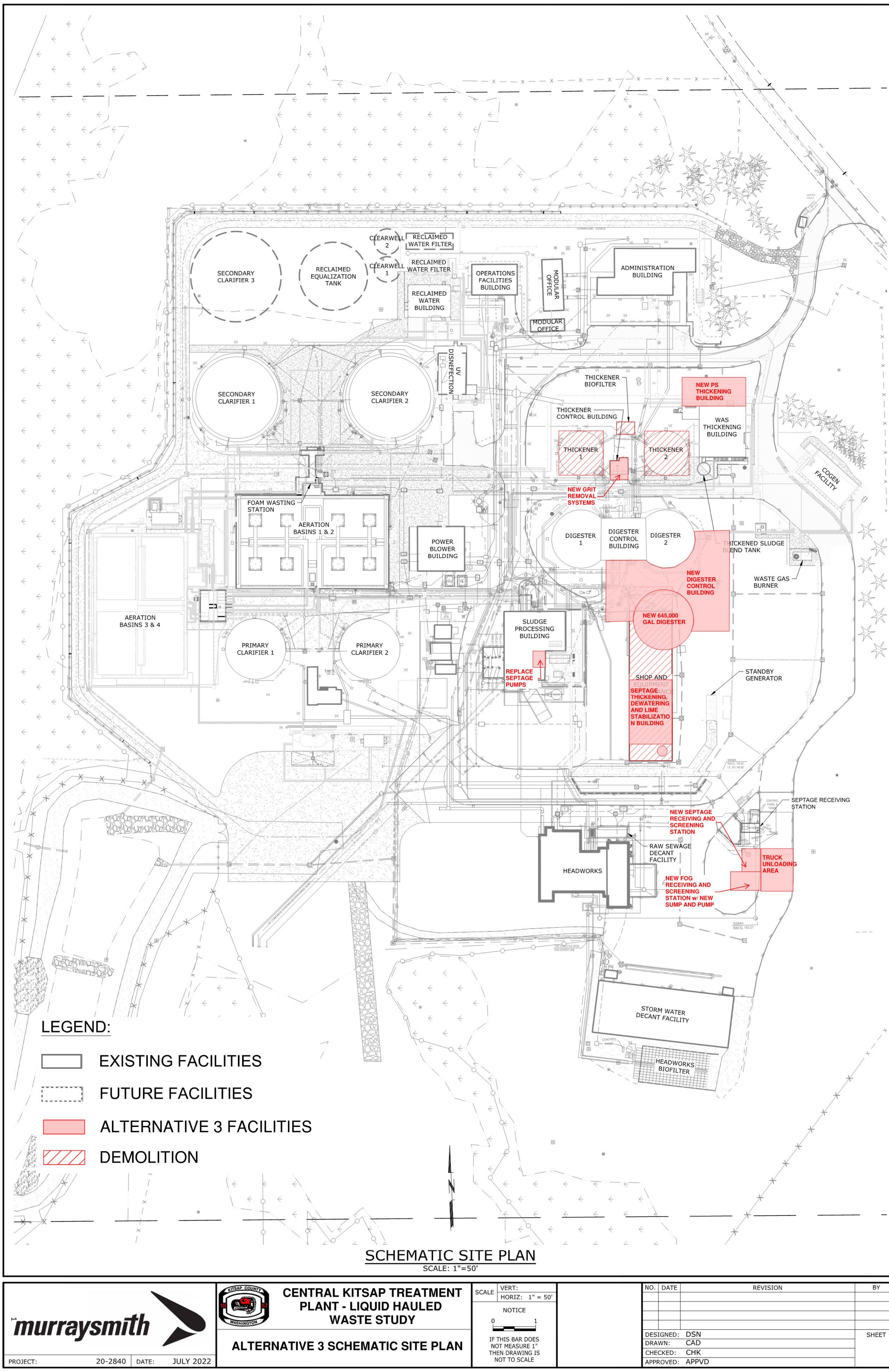


The proposed improvements include:

- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone will be replaced with a new grit removal system.
- A new FOG receiving station and associated sump and pump will be constructed.
- Septage will be treated separately with new thickening and dewatering equipment prior to a pasteurization and lime stabilization system which will stabilize the dewatered septage to either Class B or Class A biosolids.
- The existing GTs will be replaced with a new thickening process.
- A third anaerobic digester at the same size as the existing ones will be constructed to add digestion capacity for thickened sludge and FOG treatment.
- All other existing solids treatment components process are sufficient to continue operating through 2042.

The proposed site layout of Alternative 3 is shown in Figure 13.

Figure 13. Site Layout of Alternative 3



Receiving and Pretreatment

A new septage receiving and screening station and grit removal system will provide higher capacity and redundancy for these processes. A new FOG receiving and screening station will avoid clogging the septage pipe. The septage receiving station, grit removal system, and FOG receiving station are the same as options discussed in Alternative 1.

Primary Sludge and Septage Thickening

The existing GTs will be replaced with new thickening equipment. Separate RDTs will be used for the septage and primary sludge to allow for optimized operation and flexibility. The RDTs for septage and primary sludge are the same as described in Alternative 2. A new building will be constructed to the north of existing WAS Thickening Building to house primary sludge thickeners and ancillary equipment. The footprint of this new building is approximately 3,000 square feet. Another new building will be constructed at the current location of the Shop and Equipment Maintenance Building to house septage thickeners, centrifuge, pasteurization and lime stabilization system and ancillary equipment. The footprint of this new building is approximately 4,500 square feet.

Digestion

A new 645,000-gallon anaerobic digester will be added to provide better digestion performance and additional capacity for stabilization of thickened primary sludge, TWAS and FOG/Scum. No digestion of the septage is needed for this alternative. The new digester volume is the same as each of the two existing digesters. Under normal operating conditions, thickened sludge would be split between two digesters with the third in standby for redundancy.

Removal of the septage stream will result in an immediate drop of hydraulic load to the digesters and will also remove a relatively inert component of the solids load out of the digesters. This will increase hydraulic residence time and improve VSR performance in the digesters. Table 15 summarizes the design criteria of the new and existing anaerobic digesters under normal operating conditions in 2028 and 2042.

Table 15. Alternative 3 Digester Design Criteria

Parameter	Thickened Sludge Digesters			
	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Flow (GPD)	23,500	32,500	32,600	46,000
Solids (ppd)	10,700	13,700	14,600	18,700
No. of Digesters	1 new + 1 existing + 1 existing (standby)			
Volume of Duty Digesters (MG)	1.3			
Residence Time (days)	55	40	40	28
Solids Loading Rate (lb/ft^3/day)	0.05	0.06	0.07	0.08

Septage Dewatering and Stabilization

A new centrifuge will be installed to dewater the thickened septage and increase the solids concentration prior to stabilization. It is the same model as the existing centrifuges. A polymer feed system will be constructed to improve the dewatering performance. Approximately 30 to 50 lbs of active polymer per dry ton solids will be added. The existing solids processing building does not have sufficient room to house this centrifuge. It will be co-located with the septage RDTs in a new building, as mentioned above. Table 16 summarizes the design criteria of new septage centrifuge in 2028 and 2042.

Table 16. Septage Dewatering Design Criteria

Parameter	2028		2042	
	Annual Average	Maximum Month	Annual Average	Maximum Month
Thickened Septage Flow (GPD)	9,600	13,600	16,600	23,600
Thickened Septage Solids (ppd)	4,800	6,800	8,300	11,800
No. of Centrifuges	1 Operating			
Capacity of Centrifuge (GPM)	111			
Operating Time (hrs/week)	10	14	17	25
Solids Capture (%)	95%			
Thickened Solids Content (%)	20 to 30			
Polymer Dosage (lb active/dry ton solids)	30 to 50			

A lime stabilization system will be installed to treat the dewatered septage sludge to either Class B or Class A standards. The RDP Class A Precision EnVessel Pasteurization system, which combines lime addition and supplemental electrical heat, is the basis of design.

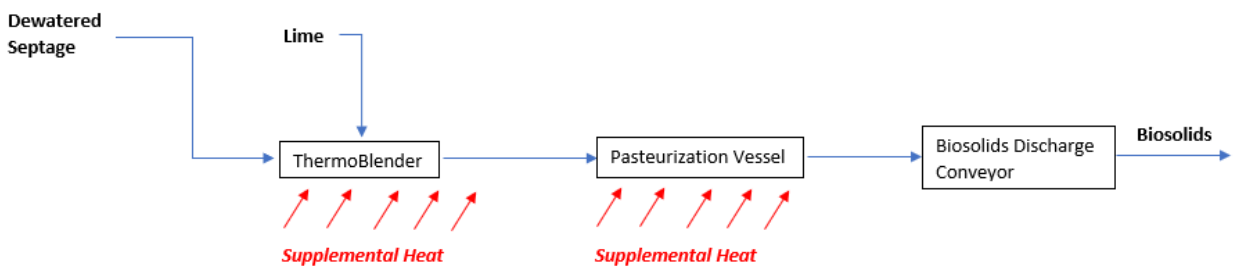
According to Washington Administrative Code (WAC) section 173-308-170, pasteurization is one of processes to further reduce pathogens (PFRP) to produce Class A biosolids. The temperature of the biosolids must be maintained at 70 degree C (158 degrees F) or higher for 30 minutes or longer during pasteurization. At the same time, according to WAC section 173-308-180, vector attraction reduction requirement could be met by raising pH of the biosolids to 12 or higher by alkali addition for two hours and then at 11.5 or higher for an additional 22 hours.

In RDP Class A Precision EnVessel Pasteurization system, as shown in Figure 14, sludge is heated in the ThermoBlender to 158 degrees F. Lime is mixed in to achieve a pH of at least 12.0 to meet the vector attraction reduction requirement. The Pasteurization vessel, which is a 48-inch-wide belt conveyor with an electrically heated and insulated bay, provides over 30 minutes of retention time to meet the PFRP requirement.

If only Class B biosolids is needed, electrical heat could be turned off and the lime dose adjusted to meet Class B pathogen reduction requirement using lime stabilization per WAC section 173-308-170. Sufficient lime must be added to the biosolids to raise the pH of the biosolids to 12 after two hours of contact.

The pasteurization and lime stabilization system will be located in the same building as the new septage thickening and dewatering equipment. The total building footprint will be approximately 4,500 square feet. An odor control system will be provided for this building.

Figure 14. Lime Stabilization Diagram



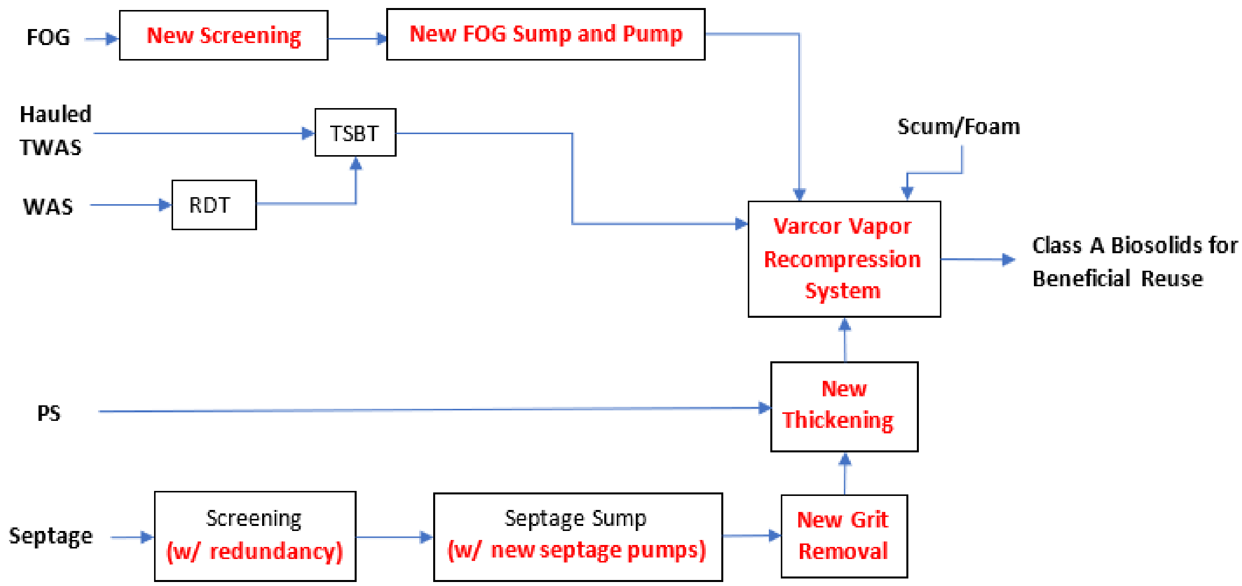
Disposal

No change to the disposal process is required for Alternative 3. The dewatered sludge and septage treated to Class B levels can be hauled for land disposal. If the septage is treated to Class A levels, additional disposal options are allowed.

6.4 Alternative 4 – Entire Solids Treatment with Sedron Varcor System

Alternative 4 treats the septage and all other solids streams with a new vapor recompression machine and also improves the capacity, redundancy, and performance of the septage receiving, and grit removal and thickening processes. Figure 15 shows the process flow diagram of Alternative 4, with new or modified components indicated in red text.

Figure 15. Alternative 4 Flow Process Diagram



The proposed improvements include:

- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone will be replaced with a new grit removal system.
- A new FOG receiving station and associated sump and pump will be constructed.
- The existing GTs will be replaced with a new thickening process.
- Varcor system provided by Sedron Technology will be installed to treat all the thickened solids to Class A biosolids, therefore, the existing digesters and dewatering equipment at Central Kitsap WWTP will be abandoned.

Receiving and Pretreatment

A new septage receiving and screening station will provide higher capacity and redundancy for these processes. A new FOG receiving and screening station will avoid clogging the septage pipe. The septage receiving station, grit removal system, and FOG receiving station are the same as options discussed in Alternative 1.

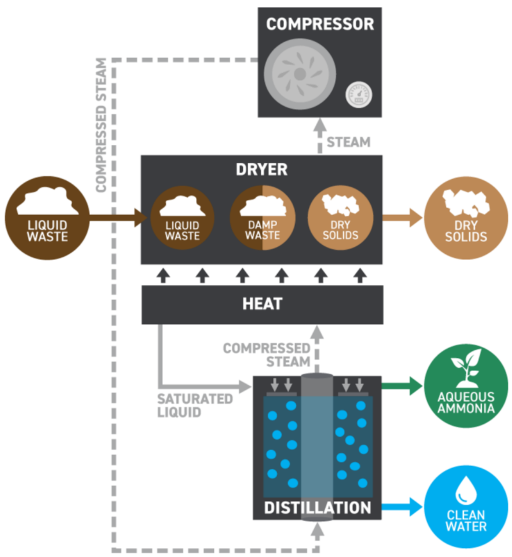
Primary Sludge and Septage Thickening

The existing GTs will be replaced with new thickening equipment. RDTs will be used for the mix of septage and primary sludge to allow for optimized operation and flexibility. The RDTs are the same as described in Alternative 1.

Stabilization, Dewatering & Drying

The Varcor system provided by Sedron Technologies is an emerging technology that will be used to stabilize thickened sludge from all sources at Central Kitsap WWTP. Solids and liquids are separated through thermal evaporation based on different boiling points. At the same time, pathogens are killed under high temperature. The resulting vapor is sent to a compressor for mechanical recompression. The compressed vapor is then used as the heat source for the evaporation process. The resulting dry solids achieve Class A biosolids classification and be used as a nutrient-rich fertilizer, soil amendment, or other beneficial reuse product. The low boiling point constituents (such as ammonia) are concentrated separately through a patented process. Clean water can be sent back to liquid stream process. Figure 16 shows the process of Varcor system.

Figure 16. Varcor System Process Diagram



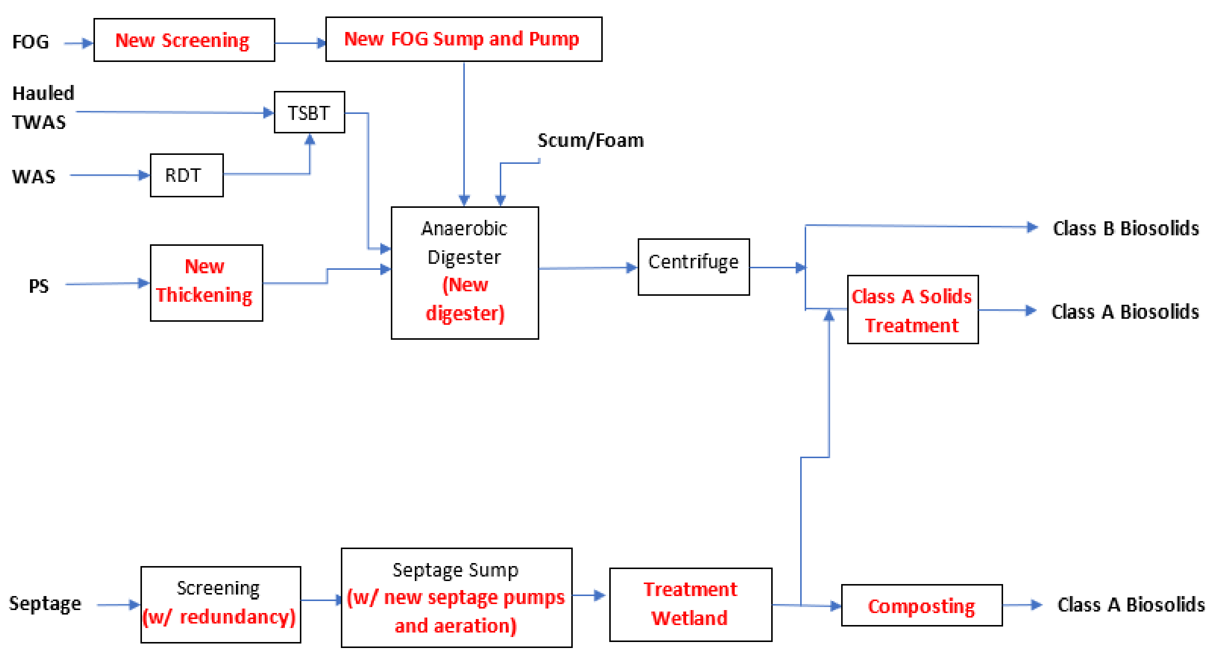
Sedron is the only manufacturer of a vapor recompression system for sludge waste applications. They have installed several similar units for animal sludge waste treatment and currently have a septage treatment installation underway in Sumner, WA, but they have not used the Varcor system for a combined septage and thickened sludge application before. The Sedron business model is to use a long-term contract of 15 to 20 years to provide treatment with the Varcor system. Sedron would construct the Varcor system at the WWTP at no cost to the County and provide both treatment and disposal at an annual or volume-based rate. However, according to Sedron Technologies' evaluation, the flowrate of the combined sludge over the next 20 years is too low to generate enough revenue to justify the capital cost of the system. The Varcor System is typically sized to process a flow rate of 90 to 100 GPM and average flows of less than 75 GPM are typically not cost effective. The 2042 average annual combined sludge stream is only expected to be 35 GPM.

Sedron reported that they are developing a smaller unit that may better suit Central Kitsap WWTP's need, however, they expect it will be approximately 5 years before it can be brought to market. Central Kitsap is facing an immediate need to upgrade several components of the solids treatment process and cannot wait five or more years to determine if a smaller Varcor is appropriate, therefore the existing Varcor system and potential smaller future system are not viable alternatives and will not be considered.

Alternative 5 – Separated Septage Treatment with Wetland and Composting

Alternative 5 completely separates the septage treatment from the existing solids treatment processes and uses a constructed wetland system to dewater the septage followed by composting to provide Class A biosolids treatment. Improvements are also made to the capacity and performance of the main solids stream by updating select processes. Figure 17 shows the process flow diagram of Alternative 5, with new or modified components indicated in red text.

Figure 17. Alternative 5 Flow Process Diagram



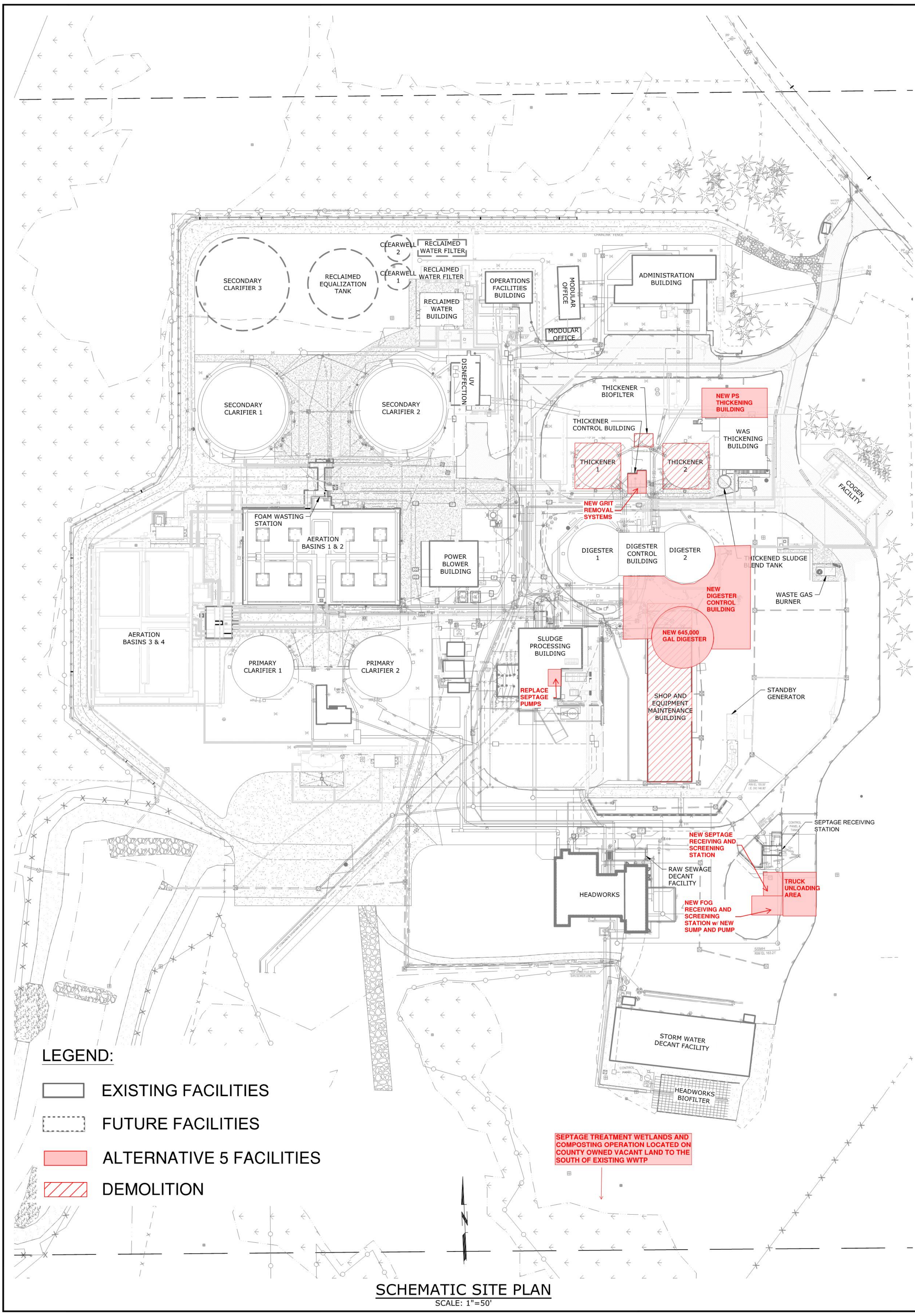
The proposed improvements include:

- The existing septage receiving station will be expanded to provide redundancy.
- Two existing septage pumps will be replaced with two new septage pumps.
- The existing grit cyclone is not required.
- A new FOG receiving station and associated sump and pump will be constructed.

- A constructed wetland and composting system will be constructed to treat the septage to Class A standard.
- The existing GTs will be replaced with a new thickening process.
- A third anaerobic digester will be constructed to add digestion capacity for thickened sludge and FOG.
- All other existing solids treatment components are sufficient to continue operating through 2042.

The proposed site layout of Alternative 5 is shown in Figure 18.

Figure 18. Site Layout of Alternative 5



murraysmith	CENTRAL KITSAP TREATMENT PLANT - LIQUID HAULED WASTE STUDY	SCALE	VERT:	NO. / DATE / REVISION / BY	
	ALTERNATIVE 5 SCHEMATIC SITE PLAN		HORIZ: 1" = 50'	DESIGNED: DSN	SHEET
			NOTICE 0 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DRAWN: CAD	
				CHECKED: CHK	
PROJECT: 20-2840 DATE: JULY 2022				APPROVED: APPVD	

Receiving and Pretreatment

A new septage receiving and screening station will provide higher capacity and redundancy for these processes. The septage receiving station is the same as discussed in Alternative 1. Treatment wetlands systems do not require grit removal, so the grit removal system is not necessary. Aeration will be added to the septage sump to reduce odors that may occur when the septage is applied to the treatment wetland. A new FOG receiving and screening station will avoid clogging the septage pipe. The FOG receiving station is the same as discussed in Alternative 1.

Primary Sludge and Septage Thickening and Dewatering

A treatment wetland for septage is similar to a conventional sand drying bed but is planted with wetlands plants which improve process efficiency. Figure 19 shows a septage treatment wetland in Ontario, Canada that is typical of these systems. Septage will be applied to the surface of the filters via a pipe distribution system and the solids are retained on a sludge layer that gradually accumulates and composts in place while the water percolates down through the sludge and gravel substrate. The plants facilitate dewatering and digestion of the sludge by limiting formation of surface crust and facilitating a diverse ecosystem in the subsurface. Sludge accumulates at a rate of approximately 3 to 4 inches per year and can be applied for 5 to 10 years before it must be removed. In addition to removing solids, treatment wetlands also provide greater than 80% removal of chemical oxygen demand and ammonia from the leachate stream, which will be sent directly to the aeration basins for further treatment. This nutrient removal will reduce loading on the aeration basins and may improve performance.

Figure 19. Typical Septage Treatment Wetland

Approximately 10 to 12 acres of wetlands beds would be required to treat the 2042 septage flow. The wetlands beds are divided into several independent cells so that each cell can be loaded for a period of up to three days, then rested for approximately 12 days. The modular nature of the cells makes it easy to construct the system for near term flows and expand with additional cells as needed in the future. Only half of the area is needed to treat current flows, so, it would be possible to only construct a portion of the system and add on as needed as flows increase. The only viable location with enough room for the treatment wetland is the undeveloped 40-acre parcel to the south of the existing WWTP. This parcel has identified wetlands and is adjacent to residential properties, so although there is sufficient space for the treatment wetlands there could be permitting, land use, and public perception challenges to develop this area.

The existing GTs will be replaced with a new thickening equipment to treat the primary sludge only. The options for the primary sludge thickener are the same as described in Alternative 2.

Stabilization and Disposal

Septage treatment wetlands provide air drying, which is an approved method to achieve Class B biosolids pathogen reduction requirements, however, they do not meet vector attraction reduction (VAR) requirements without further treatment. If a composting system is constructed for the main sludge stream, as discussed in the draft TM "*Central Kitsap WWTP Class A Biosolids Evaluation*" (Murraysmith, July 2022), the septage solids could be easily incorporated to meet VAR requirements and attain Class A biosolids classification. If a composting facility is not constructed for the main sludge stream, the septage sludge can be composted with a smaller system operated intermittently as needed when the cells are cleaned.

A new 645,000-gallon anaerobic digester will be added to provide better digestion performance and higher capacity for stabilization of the primary sludge, TWAS, FOG, and scum, as previously described in Alternative 3. No change to the dewatering process is required for the anaerobically digested biosolids. The existing centrifuges have sufficient capacity to treat all the biosolids from the anaerobic digesters.

6.5 Cost Analysis

The probable costs are developed for each feasible alternative based on average costs estimated based on RSMeans Heavy Construction Cost Data, recent Kitsap County project bid tabs, County input, engineer experience, and local contractor and supplier costs. All costs were developed based on the preliminary concepts and layouts of the system components in 2022 dollars should be escalated with the future CCI for use in project budgeting.

Class 5 cost estimates were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE), for planning-level evaluations with a range of -50 percent to +100 percent, based on the *AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries - TCM Framework: 7.3 - Cost Estimating and Budgeting*.

Construction and capital cost estimates for the 20-year planning period are summarized below in Table 17. Construction costs include the estimated cost of construction work plus markups for mobilization, general contractor markups, overhead, and profit, taxes, and a construction contingency. The capital costs include an additional markup of 25% for engineering, legal, and administration costs associated with project delivery. The detailed estimates for each alternative and included in Appendix A.

Table 17. Alternatives Cost Estimate

Alternatives	Construction Cost	Capital Cost
Alternative 1 – Treat Septage with Other Solids Streams	$34,000,000	$43,000,000
Alternative 2 - Separated Septage Treatment with Anaerobic Digestion	$37,000,000	$46,000,000
Alternative 3 – Separated Septage Treatment with Lime Stabilization	$40,000,000	$49,000,000
Alternative 5 - Separated Septage Treatment with Wetland and Composting	$40,000,000	$50,000,000

7. Discussion and Recommendations

All four viable alternatives provide some common benefit as below:

1. Improved septage receiving and pre-treatment capacity and reliability.
2. Improved FOG receiving reliability.
3. Improved primary sludge and septage thickening condition and performance.
4. Improved anaerobic digestion capacity and reliability.

Table 18 summarizes some specific advantages and disadvantages of each alternative.

Table 18. Alternatives Comparison

Alternative	Advantages	Disadvantages
1 – Treat septage with other solids streams	• Lowest cost • Familiar technology • No changes from current biosolids management practice • Simple O&M	• Risk of not meeting VSR requirement for vector attraction reduction, although the risk is very low since additional digester will significantly increase digestion HRT and new thickening system will minimize any VSR prior to digestion

Alternative	Advantages	Disadvantages
2 – Separated septage treatment with anaerobic digestion	• Relatively low cost • Familiar technology • Minimal changes from current biosolids management practice • Separating septage eliminates any undesirable impact from septage on the main solids stream • Separating septage allows flexible and customized septage treatment	• More complex O&M • Risk of septage not meeting VSR requirement for vector attraction reduction, although the risk is very low since the dedicated digester with a redundant unit will significantly increase digestion HRT and new thickening system will minimize any VSR prior to digestion
3 – Separated septage treatment with lime stabilization	• Separating septage eliminates any undesirable impact from septage on the main solids stream • Lime stabilization provides a reliable method to convert septage to Class A or Class B biosolids	• High cost • Complex O&M • Unfamiliar technology • Lime stabilization could generate higher dust and odor
5 – Separated septage treatment with wetland and composting	• Separating septage eliminates any undesirable impact from septage on the main solids stream • Provides opportunity to integrate with main solids stream composting for Class A • Relatively simple O&M	• High cost • Large land requirement • Unfamiliar technology

Based on the comparison presented in Table 18, Alternative 2 is recommended for a more reliable septage treatment with relatively low cost. Alternative 2 proposes the same technologies for thickening and stabilization which will allow the County staff to quickly adjust to new treatment approach. Although O&M effort will be slightly higher the use of familiar technologies and equipment can minimize additional effort. Alternative 2 provides flexibility, redundancy, and ability to customize treatment of septage and other WWTP sludge streams independently which will help ensure consistent and efficient operation.

Central Kitsap WWTP has several immediate needs for upgrades to the LHW and solids processes.

- The septage grit cyclone and classifier, gravity thickeners, and gravity thickener control building have all exceeded their typical lifespan and are in poor condition. Each of these components should be replaced as soon as possible.

- The plant does not have a dedicated FOG receiving and pumping system. The existing scum/FOG sumps and piping have exceeded their lifespan and have no redundancy. A new FOG receiving and screening station with dedicated sump, pumps and piping should be constructed as soon as possible.
- The anaerobic digesters do not provide sufficient redundancy and do not consistently meet VSR requirements, so the new digester should be designed and constructed as soon as possible, followed immediately by a rehabilitation of the existing digesters.

The septage receiving station is in good condition but does not have redundancy, therefore, the new septage receiving station construction is not an immediate need and can be scheduled in the near term as soon as capital budget allows. The septage pumps have exceeded their expected lifespan but are operating well, so they should be monitored and replaced when their condition or reliability deteriorates.

Appendices

Appendix A – Detailed Cost Estimate

APPENDIX P

CLASS A BIOSOLIDS EVALUATION

MURRAYSMITH, 2022

Technical Memorandum

Date: August 17, 2022

Project: Wastewater General Sewer Plan

To: Barbara Zaroff, PE, PMP
Christopher Sheridan
Kitsap County, WA

From: Jefferson Moss, PE
Xinyi Xu, EIT
Murraysmith

Reviewed By: Miaomiao Zhang, PE, PMP
Erika Schuyler, PE, PMP

Re: Central Kitsap WWTP Class A Biosolids Evaluation

Introduction

This technical memorandum evaluates Class A biosolids options for beneficial reuse at Central Kitsap Wastewater Treatment Plant (WWTP). Biosolids are the solids derived from stabilized sludge obtained from treatment of domestic wastewater at a wastewater treatment facility. Chapter 173-308 of the Washington Administrative Code (WAC) requires biosolids be beneficially used after appropriate treatment. Treatment of biosolids in the United States must meet the Environmental Protection Agency's (EPA's) Class A or Class B pathogen and vector attraction reduction (VAR) requirements before biosolids are land applied. Class A has more restrictive treatment requirements than Class B, but fewer site restrictions when applied for reuse. Untreated solids do not receive a class designation and are not suitable for land application until additional treatment is provided.

Currently, all the solids streams at Central Kitsap WWTP, including thickened primary and secondary sludge, primary scum, thickened wasted activated sludge (WAS) from the County's other WWTPs, and liquid hauled waste (LHW) are digested in two mesophilic anaerobic digesters and then dewatered in a centrifuge to Class B biosolids. The County has a contract with a trucking company to haul the Class B biosolids to Natural Selections Farm near Moxee, WA for land application. Currently, the County pays $62 per ton for hauling and land application. In 2019 and 2020, Central Kitsap WWTP produced an average of 383 gross tons per month of Class B biosolids and land applied them at an average annual cost of $365,400. The County is interested in evaluating Class A biosolids alternatives to produce a more sustainable product and reduce disposal costs. This technical memorandum includes the following sections:

- Class A biosolids treatment requirement
- Class A technology review and screening
- Detailed alternatives evaluation
- Recommendations

Class A Biosolids Treatment Requirements

Treatment and application of biosolids in Washington is regulated by the Washington State Department of Ecology (Ecology). Washington state law requires that biosolids be put to beneficial use and establishes regulations for the treatment, analysis, and application of biosolids.

Ecology implements regulatory oversight of biosolids in Washington in accordance with WAC 173-308 (Biosolids Management) which references and is consistent with EPA's biosolids regulations Title 40 Code of Federal Regulations (CFR) Part 503 (Standards for the Use and Disposal of Sewage Sludge). The Statewide General Permit for Biosolids Management is the vehicle Ecology uses for implementing the biosolids management regulations and authorizes and establishes conditions for the beneficial use of biosolids, the transfer of biosolids from one facility to another, and the disposal of biosolids in municipal solid waste landfills. Treatment works processing domestic sewage, beneficial use facilities that land apply biosolids, and all other facilities that handle sewage sludge or non-exceptional quality biosolids must apply for coverage under the general permit.

A new Statewide General Permit for Biosolids Management was published on June 15, 2022 and becomes effective on July 15, 2022. The structure of the new permit is slightly different from those issued previously. It is organized based on facility operations. A baseline section establishes requirements for all facilities. Two additional sections establish requirements for facilities with an Active Septage Management or Active Biosolids Management program.

- Baseline (applies to all facilities)
- Active Septage Management (facilities managing septage only)
- Active Biosolids Management (facilities actively managing biosolids only, or a mixture with septage)

Central Kitsap WWTP is considered an Active Biosolids Management facility because it actively treats biosolids as well as septage. The new General Permit states "When a facility mixes septage, sewage sludge or biosolids together in any combination, the mixture must be treated to the same standards for biosolids produced from the treatment of sewage in a wastewater treatment plant". The Baseline section of the permit requires facilities to submit general information, establishes basic handling and storage requirements. The Active Biosolids Management section has additional requirements for providing public notice, conducting sampling, analysis, and process monitoring, and managing land application.

Biosolids regulations define three measures for biosolids quality which affect handling and reuse requirements:

- Pathogen Reduction
- Vector Attraction Reduction
- Pollutants

Pathogen Reduction Requirements

Pathogens are disease causing organisms such as viruses, parasites and certain types of bacteria. These organisms are significantly reduced during the biosolids treatment process so that they can be beneficially used. Pathogen reduction requirements are defined by the EPA's two classifications of biosolids – Class A and Class B. These classifications indicate the density (number per unit mass) of pathogens in biosolids. Class A requirements necessitate almost complete destruction of pathogens. Class B requirements call for significantly reducing the density of pathogens and land applying biosolids by implementing specific site management practices such as buffers from rivers and streams. A third classification of biosolids is Class A EQ (Exceptional Quality). This refers to biosolids that have met both the Class A pathogen reduction requirements and have met additional lower concentration standards for pollutants or metals.

Class A

To be classified as Class A, biosolids must meet the following pathogen reduction criteria prior to the sewage sludge being used or disposed:

- The density of the fecal coliform in the biosolids shall contain less than 1,000 Most Probable Number (MPN) per gram of total solids (dry-weight basis).

- The density of Salmonella bacteria in the biosolids shall contain less than three MPN per four grams of total solids (dry-weight basis).

The WAC requires one of the following methodologies to meet pathogen reduction requirements for Class A biosolids in accordance with EPA rules:

Alternative 1: Time and Temperature – solids are subjected to one of four time and temperature requirements.

Alternative 2: pH, Time, Temperature and Percent Solids – solids are raised to a temperature of 52°C and a pH of 12 for 72 hours, and dried to a solids content of greater than 50%.

Alternative 3: Process to Further Reduce Pathogens (PFRP) – solids are treated in accordance with one of the following approved processes:

- Composting
- Heat Drying
- Heat Treatment

- Thermophilic Anaerobic Digestion
- Beta Ray Irradiation
- Gamma Ray Irradiation
- Pasteurization

Alternative 4: Equivalent Process to Further Reduce Pathogens – Demonstrate a nonspecific method of treatment that reduces the enteric viruses and viable helminth ova to acceptable levels as determined by Ecology.

Class B

Class B biosolids pathogen reduction standards are less stringent compared to Class A biosolids. Class B biosolids can receive further treatment after being applied to the land as fertilizer. The sunlight, wind, and soil microbes can stabilize the biosolids naturally. To be classified as Class B, biosolids must meet the following criteria:

- The geometric mean of the density of fecal coliform in the biosolids collected from seven representative samples shall contain less than either 2,000,000 MPN or Colony Forming Units (CFU) per gram of total solids (dry weight basis).

Ecology has developed a list of approved Processes to Significantly Reduce Pathogens (PSRP):

- Aerobic Digestion
- Air Drying
- Anaerobic Digestion
- Composting
- Lime Stabilization

Ecology does allow for the biosolids to be treated in a process that is equivalent to a PSRP, as determined by the permitting authority.

Vector Attraction Requirements

Vector attraction refers to the tendency of biosolids to attract rodents, insects, and other organisms that can spread disease. Biosolids must meet one of the following requirements for reducing vector attraction if they are to be applied to land without restrictions:

Alternative 1: Volatile solids in the biosolids must be reduced by a minimum of 38 percent.

When the 38 percent volatile solids reduction requirement cannot be met for an anaerobically digested sewage sludge, vector attraction reduction can also be demonstrated by digesting a portion of the previously digested sewage sludge anaerobically in the laboratory in a bench-scale unit for 40 additional days at a temperature between 30 and 37 degrees Celsius. When at the end of the 40 days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 17 percent, vector attraction reduction is achieved.

When the 38 percent volatile solids reduction requirement cannot be met for an aerobically digested sewage sludge and the solids content is less than 2%, vector attraction reduction can also be demonstrated by digesting a portion of the previously digested sewage sludge anaerobically in the laboratory in a bench-scale unit for 30 additional days at a temperature of 20 degrees Celsius. When at the end of the 30 days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 15 percent, vector attraction reduction is achieved.

Alternative 2: The specific oxygen uptake rate (SOUR) for biosolids treated by aerobic digestion must be less than or equal to 1.5 MG oxygen per hour per gram of total solids at a temperature of 20 degrees C.

Alternative 3: Aerobic treatment of the biosolids for a minimum of 14 days with an average temperature of at least 45 degrees C and a minimum temperature of 40 degrees C.

Alternative 4: Lime or other alkali addition must raise the pH of the biosolids to a minimum of 12 for 2 hours and maintain the pH at a minimum of 11.5 for an additional 22 hours without additional lime.

Alternative 5: For biosolids with no unstabilized solids (i.e. no primary sludge), the moisture content must be reduced to less than 25 percent.

Alternative 6: For biosolids with unstabilized solids (i.e. includes primary sludge) the moisture content must be reduced to less than 10 percent.

Pollutants

Wastewater facilities that generate and beneficially use biosolids must monitor for and meet concentration limits for nine pollutants. Biosolids may be classified as EQ if the monthly average concentrations do not exceed threshold values shown in Table 1, which allows the biosolids to be distributed without land application requirements and site management practices. If the biosolids do not meet the EQ concentration limits but are below the ceiling concentration limits, the biosolids may only be land applied in bulk at specific application rates. In addition to the nine pollutants, several other parameters must be monitored. The parameters include nitrogen, phosphorus, potassium, pH, total solids, and volatile solids.

The County routinely tests the biosolids for the heavy metals that determine EQ classification. The test results are well below the EQ limits, as shown in Table 1. It is anticipated that the Central Kitsap WWTP will continue to produce biosolids that can meet EQ classification unless there is a significant change in the influent water quality.

Table 1
Pollutant Limits

Pollutant	Ceiling Concentration Limit[1] (mg per kg)	Monthly Average Concentration Limits [1] (mg per kg)	Central Kitsap WWTP Biosolids [2] (mg per kg)	
			Maximum	Average
Arsenic	75	41	13.6	7.90
Cadmium	85	39	4.68	2.38
Copper	4,300	1,500	474	409
Lead	840	300	37.1	17.4
Mercury	57	17	3.24	1.27
Molybdenum	75	N/A	33.0	14.1
Nickel	420	420	155	32.4
Selenium	100	100	22.7	13.2
Zinc	7,500	2,800	1,902	1,287

1. *Table 1 and 2 of 503.13, Title 40 CFR Part 503*
2. *Based on Central Kitsap WWTP data 2010-2019*

PFAS Consideration

Recently there has been increasing concern and discussion on per- and poly-fluoroalkyl substances (PFAS), which could be found in biosolids if they are discharged to the sewer system. The Washington Departments of Ecology and Health published a *PFAS Chemical Action Plan* in November of 2021 which is broad in scope but recommends additional evaluation of PFAS at WWTPs. In its PFAS Strategic Roadmap 2021-2024, the EPA committed to finalizing its risk assessment for perfluorooctane sulfonate (PFOA) and perfluorooctanoic acid (PFOS), the most prominent compounds in PFAS, in biosolids by winter 2024. The assessment will serve as the basis for determining whether regulation of PFOA and PFOS in biosolids is appropriate. Based on this on-going effort by the State and Federal agencies, potential regulations are expected to affect PFAS producers, consumers, and dischargers to control the source. This should keep PFAS concentrations at WWTPs low, so regulatory risks of biosolids reuse restriction are low but PFAS monitoring requirements for all biosolids may be possible.

Among the current biosolids treatment technologies, thermal treatment (combustion or incineration) is known to be the only way that has the potential to destroy PFAS. The effectiveness of complete PFAS destruction depends on time, turbulence and temperature of the specific thermal treatment. A sewage sludge incinerator may be less effective to destruct PFAS compared to a cement kiln and has a higher potential to generate products of incomplete combustion that are similar to PFAS in the air phase. Although gasification manufacturers claim their systems can remove PFAS, the technology has not been officially approved by the EPA.

Given the uncertainty on the future regulation and approved treatment technologies associated with the biosolids PFAS, this evaluation did not include PFAS removal as a critical factor.

Class A Technology Review and Screening

Methods and technologies have been developed to process sludge from WWTPs in accordance with the pathogen reduction and vector attraction requirements to meet Class A biosolids criteria. This section introduces all the available Class A technologies based on the Title 40 CFR Part 503 requirement. These technologies can be categorized into three categories:

- Adding Class A treatment post Class B anaerobic digestion, such as composting and heat drying.
- Converting Class B anaerobic digestion to Class A non-anaerobic digestion, such as high temperature lime stabilization, pyrolysis and gasification, thermophilic aerobic digestion, beta or gamma ray irradiation, and pasteurization.
- Converting Class B anaerobic digestion to Class A anaerobic digestion, such as thermophilic anaerobic digestion, and temperature-phased anaerobic digestion. Thermal hydrolysis process (THP) is also discussed as an enhanced pre-treatment for Class A anaerobic digestion.

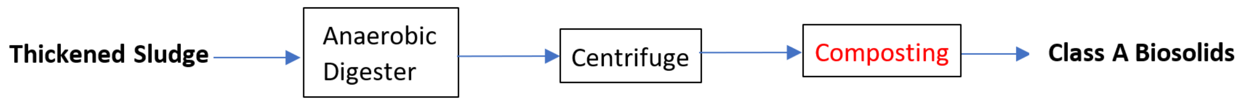
These technologies and their applicability to Central Kitsap WWTP are discussed briefly in the sections below.

Composting

Composting is recognized as a PFRP by the EPA provided the temperature exceeds 55 degrees C for at least three days if the compose is statically aerated or within a vessel, or 15 days for windrow compost heaps turned at least five times. Many biosolids composting systems use the statically aerated pile method to reduce the labor required to manage the pile. Statically aerated biosolids are typically mixed with a dry carbon bulking agent such as wood chips to reduce moisture content in the pile and promote airflow. It is common practice to extend the composting time for biosolids to 6 to 8 weeks to create a higher quality product with minimal odors, which many WWTPs are able to give away or sell to the public or bulk buyers.

Maintaining a compost process requires labor, heavy equipment, operational knowledge, and sufficient space for the piles but does not require high amounts of energy input or advanced mechanical components. Composting is generally cost competitive for WWTPs with sufficient space. The feasibility of a composting system is further discussed as a process alternative below in the alternatives analysis. Figure 1 shows the solids stabilization process if Class A composting is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 1
Class A Composting Process Flow Diagram

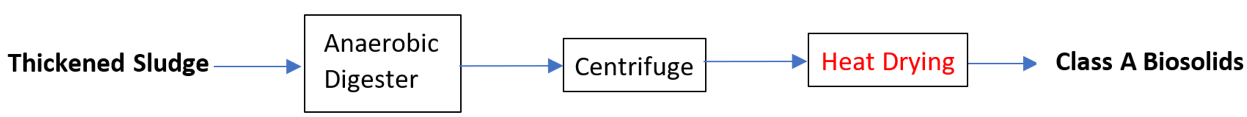


Heat Drying

Heat dryer systems are constructed to meet Class A requirements by simultaneously heating the sludge to meet time and temperature requirements and reducing the moisture content to below 10 percent. There are several configurations of dryers, but sludge must first be dewatered for any dryer to be used. Dryer systems include a condenser and heat exchanger to allow air to be recycled to make the systems more energy efficient, however the energy use remains high. There are three general types of dryer systems, belt dryers, direct dryers, and indirect dryers.

Dryer systems are feasible for a wide range of wastewater plant sizes including Central Kitsap WWTP because the units are scalable and can operate in parallel. They generally have moderate capital costs but high operational costs due to high energy requirement for heating. Dryer systems are automated to reduce operator workload, but regular inspection and cleaning are still required. A belt dryer system is one of the Class A alternatives further discussed and analyzed in this memorandum. Figure 2 shows the solids stabilization process if heat drying is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 2
Heat Drying Process Flow Diagram

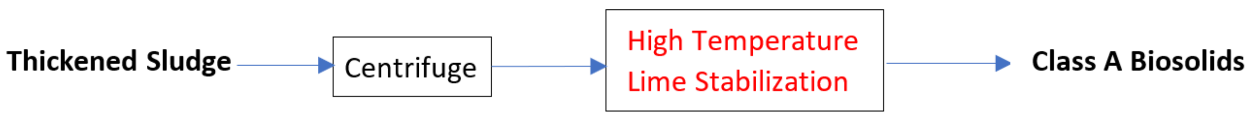


High Temperature Lime Stabilization

Lime stabilization systems use a multi-step process where lime is mixed with dewatered solids to adjust the pH, which makes the solids unsuitable for microorganisms and meets the VAR. The solids can then be heated to meet the time and temperature pathogen reduction requirements to gain Class A classification. If the supplementary heat is not applied, the biosolids are Class B.

Addition of lime to the solids increases the net volume of biosolids produced which increases the disposal volumes and costs. Furthermore, bulk lime is very corrosive and dusty. The operation and maintenance (O&M) staff will need to use extra caution and personal protection equipment when handling lime and can expect higher than normal rates of equipment repair due to accelerated corrosion. While lime stabilization is generally cost effective for smaller plants, at larger plants such as Central Kitsap there are other treatment processes that are more cost effective and less difficult to manage. Therefore, lime stabilization is not further considered as a process alternative in this memorandum. Figure 3 shows the solids stabilization process if lime stabilization is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 3
High Temperature Lime Stabilization Process Flow Diagram



Pyrolysis and Gasification

Pyrolysis and gasification are two advanced drying methods that meet the same solids content and time and temperature requirements as conventional dryers to meet Class A requirements but operate at higher temperatures to increase process efficiency.

Pyrolysis is the process of decomposing organic matter under high heat (greater than 500 degrees C) in the absence of oxygen. The process converts biosolids into syngas, bio-oil, and biochar. The syngas and bio-oil are used by the pyrolysis machine to produce heat, which allows the process to be self-sustaining without additional energy input after startup. The only byproduct is the biochar which meets the vector attraction reduction and time and temperature requirements for Class A biosolids.

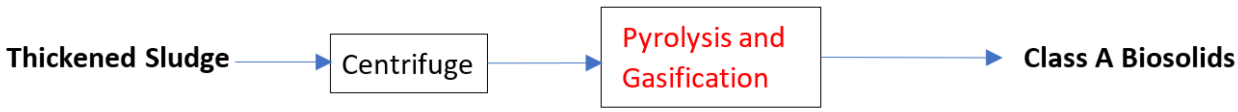
Gasification is similar to pyrolysis, but the process uses even higher heat and a small amount of oxygen to further decompose the biochar that would remain from a pyrolysis process into additional syngas. The gasification process also uses the produced syngas create heat, making the process more energy efficient. The systems produce a small amount of ash which meets the vector attraction reduction and time and temperature requirements for Class A biosolids.

Pyrolysis and gasification have been widely used in other industries, primarily using wood waste as carbon fuel, but with very limited applications in the wastewater and biosolids industry. Only a few full-scale biosolids pyrolysis/gasification facilities are operational in the US. The largest operational biosolids pyrolysis facility is at the Silicon Valley Clean Water Authority in Redwood City, California, processing 7,000 wet tons per year. A few new facilities are also under construction or close to startup, including a 130,000-wet ton per year gasification facility at Linden Roselle Sewerage Authority, New Jersey, and a 14,000-wet ton per year gasification facility at City of Edmonds WWTP, Washington.

Pyrolysis and gasification require complex equipment with high capital cost. The O&M of the equipment also requires significant attention. Generally, pyrolysis and gasification are more appropriate for WWTPs that don't have any existing biosolids stabilization process but have a desire to recover energy. Given the immaturity of the technology, limited application, complex

O&M and high costs, pyrolysis and gasification are not further considered as a process alternative in this memorandum. Figure 4 shows the solids stabilization process if pyrolysis and gasification is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

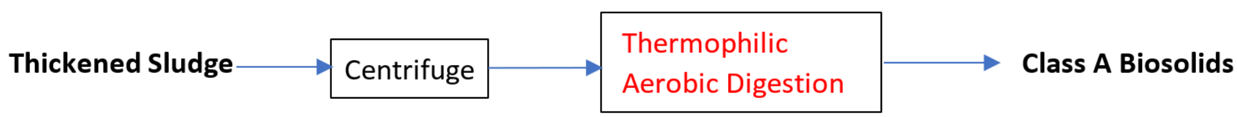
Figure 4
Pyrolysis and Gasification Process Flow Diagram



Thermophilic Aerobic Digestion

Thermophilic aerobic digesters maintain aerobic conditions and elevated sludge temperatures of 55 to 60 degrees Celsius for 10 days to meet Class A requirements. Thermophilic aerobic digesters are not commonly used due to the large volume and high energy usage required to maintain aerobic conditions. They require different tankage and equipment from the existing mesophilic anaerobic digestion at Central Kitsap WWTP. Therefore, thermophilic aerobic digesters are not further considered as a process alternative in this memorandum. Figure 5 shows the solids stabilization process if thermophilic aerobic digestion is implemented at the WWTP, with new or modified components indicated in red text.

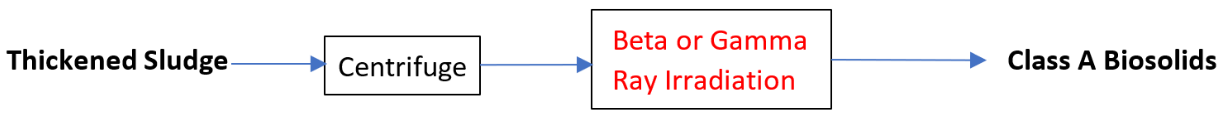
Figure 5
Thermophilic Aerobic Digestion Process Flow Diagram



Beta or Gamma Ray Irradiation

Biosolids are irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad or with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137 at room temperature. Irradiation technology is not commonly used or available from vendors and therefore, irradiation is not further considered as a process alternative in this memorandum. Figure 6 shows the solids stabilization process if beta or gamma ray irradiation is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

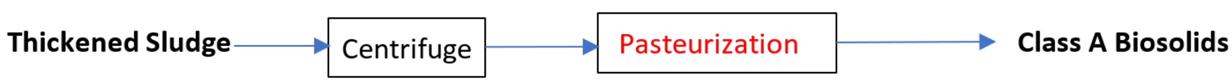
Figure 6
Beta or Gamma Ray Irradiation Process Flow Diagram



Pasteurization

Class A biosolids classification can be reached if the temperature of biosolids is maintained at 70 deg C or higher for 30 minutes or longer. This requires batch storage and heating of the sludge. Pasteurization has a high operational cost due to the high temperature requirement and is best suited to small plants where batch vessel storage is easily implemented, and high temperatures can be reached quickly. Therefore, pasteurization is not further considered as a process alternative in this memorandum. Figure 7 shows the solids stabilization process if pasteurization is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 7
Pasteurization Process Flow Diagram



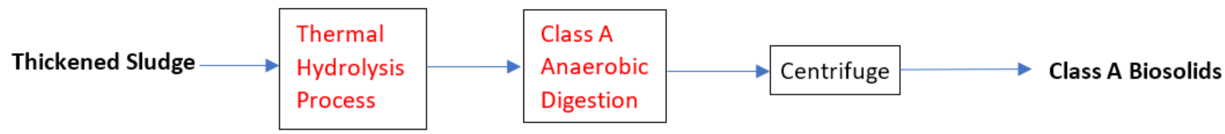
Thermal Hydrolysis

Thermal hydrolysis process (THP) is a pretreatment process prior to anaerobic digestion. It is a physiochemical process in which sludge are simultaneously heated and pressurized for a short period of time, then rapidly depressurized and digested anaerobically. The process makes the sludge much more biodegradable, which results in high VSR in the anaerobic digesters and can meet Class A requirements if the time and temperature requirements are met or the sludge is dried after digestion. This process itself cannot meet Class A requirements. This process has the added benefit of increasing digester capacity since the sludge digestibility is improved. Ancillary buildings and equipment are required to operate a THP system, including steam boilers, solids screening, pre-dewatering, raw cake storage and pumping, and solids dilution and cooling systems. While THP system can reduce the required digester volume, the ancillary systems impact total system cost, complexity and footprint.

The most popular THP manufacturer in the US is Cambi, although its competitors, i.e. Veolia, have installations in Europe. The first Cambi installation in the US is at Blue Plains plant in Washington DC and has been in operation since late 2014. A few other US installations are in the design or construction phases, including the THP system at San Francisco Public Utilities Commission's Southeast Treatment Plant Biosolids Digester Facilities in California.

Thermal hydrolysis requires advanced process equipment, high capital cost and high operating costs. It is typically only cost effective for large WWTPs or WWTPs that have space constraints. Thermal hydrolysis is not expected to be cost effective at Central Kitsap WWTP and is not further considered as a process alternative in this memorandum. Figure 8 shows the solids stabilization process if THP is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 8
Thermal Hydrolysis Process Flow Diagram

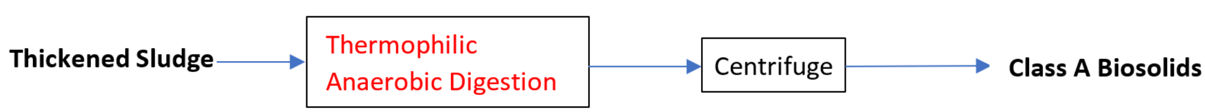


Thermophilic Anaerobic Digestion

Thermophilic anaerobic digestion (TAD) is similar to Central Kitsap WWTP's existing mesophilic anaerobic digestion (MAD) process but operates at higher temperatures. Based on the Title 40 CFR Part 503 Alternative 1 - time and temperature requirement, biosolids could be digested in anaerobic conditions at temperature of 55 to 57 degrees C, then held in a series of batch tanks at 55 to 57 degrees C for about 24 hours to meet Class A pathogen reduction requirement.

TAD increases VSR and biogas production compared to MAD. However, the disadvantages include increased moisture in biogas, increased odor generation, and increased ammonia and phosphorous release in the dewatering recycle stream. The biggest concerns at Central Kitsap WWTP are the existing mesophilic digestion structures and equipment may need significant improvement in order to operate at higher temperatures. TAD will require high capital and O&M costs due to the new batch tanks and more complex operation. TAD is not expected to be cost effective at Central Kitsap WWTP and was previously analyzed as one of the digestion upgrade alternatives and rejected in the *Anaerobic Digestion and Thickening Process Selection* Technical Memorandum (Brown & Caldwell, 2007), therefore, it is not further considered as a process alternative in this memorandum. Figure 9 shows the solids stabilization process if TAD is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 9
Thermophilic Anaerobic Digestion Process Flow Diagram

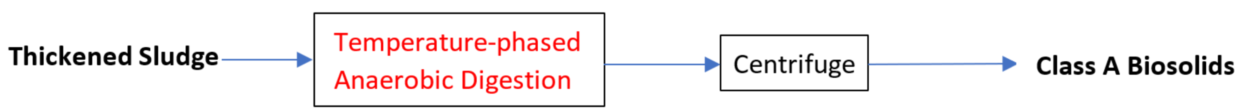


Temperature-Phased Anaerobic Digestion

Temperature-phased anaerobic digestion (TPAD) incorporates the advantages and mitigates some of the disadvantages of TAD by incorporating MAD to improve performance. TPAD uses digesters in series, with a thermophilic stage followed by a mesophilic stage. The high biochemical reaction rate in the thermophilic stage improves VSR, improves dewaterability of the sludge, increases gas production and increases pathogen destruction rates. As with TAD, TPAD can be configured with batch tanks to produce Class A biosolids. More heat exchangers and heat resources are required to heat the biosolids to thermophilic temperatures and then cool the solids to mesophilic temperatures.

Comparing to TAD, TPAD is even more complex, and requires higher capital cost and O&M attention. It is not expected to be cost effective at Central Kitsap WWTP and was previously analyzed as one of the digestion upgrade alternatives and rejected in the *Anaerobic Digestion and Thickening Process Selection* Technical Memorandum (Brown & Caldwell, 2007), therefore, it is not further considered as a process alternative in this memorandum. Figure 10 shows the solids stabilization process if TPAD is implemented at Central Kitsap WWTP, with new or modified components indicated in red text.

Figure 10
Temperature-phased Anaerobic Digestion Process Flow Diagram



Summary of Class A Biosolids Technology

Table 2 summarizes the comparison of the above Class A biosolids technologies and screening results.

Table 2
Class A Biosolids Technology Screening

Class A Technology	Established Technology	Suitable Size	Compatible with Existing Process	Reasonable O&M and Capital Cost	Further Evaluation (Y/N)
Composting	✓	✓	✓	✓	Y
Heat Drying	✓	✓	✓	✓	Y
High Temperature Lime Stabilization	✓	×	×	×	N
Pyrolysis and Gasification	×	×	×	×	N
Thermophilic Aerobic Digestion	✓	×	×	×	N

Class A Technology	Established Technology	Suitable Size	Compatible with Existing Process	Reasonable O&M and Capital Cost	Further Evaluation (Y/N)
Beta or Gamma Ray Irradiation	×	×	×	×	N
Pasteurization	×	×	×	×	N
Thermal Hydrolysis	✓	✓	✓	×	N
Thermophilic Anaerobic Digestion (TAD)	✓	✓	×	×	N
Temperature-phased Anaerobic Digestion (TPAD)	✓	✓	×	×	N

Detailed Alternatives Evaluation

Composting and heat drying are the two technologies remaining from the initial screening for further evaluation. Both technologies represent an appropriate scale and cost for a mid-sized WWTP such as Central Kitsap and have long-standing records of successful Class A biosolids treatment at many WWTPs around the country. In this section, these two alternatives are further evaluated in detail against the existing Class B biosolids operation at Central Kitsap WWTP from the following aspects: conceptual design, product reuse potential and costs.

Influent BOD, TSS, and TKN loads to Central Kitsap WWTP were projected in Section 3 of Wastewater General Sewer Plan and are forecasted to increase from 2020 loads by 15 percent in 2028 and 54 percent in 2042. For planning purposes, biosolids production is assumed to increase at the same rate. As shown in Table 3, Central Kitsap WWTP is expected to generate approximately 3.3 dry tons per day of biosolids cake in 2028 and 4.5 dry tons per day biosolids cake in 2042.

Table 3
Central Kitsap WWTP Biosolids Production

Year	Loading % Increase from Current	Daily Biosolids Production (dry tons)	Annual Biosolids Production (dry tons)
2020		2.9	1059
2028	115%	3.3	1222
2042	154%	4.5	1635

Nearby WWTPs were surveyed to determine interest in a collaborative regional approach to biosolids management. Several expressed discontent with their current Class B process and are interested in discussing a collective approach to implement and operate a Class A process, as summarized in Table 4, below.

Table 4
Nearby WWTPs Collaboration Interest

Treatment Plant	Current Process	Interest in Collaboration on Class A Program
South Kitsap WRF (West Sound Utility District)	Anaerobic digestion with screw press dewatering, Class B biosolids	Very interested, especially in composting. Willing to explore cost sharing.
Bainbridge Island WWTP (City of Bainbridge Island)	Aerobic sludge storage tank with screw press dewatering, unclassified solids	Interested. Unhappy with current disposal costs.
Gig Harbor WWTP (City of Gig Harbor)	Aerobic digestion with dewatering, Class B biosolids	Interested.
Lakota and Redondo WWTPs (Lakehaven Water and Sewer District)	Anaerobic digestion with dewatering, Class B biosolids	Interested.
Bremerton WWTP (City of Bremerton)	Anerobic digestion with centrifuges, Class B biosolids	Not interested. The City already owns and operates their own reuse site. Their reuse site does not have capacity to accommodate the County's sludge under normal long-term situation.
Tacoma Central WWTP (City of Tacoma)	Dual-stage TAD followed by TPAD, with dewatering, and soil blending, Class A biosolids	Not interested, but happy to provide advice and assistance with Class A biosolids planning. Tacoma will not accept sludge from other plants under normal long-term situation.
Chambers Creek WWTP (Pierce County)	Anaerobic digestion, centrifuge and heat drying, Class A biosolids	Not interested, but happy to provide advice and assistance with Class A biosolids planning. Pierce County will not accept sludge from other plants under normal long-term situation.

For the purpose of this alternatives analysis, it is assumed that the Class A biosolids facility will only treat solids generated from Kitsap County's WWTPs. If the County does elect to move forward with implementation of a Class A program, the parties interested in collaboration should be further consulted to discuss the details of how a partnership would work. Economies of scale may allow Central Kitsap to generate income from accepting sludge from other utilities without incurring significant additional capital or operating costs.

Alternative A: Composting

Conceptual Design

An engineered statically aerated composting system is one of the common composting systems to meet Class A biosolids requirements. The system consists of several bays to hold the compost piles, which are treated in batches. For the purpose of the evaluation, a statically aerated composting system by Sustainable Generation is used as the basis for this conceptual design. There are several composting system vendors, the selection of which will ultimately be done during the design and construction process if this alternative was selected for implementation. The system can be installed on the ground surface with Ecology block bays or can be incorporated into an engineered concrete structure. Figure 11 shows a Sustainability Generation composting facility in operation.

Figure 11
Composting Facility Example

The Gore® cover by Sustainable Generation is constructed of a waterproof, breathable material that is used to cover the pile to prevent excessive moisture or over-drying. Aeration piping beneath the pile maintains aerobic conditions within the pile. The control unit monitors temperature and oxygen using probes inserted into the pile through the cover and regulates flow through the aeration lines to keep the pile adequately aerated and moist. The system can operate effectively in a wide range of conditions that encompass the seasonal climate of the Kitsap Peninsula. The underground aeration lines also serve as leachate collection lines with valved connections to a common header conveying leachate to the headworks via the plant waste pump station. A cover rolling machine is used to unroll the covers over the top of a compost pile and to roll up the cover if the pile needs to be accessed.

Carbon bulking materials such as woodchips are mixed 1:1 by weight (3:1 by volume) with the sludge cake to support air flow through the pile and provide additional nutrients. The characteristics of the bulking material added to the dewatered solids can be optimized to maintain an effective process and quality product. The bulking material can be purchased from sawmills or lawncare suppliers, but it may be feasible to get the material for free or even be paid to accept it by accepting of green waste materials.

The incorporation of green waste as bulking material also has the potential to increase the level of services that the County offers to the public and generate income to offset operating costs because the County's Olympic View Transfer Station does not currently recycle yard waste on weekdays and charges $74 per ton to accept yard waste on weekends. A new location to recycle yard waste may reduce traffic at the transfer station, offset other costs associated with green waste management for the County, and improve the cosmetic quality of the Class A biosolids. However, this would also introduce operational challenges to ensure the yard waste does not have other materials mixed in. It may also be feasible to obtain sufficient bulking material by allowing drop of wood chips from landscaping companies only, which would provide better material control and reduce operational challenges.

Jopp Energy is a wood recycling company that accepts clean wood, grinds the wood into hog fuel and sells the processed wood as fuel. One of their locations borders Central Kitsap WWTP on the east. Collaboration with this type of company may provide a simple and low-cost way to ensure bulking agent supply. Overall, the risk of wood product supply is expected to be low, but will require the County some coordination effort to secure.

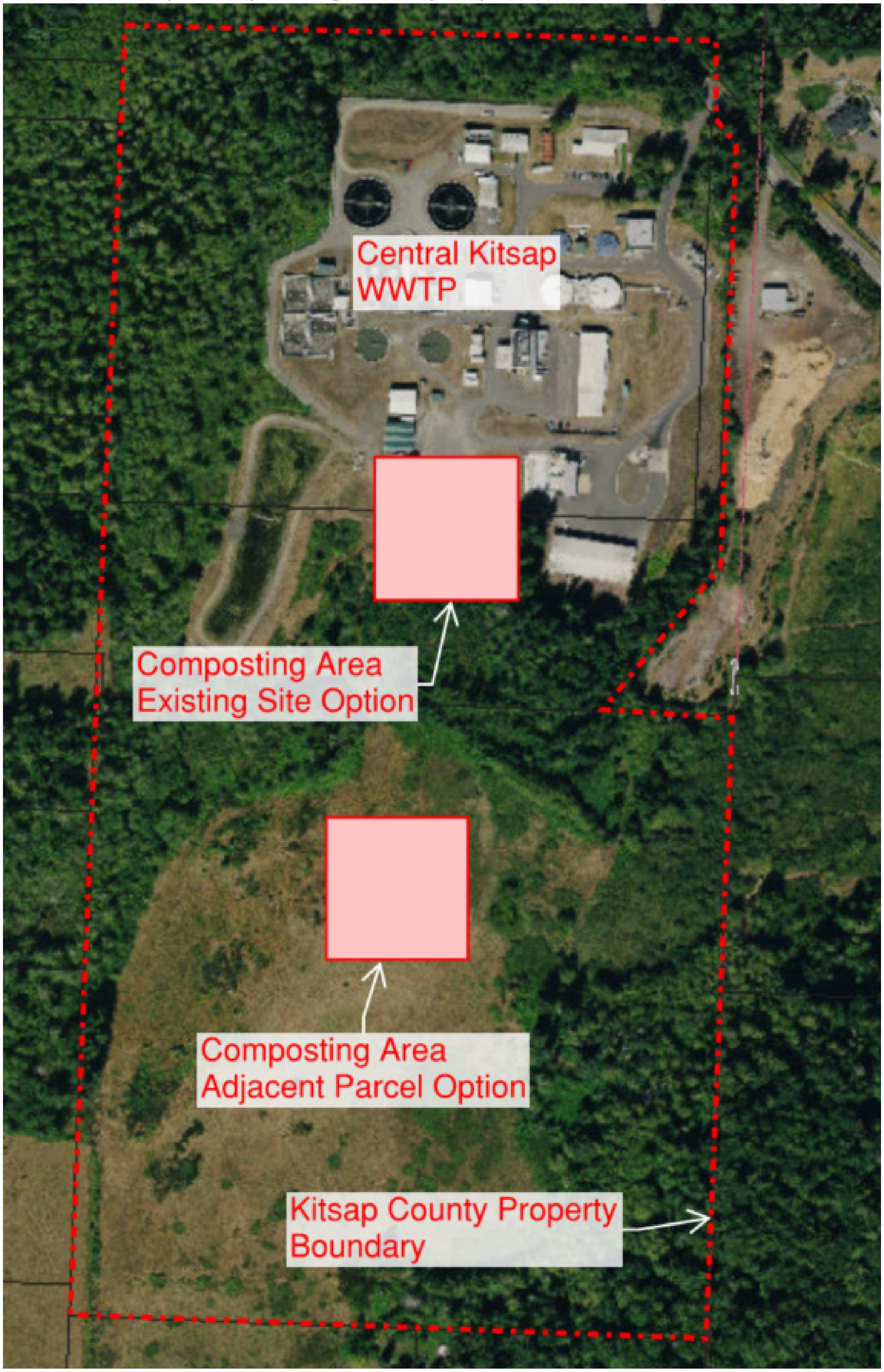
Chipping and mixing equipment is used to improve the efficiency of the operation and the consistency of the compost blend and front loaders are used to transfer materials. Figure 12 shows an empty composting bay with above ground aeration system and a front loader transferring finished compost at City of Missoula's composting facility.

Figure 12
City of Missoula Composting Operation

Each composting bay at Central Kitsap WWTP would be approximately 27 feet wide by 100 feet long and a total of eight bays are required to provide treatment for the estimated 2042 solids loading. A single batch of compost would require a minimum of six weeks of processing to be suitable for land application, with one turning after four weeks. Eight weeks of processing is recommended if the batch is to be bagged, but this introduces additional operational challenges that can be avoided if the compost is sold loose. A finished compost pile will contain a substantial amount of bulking material that can be screened out for reuse, which can balance the green waste input as well as introduce beneficial microbes to a fresh pile. An area for screening and storage of finished compost is needed. It is generally most effective to rent screening equipment or contract the screening work on an intermittent basis.

The total area required for a yard waste receiving area, composting bays, mixing, screening, storage is approximately 2 acres. The composting area could be placed on the existing developed area of the WWTP site, or on the adjacent undeveloped parcel, which the county also owns. Figure 13 shows two possible locations of composting facility at or near Central Kitsap WWTP. If placed on the developed portion of the site, the composing bays and the handling area could fit on the south side of the site between the headworks and a stormwater detention pond. This area had previously been identified as the future location of the primary clarifier and the shop and maintenance building, so those facilities would need to be replaced elsewhere. Alternatively, the composting facility could be located on the undeveloped 40-acre parcel to the south of the developed site. This parcel has ample space and is fairly flat, making it an ideal candidate for the composting site. It is zoned Rural Residential and would require an administrative use permit for development as part of the WWTP. There are some wetlands around the edges of the property which were delineated in 2007 which would have to be delineated again to establish required setbacks for any improvements.

Figure 13
Central Kitsap Composting Facility Layout (Location)



Product Beneficial Reuse Potential

Composting of biosolids in Washington has grown rapidly in recent years, from approximately 3,300 tons composted in 2010 to over 11,000 tons in 2020. Most of the composed biosolids are given away or even sold for a nominal fee to either the public or bulk distributors. Composting facilities for biosolids are owned by both municipalities and third-party companies.

Class A biosolids can be used by the public without restrictions if it meets the Exceptional Quality designation for metals content. Composted biosolids are a useful and well received product when the composting process is managed well. The compost can be used on farms, in home gardens, and as a soil quality Best Management Practice under the Stormwater Management Manual for Western Washington.

Several biosolids composters were surveyed to gather more information about their experience operating the process and marketing the product. Biosolids compost products are sold to individual members of the public, landscapers, nurseries, and general contractors in varying quantities, containers, and product blends. Operators generally reported that they are successful at creating a high-quality compost product that is sought after and several utilities experience demand that exceeds their capacity to generate compost. Most of the utilities sell their compost for between 10 and 20 dollars per cubic yard with costs varying depending on location, packaging, and compost blend.

Distribution of compost will require some marketing and it may take several years to generate significant demand as awareness and comfort with the product spread. The experience of other composters in Washington suggests that demand for compost is generally high and can be a significant source of income. Kitsap County has a population of nearly 300,000 and land uses are primarily rural and low or medium density residential, so expected demand for a compost product is high. The public is likely already fairly comfortable with use of compost and many regional resources are available to assist in knowledge building, both among process operators and marketing staff. Public awareness and concern regarding PFAS is growing and may affect demand for compost, however, composters surveyed reported that questions and concerns about this are rare and do not seem to be affecting demand.

Appendix A contains the site visit and meeting notes with several wastewater facilities that operate Class A composting or soil blending systems that produce a similar product.

Costs

Capital costs to construct a slab-on-grade aerated static pile composting system were analyzed as shown in Table 5. Sustainable Generation provided a base price estimate of $1.6M to provide Gore covers, the aeration system, a cover winding machine, and ancillary services. Additional site civil improvements are needed including construction of the composting area slab and construction of a covered storage and mixing area. Contractor markups are estimated at 30%. A sales tax of 9.2% and a contingency of 30% are included. Engineering, County management and administration are estimated at 25%. Additional $650,000 for a front loader and compost mixer is added separately in the O&M analysis without markups.

Table 5
Capital Cost of Composting System

Item	Cost
Clearing and Grading	$90,000
Composting System	$2,000,000
Contractor Install	$400,000
Concrete Slab	$320,000
Gravel Work Area	$60,000
Roof Covered Structure and Concrete	$1,500,000
Construction Material and Labor Subtotal	**$4,400,000**
General Conditions	$350,000
Mobilization/Demobilization	$440,000
Overhead & Profit (OHP)	$530,000
Construction Subtotal	**$5,700,000**
Sales Tax (9.2%)	$520,000
Contingency	$1,700,000
Total Construction Cost	**$7,900,000**
Engineering, Legal, and Administration	$2,000,000
Wheel Front Loader	$300,000
Mixer	$350,000
Total Capital Cost	**$10,600,000**

O&M costs were analyzed over a 20-year period to determine the net present value of the composing alternative. Costs include replacement of the covers every 7-years, labor and loader operation, blower power, purchase and mixing of the bulking agent, screening rental, vendor provided maintenance and support, and compost sales. The net present value of the composting alternative is highly dependent on assumed labor requirements and compost sale price, so a "conservative scenario", an "estimated scenario", and a "best case scenario" were analyzed as shown below in Table 6. The "estimated scenario" assumptions are intended to represent to most likely O&M costs for this alternative. The "conservative scenario" uses more conservative O&M assumptions for labor hours, bulking agent cost, O&M support, and compost sales to evaluate the effect of higher than expected costs for these items. Conversely, the "best case scenario" uses less conservative O&M assumptions for these items to evaluate the lowest reasonable cost that may be achievable. The combined effect of varying these O&M costs is substantial over the 20-year lifecycle, with the "best case scenario" generating a profit of $1.1M but the "conservative scenario" costing $16M.

Table 6
Annual Net Present Value for Various Scenarios

Item	Conservative Scenario	Estimated Scenario	Best Case Scenario
Weekly Labor Hours	140	100	30
Bulking Agent Cost ($/CY)	$30	$5	$0
Vendor Operation and Support ($/yr)	$31,000	$0	$0
Compost Sales ($/YD)	$0	$10	$15
20-year O&M Net Present Cost*	$16.0M	$6.7M	($1.1M)
Total 20-year Net Present Cost	$26.6M	$17.2M	$9.5M

*Values are reported as costs, values in parenthesis indicate a negative cost or a profit.

The total 20-year net present value combines the capital costs and the operation and maintenance costs for a 20-year planning period. Even in the 'best case scenario' which results in an annual operating profit, revenue from the compost sales is not high enough to offset capital costs for the 20-year planning period. Appendix C contains the detailed cost estimate for all alternatives.

Alternative B: Heat Drying

Conceptual Design

A heat dryer is another technology that can provide Class A treatment. For this analysis, a low temperature belt dryer system by Centrisys is used as the basis of the evaluation, although there are other types of drying systems and manufacturers that could be applicable to Central Kitsap WWTP. The selection of the dryer supplier will ultimately be done during the design and construction process if this alternative was selected for implementation. The belt dryer extrudes dewatered solids onto a belt, which slowly carries the solids through the drying chambers. Heat is provided by a separate boiler and hot water loop. Biosolids exit the dryer at greater than 90 percent solids to meet the Class A requirements. An odor control system on the exhaust is required to treat the exhaust gas before it is discharged. Figure 14 below shows an example of a belt dryer by Centrisys. Figure 15 shows an example of the drum dryer by Andritz installed at Pierce County's Chambers Creek WWTP.

Figure 14
Belt Dryer by Centrisys

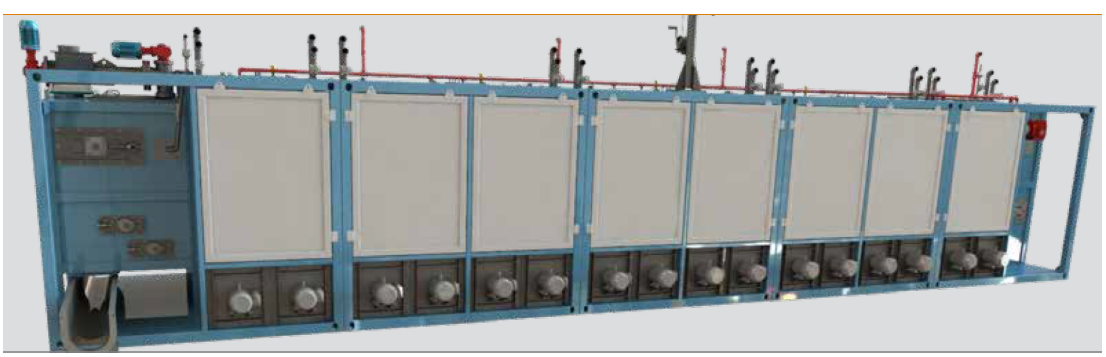


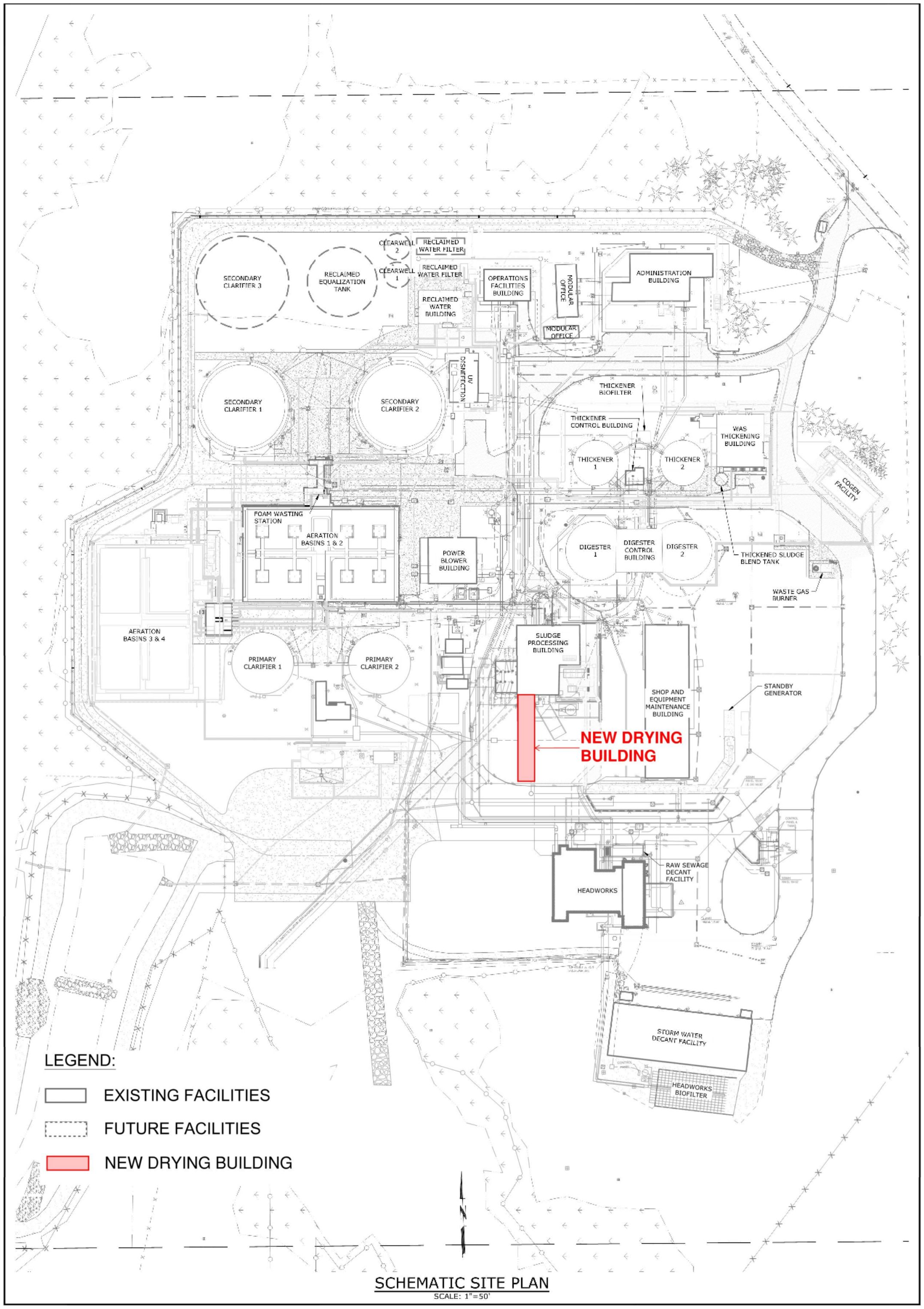
Figure 15
Drum Dryer by Andritz at Chambers Creek WWTP

A Centrisys DLT 720 dryer is appropriately sized for Central Kitsap WWTPs 2042 solids production and has a design sludge loading rate of 3027 wet lbs/hr. At the anticipated 2042 solids loading rate of 4.5 dry tons/day and a solids content of 23%, the dryer would be operated in batches of approximately 13 hours per day. The resulting dried Class A biosolids are small cylindrical pellets which could be hauled for land application or distributed locally as a 'soil amendment' product.

The DLT 720 dryer is 10.5 feet wide by 72 feet long and requires a minimum of 4 feet of clearance around all sides. Heat for the dryer is supplied by a hot water loop, which could be fed from a new boiler or connected to the existing hot water loop and boilers. The dryer requires 420 GPM of hot water at 195 degrees Fahrenheit. The dryer creates 11,000 SCFM of foul air which would be treated in an odor control system. The dryer, boiler, and odor control system would be located in a new, 2000 square-foot building located where the existing Shop and Equipment Maintenance Building currently stands. Per recommendations from previous planning, the existing Shop and Equipment Maintenance Building would be relocated to the south end of the plant.

Figure 16 shows the proposed drying building on the site plan.

Figure 16
Proposed Drying Building Location



Product Beneficial Reuse Potential

Dried Class A biosolids can be put to beneficial reuse, however, there can be challenges due to the nature of the dried product. The biosolids can be land applied at large scale agricultural operations similar to a Class B product, but the dry nature of the product requires different equipment than Class B biosolids and the existing land application sites in Washington may not accept dried solids. Pelletizing equipment may be needed to produce a consistent enough pellet size for end users. The low water content of the solids reduces the weight and thus the hauling costs by about a factor of three compared to the existing Class B process. Additionally, problems with the biosolids generating dust if they get too dry or smoldering or combusting if exposed to moisture are common.

Pierce County has been distributing a dried, pelletized biosolids branded as SoundGRO fertilizer since 2006. The pelletized biosolids are show in Figure 17. SoundGRO, is available in bulk, in one-ton totes, and in 50-pound bags, and is shown in storage in Figure 18. The majority of SoundGRO sales are to large fertilizer manufacturers and soil blenders in Oregon in one-ton totes. These users pick up loads intermittently and seasonally, therefore, Pierce County only dries about 40 percent of their solids, the remainder is treated to Class B and land applied. Irvine Ranch Water District, CA and North Shore Water Reclamation District, IL also operate Class A drying processes but are not able to sell the product to generate revenue. It may also be feasible to distribute the biosolids on local farms to further reduce hauling costs, however, western Washington generally does not have large scale agricultural operations like those that are found in the easter part of the state, so it may be challenging to identify local users that will commit to accepting the biosolids.

Figure 17
Dried and Pelletized Biosolids

Figure 18
Packaged SoundGRO

The biosolids can also be marketed to the public locally as a fertilizer or soil amendment product. Pierce County has put limited effort into distributing to the public and has conducted limited giveaways with success. The anticipated demand for dried biosolids products is low to moderate. The public is generally more familiar with the process and end usage associated with compost, but dried Class A products encounter more hesitation and can be expected to require more branding effort and time to build demand. The potential for revenue generation from dried biosolids is lower than that of composting but has higher capital and operational costs, so public sales are not recommended or further considered.

Appendix B contains the site visit and meeting notes with several wastewater facilities that operate Class A biosolids heat dryer system.

Costs

Capital costs to construct a heat dryer system housed within a slab-on-grade structure were analyzed as shown in Table 7. Centrisys provided a base price estimate of $2.2M to provide a DLT 720 belt dryer. Site civil construction of the building, odor control system, boiler and ancillary mechanical are also required. Contractor markups are estimated at 30%. A sales tax of 9.2% and a contingency of 30% are included. Engineering, County management and administration are estimated at 25%.

Table 7
Capital Costs of Heat Dryer System

Item	Cost
Belt Dryer	$2,800,000
Odor Control System	$1,900,000
Boiler System (or HRR Loop)	$350,000
Site Piping, Auger, Electrical, etc	$200,000
Building Construction	$600,000
Installation Cost	$1,500,000
Construction Material and Labor Subtotal	**$7,300,000**
General Conditions	$580,000
Mobilization/Demobilization	$730,000
Overhead & Profit (OHP)	$870,000
Construction Subtotal	**$9,400,000**
Sales Tax (9.2%)	$870,000
Contingency	$2,800,000
Total Construction Cost	**$13,100,000**
Engineering, Legal, and Administration	$3,300,000
Total Capital Cost	**$16,400,000**

O&M costs were analyzed over a 20-year period to determine the net present value of the drying alternative as shown below in Table 8. Costs include power and fuel consumption, regular maintenance, and hauling and disposal at current rates.

Table 8
Alternative B Annual Net Present Value

Item	Value
Weekly Labor Hours	30
Natural Gas Cost ($/MBTU)	$8.40
Electricity Cost ($/kWh)	$0.10
20-year O&M Net Present Cost	$10.6M
Total 20-year Net Present Cost	$27.1M

Alternative C: Keep Existing Class B Process

Existing Process

Currently, sludge is treated to Class B requirements by anaerobic digestion, then is dewatered with a centrifuge to approximately 23 percent solids. The dewatered biosolids are loaded into a truck through a hatch in the dewatering room and hauled away for land application. The hauling is contracted to a local trucking company, who delivers the biosolids to Natural Selections Farms near Moxee, WA.

Product Beneficial Reuse Potential

Class B land application meets Washington beneficial reuse requirements. The only existing beneficial use facilities for land disposal are on the east side of the Cascades and large-scale, non-food farming is uncommon in western Washington, so it is not feasible to reuse the Class B biosolids at a closer location. Hauling the biosolids to eastern Washington results in occasional operational challenges when mountain passes close due to inclement weather or fires, and carbon emissions from the lengthy trip are high. Additionally, there are a very limited number of farms that will accept Class B biosolids which leaves the County vulnerable to permitting or other problems, which happened in 2015 when the County's previous reuse site was closed due to a permit violation.

Costs

The existing process will stay the same for all alternatives though dewatering. There are improvements needed to the solids process upstream of the dewatering step which are outside the scope of this analysis (see *Central Kitsap WWTP Liquid Hauled Waste Study* technical memorandum, Murraysmith, July 2022) and are not discussed here. Therefore, there are no capital costs associated with continuing the current process.

For the existing biosolids treatment process the County simply loads the sludge from the centrifuges directly into a tractor trailer. Hauling and reuse is contracted with 3rd party entities, so the only O&M cost to the County is the hauling and disposal contract. The hauling and disposal contract was recently renewed at a combined cost of $62 per ton of sludge. Previously, the contract price was nearly $80 per ton. Due to the large change in price, scenarios using both contract prices were analyzed as shown below in Table 9.

Table 9
Alternative C Annual Net Present Value

Item	Current Hauling Scenario	Previous Hauling Scenario
Hauling and Disposal Contract Cost ($/Ton)	$62	$80
20-year O&M Net Present Cost	$9.3M	$12.0M
Total 20-year Net Present Cost	$9.3M	$12.0M

Recommendations

The results of the net present value analysis are summarized for all alternatives and scenarios below in Table 10. The best-case scenario for the composting alternative has the lowest 20-year net present cost and is the only scenario analyzed that creates a net revenue annually, although not enough to offset the capital cost. The less optimistic estimated scenario for composting operates at a loss and has a total net present cost that is higher than either of the existing process scenarios. The drying alternative has the highest costs, higher even than the conservative scenario for composting.

Table 10
Net Present Value Summary

Alternative	Scenario	Capital Cost	O&M 20-year Net Present Cost	Total 20-year Net Present Cost
Class A Composting	Conservative Scenario	$10.6M	$16.0M	$26.6M
Class A Composting	Estimated Scenario	$10.6M	$6.7M	$17.2M
Class A Composting	Best Case Scenario	$10.6M	($1.1M)	$9.5M
Class A Drying		$16.4M	$10.6M	$27.1M
Existing Class B	Current Hauling Cost	$0	$9.3M	$9.3M
Existing Class B	Previous Hauling Cost	$0	$12.0M	$12.0M

Based on financial considerations, continuing the existing process appears to be the best option. The annual cost is contractually established and even at the previous, higher contract price the costs are not dramatically higher. Continuing the existing process requires no additional capital costs or changes to operations. In addition to helping reduce to net present cost, this also simplifies management of capital and operations for the County.

It is feasible that composting could have a lower 20-year lifecycle cost, but under the more likely estimated scenario, composting would be more expensive than either of the existing process scenarios. In order for the County to benefit financially from composting, the labor hours would have to be carefully minimized, and a strong market for the compost would need to be developed. There are, however, other non-financial benefits to the composting process. Hauling biosolids to eastern Washington for disposal generates approximately 360 metric tons of carbon emissions annually, which would be substantially reduced by composting and distributing the compost locally instead. Local distribution also makes the WWTP operations less vulnerable to weather and fire disruptions and reduces risk associated with relying on a single disposal site with limited alternatives. In addition, composting would offer a valuable product to the public and potentially provide a convenient location to recycle green waste. These non-financial considerations make composting an attractive alternative.

There is not an immediate need or financial incentive to upgrade the solids treatment process to produce Class A biosolids, but there are numerous benefits to constructing and operating a composting process. Other parts of Central Kitsap WWTP are in need of refurbishment or replacement in the near future. Therefore, it is recommended to reserve land area for the composting site as other improvements are considered, but delay implementation of the composting alternative until more critical improvements are addressed or the financial outlook becomes more favorable.

Appendix

Appendix A – Composting and Soil Blending Facilities Site Visit and Meeting Notes

Appendix B – Heat Drying Facilities Site Visit and Meeting Notes

Appendix C – Detailed Cost Estimate

APPENDIX A

Tacoma Central Plant TARGO Site Visit Notes

Date:	February 22, 2022
Project:	Central Kitsap WWTP Class A Biosolids Evaluation
Notes By:	Patrick Davis, PE; Miaomiao Zhang, PE, PMP; Jeff Moss, PE, Murraysmith
Re:	Tacoma Central Plant TAGRO
Interviewed with:	Dan Eberhardt, Biosolids Supervisor, TAGRO Dan Thompson, Division Manager, City of Tacoma

Production Overview

- Approximate Amount of Biosolids Produced: 7,000 to 8,000 dry tons per year out of the plant. Approximately 90% is used to produce TAGRO. The plant can still truck Class B biosolids for land application if needed in order to control TAGRO inventory.
- Among all the TAGRO produced, 90 percent has been sold to the local home growers/gardeners, landscapers, and nurseries. The remaining 10% is given away to local residents for free. TAGRO has provided delivery as far as Lake Chelan. No long-term contract with customers. They just call or order online. Especially busy in March/April.
- Biosolids Treatment Process: Tacoma Central Plant utilizes a two-stage thermophilic/mesophilic aerobic and anaerobic digestion process to produce Class A biosolids. The first stage is aerobic digestion using high purity oxygen at 64 deg C and a SRT of 12 to 24 hours to meet the pathogen inactivation requirement. The second stage is temperature-phased anaerobic digestion (TPAD) that consists of thermophilic, mesophilic and low mesophilic digestion. The total TPAD SRT is about 21 days (7+14 days) to meet the EPA Part 503 regulation Class A requirement. This Class A digestion process is a continuous operation instead of a batch process, which has been approved by EPA since the beginning of the operation. The liquid biosolids are run through a screw press to 25% solids content then trucked a short distance to the TAGRO (which is directly adjacent to the WWTP) to be directly mixed with bulking material. Currently using roll-off boxes for hauling.
- Bulking Agent Used: Sand, clean sawdust, aged bark, and, to a limited degree, biochar (experiential, obtained from green waste facility)
    - Sawdust sourcing has become more difficult over time as mills close and/or get better as using all of their byproducts. Currently getting from Hardwood Northwest

  - Sand is easy, from any bulk sand and gravel supplier. Occasionally they are able to get paid to receive sand from a foundry, which was previously landfilling the spent sand from the casting process.
  - Bark – did not specifically comment on difficulty or ease. They are paying for this product.
- How it is created: Two medium sized earth movers are used to spread a layer of Class A biosolids within a covered staging area. The equipment then adds layers of sand and sawdust to the mixture. The mixture is turned over repeatedly until homogenous (or close to). It is then sent through a Royer soil shredder to break up large clumps and mix further.
- Required Labor: Approximately 12 people are employed to manage and produce the TAGRO products. They are responsible for the material procurement, new product development, marketing, sales, production, packaging, delivery in the program.
- End Products:
  - Tagro Mix – 50% biosolids, 25% sawdust, 25% sand (by volume or weight?)
  - Tagro Potting Soil – Tagro mix plus aged black bark
  - Tagro Topsoil – Similar to potting soil, but meets WSDOT spec. Adjusted to meet spec changes as needed (can be challenging)
  - Aged Bark – bark only, obtained from supplier and sold at markup due to customer demand

Associated Cost Benefits

- TAGRO is typically given away for free at the plant if shoveled and hauled by the residents. Otherwise, it can be loaded into a personal vehicle/trailer at the plant or delivered for a small fee (approx. $10/yd at the plant, delivery costs vary). The product is also bagged and sent to local gardening shops for sale.
- Overall Costs and Income: TAGRO does not produce any income for the plant; however, it reduces the costs associated with biosolids management. Approximately 50% of the costs to treat the solids is recouped by TAGRO sales/giveaways. Approximate cost to operate is $30/wet ton

Marketability

- TAGRO is a popular product that has been "selling" out for the past 3 years. Customers range from mid-scale landscapers to small scale gardeners. They have thousands (approx. 5,000) of smaller customers. Occasionally they have large scale projects, for example they were specified on a big UW project and had some logistical issues coordinating the delivery volume and timing with the contractor.
- The product began in 1992. There has been 30 years of building up to the current demand

- Additional marketing stems from obtaining booths at local gardening conventions, home & garden shows, communicating with local gardening community groups, (i.e. Garden Clubs and Masters of Garden), partnering with universities (i.e. Sally Brown from UW, and WSU) and obtaining endorsement from the credible end users. The general marketing advice revolved around the idea that local community members would be the best spokespeople for the product.
- Tagro is considering internet sales though amazon. Some similar vendors are doing this already in other places.

Additional Items

- Sourcing bulking material: The plant has relationships with multiple local wholesalers and businesses. This provides them with the sawdust and sand needed for bulking material. There have been issues in the past with suppliers drying up or going out of business. It seems like there is a constant need to reach out to new people in order to retain a redundant supply.
- Operational Challenges: The soil shredder goes down from time to time. They have a backup unit. Otherwise, the equipment is fairly modest needing only standard preventative maintenance.
- Site Requirements: The TAGRO facility sits on approximately 2.5-3 acres of land. This provides enough space to build up and store three different TAGRO products over the winter months. It seemed that there was adequate space for the heavy equipment to maneuver and operate without issue. Tagro has constructed roofs over the main areas where material is stored. For many years, they had open piles and had to cover with large tarps, which was difficult and often not effective (tarps blown off pile). The roofs are much nicer, safer, and effective.
- Public Pushback: When the product was first introduced, there was some public pushback; however, TAGRO has numerous customers who are willing to attest to its benefit. The overall issues coming from the public have been muted. Having a wide customer base means that if one decides to do something else, it is not a huge loss.
- Plant staff mentioned they generally approach the operation with a business mindset and try to operate to keep the customers happy and coming back for more. Said several times that the customer spreading the word is the best marketing tool. Staff is also creative about thinking of new mixes, alternative sources, etc.
- PFAS: Meso and thermophilic digestion process does not remove PFAS from biosolids. TAGRO staff has been closely following the national and local research and regulatory trend regarding biosolids PFAS. A testing regimen is in process to determine the levels of PFAS within the TAGRO. Fate and transport models are in the works, which will be used by EPA. The main concern involves the producers of PFAS and source control.

DC Water's Bloom Program Meeting Notes

Date:	March 22, 2022
Project:	Central Kitsap WWTP Class A Biosolids Evaluation
Notes By:	Patrick Davis, PE; Miaomiao Zhang, PE, PMP; Kim Marshall, Murraysmith
Re:	DC Water's Blue Drop Bloom Program
Interviewed with:	Chris Peot, PE, Director of Resource Recovery, DC Water April Thompson, Director of Bloom Marketing, Blue Drop, DC Water

Production Overview

- Approximate Amount of Biosolids Produced: DC Water produces about 160,000 wet tons of Class A biosolids per year. In 2021 about one third of it, 48,000 tons, was sold as Bloom to farmers, landscapers, soil blenders, and homeowners. The remaining two third of it was hauled away by paid contractors for land application.
- Biosolids Process: The Class A biosolids are produced through the batch thermal hydrolysis process (THP) and mesophilic anaerobic digestion. The biosolids are then dewatered to approximately 32% total solids (TS). A small percentage of Bloom (~ 15 percent) is blended with bulking agent for sale to landscapers.
- Bulking Agent Used: Sand, woodfines, hardwood fines.

Associated Cost Benefits

- The pre-blended Class A biosolids, Bloom, sell for $10/ yd plus a hauling fee. The blends are sold for $20/ton and a minimum delivery fee of $200. During winter the Bloom hauling is subsidized to $1/ton.
- Overall Costs and Income: Bloom does not produce any income for the plant; however, it reduces the costs associated with biosolids management. Approximately 75% of the costs to treat the solids is recouped by Bloom sales. The old solids program costs the plant $20 M/yr. The current program costs the plant $5M/yr.

Marketability

- Bloom is a popular and consistent product that is able to meet DOT specifications for landscaping, as well as, the needs of individual buyers and soil blending facilities.

- The plant began its Class A program approximately 7 years ago. There was a 2-year startup period when the facility needed to prove that the biosolids were meeting vector and pathogen reduction. The Bloom product has been on the market for approximately five years.
- Bloom's original marketing approach involved sending people out to contact various user groups. These groups included mid to large-scale farmers, individual households, and soil blenders. Much of the initial marketing effort was "cold calling". Additional marketing involved tabling events at conferences. In general, the marketing approach was similar to TAGRO's approach. In the last four years Bloom has hired dedicated sales people with connections in the landscaping and farming communities to market and sell the product.
- One key to success was the development of cool hats and logos (tongue-in-cheek remark, but it does have validity).

Additional Items

- Distribution: Bloom is distributed in three ways. Customers can pick it up themselves; Bloom has in-house delivery service for smaller, local customers; or they utilize third-party delivery services for larger deliveries.
- Regulations: There are some county and state regulations that restrict how the Bloom/ Class A biosolids are distributed.
- Long Term Contracts: The nature of the Bloom product is such that long term contracts are not typical. Demand rises and falls with the season, so there is little incentive for large scale soil blenders, farmers, and contractors, to take on a long term delivery contract. The Bloom program is also still in its early years and the marketing team does not believe long-term contracts would benefit the program at this stage. They fear "leaving money on the table" if they sign long-term contracts now and prices rise in the future. Bloom did previously have one long-term contract with a whole-sale garden supplier, but the garden supplier did not follow through on the terms of the contract and the contract was severed.
- Future Plans: The main goal for the future is to have a better handle on the inventory of the Bloom / Class A biosolids. This involves increasing the storage capabilities for the solids. Blue Drop is currently in the process of purchasing a farm in Maryland to store the solids during winter months. Additionally, there are plans to purchase specialty loading pads to allow deliveries onto farmland during the wet, winter season. These pads prevent damage to the farm fields making the customers more amenable to receiving deliveries during wetter months.
- Odors: The product has some odors, but they tend to be caused by ammonia, which is not as offensive as odor caused by sulfide.

City of Missoula Garden City Compost Site Visit Notes

Date: April 6, 2022

Project: Central Kitsap WWTP Class A Biosolids Evaluation

Notes By: Jeff Moss, PE, Murraysmith

Re: City of Missoula Composting Site Visit

Production Overview

- Approximate Amount of Biosolids: 2,100 dry tons/yr
- Approximate Amount of Compost: 18,000 wet tons/yr or 26,000 cy-yds/yr
  - Also incorporates (estimate only, not actually weighed):
    - ~1,900 tons of organics/municipal compost collection
    - ~12,000 tons of leaves
    - ~6,700 tons of brush
- City currently distributes over 100% of annual compost production as they purchased the facility in 2016 with huge stockpiles on site and have been working to reduce the backlog of excess compost.
- Class of Solids Used: Missoula WWTP uses anaerobic digestion followed by dewatering with either a belt press (preferred) or centrifuge. The dewatered sludge is conveyed over the fence to the composting site, approximately 13-15% total solids
- Bulking Agent Used: Chipped brush, sawdust, lumber
  - Accept woody brush, dimensional lumber (untreated, unpainted, <6ft long) and chips in their own chipper to generate woody bulking agent. Cost is $7/10 cu-yd to dump. Fee basically just pays for inspection – people will try to dump all kinds of stuff.
  - Also accepts clean sawdust from mills at no cost.
  - Accept brewery waste and food waste, not for bulking agent but provides a public service. Not 100% sure about cost but believe it is the same as for woody materials.
- How it is created: Bulking agents are accepted and dumped near the entrance, where they are chipped in a 'tub grinder' and stockpiled. Organic food waste and brewery waste is accepted and 'chipped' here also to blend it in. Sawdust and biosolids are stockpiled

separately near the mixer. Biosolids are mixed at a 3:1 ratio with bulking products in the mixer, which creates a homogenous product ready for composting. Composting is aerated statice pile, done in bays constructed of ecology blocks with above ground aeration pipework. Entire operation is 'bare ground' on dirt without concrete or gravel base. They are working to change that but grandfathered in with DEQ. Raw compost pile is topped with finished compost to help contain odors (pretty effective). The site only gets a few odor complaints on hottest days of summer. Usually the WWTP smell is worse. Compost for about 4 weeks, then screened in a trommel screen. Screened compost is 'cured' for 1-3 months before it is sold. Trommel screens remove large debris which is reused as bulking agent. All material movement after acceptance on site is done with several large front loaders.

- Required Labor: 10 people are employed, full time. They are responsible everything, from marketing to accepting incoming wood debris to loading products into totes.
- End Products:
  - Compost ($26/cy-yd, discount for large volumes)
  - Enriched Topsoil – topsoil + 25% compost ($40/cu-yd)
  - Topdressing – fine screened compost, good for direct placement into grass and golf courses ($35/cu-yd)
  - Potting Soil – Compost mixed with mulch, peat moss, and pearlite ($65/cy-yd)

Associated Cost Benefits

- Products are available to the public, private resellers, and landscapers/contractors. Can be picked up from the plant in bulk or totes. Distribute widely to nurseries and landscaping suppliers regionally within a couple hour drive. Occasionally used for large restoration projects even further. There is not much local competition so they can set the price. Working to see if agricultural operations are interested, but location is a challenge.
- Overall Costs and Income: Garden City Compost is a recent acquisition by the City, before that it was operated as a private company that was paid to accept the biosolids. The Composting operation is 'revenue neutral' when considering previous cost to dispose biosolids. They make roughly $600k in revenue and provide $450k in 'biosolids disposal service' value (which is roughly $32/wet ton of biosolids). Additionally divert a lot of compostable material from the landfill, which is viewed as a benefit and service to the public. City wastewater rates are the lowest in the state (did not verify this).

Marketability

- Garden City Compost products are pretty popular, and they are working into the stockpile.
- Eko Compost began in the 1985 and the City bought the facility in 2016. People are very familiar with the product but since the City purchased they have been working to expand

the market to address the stockpile. There are occasional minor concerns over 'non-organic' nature of the compost and metals/chemical concentrations.

Additional Items

- Sourcing bulking material: Accepting and processing woody debris from the public presents some operational challenges but alleviates sourcing issues.
- Organic composting: Garden City Compost also accepts food waste from local municipal composters (Missoula Compost Collection) and businesses (primarily Walmart). This is a relatively small % of the total but provides an additional service. BPI certified compostable materials has been a huge help to make sure these materials can be processed.
- Operational Challenges: Nothing too bad. The stockpile is a concern but they are working on reducing it. Equipment needs maintenance and repair regularly, but that is expected and accounted for. Inspection of public drop off is key, people will try to dump crazy things (for example, a transmission hidden in grass clippings). Also hoping to improve SCADA integration so pile temp can be monitored remotely.
- Site Requirements: The entire lot is about 35 acres, but they only use probably 12-15 actively, the rest is stockpiled compost or not used. As mentioned previously, they are working on getting funding to add concrete pads to the site to help reduce rocks and make the operation cleaner.
- PFAS: Staff is closely following PFAS regulations but has not done any testing yet. Planning to begin once an EPA method is finalized because they don't want varying methods to affect results.
- Site is also used for a couple other things – glass recycling transfer station (since Republic Services will not do this at landfill) and hosting an experimental fungi degradation of particle board with local group.
- Generally got the feeling that the operators have a lot of passion for the operation and take pride in providing valuable services for the community. Flexibility to try new things and seem well supported by WWTP management and City.
- Hamilton has a good small-scale operation. Coeur d'Alene also has a nice operation.

Composter Survey Summary
Class A Biosolids Technology Analysis
King County
20-2900.07

Facility	Product	Location	What is the approximate weight of biosolids you treat annually (dry, or, if wet at what % solids)?	What type of process do you use (ex. Aerated piles, windrows, etc.) and are you producing a Class A product?	What types of bulking agent (wood chips, hog fuel, yard waste, etc) do you use and where do you obtain it?	How do you dispose or reuse the product? What are the costs or incomes you generate from this?	What is the approximate level of labor that the composting process requires?	What major operational challenges have you encountered?	Have you encountered concerns from the public about use of the compost?	Are there other considerations or advice you would give to another utility considering Class A reuse?
Centralia WWTP	Compost	Centralia, WA	70 dry tn/yr	Aerated static piles	Ground woody debris. The local land fill has a yard debris program (not grass clippings) that they grind and use.	Sell to the public at our WWTP plant for $10/ yard loaded. Also have a bin at a local park that is stocked for people to self-load free of charge. If they run out of room at the plant, the department owns a 400 acre farm that they can land apply. However recent history of selling out of material. Last year sold 1068 yards at $10/yard for a total of $10,680.	1 FTE	No real major operational challenges. There has been a few occasions where feed stocks (woody debris) have been hard to come by.	Initially there were concerns by the public. Public education played a big part of easing the concerns. Created flyers, did presentations at city council meetings and the local newspaper wrote an article on the benefits of composting biosolids. Also had a garden at the treatment plant where we grew vegetables. Then had them tested alongside store bought vegetables and made the results available. The vegetable grown in our compost in many cases had lower levels of pharmaceuticals and metals compared to store bought.	Do your research. Tour other municipal facilities. Send staff to the Compost Facility Operator Training through the Washington Organic Recycling Council. Build your facility/purchase equipment the best your budget will allow. Future upgrades can be challenging both logistically and financially.
Cheney WWTP	Compost	Cheney, WA	212 dry tn/yr	Aerated static piles	1,000 yards Hog Fuel, 13,977 yards yard waste. The current hog fuel supplier is Idaho Forest Group, LLC. Yard waste is collected at a drop off site from our residents free of charge.	Resale to the public at $14.00 per yard. Approx. 2900 yards @ $41,000 per year revenue.	3,500 man-hours were dedicated to the composting operation for hauling, monitoring, mixing, grinding, screening, loading, and equipment maintenance.	Biggest challenge is the ongoing degradation of equipment in the composting building, the maintenance to the mixers and compost screen and rolling stock.	Initially in 1995 when they started producing the biosolids compost it was a challenge to over come the negative attitude from the biosolids human source. Within a couple years, word of mouth got out as to how good the compost was and quickly turned the compost into a hot commodity. They sell all our production each year just by word of mouth and repeat customers.	Individual municipal operation can be expensive to set up and operate initially. Investigate the possibility of joining other entities in a shared facility if possible. Return on sales offsets some costs of operation. Overall annual debt service and operational costs are less than the anticipated annual combined disposal costs of the biosolids and the yard waste that the citizens would occur.
Lynden WWTP	Compost	Lynden, WA	63 dry tn/yr	Aerated static piles	Hog fuel	Sell to the public and provide a "free" loading day to citizens. Calculating compost-only costs have been a challenge and they are making efforts to improve this. Our cost estimation for 2020 was $55,000, revenue was $16,500	Approx. 1 FTE	Labor, equipment O&M	Minimal concerns today. There may have been more questions and concerns 20 years ago. Most customers know what they are getting and understand that it is safe.	Very resource and labor intensive. Boulder Park is a simple, cost effective solution. That being said we appreciate having multiple options for disposal and find value in producing a value-added product to our community.
Port Townsend WWTP	Compost	Port Townsend, \	213 dry tn/yr	Aerated static piles	Use ground yard waste for our bulking agent. We get it from the public bringing it to us. Also we have yard waste collection inside the City of Port Townsend through D.M. Disposal as part of the garbage contract.	Sell all of the compost in bulk to the public, @ $12.00 per yard unless you buy 10 yards or more at a time then it is $9.00 per yard. Usually make between 3500 and 4000 yards a year.	3 FTE	Problems come up, but nothing major	Occasional resistance but generally well accepted.	"My opinion is this is the best thing we can be doing with the bio-solids we all create."
Richland WWTP	Compost	Richland, WA	4,940 wet tons/yr	Aerated static piles	Yard waste from self-haul and curbside collection	Sell some @ $15/tn. Charge to accept greenwaste so process is revenue neutral.	1 FTE	Maintaining appropriate moisture content, fire during certain times of year, marketing product.	Only occasional questions.	Dust and odor may cause concerns in more heavily developed areas.
Westport WWTP	Compost	Westport, WA	6 wet tons/week @14% solids	4x12,000 lb in-vessel containers, but also spread on ground to reduce moisture. Yes it is class A. Designed by Engineered Compost Systems	Wood chips and sawdust to dry out. Woodchips are dropped off by local wood chippers. Sometimes the plant staff go to nearby forest to chip standing deadfall wood if they run out	Sell to public, also used by parks department and maintenance. Will load public container or truck, or deliver whole dump truck load if requested. Generates about $6-8k/yr.	Minimal labor. Total staff is 4 people, 1-2 people responsible for the whole plant. Roughly 25-50% of one person time on compost. Have augers to convey solids	Solids from screw press are too wet. Major challenge to dry out. Otherwise not too bad.	Only concern from public is that there is not enough compost to meet demand.	Be careful with machinery selection. Screw press is really a headache. Mixer is from Luck in Canada and has been great

murraysmith

APPENDIX B

Pierce County Chambers Creek WWTP Fertilizer Manufacturing Facility SoundGRO Site Visit Notes

Date:	February 22, 2022
Project:	Central Kitsap WWTP Class A Biosolids Evaluation
Notes By:	Patrick Davis, PE; Miaomiao Zhang, PE, PMP; Jeff Moss, PE, Murraysmith
Re:	Chambers Creek WWTP SoundGRO, Pierce County WA
Interviewed with:	Karla Guevarra, Wastewater Operations Program Manager, Pierce County Jon Kercher, Wastewater Operations Supervisor, Pierce County Jeremy Carnahan, Wastewater Operations Supervisor, Pierce County

Production Overview

- History: The Fertilizer Manufacturing Facility (FMF) at Pierce County's Chambers Creek wastewater treatment plant started in 2006. Before 2018, the facility dried almost 100 percent of biosolids produced at the plant and sold them to several large fertilizer manufacturers and soil blenders, such as Marion Ag, Simplot and Wilbur-Ellis. One of manufacturers' facilities caught a fire in 2017 and attributed the cause to SoundGRO product, therefore stopped SoundGRO purchase for several years. The demand for SoundGRO in recent years has been dropping.
- Approximate Amount of Biosolids Produced: 2,500 dry tons per year out of the plant. Approximately 40% is used to produce SoundGRO. The remaining Class B biosolids is hauled to Boulder Park for land application. The production is based on the demand for the year. Some years it is higher. Some years it is lower.
- Class of Solids Used: Pierce County Chambers Creek plant has mesophilic anaerobic digestion process to produce Class B biosolids. The digested biosolids is dewatered in one of two Andritz centrifuges. A portion of dewatered Class B biosolids is converted to the dried pellets through an Andritz thermo drying system. The dried pellets are Class A biosolids with exceptional quality per EPA Part 503 regulation and Pierce County markets this product as a fertilizer using a trade name of SoundGRO.
- Bulking Agent Used: None/ The SoundGRO is often sold to other manufacturers to produce a mixed product, but the plant does not mix any product itself
- How it is created: The biosolids are digested in a typical mesothermic anaerobic digestion process creating Class B solids. The solids are then dewatered using a centrifuge. This takes

the sludge to approximately 18%-20% TS. The cake is then sent through a drying process to produce the Class A pellets. The pellets are then sent to a silo for storage prior to bagging and distribution.

- Required Labor: The maintenance and operation of the SoundGRO facility is integrated into the rest of the plant operations. It is difficult to extract the FTEs of SoundGRO from the rest of the plant. The minimum assumption is the 2 FTEs are required; however, this is likely not all encompassing of the true needs of the facility.
- Operation of Dryer: Due to the limited demand for SoundGRO, the dryer is only operated for about six months in a year, usually in the winter/spring to match the high demand fertilizer season. During the operating season, it runs about 4 days a week depending on the storage of final product silos and the wastewater treatment plant operation. Although the burner in the drying system is designed to use up to 80 percent of biogas and 20 percent of natural gas, in reality, approximately 50 percent of each type of gas is used to meet the heating BTU requirements.

Associated Cost Benefits

- SoundGRO is sold for \$300/ton when sold in 50lb individual bags, or it is sold for \$88/ton when sold in one-ton totes. The 50 lb bags are sold in bulk (40 bags per pallet). There is no small-scale sale of SoundGRO. Most consumers are mid to large scale soil blenders with some sale to mid-scale nurseries.
- Overall Costs and Income: SoundGRO does not produce any income for the plant; however, it reduces the costs associated with biosolids management. Minimal information is available regarding discrete numbers as the amount of production changes year over year.
- Class B biosolids Boulder Park hauling and tipping cost is approximately \$66/WT or approximately \$2,000 per truck.

Marketability

- SoundGRO is a lesser known product. It is integrated directly into the plant and there is minimal marketing. The plant has never "sold out" of the product due to lack of biosolids feedstock. There have been instances where supply (and production rate) has been temporarily outpaced by demand.
- SoundGRO has not done much marketing. No budget for it.
- When SoundGRO was first getting started, they did some marketing and distribution to the public, however, this strategy was abandoned in favor of distributing to large scale users due to the lower overhead required. Marketing effort was also affected by retirement of key personnel and the decision to not hire to replace the role.
- SoundGRO is a registered fertilizer in 3 states with N-P-K (Nitrogen-Phosphate-Potassium) ratio of 5-5-0. Due to some historical legal issue around the design of the bags, SoundGRO bagged product cannot be sold in the large hardware and garden stores like the Home Depot.

- The County has used the Facebook posts and the giveaways events as ways to market the product. They gave away about 70 tons last year, which was an increase from about 42 tons the year before. There is some interest in increasing efforts to distribute to the public, however, the County is hesitant to make marketing or capital improvements a priority.

Additional Items

- Operations and Maintenance: The drying equipment has a full preventative maintenance schedule, and an Andritz representative visits the plant every year to perform checks of the equipment. The bagging system allows 2 people to bag about 2-3 tons/day.
- Operational Challenges: The facility runs the dryer on a schedule of 4 days on 2 days off starting in mid-winter through mid-summer – depending on demand. If the dryer is off for too long, it requires a lot of additional maintenance to bring it back on-line. During off season, the dryer is brought online periodically to prevent these excessive maintenance issues from cropping up. Plant staff mentioned several times the importance of diversity of treatment/disposal methods, and flexibility and redundancy with operations.
- Site Requirements: The SoundGRO facility sits within Peirce County's WWTP. It requires a three-story building at approximately 11,000 square feet. Pallets of SoundGRO are stored in equipment bays nearby until they are picked up by end users.
- Public Pushback: None to speak of, yet the product is not heavily marketed – little exposure
- PFAS: The dryer does not operate at temperatures required to degrade PFAS
- Of Note: When writing the report it is important to consider the human cost of hauling the biosolids. Approximately 1 truck driver dies each year during the Class B biosolids hauling over the pass during wintertime.
- Large scale blenders use SoundGRO as a component of their own fertilizer mixes. Each of the three main users are located in Oregon, so the process is only reducing the hauling required for disposal because the dry material is lighter so more solids can be moved in each load.
- The fire at Simplot and the reduction in ability to dispose when they halted operations caused considerable problems with storage of finished SoundGRO at the plant. They were storing pallets everywhere they could.
- Permitting: When the dryer was first installed there were less stringent air permitting requirements. This is likely changed.
- Haven't needed to land apply dried pellets. The spreading equipment for Class B biosolids cannot be used to spread dried pellets.
- The plant has boilers that can use both natural gas and biogas. However, it stopped feeding biogas to the boilers since last winter because the biogas contains very high level of H_2S which will cause corrosion to the boilers. Except being used for the dryer burner for half a year, the rest of biogas is flared. The County is trying digester micro-aeration with an attempt to reduce H_2S in biogas.

- The driers burners can be designed to use natural gas and/or alternative fuel sources, including digester gas, hog fuel, the pellets themselves, or other materials that can be burned to generate the required BTUs. The plant uses a combination natural gas and digester gas burner, which operates at about 50% of each by volume, and about 70% of the BTUs from natural gas.
- The Andritz centrifuges posed lots of challenges to the plant. After a recent rebuilt, those two units can still only produce 18-19% cake. The County staff is not very pleased with Andritz's service related to the centrifuges. Andritz provides annual inspection of the dryer system and staff does like the inspector who does that work. Not that happy with the company overall.
- Fire hazard related to the equipment and the dried pellets is something needs attention. Equipment at several drying facilities caught on fire in the past, i.e. Snoqualmie WWTP, WA and Sand Island WWTP, HI. The County staff also mentioned pellets need to be stored with caution to prevent fire. A pallet of SoundGRO caught on fire a few years ago during hauling, the plant got a call from the police department responding to determine if it was hazardous.
- Milwaukee has a similar product – Morganite – but they have invested more in marketing and public distribution.

Irvine Ranch Water District Michelson Water Recycling Plant Site Visit Notes

Date of Site Visit:	March 9, 2022
Project:	Central Kitsap WWTP Class A Biosolids Evaluation
Notes By:	John Thayer, PE, Murraysmith
Re:	Irvine Ranch Water District, Michelson Water Recycling Plant Site Visit, Irvine, California
Interviewed with:	Scott Toland, PE Senior Engineer, Irvine Ranch Water District

Key Process Parameters:

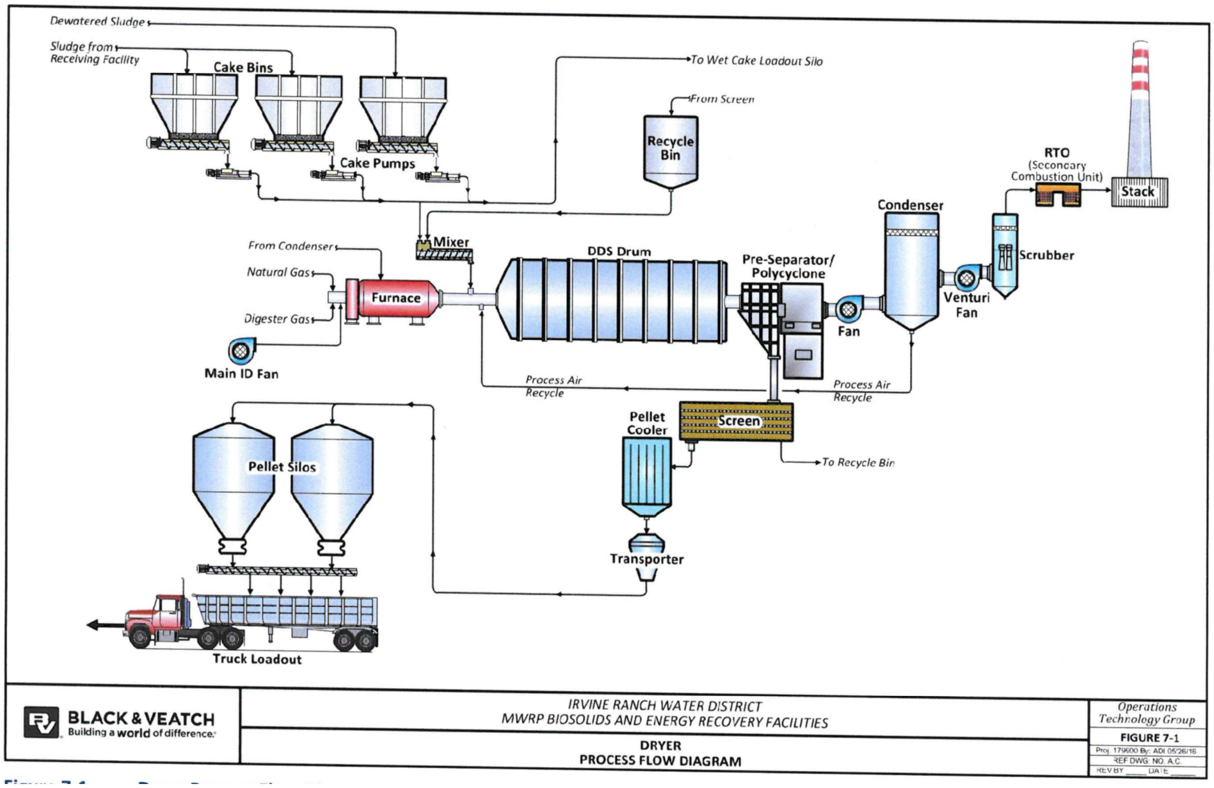
- Michelson Water Recycling Plant (WRP) is a 28 MGD-capacity tertiary wastewater treatment plant which produces recycled water. The anticipated ultimate build-out capacity is 33 MGD.
- The biosolids thermal drying equipment is sized to handle up to 57.5 dry tons per day of dewatered cake feed. However, the estimated build-out maximum-month digested sludge production at Michelson is 67,000 lbs/day of dry solids, which equates to 33.5 dry tons/day at the projected build-out plant flow of 33 MGD.
- The biosolids process train includes:
    - Centrifuge thickening of combined primary + waste-activated sludge
    - Acid-phase digestion in circular digesters, followed by methane-phase digestion in egg-shaped digesters.
    - Centrifuge dewatering, followed by trucking of Class B biosolids to Cynagro in Bakersfield, California.
    - When the thermal dryer is operational, Class B biosolids are converted to Class A pellets and then blended on-site with Class B biosolids being trucked to Cynagro. Currently, the plant has no beneficial local use of the Class A biosolids, with the only tangible benefit of thermal drying being volumetric reduction of sludge and thus reduction in the number of truck loads. IRWD has an interest in local sale and distribution of the Class A biosolids, but currently there is no developed market for this.
- The thermal drying system is designed for the following parameters:

- Dewatered sludge cake solids content: 20 to 26% TS
- Dried pellet solids content: 92% TS
- Dried pellet mass flow: 5,147 lb/hr
- Water evaporation rate: 13,320 lb/hr
- Dry Cake Feed Rate to Thermal Dryer (from Equipment Specification): 40.6 to 57.5 dry tons/day

Project Timeframes:

- It took 9 years to construct the new Sludge Thickening, Digestion, Dewatering, Thermal Drying, and Energy Recovery Facilities. The facilities allow the Michelson Plant to process its own biosolids instead of relying on the old method of sending unprocessed primary and secondary sludge to Orange County Sanitation District, a neighboring agency. The thickening, dewatering, and thermal drying facilities at the Michelson Plant are housed in a large, new, high-bay masonry building. The energy recovery microturbines and odor control facilities are located outside the building at grade. The digesters were constructed on a separate footprint adjacent to the building. The facilities were designed by Black and Veatch. The construction contract amount including change orders was approximately $185 Million. The thermal drying facilities were a pre-negotiated portion of the construction contract, with Andritz as the system supplier. IRWD attributes the long construction duration to delays caused by the Contractor. There was litigation on the project. Nevertheless, the biosolids facilities started up about one year ago.
- In the last year since start-up, Andritz operated the thermal drying facility for the first 7-8 months, followed by IRWD operation for 2 months, followed by the most recent 2-month period of non-operation. The thickening centrifuges, digesters, and dewatering centrifuges remain in continuous service. At the time of the March 9 site visit, the thermal dryer was not operating. During periods of non-operation, IRWD evacuates the drying drum and other system components of dried or partially dried solids. Reasons for non-operation are detailed below.

Process Flow Diagram of Thermal Drying Facilities:



Key Issues and Challenges Experienced by IRWD with New Facility Operation:

- Since start-up about one year ago, the facility has had 7 to 8 smoldering events. The smoldering events occur when the dried pellets are allowed to sit too long and heat up over time. During the most recent smoldering event, the heat from the pellets caused the seals to fail in the pellet cooler outlet valve. As IRWD did not have a spare outlet valve, the system had to be shut down while a new outlet valve was ordered. IRWD attributes smoldering to high iron content, with the possibility that ferric chloride addition on the liquid side contributes to the iron content. Air leaking into the system and the presence of human hair are also potential contributing factors to smoldering, according to IRWD.
- Excessive dust build-up became an issue during the 2-month period that IRWD operated the thermal drying facility. IRWD reports that smoldering is the main cause of dust. Operators report that accessing dust laden surfaces was difficult, as the thermal drying equipment is very tall and inaccessible in places. Operators had to go up on a scissor-lift to vacuum difficult-to-reach surfaces. The facility was built with a common, hard-piped vacuum piping network that operators can tap into with vacuum hoses.
- Build-up of human hair fibers within the thermal drying system is a recurring issue.
- The foul air piping for the entire biosolids building is linked together. Solids from the thickening centrifuges have leaked into the centrifuge vent pipes and have migrated to the foul air piping in the entire building. IRWD has initiated recent contracts to add new access ports to the foul air piping, CCTV the piping, and clean the piping.

- To aid in start-up, the facility was designed and outfitted with a cake bypass line which allows dewatered sludge received at the inlet cake bins in the thermal drying area to be bypassed to a Class B loadout silo when the thermal dryer is not operational. This cake offload line is “too long” according to IRWD and has become plugged with biosolids.
- During start-up, the Thermal Oxidizer (a device which burns the exhaust air from the dryer) had issues with lining bricks delaminating from the inside wall of the oxidizer unit. IRWD said that Gulf Coast Environmental, the subcontractor to Andritz responsible for supplying the thermal oxidizer, was responsive in terms of coming to the site multiple times to fix the issue.
- The gas microturbines (manufacturer: Capstone), which generate electricity from digester gas, are currently non-operational due to condensate migration from the chillers. Currently, all of the digester gas is being flared with a single flare. IRWD plans to re-start the microturbines in the coming weeks.
- When the thermal dryer is operational, it can only operate at 50% capacity. The reason is that cooling water from the Venturi air scrubber system is dust-laden and for water quality reasons cannot be discharged to the on-site stormwater retention pond. As a result, IRWD has to divert this waste stream to the headworks, but the piping for the diversion to headworks is not adequately sized. The dryer can only run at 50% volumetric capacity, to limit the flowrate of spent cooling water discharge from the air scrubber system back to the headworks.

Energy:

- The thermal dryer is fueled by natural gas, and the unit is also designed to operate with a fuel mix containing up to 30% biogas. The 30% maximum biogas threshold is based on the need to maintain a minimum required BTU content in the fuel feed.
- The microturbines, when operational, are capable of supplying electricity for between 50% and 80% of the electrical demand for the entire biosolids facility. The microturbines are sized to consume most of the digester gas currently produced. Each microturbine has a heat exchanger for heat recovery. As a secondary use for biogas, IRWD has the ability to fuel hot water boilers, although the preferred mode of operation is to send digester gas to the microturbines.

North Shore Water Reclamation District Biosolids Recycling Facility Phone Interview Notes

Date:	May 11, 2022
Project:	Central Kitsap WWTP Class A Biosolids Evaluation
Notes By:	Patrick Davis, PE; Miaomiao Zhang, PE, PMP, Murraysmith
Re:	North Shore Water Reclamation District Biosolids Drying
Interviewed with:	Steve Waters, Director of Engineering NSWRD Dave Swarthout, Project Manager, Veolia Peter Dorn, Operations Supervisor

Production Overview

- Biosolids Treatment Process: This stand-alone Biosolids Recycling Facility receives and treats solids from three treatment plants owned and operated by NSWRD. Two of the plants do not have digestion process. The raw sludge is dewatered to ~ 18% solids content before being trucked to the Biosolids Recycling Facility. These undigested sludges are approximately 80% of the total solids loading to the facility. The third plant has mesophilic anaerobic digestion. The digested and dewatered sludge (at ~ 20%) is trucked to the Biosolids Recycling Facility. Enhanced biological phosphorous removal (EBPR) is done at all plants. There are two receiving bins and a 3-day-storage on-site storage silo at the Biosolids Recycling Facility. There is one Andritz fluid bed dryer system that is normally running continuously except during the downtime for maintenance. The final product is ~ 92 to 93% solids content. The facility has been operating for approx. 15 years. NSWRD contracts Veolia to operate the facility.
- Approximate Amount of Biosolids Processed: ~9,000 dry tones per year from three plants.
- Product Market: Veolia contracts with a hauling company to haul away and land apply the dried pellets to the farm field. Veolia pays the land application and hauling fee. No revenue. The dried pellets are used solely for mid to large-scale agriculture. There is enough farmland in the Midwest with sufficient demand for the Class A biosolids. The odor of the pellets is strong, which limits the public acceptance for use in the small-scale farm or gardens.
- Bulking Agent Used: No Bulking agent is used. Mineral oil is applied to the solids after bulk loading. This is intended for dust control. Dried pellets are applied directly to the fields

- Issues With the Product: There have been several smoldering incidents. Rarely the product has caught fire. This is due to the nature of the dried pellet as well as the feedstock. The WAS has a lot of volatile organics within it, which tends to be more reactive. Additionally, the pellets have an odor associated with them due to the undigested nature of the feedstock. Plant staff has noticed that more stringent screening of the upstream wastewater flows reduced smoldering incidents.
- Required Labor: The facility is operated by Veolia under a contract operation. Veolia has 8 full time equivalents staff at the facility. This includes four operators with one "floating" operator, one dedicated maintenance person, one project manager, and one assistant project manager. The facility began with 12 people, but they found ways to drop the number of operations personnel without sacrificing operability and maintenance.
- End Products: 92%-94% Class A pellet at approximately 4:5:1 NPK (nutrient value)

Associated Cost Benefits

- The process has had the result of reducing the costs associated with biosolids management; however, they are not making any direct revenue from the process.
- Veolia has a contract with biosolids distributors. The costs associated with these contracts are confidential, and we were unable to obtain a range of values.

Marketability

- The dried pellets are not available to the public. No marketing on that front has been made.
- Due to the contract with Veolia, minimal information on the marketing strategies were made available to us.

Additional Items

- Sludge Characteristics: The sludge that they are running through the dryer tends to be sticky. The sticky sludge tends to stick to and plug the heat exchanger tubes reducing efficiency through the dryer. Plant staff have found that aging the sludge (or using aged sludge) improves operational efficiency.
- Extensive Maintenance: Due to the plugging of the heat exchanger tubes, the dryer requires shutdown and cleaning about once per week during the winter months. During summer, cleaning occurs about once per month. The cleaning cycle takes approximately 17 to 36 hours including shut down, cool down, cleaning and startup. The actual cleaning takes about 10 hours each. They typically clean it on Thursday and run it through the weekend. This level of maintenance is considered preventative.
- Runtimes: The dryer runs constantly except during cleaning. They do not operate it solely remotely. They are always staffed while it runs
- Redundancy: The plant has one dryer – no redundant dryer. During cleaning operations solids are stockpiled and mixed in their storage silo

- Fuel and Ancillaries: The dryer utilizes natural gas for its thermal energy. Thermal fluid is oil. The plant does not have heat recovery, but they are intending to install heat recovery – not by Andritz.
- Permitting: They do have an air permit, but it is not Title V. It is a state operating permit. All the air for the drying process is closed loop. The only emissions are associated with the burning of natural gas.
- Odor Control: The building operates a wet scrubbing odor control unit.
- Andritz Customer Service: The operations staff seemed reasonably pleased with Andritz's customer service. They mentioned that the folks working there genuinely want to find a solution to their problems, but they are a bit closed with their information. The facility tends to do their own modifications and maintenance. They have not recently needed Andritz.
- General Feeling About the Equipment: Operation staff report that the equipment feels safe and reliable. Critical equipment has redundancy and spare parts. Beyond normal wear and tear, the facility has run well. The main issues with the equipment have been with the dust collection system and the dryer solids mixing system. Both systems have caused problems requiring facility staff to make changes. The routine cleaning of the equipment is a very labor-intensive process.

murraysmith

APPENDIX C

Option A: Composting (Conservative Scenario)

Project Cost Estimate		
Clearing and Grading		$ 87,120
System Cost Estimate		$ 2,000,000
Contractor Install	20.0%	$ 400,000
Concrete Slab		$ 324,000
Gravel Work Area		$ 56,628
Roof Covered Strucutre and Concrete		$ 1,512,000
Construction Material&Labor Subtotal		**$ 4,379,748**
General Conditions	8.0%	$ 350,380
Mobilization/Demobilization	10.0%	$ 437,975
Overhead & Profit (OHP)	12.0%	$ 525,570
Construction Bid Subtotal		**$ 5,693,672**
Sales Tax	9.2%	$ 523,818
Contingency	30%	$ 1,708,102
Total Costructon Cost		**$ 7,925,592**
Engineering, Legal, and Administration	25.0%	$ 1,981,398
Total Project Cost		***$ 9,906,990***
Rounded Total Project Cost	-4	**$ 9,910,000**

Key
Input
Input Reference
Calculation

Lifecycle Analysis Assumptions	
Analysis Start Year	2022
Planning Horizon (yrs)	20
Discount Rate	3.0%
Biosolids Production (Dry TN/Yr)	1300
Labor Cost ($/hr)	$ 60.00
Weekly Labor Hrs	120
Loader Cost ($/hr)	$ 50
Weekly Loader Hrs	24
Centrifuge Solids Content	23%
Electrical Usage (kWh/Yr)	56522
Electricity Cost	$0.10
Compost Program Labor Cost	$ 60
Weekly Labor Hrs	20
Bulking Agent Cost ($/CY)	$ 30.00
Bulking Agent Density (lb/CY)	500
Compost Sales ($/YD)	$ -
Solids Content	65%

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000	2022	100	0%
Wheel Front Loader	$300,000	2022	30	0%
Mixer	$350,000	2022	30	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Cover Replacement	$50,000	2029	7	0%
Labor	$436,800	2023	1	0%
Loader Operation	$62,400	2023	1	0%
Bulking Agent	$78,000	2023	1	0%
Screening Rental	$10,000	2023	1	0%
Power	$5,652	2023	1	0%
Maintenance	$15,000	2023	1	0%
Software & Support	$16,000	2023	1	0%
Compost Sales	$0	2023	1	0%

Construction Costs	Estimated Present Cost	Year of Next Event	Frequency/ Design Life	Additional Cost Escalation Factor	Count Check	Sum of PV
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000.00	2022	100	0%	1	$ 9,910,000
Wheel Front Loader	$300,000.00	2022	30	0%	1	$ 300,000
Mixer	$350,000.00	2022	30	0%	1	$ 350,000
					Subtotal Present Value of Costs	**$ 10,560,000**
Operation & Maintenance Costs	Estimated Present Cost					
Cover Replacement	$50,000.00	2029	7	0%	2	$ 135,938
Labor	$436,800.00	2023	1	0%	19	$ 11,129,654
Loader Operation	$62,400.00	2023	1	0%	19	$ 1,589,951
Bulking Agent	$78,000.00	2023	1	0%	19	$ 1,987,438
Screening Rental	$10,000.00	2023	1	0%	19	$ 254,800
Power	$5,652.17	2023	1	0%	19	$ 144,017
Maintenance	$15,000.00	2023	1	0%	19	$ 382,200
Software & Support	$16,000.00	2023	1	0%	19	$ 407,680
Compost Sales	$0.00	2023	1	0%	19	$ -
					Subtotal Present Value of Costs	**$ 16,031,677**
					TOTAL NET PRESENT COST	**$ 26,591,677**

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
Gore Composting System (Bunkers, Cover, Winder)	$ 9,910,000	-	-	-	-	-	-	-	-	-
Wheel Front Loader	$ 300,000	-	-	-	-	-	-	-	-	-
Mixer	$ 350,000	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ 10,560,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	-	-	-	$ 65,671	-	-
Labor	-	$ 474,967	$ 516,469	$ 541,540	$ 557,313	$ 562,724	$ 568,187	$ 573,704	$ 579,274	$ 584,898
Loader Operation	-	$ 67,852	$ 73,781	$ 77,363	$ 79,616	$ 80,389	$ 81,170	$ 81,958	$ 82,753	$ 83,557
Bulking Agent	-	$ 84,816	$ 92,227	$ 96,704	$ 99,520	$ 100,486	$ 101,462	$ 102,447	$ 103,442	$ 104,446
Screening Rental	-	$ 10,874	$ 11,824	$ 12,398	$ 12,759	$ 12,883	$ 13,008	$ 13,134	$ 13,262	$ 13,391
Power	-	$ 6,146	$ 6,683	$ 7,008	$ 7,212	$ 7,282	$ 7,352	$ 7,424	$ 7,496	$ 7,569
Maintenance	-	$ 16,311	$ 17,736	$ 18,597	$ 19,139	$ 19,324	$ 19,512	$ 19,701	$ 19,893	$ 20,086
Software & Support	-	$ 17,398	$ 18,918	$ 19,837	$ 20,414	$ 20,613	$ 20,813	$ 21,015	$ 21,219	$ 21,425
Compost Sales	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ -	$ 678,364	$ 737,638	$ 773,446	$ 795,973	$ 803,701	$ 811,504	$ 885,054	$ 827,338	$ 835,370

	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
Gore Composting System (Bunkers, Cover, Winder)	-	-	-	-	-	-	-	-	-	-
Wheel Front Loader	-	-	-	-	-	-	-	-	-	-
Mixer	-	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	$ 70,266	-	-	-	-	-
Labor	$ 590,576	$ 596,310	$ 602,100	$ 607,945	$ 613,848	$ 619,807	$ 625,825	$ 631,901	$ 638,036	$ 644,230
Loader Operation	$ 84,368	$ 85,187	$ 86,014	$ 86,849	$ 87,693	$ 88,544	$ 89,404	$ 90,272	$ 91,148	$ 92,033
Bulking Agent	$ 105,460	$ 106,484	$ 107,518	$ 108,562	$ 109,616	$ 110,680	$ 111,754	$ 112,839	$ 113,935	$ 115,041
Screening Rental	$ 13,521	$ 13,652	$ 13,784	$ 13,918	$ 14,053	$ 14,190	$ 14,327	$ 14,467	$ 14,607	$ 14,749
Power	$ 7,642	$ 7,716	$ 7,791	$ 7,867	$ 7,943	$ 8,020	$ 8,098	$ 8,177	$ 8,256	$ 8,336
Maintenance	$ 20,281	$ 20,478	$ 20,676	$ 20,877	$ 21,080	$ 21,285	$ 21,491	$ 21,700	$ 21,911	$ 22,123
Software & Support	$ 21,633	$ 21,843	$ 22,055	$ 22,269	$ 22,485	$ 22,704	$ 22,924	$ 23,147	$ 23,371	$ 23,598
Compost Sales	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ 843,481	$ 851,670	$ 859,938	$ 868,287	$ 946,984	$ 885,229	$ 893,824	$ 902,502	$ 911,264	$ 920,111

Option A: Composting (Estimated Scenario)

Project Cost Estimate		
Clearing and Grading		$ 87,120
System Cost Estimate		$ 2,000,000
Contractor Install	20.0%	$ 400,000
Concrete Slab		$ 324,000
Gravel Work Area		$ 56,628
Roof Covered Strucutre and Concrete		$ 1,512,000
Construction Material&Labor Subtotal		**$ 4,379,748**
General Conditions	8.0%	$ 350,380
Mobilization/Demobilization	10.0%	$ 437,975
Overhead & Profit (OHP)	12.0%	$ 525,570
Construction Bid Subtotal		**$ 5,693,672**
Sales Tax	9.2%	$ 523,818
Contingency	30%	$ 1,708,102
Total Costructon Cost		**$ 7,925,592**
Engineering, Legal, and Administration	25.0%	$ 1,981,398
Total Project Cost		***$ 9,906,990***
Rounded Total Project Cost	-4	**$ 9,910,000**

Key
Input
Input Reference
Calculation

Lifecycle Analysis Assumptions	
Analysis Start Year	2022
Planning Horizon (yrs)	20
Discount Rate	3.0%
Biosolids Production (Dry TN/Yr)	1300
Labor Cost ($/hr)	$ 60.00
Weekly Labor Hrs	80
Loader Cost ($/hr)	$ 50
Weekly Loader Hrs	24
Centrifuge Solids Content	23%
Electrical Usage (kWh/Yr)	56522
Electricity Cost	$0.10
Compost Program Labor Cost	$ 60
Weekly Labor Hrs	20
Bulking Agent Cost ($/CY)	$ 5.00
Bulking Agent Density (lb/CY)	500
Compost Sales ($/YD)	$ 10.00
Solids Content	65%

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000	2022	100	0%
Wheel Front Loader	$300,000	2022	30	0%
Mixer	$350,000	2022	30	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Cover Replacement	$50,000	2029	7	0%
Labor	$312,000	2023	1	0%
Loader Operation	$62,400	2023	1	0%
Bulking Agent	$13,000	2023	1	0%
Screening Rental	$10,000	2023	1	0%
Power	$5,652	2023	1	0%
Maintenance		2023	1	0%
Software & Support		2023	1	0%
Compost Sales	-$146,957	2023	1	0%

Construction Costs	Estimated Present Cost	Year of Next Event	Frequency/ Design Life	Additional Cost Escalation Factor	Count Check	Sum of PV
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000.00	2022	100	0%	1	$ 9,910,000
Wheel Front Loader	$300,000.00	2022	30	0%	1	$ 300,000
Mixer	$350,000.00	2022	30	0%	1	$ 350,000
					Subtotal Present Value of Costs	**$ 10,560,000**
Operation & Maintenance Costs	Estimated Present Cost					
Cover Replacement	$50,000.00	2029	7	0%	2	$ 135,938
Labor	$312,000.00	2023	1	0%	19	$ 7,949,753
Loader Operation	$62,400.00	2023	1	0%	19	$ 1,589,951
Bulking Agent	$13,000.00	2023	1	0%	19	$ 331,240
Screening Rental	$10,000.00	2023	1	0%	19	$ 254,800
Power	$5,652.17	2023	1	0%	19	$ 144,017
Maintenance	$0.00	2023	1	0%	19	$ -
Software & Support	$0.00	2023	1	0%	19	$ -
Compost Sales	-$146,956.52	2023	1	0%	19	$ (3,744,449)
					Subtotal Present Value of Costs	**$ 6,661,249**
					TOTAL NET PRESENT COST	**$ 17,221,249**

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
Gore Composting System (Bunkers, Cover, Winder)	$ 9,910,000	-	-	-	-	-	-	-	-	-
Wheel Front Loader	$ 300,000	-	-	-	-	-	-	-	-	-
Mixer	$ 350,000	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ 10,560,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	-	-	-	$ 65,671	-	-
Labor	-	$ 339,262	$ 368,906	$ 386,814	$ 398,081	$ 401,946	$ 405,848	$ 409,788	$ 413,767	$ 417,784
Loader Operation	-	$ 67,852	$ 73,781	$ 77,363	$ 79,616	$ 80,389	$ 81,170	$ 81,958	$ 82,753	$ 83,557
Bulking Agent	-	$ 14,136	$ 15,371	$ 16,117	$ 16,587	$ 16,748	$ 16,910	$ 17,075	$ 17,240	$ 17,408
Screening Rental	-	$ 10,874	$ 11,824	$ 12,398	$ 12,759	$ 12,883	$ 13,008	$ 13,134	$ 13,262	$ 13,391
Power	-	$ 6,146	$ 6,683	$ 7,008	$ 7,212	$ 7,282	$ 7,352	$ 7,424	$ 7,496	$ 7,569
Maintenance	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Software & Support	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Compost Sales	-	$ (159,797)	$ (173,760)	$ (182,195)	$ (187,502)	$ (189,322)	$ (191,160)	$ (193,016)	$ (194,890)	$ (196,782)
Subtotal Present Value of Costs	$ -	$ 278,473	$ 302,806	$ 317,505	$ 326,753	$ 329,925	$ 333,128	$ 402,034	$ 339,628	$ 342,925

	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
Gore Composting System (Bunkers, Cover, Winder)	-	-	-	-	-	-	-	-	-	
Wheel Front Loader	-	-	-	-	-	-	-	-	-	
Mixer	-	-	-	-	-	-	-	-	-	
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	$ 70,266	-	-	-	-	-
Labor	$ 421,840	$ 425,936	$ 430,071	$ 434,247	$ 438,463	$ 442,719	$ 447,018	$ 451,358	$ 455,740	$ 460,164
Loader Operation	$ 84,368	$ 85,187	$ 86,014	$ 86,849	$ 87,693	$ 88,544	$ 89,404	$ 90,272	$ 91,148	$ 92,033
Bulking Agent	$ 17,577	$ 17,747	$ 17,920	$ 18,094	$ 18,269	$ 18,447	$ 18,626	$ 18,807	$ 18,989	$ 19,174
Screening Rental	$ 13,521	$ 13,652	$ 13,784	$ 13,918	$ 14,053	$ 14,190	$ 14,327	$ 14,467	$ 14,607	$ 14,749
Power	$ 7,642	$ 7,716	$ 7,791	$ 7,867	$ 7,943	$ 8,020	$ 8,098	$ 8,177	$ 8,256	$ 8,336
Maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Software & Support	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Compost Sales	$ (198,693)	$ (200,622)	$ (202,570)	$ (204,536)	$ (206,522)	$ (208,527)	$ (210,552)	$ (212,596)	$ (214,660)	$ (216,744)
Subtotal Present Value of Costs	$ 346,255	$ 349,616	$ 353,011	$ 356,438	$ 430,165	$ 363,393	$ 366,921	$ 370,483	$ 374,080	$ 377,712

Option A: Composting (Best Case Scenario)

Project Cost Estimate			
Clearing and Grading		$	87,120
System Cost Estimate		$	2,000,000
Contractor Install	20.0%	$	400,000
Concrete Slab		$	324,000
Gravel Work Area		$	56,628
Roof Covered Strucutre and Concrete		$	1,512,000
Construction Material&Labor Subtotal		**$**	**4,379,748**
General Conditions	8.0%	$	350,380
Mobilization/Demobilization	10.0%	$	437,975
Overhead & Profit (OHP)	12.0%	$	525,570
Construction Bid Subtotal		**$**	**5,693,672**
Sales Tax	9.2%	$	523,818
Contingency	30%	$	1,708,102
Total Costructon Cost		**$**	**7,925,592**
Engineering, Legal, and Administration	25.0%	$	1,981,398
Total Project Cost		***$***	***9,906,990***
Rounded Total Project Cost	-4	**$**	**9,910,000**

Key
Input
Input Reference
Calculation

Lifecycle Analysis	
Analysis Start Year	2022
Planning Horizon (yrs)	20
Discount Rate	3.0%
Biosolids Production (Dry TN/Yr)	1300
Labor Cost ($/hr)	$ 60.00
Weekly Labor Hrs	20
Loader Cost ($/hr)	$ 50
Weekly Loader Hrs	24
Centrifuge Solids Content	23%
Electrical Usage (kWh/Yr)	56522
Electricity Cost	$0.10
Compost Program Labor Cost	$ 60
Weekly Labor Hrs	10
Bulking Agent Cost ($/CY)	$ -
Bulking Agent Density (lb/CY)	500
Compost Sales ($/YD)	$ 15.00
Solids Content	65%

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	**Additional Cost Escalation Factor**
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000	2022	100	0%
Wheel Front Loader	$300,000	2022	30	0%
Mixer	$350,000	2022	30	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	**Additional Cost Escalation Factor**
Cover Replacement	$50,000	2029	7	0%
Labor	$93,600	2023	1	0%
Loader Operation	$62,400	2023	1	0%
Bulking Agent	$0	2023	1	0%
Screening Rental	$10,000	2023	1	0%
Power	$5,652	2023	1	0%
Maintenance		2023	1	0%
Software & Support		2023	1	0%
Compost Sales	-$220,435	2023	1	0%

Construction Costs	Estimated Present Cost	**Year of Next Event**	**Frequency/ Design Life**	**Additional Cost Escalation Factor**	**Count Check**	**Sum of PV**
Gore Composting System (Bunkers, Cover, Winder)	$9,910,000.00	2022	100	0%	1	$ 9,910,000
Wheel Front Loader	$300,000.00	2022	30	0%	1	$ 300,000
Mixer	$350,000.00	2022	30	0%	1	$ 350,000
					Subtotal Present Value of Costs	**$ 10,560,000**
Operation & Maintenance Costs	Estimated Present Cost					
Cover Replacement	$50,000.00	2029	7	0%	2	$ 135,938
Labor	$93,600.00	2023	1	0%	19	$ 2,384,926
Loader Operation	$62,400.00	2023	1	0%	19	$ 1,589,951
Bulking Agent	$0.00	2023	1	0%	19	$ -
Screening Rental	$10,000.00	2023	1	0%	19	$ 254,800
Power	$5,652.17	2023	1	0%	19	$ 144,017
Maintenance	$0.00	2023	1	0%	19	$ -
Software & Support	$0.00	2023	1	0%	19	$ -
Compost Sales	-$220,434.78	2023	1	0%	19	$ (5,616,673)
					Subtotal Present Value of Costs	**$ (1,107,042)**
					TOTAL NET PRESENT COST	**$ 9,452,958**

	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
Gore Composting System (Bunkers, Cover, Winder)	$ 9,910,000	-	-	-	-	-	-	-	-	-
Wheel Front Loader	$ 300,000	-	-	-	-	-	-	-	-	-
Mixer	$ 350,000	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ 10,560,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	-	-	-	$ 65,671	-	-
Labor	-	$ 101,779	$ 110,672	$ 116,044	$ 119,424	$ 120,584	$ 121,754	$ 122,937	$ 124,130	$ 125,335
Loader Operation	-	$ 67,852	$ 73,781	$ 77,363	$ 79,616	$ 80,389	$ 81,170	$ 81,958	$ 82,753	$ 83,557
Bulking Agent	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Screening Rental	-	$ 10,874	$ 11,824	$ 12,398	$ 12,759	$ 12,883	$ 13,008	$ 13,134	$ 13,262	$ 13,391
Power	-	$ 6,146	$ 6,683	$ 7,008	$ 7,212	$ 7,282	$ 7,352	$ 7,424	$ 7,496	$ 7,569
Maintenance	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Software & Support	-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Compost Sales	-	$ (239,696)	$ (260,640)	$ (273,293)	$ (281,253)	$ (283,983)	$ (286,741)	$ (289,524)	$ (292,335)	$ (295,174)
Subtotal Present Value of Costs	$ -	$ (53,045)	$ (57,680)	$ (60,480)	$ (62,242)	$ (62,846)	$ (63,456)	$ 1,599	$ (64,694)	$ (65,322)

	2032	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
Gore Composting System (Bunkers, Cover, Winder)	-	-	-	-	-	-	-	-	-	-
Wheel Front Loader	-	-	-	-	-	-	-	-	-	-
Mixer	-	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cover Replacement	-	-	-	-	$ 70,266	-	-	-	-	-
Labor	$ 126,552	$ 127,781	$ 129,021	$ 130,274	$ 131,539	$ 132,816	$ 134,105	$ 135,407	$ 136,722	$ 138,049
Loader Operation	$ 84,368	$ 85,187	$ 86,014	$ 86,849	$ 87,693	$ 88,544	$ 89,404	$ 90,272	$ 91,148	$ 92,033
Bulking Agent	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Screening Rental	$ 13,521	$ 13,652	$ 13,784	$ 13,918	$ 14,053	$ 14,190	$ 14,327	$ 14,467	$ 14,607	$ 14,749
Power	$ 7,642	$ 7,716	$ 7,791	$ 7,867	$ 7,943	$ 8,020	$ 8,098	$ 8,177	$ 8,256	$ 8,336
Maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Software & Support	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Compost Sales	$ (298,039)	$ (300,933)	$ (303,855)	$ (306,805)	$ (309,783)	$ (312,791)	$ (315,828)	$ (318,894)	$ (321,990)	$ (325,116)
Subtotal Present Value of Costs	$ (65,957)	$ (66,597)	$ (67,244)	$ (67,896)	$ 1,711	$ (69,221)	$ (69,893)	$ (70,572)	$ (71,257)	$ (71,949)

Option B: Dryer

Project Cost Estimate			
Belt Dryer		$	2,776,125
Odor Control System		$	1,880,000
Boiler System (or HRR Loop)		$	350,000
Site Piping, Auger, Electical, etc		$	200,000
Building Construction		$	600,000
Installation Cost	25.0%	$	1,451,531.3
Construction Material&Labor Subtotal		**$**	**7,257,656.3**
General Conditions	8.0%	$	580,613
Mobilization/Demobilization	10.0%	$	725,766
Overhead & Profit (OHP)	12.0%	$	870,919
Construction Subtotal		**$**	**9,434,953**
Sales Tax	9.2%	$	868,016
Contingency	30%	$	2,830,486
Total Costruction Cost		**$**	**13,133,455**
Engineering, Legal, and Administration	25.0%	$	3,283,364
TOTAL PROJECT COST		**$**	**16,416,818**
Rounded Total Project Cost	-4	**$**	**16,420,000**

Key
Input
Reference
Calculation

Lifecycle Analysis		
Analysis Start Year		2022
Planning Horizon (yrs)		20
Discount Rate		3.0%
Biosolids Production (Dry TN/Yr)		1300
Labor Cost ($/hr)	$	60.00
Hauling & Disposal Costs ($/TN)	$	62
Solids Content		90%
Dryer Thermal Energy Reqd (M BTU/hr)		3.5
Natural Gas Cost ($/MBTU)	$	8.40
Boiler Efficiency		0.85
Dryer Electricity Required (kW)		112
Electricity Cost		$0.10
Dryer Capacity (dry-lb/hr)		544.86
Dryer Operating Time (hrs/yr)		4772
Dryer Operating Cost ($/yr)	$	218,495
Dryer Labor (hrs/wk)		30
Centrifuge Solids Content		23%

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Belt Dryer	$16,420,000	2022	50	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Annual Hauling and Disposal	$89,556	2022	1	0%
Dryer Operating Cost	$218,495	2022	1	0%
Dryer Labor Cost	$93,600	2022	1	0%

Construction Costs	Estimated Present Cost	**Year of Next Event**	**Frequency/ Design Life**	**Additional Cost Escalation Factor**	**Count Check**	**Sum of PV**
Belt Dryer	$16,420,000.00	2022	50	0%	1	$ 16,420,000
				Subtotal Present Value of Costs		**$ 16,420,000**
Operation & Maintenance Costs	Estimated Present Cost					
Annual Hauling and Disposal	$89,555.56	2022	1	0%	20	$ 2,371,429
Dryer Operating Cost	$218,495.41	2022	1	0%	20	$ 5,785,754
Dryer Labor Cost	$93,600.00	2022	1	0%	20	$ 2,478,526
				Subtotal Present Value of Costs		**$ 10,635,709**
				TOTAL NET PRESENT VALUE		**$ 27,055,709**

	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
Belt Dryer	$ 16,420,000	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ 16,420,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 89,556	$ 97,381	$ 105,890	$ 111,030	$ 114,264	$ 115,373	$ 116,493	$ 117,624	$ 118,766	$ 119,920
Dryer Operating Cost	$ 218,495	$ 237,587	$ 258,347	$ 270,888	$ 278,778	$ 281,485	$ 284,218	$ 286,977	$ 289,763	$ 292,577
Dryer Labor Cost	$ 93,600	$ 101,779	$ 110,672	$ 116,044	$ 119,424	$ 120,584	$ 121,754	$ 122,937	$ 124,130	$ 125,335
Subtotal Present Value of Costs	$ 401,651	$ 436,747	$ 474,909	$ 497,963	$ 512,467	$ 517,442	$ 522,466	$ 527,538	$ 532,660	$ 537,831

	2032	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
Belt Dryer	-	-	-	-	-	-	-	-	-	-
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 121,084	$ 122,259	$ 123,446	$ 124,645	$ 125,855	$ 127,077	$ 128,311	$ 129,556	$ 130,814	$ 132,084
Dryer Operating Cost	$ 295,417	$ 298,285	$ 301,181	$ 304,105	$ 307,058	$ 310,039	$ 313,049	$ 316,088	$ 319,157	$ 322,256
Dryer Labor Cost	$ 126,552	$ 127,781	$ 129,021	$ 130,274	$ 131,539	$ 132,816	$ 134,105	$ 135,407	$ 136,722	$ 138,049
Subtotal Present Value of Costs	$ 543,053	$ 548,325	$ 553,649	$ 559,024	$ 564,452	$ 569,932	$ 575,465	$ 581,052	$ 586,693	$ 592,389

Option C: Continue Current Operations

Key
Input
Input Reference
Calculation

Project Cost Estimate
No construction required for this option

Lifecycle Analysis	
Analysis Start Year	2022
Planning Horizon (yrs)	20
Discount Rate	3.0%
Biosolids Production (Dry TN/Yr)	1300
Labor Cost ($/hr)	$ 60.00
Hauling & Disposal Costs ($/TN)	$ 62
Centrifuge Solids Content	23%

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
N/A	$0.00	2021	1	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Annual Hauling and Disposal	$350,434.78	2022	1	0%

	Estimated Present Cost	Year of Next Event	Frequency/ Design Life	Count Check	Additional Cost Escalation Factor	Sum of PV
Construction Costs						
N/A	$0.00	2021	1	20	0%	$ -
Subtotal Present Value of Costs						$ -
Operation & Maintenance Costs	Estimated Present Cost					
Annual Hauling and Disposal	$350,434.78	2022	1	20	0%	$ 9,279,505
Subtotal Present Value of Costs						**$ 9,279,505**
TOTAL NET PRESENT VALUE						**$ 9,279,505**

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
N/A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 350,435	$ 381,055	$ 414,351	$ 434,466	$ 447,120	$ 451,461	$ 455,844	$ 460,270	$ 464,738	$ 469,250
Subtotal Present Value of Costs	$ 350,435	$ 381,055	$ 414,351	$ 434,466	$ 447,120	$ 451,461	$ 455,844	$ 460,270	$ 464,738	$ 469,250

	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
N/A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 473,806	$ 478,406	$ 483,051	$ 487,741	$ 492,476	$ 497,257	$ 502,085	$ 506,960	$ 511,882	$ 516,851
Subtotal Present Value of Costs	$ 473,806	$ 478,406	$ 483,051	$ 487,741	$ 492,476	$ 497,257	$ 502,085	$ 506,960	$ 511,882	$ 516,851

Option C: Continue Current Operations

Project Cost Estimate

No construction required for this option

Lifecycle Analysis	
Analysis Start Year	2022
Planning Horizon (yrs)	20
Discount Rate	3.0%
Biosolids Production (Dry TN/Yr)	1300
Labor Cost ($/hr)	$ 60.00
Hauling & Disposal Costs ($/TN)	$ 80
Centrifuge Solids Content	23%

Key
Input
Input Reference
Calculation

Construction Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
N/A	$0.00	2021	1	0%

Operation & Maintenance Costs	Estimated Present Cost	Start Year	Interval (yrs)	Additional Cost Escalation Factor
Annual Hauling and Disposal	$452,173.91	2022	1	0%

Construction Costs	Estimated Present Cost	Year of Next Event	Frequency/ Design Life	Count Check	Additional Cost Escalation Factor	Sum of PV
N/A	$0.00	2021	1	20	0%	$ -
					Subtotal Present Value of Costs	**$ -**
Operation & Maintenance Costs	Estimated Present Cost					
Annual Hauling and Disposal	$452,173.91	2022	1	20	0%	$ 11,973,555
					Subtotal Present Value of Costs	**$ 11,973,555**
					TOTAL NET PRESENT VALUE	**$ 11,973,555**

	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Inflation	0%	12%	12%	8%	6%	4%	4%	4%	4%	4%
Inflation Multiplier	1.000	1.120	1.254	1.355	1.436	1.493	1.553	1.615	1.680	1.747
Discount Rate Multiplier	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766
N/A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 452,174	$ 491,684	$ 534,647	$ 560,601	$ 576,929	$ 582,530	$ 588,186	$ 593,896	$ 599,662	$ 605,484
Subtotal Present Value of Costs	$ 452,174	$ 491,684	$ 534,647	$ 560,601	$ 576,929	$ 582,530	$ 588,186	$ 593,896	$ 599,662	$ 605,484

	2032	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Inflation	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Inflation Multiplier	1.817	1.890	1.965	2.044	2.126	2.211	2.299	2.391	2.487	2.586
Discount Rate Multiplier	0.744	0.722	0.701	0.681	0.661	0.642	0.623	0.605	0.587	0.570
N/A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal Present Value of Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Hauling and Disposal	$ 611,363	$ 617,298	$ 623,291	$ 629,343	$ 635,453	$ 641,622	$ 647,852	$ 654,142	$ 660,492	$ 666,905
Subtotal Present Value of Costs	$ 611,363	$ 617,298	$ 623,291	$ 629,343	$ 635,453	$ 641,622	$ 647,852	$ 654,142	$ 660,492	$ 666,905

APPENDIX Q
OPINIONS OF PROBABLE
PROJECT COST

Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-3

Project Summary

- Replace the pump station
- Inflows are not projected to exceed firm capacity until after 2038
- Increase capacity to 2,315 gpm Rehabilitate wet well
- Replace pumps and piping
- Replace electrical equipment in existing building

Item	Description	Quantity	Unit	Unit Cost	Total
1	Preconstruction Work Phase	1	LS	$ 53,000	$ 53,000
2	Final Cleanup and Restoration	1	LS	$ 8,500	$ 8,500
3	Surveying	1	LS	$ 17,000	$ 17,000
4	Project Record Drawings	1	LS	$ 22,000	$ 22,000
5	Type B Schedules	12	MO	$ 700	$ 8,400
6	Minor Changes (Allowance)	1	FA	$ 156,000	$ 156,000
7	Mobilization and Demobilization	1	LS	$ 216,000	$ 216,000
8	Operation and Maintenance Manuals	1	LS	$ 4,000	$ 4,000
9	Dewatering	1	LS	$ 60,000	$ 60,000
10	Bypass Pumping	1	LS	$ 125,000	$ 125,000
11	Trench Safety Systems	1	LS	$ 313,000	$ 313,000
12	Gravel Backfill for Foundations (Allowance)	10	TN	$ 40	$ 400
13	Crushed Surfacing Base Course	100	TN	$ 34	$ 3,400
14	Crushed Surfacing Top Course	50	TN	$ 34	$ 1,700
15	HMA Pavement	50	TN	$ 200	$ 10,000
16	Temporary Erosion and Sediment Control	1	LS	$ 8,000	$ 8,000
17	Pumps	1	LS	$ 340,000	$ 340,000
18	Mechanical Work	1	LS	$ 690,000	$ 690,000
19	Electrical Work	1	LS	$ 550,000	$ 550,000
20	Structures (Slab on Wet Well)	1	LS	$ 300,000	$ 300,000
21	Miscellaneous Site Work	1	LS	$ 250,000	$ 250,000
	SUBTOTAL				$ 3,136,400
	Contingency (50%)				$ 1,569,000
	Sales Tax (9.2%)				$ 432,897
	CONSTRUCTION SUBTOTAL				$ 5,139,000
	Design Services Engineering and Allied Costs (25%)				$ 1,284,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,284,750
	TOTAL PROJECT COST (ROUNDED)				**$ 7,800,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

NOTE: PROJECT HAS BEEN AWARDED AND THIS ESTIMATE SHOULD NOT BE USED

Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-4 and Forcemain

Project Summary

• Replace the pump station
• Increase capacity to 4,650 gpm

Item	Description	Quantity	Unit	Unit Cost	Total
1	Preconstruction Work Phase	1	LS	$ 53,000	$ 53,000
2	Final Cleanup and Restoration	1	LS	$ 8,500	$ 8,500
3	Surveying	1	LS	$ 17,000	$ 17,000
4	Project Record Drawings	1	LS	$ 22,000	$ 22,000
5	Type B Schedules	12	MO	$ 700	$ 8,400
6	Minor Changes (Allowance)	1	FA	$ 187,000	$ 187,000
7	Mobilization and Demobilization	1	LS	$ 275,000	$ 275,000
8	Operation and Maintenance Manuals	1	LS	$ 4,000	$ 4,000
9	Dewatering	1	LS	$ 45,000	$ 45,000
10	Bypass Pumping	1	LS	$ 125,000	$ 125,000
11	Trench Safety Systems	1	LS	$ 495,000	$ 495,000
12	Gravel Backfill for Foundations (Allowance)	10	TN	$ 40	$ 400
13	Crushed Surfacing Base Course	170	TN	$ 34	$ 5,780
14	Crushed Surfacing Top Course	90	TN	$ 34	$ 3,060
15	HMA Pavement	80	TN	$ 200	$ 16,000
16	Temporary Erosion and Sediment Control	1	LS	$ 8,000	$ 8,000
17	Pumps	1	LS	$ 630,000	$ 630,000
18	Mechanical Work	1	LS	$ 1,000,000	$ 1,000,000
19	Electrical Work	1	LS	$ 570,000	$ 570,000
20	Structures (Slab on Wet Well)	1	LS	$ 240,000	$ 240,000
21	Miscellaneous Site Work	1	LS	$ 260,000	$ 260,000
	SUBTOTAL				$ 3,973,140
	Contingency (50%)				$ 1,987,000
	Sales Tax (9.2%)				$ 548,333
	CONSTRUCTION SUBTOTAL				$ 6,509,000
	Design Services Engineering and Allied Costs (25%)				$ 1,627,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,627,250
	TOTAL PROJECT COST (ROUNDED)				**$ 9,800,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

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NOTE: PROJECT HAS BEEN AWARDED AND THIS ESTIMATE SHOULD NOT BE USED

Kitsap County General Sewer Plans
Central Kitsap Basin

15" DI Gravity Sewer NW Carlton ST and Pacific Ave

Project Summary

• Install 700 lf of new 15-inch diameter gravity sewer to intercept flows from NW Carlton Street and Pacific Ave NW and divert to LS-3

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 40,000	$ 40,000
2	Traffic Control	1	LS	$ 19,000	$ 19,000
3	Dewatering	1	LS	$ 7,600	$ 7,600
4	SWPPP & BMPs	1	LS	$ 1,400	$ 1,400
5	Sewer Bypass	1	LS	$ 7,000	$ 7,000
6	Open Trench New 15-inch Pipe (SDR 35 PS46)	700	LF	$ 230	$ 161,000
7	6-inch Side Sewer Replacement	90	LF	$ 180	$ 16,200
8	Shoring and Trench Safety	1	LS	$ 2,800	$ 2,800
9	Imported Trench Backfill	600	TON	$ 25	$ 15,000
10	Manhole 48-inch diameter	3	EA	$ 15,000	$ 45,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	190	TON	$ 200	$ 38,000
12	Grind and Overlay, Channelization**	1	LS	$ 80,000	$ 80,000
13	Cleanup & Site Restoration	1	LS	$ 9,000	$ 9,000
	SUBTOTAL				$ 442,000
	Contingency (50%)				$ 221,000
	Sales Tax (9.2%)				$ 60,996
	CONSTRUCTION SUBTOTAL				$ 724,000
	Design Services Engineering and Allied Costs (25%)				$ 181,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 181,000
	TOTAL PROJECT COST (ROUNDED)				**$ 1,100,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

NOTE: PROJECT HAS BEEN AWARDED AND THIS ESTIMATE SHOULD NOT BE USED

Kitsap County General Sewer Plans
Central Kitsap Basin

consor

LS4 FM Replacement

Project Summary

• Replace forcemain with 1,570 lf of 20-inch diameter pipe with air-vacuum station at SSMH J18-3048

Item	Description	Quantity	Unit	Unit Cost	Total
1	Preconstruction Work Phase	1	LS	$ 17,000	$ 17,000
2	Final Cleanup and Restoration	1	LS	$ 40,000	$ 40,000
3	Surveying	1	LS	$ 8,500	$ 8,500
4	Project Record Drawings	1	LS	$ 6,000	$ 6,000
5	Type B Schedules	2	MO	$ 750	$ 1,500
6	Minor Changes and Additions (Allowance)	1	FA	$ 50,000	$ 50,000
7	Mobilization and Demobilization	1	LS	$ 65,000	$ 65,000
8	Project Temporary Traffic Control	1	LS	$ 22,000	$ 22,000
9	Removal of Structures and Obstructions	1	LS	$ 10,000	$ 10,000
10	Trench Safety Systems	1,570	LF	$ 5	$ 7,850
11	Gravel Backfill for Foundation (Allowance)	50	TN	$ 50	$ 2,500
12	Crushed Surfacing Top Course	660	TN	$ 50	$ 33,000
13	Crushed Surfacing Base Course	280	TN	$ 50	$ 14,000
14	Temporary HMA Pavement	150	TN	$ 200	$ 30,000
15	Permanent HMA Pavement	385	TN	$ 200	$ 77,000
16	Imported Trench (Subsequent) Backfill	2,160	TN	$ 50	$ 108,000
17	Controlled Density Fill (Allowance)	20	CY	$ 130	$ 2,600
18	Dewatering	1	LS	$ 8,000	$ 8,000
19	Extra Trench Excavation	50	CY	$ 65	$ 3,250
20	20-inch C905 PVC Force Main	1,570	LF	$ 240	$ 376,800
21	TESC	1	LS	$ 23,500	$ 23,500
	SUBTOTAL				$ 906,500
	Contingency (50%)				$ 454,000
	Sales Tax (9.2%)				$ 125,166
	CONSTRUCTION SUBTOTAL				$ 1,486,000
	Design Services Engineering and Allied Costs (25%)				$ 372,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 372,000
	TOTAL PROJECT COST (ROUNDED)				**$ 2,300,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-24

Project Summary

- Upgrade the pump station
- Replace pumps
- Increase capacity to 6,800 gpm
- Replace valves
- Replace electrical, instrumentation, and control equipment in existing building
- Replace generator set

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 269,000	$ 269,000
2	Traffic Control	1	LS	$ 53,000	$ 53,000
3	TESC	1	LS	$ 26,000	$ 26,000
4	Pumps	3	EA	$ 320,000	$ 960,000
5	Valves and Piping	1	LS	$ 200,000	$ 200,000
6	Standby Generator	1	LS	$ 202,500	$ 202,500
7	Electrical, Instrumentation, and Controls	1	LS	$ 1,066,500	$ 1,066,500
8	Temporary Bypass Pumping	1	LS	$ 125,000	$ 125,000
9	Site Restoration	1	LS	$ 52,000	$ 52,000
	SUBTOTAL				$ 2,954,000
	Contingency (50%)				$ 1,477,000
	Sales Tax (9.2%)				$ 407,652
	CONSTRUCTION SUBTOTAL				$ 4,839,000
	Design Services Engineering and Allied Costs (25%)				$ 1,209,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,209,750
	TOTAL PROJECT COST (ROUNDED)				**$ 7,300,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-36

Project Summary

- Replace the pump station
- Increase capacity to 170 gpm
- Construct new wet well to replace corroding steel wet well
- Construct new valve vault
- Construct new electrical, instrumentation, and controls equipment under a new canopy
- Construct new diesel generator set with Level 2 sound attenuating enclosure

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 69,000	$ 69,000
2	Traffic Control	1	LS	$ 14,000	$ 14,000
3	TESC	1	LS	$ 7,000	$ 7,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 8,000	$ 8,000
7	8-foot Diameter Wet Well	1	LS	$ 116,000	$ 116,000
8	Valve Vault	1	LS	$ 10,000	$ 10,000
9	Pumps	2	EA	$ 75,000	$ 150,000
10	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
11	Yard Piping	1	LS	$ 7,000	$ 7,000
12	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
13	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
14	Canopy	1	LS	$ 21,000	$ 21,000
15	Fencing	1	LF	$ 40	$ 40
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 40,000	$ 40,000
18	Site Restoration	1	LS	$ 14,000	$ 14,000
	SUBTOTAL				$ 760,040
	Contingency (50%)				$ 381,000
	Sales Tax (9.2%)				$ 104,976
	CONSTRUCTION SUBTOTAL				$ 1,247,000
	Design Services Engineering and Allied Costs (25%)				$ 311,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 311,750
	TOTAL PROJECT COST (ROUNDED)				**$ 1,900,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-11

Project Summary

- Replace the pump station
- Rehabilitate dry wet well can
- Install new generator set
- Install new electrical, instrumentation, and controls equipment under new canopy
- Install new fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 28,000	$ 28,000
2	Traffic Control	1	LS	$ 5,000	$ 5,000
3	TESC	1	LS	$ 3,000	$ 3,000
4	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
5	Rehabilitate Dry Can	1	LS	$ 5,000	$ 5,000
6	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
7	Canopy	1	LS	$ 21,000	$ 21,000
8	Fencing	1	LF	$ 40	$ 40
9	Site Restoration	1	LS	$ 6,000	$ 6,000
	SUBTOTAL				$ 306,040
	Contingency (50%)				$ 154,000
	Sales Tax (9.2%)				$ 42,324
	CONSTRUCTION SUBTOTAL				$ 503,000
	Design Services Engineering and Allied Costs (25%)				$ 125,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 125,750
	TOTAL PROJECT COST (ROUNDED)				**$ 760,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-33

Project Summary

• Upgrade the pump station
• Install generator set
• Upgrade electrical to comply with NFPA 820
• Construct canopy over electrical, instrumentation, and control equipment
• Replace fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 9,000	$ 9,000
2	Traffic Control	1	LS	$ 2,000	$ 2,000
3	TESC	1	LS	$ 1,000	$ 1,000
4	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
5	Electrical Improvements	1	LS	$ 20,000	$ 20,000
6	Canopy	1	LS	$ 21,000	$ 21,000
7	Fencing	1	LF	$ 40	$ 40
8	Site Restoration	1	LS	$ 2,000	$ 2,000
	SUBTOTAL				$ 95,040
	Contingency (50%)				$ 48,000
	Sales Tax (9.2%)				$ 13,160
	CONSTRUCTION SUBTOTAL				$ 157,000
	Design Services Engineering and Allied Costs (25%)				$ 39,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 39,250
	TOTAL PROJECT COST (ROUNDED)				**$ 240,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Northern Old Military Road Sewer Upgrades

Project Summary

• Replace 6,180 lf of pipe with 30-inch diameter pipe from Old Military Road NE to NE Paulson Road

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 350,000	$ 350,000
2	Traffic Control	1	LS	$ 220,000	$ 220,000
3	Dewatering	1	LS	$ 86,000	$ 86,000
4	SWPPP & BMPs	1	LS	$ 13,000	$ 13,000
5	Sewer Bypass	1	LS	$ 62,000	$ 62,000
6	Open Trench New 30-inch Pipe (PS46)	6,200	LF	$ 340	$ 2,108,000
7	6-inch Side Sewer Replacement	800	LF	$ 180	$ 144,000
8	Shoring and Trench Safety	1	LS	$ 25,000	$ 25,000
9	Imported Trench Backfill	5,600	TON	$ 25	$ 140,000
10	Manhole 60-inch diameter	21	EA	$ 22,000	$ 462,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	2,200	TON	$ 200	$ 440,000
12	Grind and Overlay, Channelization**	1	EST	$ 800,000	$ 800,000
13	Cleanup & Site Restoration	1	LS	$ 80,000	$ 80,000
	SUBTOTAL				$ 4,930,000
	Contingency (50%)				$ 2,465,000
	Sales Tax (9.2%)				$ 680,340
	CONSTRUCTION SUBTOTAL				$ 8,076,000
	Design Services Engineering and Allied Costs (25%)				$ 2,019,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 2,019,000
	TOTAL PROJECT COST (ROUNDED)				**$ 12,200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Lemolo Inverted Siphon Upgrades

Project Summary

• Install 2,200 lf of 24-inch diameter inverted siphon pipe using HDD

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 300,000	$ 300,000
2	Traffic Control	1	LS	$ 180,000	$ 180,000
3	Dewatering	1	LS	$ 70,000	$ 70,000
4	SWPPP & BMPs	1	LS	$ 5,000	$ 5,000
5	Sewer Bypass	1	LS	$ 125,000	$ 125,000
6	24-inch HDD for Inverted Siphon	2,100	LF	$ 1,500	$ 3,150,000
7	Manhole 60-inch diameter	5	EA	$ 22,000	$ 110,000
8	Manhole 48-inch diameter	6	EA	$ 15,000	$ 90,000
	SUBTOTAL				$ 4,030,000
	Contingency (50%)				$ 2,015,000
	Sales Tax (9.2%)				$ 556,140
	CONSTRUCTION SUBTOTAL				$ 6,602,000
	Design Services Engineering and Allied Costs (25%)				$ 1,651,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,651,000
	TOTAL PROJECT COST (ROUNDED)				**$ 10,000,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Johnson to Norum Pipeline

Project Summary

• Replace 4,200 lf of pipe with 24-inch diameter pipe from Johnson Road to the Lemolo Siphon

Item	Item Description	Quantity	Unit	Unit Cost	Total
1	Preconstruction Work Phase	1	LS	$ 48,000	$ 48,000
2	Final Cleanup and Restoration	1	LS	$ 48,000	$ 48,000
3	Surveying	1	LS	$ 30,000	$ 30,000
4	Project Record Drawings	1	LS	$ 25,000	$ 25,000
5	Type B Schedules	6	MO	$ 1,000	$ 6,000
6	Minor Change (Allowance)	1	FA	$ 145,000	$ 145,000
7	Mobilization and Demobilization	1	LS	$ 480,000	$ 480,000
8	Dewatering	1	FA	$ 145,000	$ 145,000
9	Pothole Existing Services	19	EA	$ 3,000	$ 57,000
10	Excavation Support Systems	1	LS	$ 240,000	$ 240,000
11	Temporary Erosion and Sediment Control	1	LS	$ 48,000	$ 48,000
12	Traffic Control	1	LS	$ 240,000	$ 240,000
13	24-inch HDPE DR 17 Pipe	4,210	LF	$ 300	$ 1,263,000
14	24-inch HDPE DR 17 45 Degree Bend	5	EA	$ 3,300	$ 16,500
15	6-in. Air Release Valve Assembly	1	EA	$ 51,000	$ 51,000
16	4-in. Blowoff Valve Assembly	1	EA	$ 15,000	$ 15,000
17	Connect IPS to New 24-Inch HDPE Pipe	14	EA	$ 11,000	$ 154,000
18	Connect Manifold to New 24-Inch HDPE Pipe	3	EA	$ 20,000	$ 60,000
19	Connect Gravity Lateral to New 24-inch HPDE Pipe	1	EA	$ 20,000	$ 20,000
20	Temporary Sewer Bypass	1	LS	$ 100,000	$ 100,000
21	Modify and Connect to Upstream Manhole	1	LS	$ 10,000	$ 10,000
22	Connect to Lemolo Siphon	1	LS	$ 10,000	$ 10,000
23	Isolate and Clean Existing Sewer Main	1	SY	$ 25,000	$ 25,000
24	Asphalt Removal	5,700	SY	$ 15	$ 85,500
25	Backfill	6,500	TN	$ 50	$ 325,000
26	Crushed Surfacing Base Course	900	TN	$ 70	$ 63,000
27	HMA Cl. 1/2-inch PG 64-22 for Trench Patch	3,950	TN	$ 320	$ 1,264,000
	SUBTOTAL				**$ 4,974,000**
	Sales Tax (9.3%)				$ 462,600
	Supply Chain Disruption (12%)				$ 596,880
	CONSTRUCTION SUBTOTAL				**$ 6,033,000**
	Construction Contingency (30%)				$ 1,809,900
	TOTAL PROJECT COST (ROUNDED)				**$ 7,850,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Solids and Liquid Hauled Waste Upgrades

Project Summary

- New septage receiving station
- New FOG receiving station
- Replace septage pump, grit cyclone, and grit classifier
- Replace gravity thickeners with new mechanical thickening equipment
- New 1.3 MG anaerobic digester
- Replace in-plant pump station
- Replace digester hot water system
- Replace O&M shop building

Item	Description	Quantity	Unit	Unit Cost	Total
1	Septage Receiving Station	1	LS	$ 428,549	$ 428,549
2	FOG Receiving Station	1	LS	$ 639,275	$ 639,275
3	Septage Pumps and Grit Cyclone and Classifier	1	LS	$ 502,516	$ 502,516
4	Septage Thickening	1	LS	$ 3,217,812	$ 3,217,812
5	Primary Sludge Thickening	1	LS	$ 3,105,410	$ 3,105,410
6	Anerobic Digester and Building	1	LS	$ 11,243,283	$ 11,243,283
7	In-plant Pump Station	1	LS	$ 307,300	$ 307,300
8	Hot Water System	1	LS	$ 1,286,454	$ 1,286,454
9	Shop and Equipment Maintenance Building Relocation	1	LS	$ 8,250,000	$ 8,250,000
	SUBTOTAL				$ 28,552,050
	Contingency (50%)				$ 14,277,000
	Sales Tax (9.2%)				$ 3,940,273
	CONSTRUCTION SUBTOTAL				$ 46,770,000
	Design Services Engineering and Allied Costs (25%)				$ 11,692,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 11,692,500
	TOTAL PROJECT COST (ROUNDED)				**$ 70,160,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Construct Third Secondary Clarifier and Replace RAS pumps

Project Summary

- Construct a third primary clarifier to increase capacity.
- Replace the existing secondary clarifiers' walkways and drive mechanisms.
- Replace the RAS pumps.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Excavation and Backfill	5809	CY	$ 175	$ 1,016,541
2	Yard Piping	500	LF	$ 390	$ 195,000
3	Clarifier Foundation	691 CY	CY	$ 1,000	$ 691,209
4	Clarifier Concrete Wall and Launder	517	CY	$ 1,000	$ 517,131
5	Clarifier Mechanism	1	LS	$ 715,000	$ 715,000
6	Effluent Weirs & Baffles	1	LS	$ 39,000	$ 39,000
7	Replace RAS Pumps	5	EA	$ 91,000	$ 455,000
8	Associated Piping and Fittings	1	LS	$ 26,000	$ 26,000
9	EI&C Allowance	1	LS	$ 358,800	$ 358,800
	SUBTOTAL				$ 4,013,681
	Contingency (50%)				$ 2,007,000
	Sales Tax (9.2%)				$ 553,903
	CONSTRUCTION SUBTOTAL				$ 6,575,000
	Design Services Engineering and Allied Costs (25%)				$ 1,643,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,643,750
	TOTAL PROJECT COST (ROUNDED)				**$ 9,900,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Centrate Equalization

Project Summary

- Construct a centrate equalization basin so that centrate flow can be evenly applied to the aeration basins.
- This project will contribute towards ensuring effluent TIN can be kept consistently below 10 mg/L.
- It may be feasible to make operational changes that improve centrate equalization without construction of a new basin.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Centrate Equalization	1	LS	$ 1,331,981	$ 1,331,981
	SUBTOTAL				$ 1,331,981
	Contingency (50%)				$ 666,000
	Sales Tax (9.2%)				$ 183,814
	CONSTRUCTION SUBTOTAL				$ 2,182,000
	Design Services Engineering and Allied Costs (25%)				$ 545,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 545,500
	TOTAL PROJECT COST (ROUNDED)				**$ 3,300,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

RAS Distribution Box Hydraulic Study & Improvements

Project Summary

• Conduct an engineering study of the aeration basin influent hydraulic box to determine how RAS and primary effluent can be mixed more efficiently.
• Implement automatic flow pacing of the RAS system.
• This project will contribute towards ensuring effluent TIN can be kept consistently below 10 mg/L.

Item	Description	Quantity	Unit	Unit Cost	Total
1	RAS Distribution Box Hydraulic Study & Improvements	1	LS	$ 100,000	$ 100,000
2	Aeration Basin Influent Hydraulics Upgrades	1	LS	$ 289,850	$ 289,850
	SUBTOTAL				$ 389,850
	Contingency (50%)				$ 195,000
	Sales Tax (9.2%)				$ 53,806
	CONSTRUCTION SUBTOTAL				$ 639,000
	Design Services Engineering and Allied Costs (25%)				$ 159,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 159,750
	TOTAL PROJECT COST (ROUNDED)				**$ 1,000,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Methanol Storage

Project Summary

• Add additional methanol storage capacity.
• This project will contribute towards ensuring effluent TIN can be kept consistently below 10 mg/L

Item	Description	Quantity	Unit	Unit Cost	Total
1	Methanol Storage	1	LS	$ 301,508	$ 301,508
	SUBTOTAL				$ 301,508
	Contingency (50%)				$ 151,000
	Sales Tax (9.2%)				$ 41,631
	CONSTRUCTION SUBTOTAL				$ 495,000
	Design Services Engineering and Allied Costs (25%)				$ 123,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 123,750
	TOTAL PROJECT COST (ROUNDED)				**$ 800,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Existing Anaerobic Digester Rehabilitation

Project Summary

• Rehabilitate the existing anaerobic digesters.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Dewatering & Dewatered GW Treatment	1	LS	$ 500,000	$ 500,000
2	Digester Gas Purge	4	EA	$ 13,000	$ 52,000
3	Digester Drainage, Cleaning & Inspection	2	EA	$ 325,000	$ 650,000
4	Equipment Pad	4	CY	$ 650	$ 2,600
5	Structural & Coating Repair	12252	SF	$ 80	$ 980,177
6	Cover and Skirt Repair or Replace	2	EA	$ 858,000	$ 1,716,000
7	Demolition	1	LS	$ 20,000	$ 20,000
8	Mixing Pumps Replace	2	EA	$ 162,493	$ 324,985
9	Mixing Piping - 16'' HDPE	1	LS	$ 500,000	$ 500,000
10	Heat Exchangers Replace	2	EA	$ 97,200	$ 194,400
11	Recirculation Pumps Replace	2	EA	$ 30,000	$ 60,000
12	MCC Replacement	1	EA	$ 260,000	$ 260,000
13	EI&C Lump Sum	1	LS	$ 219,877	$ 219,877
	SUBTOTAL				$ 5,480,039
	Contingency (50%)				$ 2,741,000
	Sales Tax (9.2%)				$ 756,336
	CONSTRUCTION SUBTOTAL				$ 8,978,000
	Design Services Engineering and Allied Costs (25%)				$ 2,244,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 2,244,500
	TOTAL PROJECT COST (ROUNDED)				**$ 13,500,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Main Switchgear

Project Summary

• Replace main plant switchgear SWBD-1

Item	Description	Quantity	Unit	Unit Cost	Total
1	Replace main switchgear	1	LS	$ 60,000	$ 60,000
	SUBTOTAL				$ 60,000
	Contingency (50%)				$ 30,000
	Sales Tax (9.2%)				$ 8,280
	CONSTRUCTION SUBTOTAL				$ 99,000
	Design Services Engineering and Allied Costs (25%)				$ 24,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 24,750
	TOTAL PROJECT COST (ROUNDED)				**$ 200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace SWGR-2960 ATS-1

Project Summary

• Replace automatic transfer switch 1 in switchgear 2960.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Replace SWGR-2960 ATS-1	1	LS	$ 27,000	$ 27,000
	SUBTOTAL				$ 27,000
	Contingency (50%)				$ 14,000
	Sales Tax (9.2%)				$ 3,772
	CONSTRUCTION SUBTOTAL				$ 45,000
	Design Services Engineering and Allied Costs (25%)				$ 11,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 11,250
	TOTAL PROJECT COST (ROUNDED)				**$ 70,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Conduct Process Load Study and Assess Generator Needs

Project Summary

• Conduct an engineering study to determine the entire facility loads and determine if generator 2994 should be replaced or if a different approach to providing standby power should be used.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Conduct Process Load Study and Assess Generator Needs	1	LS	$ 24,000	$ 24,000
	SUBTOTAL				$ 24,000
	Contingency (50%)				$ 12,000
	Sales Tax (9.2%)				$ 3,312
	CONSTRUCTION SUBTOTAL				$ 40,000
	Design Services Engineering and Allied Costs (25%)				$ 10,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 10,000
	TOTAL PROJECT COST (ROUNDED)				**$ 60,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Utilidor Panel 1990 and Septage Panel 5012

Item	Description	Quantity	Unit	Unit Cost	Total
	Project Summary				
	• Replace the electrical panels for the utilidor (PNL-1990) and septage receiving station (PNL-5012).				
1	Replace Utilidor Panel 1990 and Septage Panel 5012	1	LS	$ 84,000	$ 84,000
	SUBTOTAL				$ 84,000
	Contingency (50%)				$ 42,000
	Sales Tax (9.2%)				$ 11,592
	CONSTRUCTION SUBTOTAL				$ 138,000
	Design Services Engineering and Allied Costs (25%)				$ 34,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 34,500
	TOTAL PROJECT COST (ROUNDED)				**$ 210,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Central Kitsap Buildings HVAC Improvements

Project Summary

• Investigate the headworks, lab/admin, and process building HVAC systems and update as needed to provide adequate ventelation.
• Project is underway, see the HVAC Upgrade Study and Report, Fsi Engineers, 2023

Item	Description	Quantity	Unit	Unit Cost	Total
1	Lab/Admin Building Cooling, WSEC Compliance, and Seismic Upgrades	1	LS	$ 1,473,207	$ 1,473,207
2	Headworks Builing New HVAC	1	LS	$ 115,372	$ 115,372
3	Process Building HVAC	1	LS	$ 127,746	$ 127,746
	SUBTOTAL				$ 1,473,207
	Contingency (50%)				
	Sales Tax (9.2%)				$ 135,535
	CONSTRUCTION SUBTOTAL				$ 1,609,000
	Design Services and Allied Costs (11%)				$ 185,035
	Construction Services and Allied Costs (25%, assumes full CM)				$ 402,250
	TOTAL PROJECT COST (ROUNDED)				**$ 2,200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-13

Project Summary

- Replace the pump station
- Maintain capacity of 400 gpm
- Construct new wet well
- Construct new valve and meter vault
- Install new electrical, instrumentation, and controls in existing controls building
- Install new generator set

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 118,000	$ 118,000
2	Traffic Control	1	LS	$ 23,000	$ 23,000
3	TESC	1	LS	$ 11,500	$ 11,500
4	Dewatering	1	LS	$ 63,000	$ 63,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 7,000	$ 7,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 27,000	$ 27,000
7	48" Manhole Type 1	1	EA	$ 9,000	$ 9,000
8	10-foot Diameter Wet Well	1	LS	$ 169,000	$ 169,000
9	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
10	CMU Control Building	1	LS	$ 125,000	$ 125,000
11	Pumps	1	LS	$ 79,000	$ 79,000
12	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 70,000	$ 70,000
13	Yard Piping	1	LS	$ 17,000	$ 17,000
14	Standby Generator	1	LS	$ 135,000	$ 135,000
15	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
16	Fencing	160	LF	$ 40	$ 6,400
17	Clearing and Grubbing	1	LS	$ 4,000	$ 4,000
18	Temporary Bypass Pumping	1	LS	$ 50,000	$ 50,000
19	Site Restoration	1	LS	$ 23,000	$ 23,000
	SUBTOTAL				$ 1,298,900
	Contingency (50%)				$ 650,000
	Sales Tax (9.2%)				$ 179,299
	CONSTRUCTION SUBTOTAL				$ 2,129,000
	Design Services Engineering and Allied Costs (25%)				$ 532,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 532,250
	TOTAL PROJECT COST (ROUNDED)				**$ 3,200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-12

Project Summary

- Replace the pump station
- Increase capacity to 1,520 gpm
- Construct new wet well
- Install new electrical, instrumentation, and controls
- Construct new controls building
- Construct new valve and meter vault
- Install new generator set

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 280,000	$ 280,000
2	Traffic Control	1	LS	$ 55,000	$ 55,000
3	TESC	1	LS	$ 27,000	$ 27,000
4	Dewatering	1	LS	$ 84,000	$ 84,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 243,000	$ 243,000
6	Removal and Backfill of Existing Wetwell, Drywell, & Building	1	LS	$ 66,000	$ 66,000
7	48" Manhole Type 1	2	EA	$ 8,500	$ 17,000
8	12' Diameter Wet Well	1	LS	$ 300,000	$ 300,000
9	Valve & Meter Vaults	1	LS	$ 74,000	$ 74,000
10	CMU Control Building	1	LS	$ 500,000	$ 500,000
11	Pumps	3	EA	$ 85,000	$ 255,000
12	Valves and Piping - Wetwell & Vaults	1	LS	$ 100,000	$ 100,000
13	Yard Piping	1	LS	$ 25,000	$ 25,000
14	Standby Generator	1	LS	$ 135,000	$ 135,000
15	Electrical, Instrumentation, and Controls	1	LS	$ 711,000	$ 711,000
16	Fencing	620	LF	$ 40	$ 24,800
17	Clearing and Grubbing	1	LS	$ 8,600	$ 8,600
18	Temporary Bypass Pumping	1	LS	$ 125,000	$ 125,000
19	Site Restoration	1	LS	$ 54,000	$ 54,000
	SUBTOTAL				$ 3,084,400
	Contingency (50%)				$ 1,543,000
	Sales Tax (9.2%)				$ 425,721
	CONSTRUCTION SUBTOTAL				$ 5,054,000
	Design Services Engineering and Allied Costs (25%)				$ 1,263,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,263,500
	TOTAL PROJECT COST (ROUNDED)				**$ 7,600,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-34

Project Summary

• Replace pump station
• Increase capacity to 1,790 gpm
• Construct new wet well
• Construct new valve vault
• Construct new controls building
• Install new electrical, instrumentation, and controls equipment
• Install new generator set
• Replace fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 280,000	$ 280,000
2	Traffic Control	1	LS	$ 55,000	$ 55,000
3	TESC	1	LS	$ 27,000	$ 27,000
4	Dewatering	1	LS	$ 84,000	$ 84,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 243,000	$ 243,000
6	Removal and Backfill of Existing Wetwell, Drywell, & Building	1	LS	$ 66,000	$ 66,000
7	48" Manhole Type 1	2	EA	$ 8,500	$ 17,000
8	12' Diameter Wet Well	1	LS	$ 300,000	$ 300,000
9	Valve & Meter Vaults	1	LS	$ 74,000	$ 74,000
10	CMU Control Building	1	LS	$ 500,000	$ 500,000
11	Pumps	3	EA	$ 85,000	$ 255,000
12	Valves and Piping - Wetwell & Vaults	1	LS	$ 100,000	$ 100,000
13	Yard Piping	1	LS	$ 25,000	$ 25,000
14	Standby Generator	1	LS	$ 135,000	$ 135,000
15	Electrical, Instrumentation, and Controls	1	LS	$ 711,000	$ 711,000
16	Fencing	620	LF	$ 40	$ 24,800
17	Clearing and Grubbing	1	LS	$ 8,600	$ 8,600
18	Temporary Bypass Pumping	1	LS	$ 125,000	$ 125,000
19	Site Restoration	1	LS	$ 54,000	$ 54,000
	SUBTOTAL				$ 3,084,400
	Contingency (50%)				$ 1,543,000
	Sales Tax (9.2%)				$ 425,721
	CONSTRUCTION SUBTOTAL				$ 5,054,000
	Design Services Engineering and Allied Costs (25%)				$ 1,263,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,263,500
	TOTAL PROJECT COST (ROUNDED)				**$ 7,600,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-22

Project Summary

- Upgrade pump station
- Maintain capacity of 450 gpm
- Replace generator
- Replace one pump with new Flygt pump

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 13,000	$ 13,000
2	Traffic Control	1	LS	$ 3,000	$ 3,000
3	TESC	1	LS	$ 1,000	$ 1,000
4	Standby Generator	1	LS	$ 65,000	$ 65,000
5	Second Flygt Pump	1	LS	$ 40,000	$ 40,000
6	Electrical Improvements	1	LS	$ 20,000	$ 20,000
7	Site Restoration	1	LS	$ 3,000	$ 3,000
	SUBTOTAL				$ 145,000
	Contingency (50%)				$ 73,000
	Sales Tax (9.2%)				$ 20,056
	CONSTRUCTION SUBTOTAL				$ 239,000
	Design Services Engineering and Allied Costs (25%)				$ 59,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 59,750
	TOTAL PROJECT COST (ROUNDED)				**$ 360,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

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Replace PS-32

Project Summary

- Replace pump station
- Increase capacity to 175 gpm
- Construct new wet well
- Construct new valve vault
- Construct new electrical, instrumentation, and controls equipment under new canopy
- Install new generator set
- Install fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 69,000	$ 69,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 7,000	$ 7,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 8,000	$ 8,000
7	8-foot Diameter Wet Well	1	LS	$ 116,000	$ 116,000
8	Valve Vault	1	LS	$ 10,000	$ 10,000
9	Pumps	2	EA	$ 75,000	$ 150,000
10	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
11	Yard Piping	1	LS	$ 7,000	$ 7,000
12	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
13	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
14	Canopy	1	LS	$ 21,000	$ 21,000
15	Fencing	1	LF	$ 40	$ 40
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 40,000	$ 40,000
18	Site Restoration	1	LS	$ 14,000	$ 14,000
	SUBTOTAL				$ 759,040
	Contingency (50%)				$ 380,000
	Sales Tax (9.2%)				$ 104,792
	CONSTRUCTION SUBTOTAL				$ 1,244,000
	Design Services Engineering and Allied Costs (25%)				$ 311,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 311,000
	TOTAL PROJECT COST (ROUNDED)				**$ 1,900,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-2

Project Summary

- Replace pump station
- Construct new valve vault
- Construct new wet well
- Construct new electrical, instrumentation, and controls equipment under new canopy
- Install new generator set
- Install fencing
- Maintain capacity of 320 gpm

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 100,000	$ 100,000
2	Traffic Control	1	LS	$ 20,000	$ 20,000
3	TESC	1	LS	$ 9,700	$ 9,700
4	Dewatering	1	LS	$ 63,000	$ 63,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 7,000	$ 7,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 27,000	$ 27,000
7	48" Manhole Type 1	1	EA	$ 9,000	$ 9,000
8	10-foot Diameter Wet Well	1	LS	$ 169,000	$ 169,000
9	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
10	Pumps	1	LS	$ 79,000	$ 79,000
11	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 70,000	$ 70,000
12	Yard Piping	1	LS	$ 17,000	$ 17,000
13	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 75,000	$ 75,000
14	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
15	Canopy	1	LS	$ 15,000	$ 15,000
16	Fencing	160	LF	$ 40	$ 6,400
17	Clearing and Grubbing	1	LS	$ 4,000	$ 4,000
18	Temporary Bypass Pumping	1	LS	$ 50,000	$ 50,000
19	Site Restoration	1	LS	$ 20,000	$ 20,000
	SUBTOTAL				$ 1,103,100
	Contingency (50%)				$ 552,000
	Sales Tax (9.2%)				$ 152,269
	CONSTRUCTION SUBTOTAL				$ 1,808,000
	Design Services Engineering and Allied Costs (25%)				$ 452,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 452,000
	TOTAL PROJECT COST (ROUNDED)				**$ 2,800,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace PS-37

Project Summary

- Replace pump station
- Maintain capacity of 150 gpm
- Construct new wet well
- Construct new valve vault
- Construct new electrical, instrumentation, and controls equipment under new canopy
- Install new generator set
- Install fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 69,000	$ 69,000
2	Traffic Control	1	LS	$ 14,000	$ 14,000
3	TESC	1	LS	$ 7,000	$ 7,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 8,000	$ 8,000
7	8-foot Diameter Wet Well	1	LS	$ 116,000	$ 116,000
8	Valve Vault	1	LS	$ 10,000	$ 10,000
9	Pumps	2	EA	$ 75,000	$ 150,000
10	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
11	Yard Piping	1	LS	$ 7,000	$ 7,000
12	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
13	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
14	Canopy	1	LS	$ 21,000	$ 21,000
15	Fencing	1	LF	$ 40	$ 40
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 40,000	$ 40,000
18	Site Restoration	1	LS	$ 14,000	$ 14,000
	SUBTOTAL				$ 760,040
	Contingency (50%)				$ 381,000
	Sales Tax (9.2%)				$ 104,976
	CONSTRUCTION SUBTOTAL				$ 1,247,000
	Design Services Engineering and Allied Costs (25%)				$ 311,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 311,750
	TOTAL PROJECT COST (ROUNDED)				**$ 1,900,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-40

Project Summary

• Install on-site generator set
• Install canopy over electrical equipment

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 9,000	$ 9,000
2	Traffic Control	1	LS	$ 2,000	$ 2,000
3	TESC	1	LS	$ 1,000	$ 1,000
4	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
5	Electrical Improvements	1	LS	$ 20,000	$ 20,000
6	Canopy	1	LS	$ 21,000	$ 21,000
7	Fencing	1	LF	$ 40	$ 40
8	Site Restoration	1	LS	$ 2,000	$ 2,000
	SUBTOTAL				$ 95,040
	Contingency (50%)				$ 48,000
	Sales Tax (9.2%)				$ 13,160
	CONSTRUCTION SUBTOTAL				$ 157,000
	Design Services Engineering and Allied Costs (25%)				$ 39,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 39,250
	TOTAL PROJECT COST (ROUNDED)				**$ 240,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

consor

Upgrade PS-35

Project Summary

• Install on-site generator set
• Replace electrical equipment
• Install canopy over electrical equipment

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 42,000	$ 42,000
2	Traffic Control	1	LS	$ 8,000	$ 8,000
3	TESC	1	LS	$ 4,100	$ 4,100
4	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 75,000	$ 75,000
5	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
6	Canopy	1	LS	$ 15,000	$ 15,000
7	Fencing	160	LF	$ 40	$ 6,400
8	Clearing and Grubbing	1	LS	$ 4,000	$ 4,000
9	Site Restoration	1	LS	$ 9,000	$ 9,000
	SUBTOTAL				$ 463,500
	Contingency (50%)				$ 232,000
	Sales Tax (9.2%)				$ 63,986
	CONSTRUCTION SUBTOTAL				$ 760,000
	Design Services Engineering and Allied Costs (25%)				$ 190,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 190,000
	TOTAL PROJECT COST (ROUNDED)				**$ 1,200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-9

Project Summary

• Replace check valve
• Install on-site generator set

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 10,000	$ 10,000
2	Traffic Control	1	LS	$ 2,000	$ 2,000
3	TESC	1	LS	$ 1,000	$ 1,000
4	Replace Check Valve	1	LS	$ 5,000	$ 5,000
5	Standby Generator	1	LS	$ 65,000	$ 65,000
6	Electrical Improvements	1	LS	$ 20,000	$ 20,000
7	Site Restoration	1	LS	$ 2,000	$ 2,000
	SUBTOTAL				$ 105,000
	Contingency (50%)				$ 53,000
	Sales Tax (9.2%)				$ 14,536
	CONSTRUCTION SUBTOTAL				$ 173,000
	Design Services Engineering and Allied Costs (25%)				$ 43,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 43,250
	TOTAL PROJECT COST (ROUNDED)				**$ 260,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

consor

Replace PS-65

Project Summary

- Replace pump station
- Increase capacity to 675 gpm
- Construct new wet well
- Construct new valve vault
- Construct new electrical, instrumentation, and controls equipment under new canopy
- Install new generator set
- Install fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 111,000	$ 111,000
2	Traffic Control	1	LS	$ 22,000	$ 22,000
3	TESC	1	LS	$ 11,000	$ 11,000
4	Dewatering	1	LS	$ 63,000	$ 63,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 7,000	$ 7,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 27,000	$ 27,000
7	48" Manhole Type 1	1	EA	$ 9,000	$ 9,000
8	10-foot Diameter Wet Well	1	LS	$ 169,000	$ 169,000
9	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
10	CMU Control Building	1	LS	$ 125,000	$ 125,000
11	Pumps	1	LS	$ 79,000	$ 79,000
12	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 70,000	$ 70,000
13	Yard Piping	1	LS	$ 17,000	$ 17,000
14	Standby Generator	1	LS	$ 65,000	$ 65,000
15	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
16	Fencing	160	LF	$ 40	$ 6,400
17	Clearing and Grubbing	1	LS	$ 4,000	$ 4,000
18	Temporary Bypass Pumping	1	LS	$ 50,000	$ 50,000
19	Site Restoration	1	LS	$ 22,000	$ 22,000
	SUBTOTAL				$ 1,219,400
	Contingency (50%)				$ 610,000
	Sales Tax (9.2%)				$ 168,305
	CONSTRUCTION SUBTOTAL				$ 1,998,000
	Design Services Engineering and Allied Costs (25%)				$ 499,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 499,500
	TOTAL PROJECT COST (ROUNDED)				**$ 3,000,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-26

Project Summary

• Install on-site generator
• Replace hatch and raise up to avoid getting covered with dirt

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 9,000	$ 9,000
2	Traffic Control	1	LS	$ 2,000	$ 2,000
3	TESC	1	LS	$ 1,000	$ 1,000
4	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
5	Electrical Improvements	1	LS	$ 20,000	$ 20,000
6	Hatch Improvements	1	LS	$ 3,000	$ 3,000
7	Canopy	1	LS	$ 21,000	$ 21,000
8	Fencing	1	LF	$ 40	$ 40
9	Site Restoration	1	LS	$ 2,000	$ 2,000
	SUBTOTAL				$ 98,040
	Contingency (50%)				$ 50,000
	Sales Tax (9.2%)				$ 13,620
	CONSTRUCTION SUBTOTAL				$ 162,000
	Design Services Engineering and Allied Costs (25%)				$ 40,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 40,500
	TOTAL PROJECT COST (ROUNDED)				**$ 250,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-30

Project Summary

- Replace pumps
- Maintain capacity of 165 gpm
- Replace electrical and controls
- Install on-site generator set
- Install canopy over electrical equipment

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 44,000	$ 44,000
2	Traffic Control	1	LS	$ 9,000	$ 9,000
3	TESC	1	LS	$ 4,000	$ 4,000
4	Pumps	2	EA	$ 75,000	$ 150,000
5	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
6	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
7	Yard Piping	1	LS	$ 7,000	$ 7,000
8	Canopy	1	LS	$ 21,000	$ 21,000
9	Fencing	1	LF	$ 40	$ 40
10	Site Restoration	1	LS	$ 9,000	$ 9,000
	SUBTOTAL				$ 482,040
	Contingency (50%)				$ 242,000
	Sales Tax (9.2%)				$ 66,612
	CONSTRUCTION SUBTOTAL				$ 791,000
	Design Services Engineering and Allied Costs (25%)				$ 197,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 197,750
	TOTAL PROJECT COST (ROUNDED)				**$ 1,200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-20

Project Summary

- Replace building with CMU controls building
- Upgrade to submersible pumps
- Maintain capacity of 426 gpm

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 24,000	$ 24,000
2	Traffic Control	1	LS	$ 5,000	$ 5,000
3	TESC	1	LS	$ 2,000	$ 2,000
4	CMU Control Building	1	LS	$ 125,000	$ 125,000
5	Pumps	1	LS	$ 79,000	$ 79,000
6	Level Sensor Upgrades	1	LS	$ 5,000	$ 5,000
7	Electrical Improvements	1	LS	$ 20,000	$ 20,000
8	Site Restoration	1	LS	$ 5,000	$ 5,000
	SUBTOTAL				$ 265,000
	Contingency (50%)				$ 133,000
	Sales Tax (9.2%)				$ 36,616
	CONSTRUCTION SUBTOTAL				$ 435,000
	Design Services Engineering and Allied Costs (25%)				$ 108,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 108,750
	TOTAL PROJECT COST (ROUNDED)				**$ 660,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-61

Project Summary

• Replace pumps

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 40,000	$ 40,000
2	Traffic Control	1	LS	$ 8,000	$ 8,000
3	TESC	1	LS	$ 4,000	$ 4,000
4	Pumps	3	EA	$ 85,000	$ 255,000
5	Temporary Bypass Pumping	1	LS	$ 125,000	$ 125,000
6	Site Restoration	1	LS	$ 8,000	$ 8,000
	SUBTOTAL				$ 440,000
	Contingency (50%)				$ 220,000
	Sales Tax (9.2%)				$ 60,720
	CONSTRUCTION SUBTOTAL				$ 721,000
	Design Services Engineering and Allied Costs (25%)				$ 180,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 180,250
	TOTAL PROJECT COST (ROUNDED)				**$ 1,090,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Upgrade PS-69

Project Summary

- Replace pump station
- Increase capacity to 165 gpm
- Construct new wet well
- Construct new valve vault
- Construct new electrical, instrumentation, and controls equipment under new canopy
- Install new generator set
- Install fencing

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 69,000	$ 69,000
2	Traffic Control	1	LS	$ 14,000	$ 14,000
3	TESC	1	LS	$ 7,000	$ 7,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Removal and Backfill of Existing Wetwell	1	LS	$ 8,000	$ 8,000
7	8-foot Diameter Wet Well	1	LS	$ 116,000	$ 116,000
8	Valve Vault	1	LS	$ 10,000	$ 10,000
9	Pumps	2	EA	$ 75,000	$ 150,000
10	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
11	Yard Piping	1	LS	$ 7,000	$ 7,000
12	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
13	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
14	Canopy	1	LS	$ 21,000	$ 21,000
15	Fencing	1	LF	$ 40	$ 40
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 40,000	$ 40,000
18	Site Restoration	1	LS	$ 14,000	$ 14,000
	SUBTOTAL				$ 760,040
	Contingency (50%)				$ 381,000
	Sales Tax (9.2%)				$ 104,976
	CONSTRUCTION SUBTOTAL				$ 1,247,000
	Design Services Engineering and Allied Costs (25%)				$ 311,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 311,750
	TOTAL PROJECT COST (ROUNDED)				**$ 1,900,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Anderson Hill Sewer Upgrades

Project Summary

• Install 3,900 lf of 12-inch diameter pipe

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 170,000	$ 170,000
2	Traffic Control	1	LS	$ 100,000	$ 100,000
3	Dewatering	1	LS	$ 39,000	$ 39,000
4	SWPPP & BMPs	1	LS	$ 7,800	$ 7,800
5	Sewer Bypass	1	LS	$ 39,000	$ 39,000
6	Open Trench New 12-inch Pipe (SDR 35 PS46)	3,900	LF	$ 200	$ 780,000
7	6-inch Side Sewer Replacement	490	LF	$ 180	$ 88,200
8	Shoring and Trench Safety	1	LS	$ 16,000	$ 16,000
9	Imported Trench Backfill	2,900	TON	$ 25	$ 72,500
10	Manhole 48-inch diameter	15	EA	$ 15,000	$ 225,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	1,000	TON	$ 200	$ 200,000
12	Grind and Overlay, Channelization**	1	EST	$ 450,000	$ 450,000
13	Cleanup & Site Restoration	1	LS	$ 50,000	$ 50,000
	SUBTOTAL				$ 2,237,500
	Contingency (50%)				$ 1,119,000
	Sales Tax (9.2%)				$ 308,798
	CONSTRUCTION SUBTOTAL				$ 3,666,000
	Design Services Engineering and Allied Costs (25%)				$ 917,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 917,000
	TOTAL PROJECT COST (ROUNDED)				**$ 5,500,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Dickey Road Sewer Upgrades

Project Summary

• Install 2,420 lf of 12-inch diameter pipe

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 120,000	$ 120,000
2	Traffic Control	1	LS	$ 70,000	$ 70,000
3	Dewatering	1	LS	$ 26,000	$ 26,000
4	SWPPP & BMPs	1	LS	$ 4,900	$ 4,900
5	Sewer Bypass	1	LS	$ 25,000	$ 25,000
6	Open Trench New 12-inch Pipe (SDR 35 PS46)	2,420	LF	$ 200	$ 484,000
7	6-inch Side Sewer Replacement	310	LF	$ 180	$ 55,800
8	Shoring and Trench Safety	1	LS	$ 10,000	$ 10,000
9	Imported Trench Backfill	1,800	TON	$ 25	$ 45,000
10	Manhole 48-inch diameter	13	EA	$ 15,000	$ 195,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	700	TON	$ 200	$ 140,000
12	Grind and Overlay, Channelization**	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 30,000	$ 30,000
	SUBTOTAL				$ 1,505,700
	Contingency (50%)				$ 753,000
	Sales Tax (9.2%)				$ 207,800
	CONSTRUCTION SUBTOTAL				$ 2,467,000
	Design Services Engineering and Allied Costs (25%)				$ 617,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 617,000
	TOTAL PROJECT COST (ROUNDED)				**$ 3,800,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

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Myhre Road Sewer Upgrades

Project Summary

• Install 2,260 lf of 21-inch diameter pipe

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 110,000	$ 110,000
2	Traffic Control	1	LS	$ 64,000	$ 64,000
3	Dewatering	1	LS	$ 26,000	$ 26,000
4	SWPPP & BMPs	1	LS	$ 5,000	$ 5,000
5	Sewer Bypass	1	LS	$ 23,000	$ 23,000
6	Open Trench New 21-inch Pipe (PS46)	2,260	LF	$ 250	$ 565,000
7	6-inch Side Sewer Replacement	290	LF	$ 180	$ 52,200
8	Shoring and Trench Safety	1	LS	$ 10,000	$ 10,000
9	Imported Trench Backfill	2,000	TON	$ 25	$ 50,000
10	Manhole 48-inch diameter	12	EA	$ 15,000	$ 180,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	300	TON	$ 200	$ 60,000
12	Grind and Overlay, Channelization**	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 27,000	$ 27,000
	SUBTOTAL				$ 1,472,200
	Contingency (50%)				$ 737,000
	Sales Tax (9.2%)				$ 203,246
	CONSTRUCTION SUBTOTAL				$ 2,413,000
	Design Services Engineering and Allied Costs (25%)				$ 604,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 604,000
	TOTAL PROJECT COST (ROUNDED)				**$ 3,700,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

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Annual Pipe Replacement

Project Summary

• Replace deteriorated and aging pipe 15-inches in diameter and smaller
• Project costs assume $4,000,000 per year totaled over 14 years
• Replacement assumes 0.5 percent of total system (3,100 linear feet) is replaced per year

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 121,000	$ 121,000
2	Traffic Control	1	LS	$ 71,000	$ 71,000
3	Dewatering	1	LS	$ 29,000	$ 29,000
4	SWPPP & BMPs	1	LS	$ 7,000	$ 7,000
5	Sewer Bypass	1	LS	$ 31,000	$ 31,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	2,800	LF	$ 150	$ 420,000
7	Open Trench New 12-inch Pipe (SDR 35 PS46)	300	LF	$ 194	$ 58,274
8	6-inch Side Sewer Replacement	780	LF	$ 180	$ 140,400
9	Shoring and Trench Safety	1	LS	$ 13,000	$ 13,000
10	Imported Trench Backfill	2,800	TON	$ 25	$ 70,000
11	Manhole 48-inch diameter	11	EA	$ 15,000	$ 165,000
12	HMA for Trench Patch (CSBC and CSTC Incidental)	1,050	TON	$ 200	$ 210,000
13	Grind and Overlay, Channelization**	1,000	TON	$ 250	$ 250,000
14	Cleanup & Site Restoration	1	LS	$ 40,000	$ 40,000
	SUBTOTAL				$ 1,625,674
	Contingency (50%)				$ 813,000
	Sales Tax (9.2%)				$ 224,358
	CONSTRUCTION SUBTOTAL				$ 2,664,000
	Design Services Engineering and Allied Costs (25%)				$ 666,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 666,000
	TOTAL PROJECT COST (ROUNDED)				**$ 4,000,000**
				14 Year Total:	**$ 56,000,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Install a New Primary Clarifiers and Primary Sludge Pumps

Project Summary

- Replace and expand the primary clarifiers with new clarifiers that have additional capacity.
- Replace and increase capacity of the primary sludge pumps.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Excavation and Backfill	9071	CY	$ 175	$ 1,587,486
2	Yard Piping	400	LF	$ 364	$ 145,600
3	Clarifier Foundation	855 CY	CY	$ 1,000	$ 855,211
4	Clarifier Concrete Wall and Launder	894	CY	$ 1,000	$ 893,536
5	Clarifier Mechanism	3	LS	$ 260,000	$ 780,000
6	Effluent Weirs & Baffles	3	LS	$ 52,000	$ 156,000
7	Associated Primary Sludge Pump	3	EA	$ 65,000	$ 195,000
8	Associated Piping and Fittings	3	LS	$ 26,000	$ 78,000
9	EI&C Allowance	1	LS	$ 315,900	$ 315,900
	SUBTOTAL				$ 5,006,733
	Contingency (50%)				$ 2,504,000
	Sales Tax (9.2%)				$ 690,987
	CONSTRUCTION SUBTOTAL				$ 8,202,000
	Design Services Engineering and Allied Costs (25%)				$ 2,050,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 2,050,500
	TOTAL PROJECT COST (ROUNDED)				**$ 12,400,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Install a New Effluent Flow Meter

Project Summary

• Install an effluent flow meter.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Excavation	74	CY	$ 350	$ 25,926
2	Dewatering	1	LS	$ 200,000	$ 200,000
3	Vault Foundation and Ceiling	0.93	CY	$ 2,000	$ 1,852
4	Vault Walls	1.85	CY	$ 2,000	$ 3,704
5	MH Risers, Frame, and Cover	1	LS	$ 20,000	$ 20,000
6	Install a New Effluent Flow Meter	1	LS	$ 112,500	$ 112,500
7	EI&C	1	LS	$ 20,000	$ 20,000
	SUBTOTAL				$ 383,981
	Contingency (50%)				$ 192,000
	Sales Tax (9.2%)				$ 52,990
	CONSTRUCTION SUBTOTAL				$ 629,000
	Design Services Engineering and Allied Costs (25%)				$ 157,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 157,250
	TOTAL PROJECT COST (ROUNDED)				**$ 1,000,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Thickened Primary Sludge Grinders

Project Summary					
• Replace the thickened primary sludge grinders.					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace Thickened Primary Sludge Grinders	2	EA	$ 39,000	$ 78,000
	SUBTOTAL				$ 78,000
	Contingency (50%)				$ 39,000
	Sales Tax (9.2%)				$ 10,764
	CONSTRUCTION SUBTOTAL				$ 128,000
	Design Services Engineering and Allied Costs (25%)				$ 32,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 32,000
	TOTAL PROJECT COST (ROUNDED)				**$ 200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Scum Grinder and Pumps

Project Summary

• Replace the scum grinder
• Replace the scum pumps

Item	Description	Quantity	Unit	Unit Cost	Total
1	Equipment Pad	3	CY	$ 750	$ 2,250
2	Existing Scum Grinder and Pumps Demolition	3	LS	$ 5,000	$ 15,000
3	New Scum Pumps	2	EA	$ 39,075	$ 78,151
4	New Scum Grinder	1	LS	$ 36,400	$ 36,400
5	Pump Seal Water Assembly	3	LS	$ 2,600	$ 7,800
6	Mechanical Piping and Fittings	1	LS	$ 6,500	$ 6,500
7	EI&C Replacement	1	LS	$ 28,770	$ 28,770
	SUBTOTAL				$ 174,871
	Contingency (50%)				$ 88,000
	Sales Tax (9.2%)				$ 24,184
	CONSTRUCTION SUBTOTAL				$ 288,000
	Design Services Engineering and Allied Costs (25%)				$ 72,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 72,000
	TOTAL PROJECT COST (ROUNDED)				**$ 440,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Centrifuge Sludge Feed Grinders & Pumps

Project Summary

• Replace the centrifuge feed grinders
• Replace the centrifuge feed pumps

Item	Description	Quantity	Unit	Unit Cost	Total
1	Equipment Pad	4	CY	$ 750	$ 3,000
2	Existing Centrifuge Sludge Feed Grinders Demolition	2	EA	$ 5,000	$ 10,000
3	New Centrifuge Sludge Feed Grinders	2	EA	$ 35,750	$ 71,500
4	Centrifuge Mechanical Piping and Fittings	1	LS	$ 6,500	$ 6,500
5	Existing Centrifuge Feed Pumps Demolition	2	EA	$ 5,000	$ 10,000
6	New Centrifuge Feed Pumps	2	LS	$ 64,220	$ 128,440
7	Mechanical Piping and Fittings	1	LS	$ 13,000	$ 13,000
8	EI&C Replacement	1	LS	$ 63,032	$ 63,032
	SUBTOTAL				$ 305,472
	Contingency (50%)				$ 153,000
	Sales Tax (9.2%)				$ 42,179
	CONSTRUCTION SUBTOTAL				$ 501,000
	Design Services Engineering and Allied Costs (25%)				$ 125,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 125,250
	TOTAL PROJECT COST (ROUNDED)				**$ 760,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

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Replace Centrate Pumps

Project Summary

• Replace the centrate pumps

Item	Description	Quantity	Unit	Unit Cost	Total
1	Equipment Pad	2	CY	$ 750	$ 1,500
2	Existing Centrate Pumps Demolition	2	EA	$ 5,000	$ 10,000
3	New Centrate Pumps	2	EA	$ 7,995	$ 15,990
4	Mechanical Piping and Fittings	1	LS	$ 13,000	$ 13,000
5	EI&C Replacement	1	LS	$ 11,697	$ 11,697
	SUBTOTAL				$ 52,187
	Contingency (50%)				$ 27,000
	Sales Tax (9.2%)				$ 7,285
	CONSTRUCTION SUBTOTAL				$ 87,000
	Design Services Engineering and Allied Costs (25%)				$ 21,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 21,750
	TOTAL PROJECT COST (ROUNDED)				**$ 140,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Blower Building Primary Power Switchgear and Transformers

Project Summary					
• Replace the blower building primary power switchgear and transformers					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace Blower Building Primary Power Switchgear and Transformers	1	LS	$ 60,000	$ 60,000
	SUBTOTAL				$ 60,000
	Contingency (50%)				$ 30,000
	Sales Tax (9.2%)				$ 8,280
	CONSTRUCTION SUBTOTAL				$ 99,000
	Design Services Engineering and Allied Costs (25%)				$ 24,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 24,750
	TOTAL PROJECT COST (ROUNDED)				**$ 200,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Aeration Basin Air Distribution Study

Project Summary

• Conduct an engineering study to review the aeration basin air system to develop design improvements.
• This project will contribute towards ensuring effluent TIN can be kept consistently below 5 mg/L and a seasonal TIN below 3 mg/L

Item	Description	Quantity	Unit	Unit Cost	Total
1	Aeration Basin Air Distribution Study	1	LS	$ 500,400	$ 500,400
	SUBTOTAL				$ 500,400
	Contingency (50%)				$ 251,000
	Sales Tax (9.2%)				$ 69,129
	CONSTRUCTION SUBTOTAL				$ 821,000
	Design Services Engineering and Allied Costs (25%)				$ 205,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 205,250
	TOTAL PROJECT COST (ROUNDED)				**$ 1,300,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Replace Aeration Blowers 1&2 and Channel Blowers 1&2

Project Summary

• Replace existing aeration basin blowers 1 and 2.
• Replace channel blowers 1 and 2.
• This project will contribute towards ensuring effluent TIN can be kept consistently below 5 mg/L and a seasonal TIN below 3 mg/L

Item	Description	Quantity	Unit	Unit Cost	Total
1	Replace Aeration Blowers 1&2 and Channel Blowers 1&2	1	LS	$ 618,500	$ 618,500
	SUBTOTAL				$ 618,500
	Contingency (50%)				$ 310,000
	Sales Tax (9.2%)				$ 85,422
	CONSTRUCTION SUBTOTAL				$ 1,014,000
	Design Services Engineering and Allied Costs (25%)				$ 253,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 253,500
	TOTAL PROJECT COST (ROUNDED)				**$ 1,600,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Construct Aeration Basins 5 & 6

Project Summary

• Construct aeration basins 5 & 6 and expand associated support systems
• This project will contribute towards ensuring effluent TIN can be kept consistently below 5 mg/L and a seasonal TIN below 3 mg/L

Item	Description	Quantity	Unit	Unit Cost	Total
1	Excavation and Backfill	15911	CY	$ 175	$ 2,784,444
2	Basins Foundation	1591	CY	$ 1,000	$ 1,591,111
3	Basins Concrete Wall	1428	CY	$ 1,000	$ 1,428,148
4	FBR Weir and Baffle Walls	1	LS	$ 130,000	$ 130,000
5	Grating, Handrail, Ladder, Catwalk Supports	1	LS	$ 55,000	$ 55,000
6	Diffusers	1	LS	$ 270,000	$ 270,000
7	Mechanical & Aeration Piping and Fittings	1	LS	$ 2,600,000	$ 2,600,000
8	EI&C	1	LS	$ 861,000	$ 861,000
	SUBTOTAL				$ 9,719,704
	Contingency (50%)				$ 4,860,000
	Sales Tax (9.2%)				$ 1,341,333
	CONSTRUCTION SUBTOTAL				$ 15,922,000
	Design Services Engineering and Allied Costs (25%)				$ 3,980,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 3,980,500
	TOTAL PROJECT COST (ROUNDED)				**$ 23,900,000**

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Kitsap County General Sewer Plans
Central Kitsap Basin

Near-term Recycled Water Improvements

Project Summary

• Connect recycled water filters to transmission pipe with control valve and chlorine monitoring and controls.
• Project allows recycled water production up to approximately 1.5 MGD. Higher flows will result in insufficient chlorine contact time.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Pipe connection, control valve, and chloring monitoring/controls	1	LS	$ 211,500	$ 211,500
	SUBTOTAL				$ 211,500
	Contingency (50%)				$ 106,000
	Sales Tax (9.2%)				$ 29,210
	CONSTRUCTION SUBTOTAL				$ 347,000
	Design Services Engineering and Allied Costs (25%)				$ 86,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 86,750
	TOTAL PROJECT COST (ROUNDED)				**$ 600,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Central Kitsap Basin

consor

Long-term Recycled Water Improvements

Project Summary

- Construct a new UV disinfection system to provide recycled water disinfection.
- Project allows disinfection of the full 3.5 MGD capacity of the recycled water filters.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Pipe connection, control valve, and chloring monitoring/controls	1	LS	$ 1,889,800	$ 1,889,800
	SUBTOTAL				$ 1,889,800
	Contingency (50%)				$ 945,000
	Sales Tax (9.2%)				$ 260,802
	CONSTRUCTION SUBTOTAL				$ 3,096,000
	Design Services Engineering and Allied Costs (25%)				$ 774,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 774,000
	TOTAL PROJECT COST (ROUNDED)				**$ 4,700,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

APPENDIX R
SUMMARY OF STATE OF WASHINGTON GRANT AND LOAN PROGRAMS FOR DRINKING WATER AND WASTEWATER CAPITAL PROJECTS

Funding Programs for Drinking Water and Wastewater Projects

Updated 9-17-2024

You can find the latest version of this document at http://www.infrafunding.wa.gov/resources.html

Please contact Amie Smith at amie.smith@commerce.wa.gov if you would like to update your program information

PLANNING Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
DWSRF Drinking Water State Revolving Fund Planning and Engineering Loans Department of Health	Preparation of planning documents, engineering reports, construction documents, permits, cultural reports, environmental reports. Potential for grant subsidy for disadvantaged communities or those with high affordability rates.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Small systems serving fewer than 10,000 people.	Loan: $500,000 maximum per jurisdiction 0% annual interest rate 2% loan service fee 2-year time of performance 10-year repayment period	On-line applications accepted year-round until funding exhausted. Approximately $3 million available to award each year. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Consolidation Grant Department of Health	Development of a feasibility study, engineering evaluation, design of a infrastructure project to consolidated one or more Group A water systems	Group A not-for-profit community water system, county, city, public utility district, or water district in Washington State Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Grant: Up to $50,000 per project Minimum of $10,000 2-year time of performance	Online applications accepted year round until funding exhausted. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Lead Service Line Inventory Loan Department of Health	Develop lead service line inventory. Can include creating or updating a planning document. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems.	Loan: Minimum $25,000 No maximum 0% annual interest rate 2% loan service fee 2-year time of performance 10-year repayment period First come, first served based on application submittal date.	Online applications available and accepted October 1 through November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

PLANNING **Programs**	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
DWSRF Drinking Water State Revolving Fund Drinking Water System Rehabilitation and Consolidation Grant Department of Health	Rehabilitation Planning and design of infrastructure to bring system into compliance. Restructuring, Consolidation, Receivership Planning Preconstruction to bring the water system into compliance. Purchase cost of the water system to be acquired. Establishment of a water program for any receiving city, town, or county.	Rehabilitation Group A water systems serving less than 10,000 people under a DOH compliance order. Restructuring, Consolidation, Receivership Group A publicly owned water system (city, town, county, public utility district, or water/sewer district), an approved Satellite Management Agency, or approved receiver.	Grant: Maximum $1.25 million 4-year time of performance	By invite only. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
SOURCE WATER PROTECTION GRANT PROGRAM Department of Health	Source water protection studies (watershed, hydrogeologic, feasibility studies). Eligible activities can lead to reducing the risk of contamination of a system's drinking water sources(s), or they can evaluate or build resiliency for a public water supply. They must contribute to better protecting one or more public water supply sources.	Non-profit Group A water systems. Local governments proposing a regional project. Project must be reasonably expected to provide long-term benefit to drinking water quality or quantity.	Grants: Funding is dependent upon project needs, but typically does not exceed $30,000.	Applications accepted anytime; grants awarded on a funds available basis. **Contact:** Deborah Johnson 253-433-4054 Deborah.Johnson@doh.wa.gov http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/SourceWater/SourceWaterProtection.aspx Grant guidelines https://www.doh.wa.gov/Portals/1/Documents/Pubs/331-552.pdf

PLANNING Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
ECOLOGY: WATER QUALITY COMBINED FUNDING PROGRAM State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP) Department of Ecology	Planning projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes	Loan: $10,000,000 reserved for preconstruction statewide Interest rates (SFY 2025) • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Preconstruction set-aside (Distressed Communities) 50% forgivable principal loan and 50% loan	Applications due October 15, 2024. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans
RD PRE-DEVELOPMENT PLANNING GRANTS (PPG) U.S. Dept. of Agriculture Rural Development – Rural Utilities Service – Water and Waste Disposal Direct Loans and Grants	Water and/or sewer planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Low-income, small communities and systems serving areas under 10,000 population. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Planning grant to assist in paying costs associated with developing a complete application for RD funding for a proposed project. Maximum $60,000 grant. Requires minimum 25% match.	Applications accepted year-round, on a fund-available basis. **Contact:** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
RD 'SEARCH' GRANTS: SPECIAL EVALUATION ASSISTANCE FOR RURAL COMMUNITIES U.S. Dept. of Agriculture Rural Development – Rural Utilities Service – Water and Waste Disposal Direct Loans and Grants	Water and/or sewer planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Low-income, small communities and systems serving areas under 2,500 population. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Maximum $30,000 grant. No match required.	Applications accepted year-round, on a fund-available basis. **Contact: :** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa

PLANNING Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
CERB PLANNING AND FEASIBILITY GRANTS Community Economic Revitalization Board – Project-Specific Planning Program	Project-specific feasibility and pre-development studies that advance community economic development goals for industrial sector business development.	Eligible statewide Counties, cities, towns, port districts, special districts. Federally recognized tribes Municipal corporations, quasi-municipal corporations w/ economic development purposes.	Grant: Up to $100,000 per project. Requires 20% (of total project cost) matching funds CERB is authority for funding approvals.	Applications accepted year-round. The Board meets six times a year. **Contact:** Janea Stark 360-252-0812 janea.stark@commerce.wa.gov
RCAC Rural Community Assistance Corporation Feasibility and Pre-Development Loans	Water, wastewater, stormwater, and solid waste planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 or less if proposed permanent financing is through USDA Rural Development.	Typically up to $50,000 for feasibility loan. Typically up to $350,000 for pre-development loan. Typically up to a 1-year term. 5.5% interest rate. 1% loan fee.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Planning, Feasibility Studies, Preliminary Engineering Reports, Environmental Consultation for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure and water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State	Grants: EDA investment share up to $500,000 Cost sharing required from applicant Standard grant rate of 50% of total project cost and up to 80%. ○ Up to 100% for Tribal Nations	Submit application through EDA Grants Management Experience "EDGE" Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov

PLANNING **Programs**	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
Public Works Board WA Department of Commerce Pre-construction program	Capital facilities planning (including small water system management plans, wastewater facility plans, transportation elements, etc.) Roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics facilities.	Counties, cities, special purpose districts, and quasi-municipal organizations that meet certain requirements. Ineligible applicants: school districts, port districts, and tribes, per statute.	Pre-construction awarded quarterly until funds are exhausted. Up $1,000,000 per project. FY25 interest rate: 0.86%. 5 year loan term. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed or Severely Distressed criteria.	**Contact:** Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

PRECONSTRUCTION ONLY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
ECOLOGY: WATER QUALITY COMBINED FUNDING PROGRAM State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP)	Design projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes. Stormwater Financial Assistance Program (SFAP) is limited to cities, counties, and public ports.	Loan: $10,000,000 reserved for preconstruction statewide Interest rates (SFY 2025) • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Preconstruction set-aside (Distressed Communities) 50% forgivable principal loan and 50% loan	Applications due October 15, 2024. A cost effectiveness analysis must be complete at the time of application. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans
Public Works Board PWB PRE-CON WA Department of Commerce Pre-Construction Program	Pre-construction activities to bring projects to a higher degree of readiness that prepare a specific project for construction. Roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics facilities.	Counties, cities, special purpose districts, and quasi-municipal organizations that meet certain requirements. Ineligible applicants: school districts, port districts, and tribes, per statute.	Pre-construction awarded quarterly until funds are exhausted. Up $1,000,000 per project. FY25 interest rate: 0.86%. 5 year loan term. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed or Severely Distressed criteria.	**Contact:** Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

PRECONSTRUCTION ONLY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
RCAC Rural Community Assistance Corporation Feasibility and Pre-Development Loans	Water, wastewater, stormwater, or solid waste planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 or less if proposed permanent financing is through USDA Rural Development.	Typically up to $50,000 for feasibility loan. Typically up to $350,000 for pre-development loan. Typically a 1-year term. 5.5% interest rate. 1% loan fee.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Design and/or Construction for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure and water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State.	Grants: EDA investment share up to $500,000 Cost sharing required from applicant Standard grant rate is 50% of total project cost, and up to 80%. ○ Up to 100% for Tribal Nations	Submit application through EDA Grants Management Experience “EDGE” Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
DWSRF Drinking Water State Revolving Fund Construction Loan Program Department of Health	Drinking water system infrastructure projects aimed at increasing public health protection. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Maximum $15 million per jurisdiction. 2.25% annual interest rate (Final rate is set September 1, 2024). 1.0% loan service fee (water systems receiving subsidy are not subject to loan fees). 4-year time of performance, encouraged 2-year time of performance Loan repayment period: 20 years or life of the project, whichever is less. No local match required.	Online applications available and accepted year-round. Applications due November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Lead Service Line (LSL) Replacement Loan Department of Health	Lead service line replacement. Galvanized service lines to be replaced per Lead and Copper Rule. Service water meters older than 1986 lead ban, as part of LSL replacement. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Minimum $25,000 No maximum 2.25% annual interest rate (Final rate is set September 1, 2024). 1% loan service fee (water systems receiving subsidy are not subject to loan fees) 4-year time of performance, encouraged 2-year time of performance 20-year repayment period	Online applications available and accepted October 1 year-round. Applications due November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
DWSRF Drinking Water State Revolving Fund Drinking Water System Rehabilitation and Consolidation Grant **Department of Health**	Rehabilitation Construction of infrastructure to bring water system into compliance. Restructuring, Consolidation, Receivership Planning Construction of infrastructure to bring water system into compliance.	Rehabilitation Group A water systems serving less than 10,000 people under a DOH compliance order. Restructuring, Consolidation, Receivership Group A publicly owned water system (city, town, county, public utility district, or water/sewer district), an approved Satellite Management Agency, or approved receiver.	Grant: Maximum $1.25 million 4-year time of performance	By invite only. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
ECOLOGY: Water Quality Combined Funding Program State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP)	Construction projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes. Stormwater Financial Assistance Program (SFAP) is limited to cities, counties, and public ports. Hardship Assistance Jurisdictions listed above with a service area population of 25,000 or less.	Loan: $200,000,000 available statewide. Interest rates (SFY 2025) • 21-30 year loans: 1.6% • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Hardship assistance for the construction of wastewater treatment facilities may be available in the form of a reduced interest rate, and up to $5,000,000 grant or loan forgiveness. SFAP grant maximum award per jurisdiction: $10,000,000, with a required 15% match, with match reduced to 5% for hardship.	Applications due October 15, 2024. A cost effectiveness analysis must be complete at the time of application. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
PWB Public Works Board Construction Program	New construction, replacement, and repair of existing infrastructure for roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics.	Counties, cities, special purpose districts, and quasi-municipal organizations. Ineligible applicants: school districts, port districts, and tribes, per statute.	FY26 Cycle: Pending appropriation FY25 interest rate: 1.71%. Loan term 20 years. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Maximum project award: $10 million per jurisdiction per biennium. Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed criteria. Construction is a competitive program with two cycles per biennium.	Typically opens in Spring Contact: Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
RD U.S. Dept. of Agriculture Rural Development - Rural Utilities Service Water and Waste Disposal Direct Loans and Grants	Pre-construction and construction associated with building, repairing, or improving drinking water, wastewater, solid waste, and stormwater facilities.	Cities, towns, and other public bodies, tribes and private non-profit corporations serving rural areas with populations under 10,000. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Loans; Grants in some cases Interest rates change quarterly; contact staff for latest interest rates. Up to 40-year loan term. No pre-payment penalty.	Applications accepted year-round on a fund-available basis. **Contact: :** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
CERB Community Economic Revitalization Board Construction Program	Public facility projects required by private sector expansion and job creation. Projects must support significant job creation or significant private investment in the state. Bridges, roads and railroad spurs, domestic and industrial water, sanitary and storm sewers. Electricity, natural gas and telecommunications General purpose industrial buildings, port facilities. Acquisition, construction, repair, reconstruction, replacement, rehabilitation	Counties, cities, towns, port districts, special districts Federally-recognized tribes Municipal and quasi-municipal corporations with economic development purposes.	Maximum grant amounts: $2,000,000 for construction projects. $500,000 for housing rehabilitation programs. $250,000 for microenterprise assistance programs.	Applications accepted year-round. The Board meets six times a year. **Contact:** Janea Stark 360-252-0812 janea.stark@commerce.wa.gov

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
CDBG-GP Community Development Block Grant General Purpose Grants	Design and construction of community facility, wastewater, drinking water, stormwater and street/sidewalk projects. Infrastructure in support of affordable housing.	Projects must principally benefit low- to moderate-income people in non-entitlement cities and counties. List and map of local governments served by state CDBG program	Maximum grant amounts: $2,000,000 for construction projects. $500,000 for housing rehabilitation programs. $250,000 for microenterprise assistance programs.	Applications accepted year-round on a fund-available basis. **Contact:** Jon Galow 509-847-5021 Jon.galow@commerce.wa.gov Visit www.commerce.wa.gov/cdbg for more information.
RCAC Rural Community Assistance Corporation Intermediate Term Loan	Water, wastewater, solid waste and stormwater facilities that primarily serve low-income rural communities.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less.	Typically up to $3 million with commitment letter for permanent financing Security in permanent loan letter of conditions Term matches construction period. 5.5% interest rate 1.125% loan fee	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
RCAC Rural Community Assistance Corporation Construction Loans	Water, wastewater, solid waste and stormwater facilities that primarily serve low-income rural communities. Can include pre-development costs.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 populations or less if using USDA Rural Development financing as the takeout.	2023-2025 solicitation closed 9/25/2024 Longstanding program will likely be offered in the 2025-2027 biennium. Minimum match requirements will apply. Other State funds cannot be used as match.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Energy Retrofits for Public Buildings Program: Energy Efficiency Grant Washington State Department of Commerce	Retrofit projects that reduce energy consumption (electricity, gas, water, etc.) and operational costs on existing facilities and related projects owned by an eligible applicant. Projects must utilize devices that do not require fossil fuels whenever possible.	Washington State public entities, such as cities, towns, local agencies, public higher education institutions, school districts, federally recognized tribal governments, and state agencies. Some percentage of funds are reserved for projects in small towns or cities with populations of 5,000 or fewer. Priority given to applicants who have not received funding previously, certain priority communities.	2023-25 solicitation closed 09/25/2024. Longstanding program will likely be offered in the 2025-27 biennium. Minimum match requirements will apply. Other State funds cannot be used as match.	**Contact:** Kristen Kalbrener 360-515-8112 energyretrofits@commerce.wa.gov For more information: https://www.commerce.wa.gov/growing-the-economy/energy/energy-efficiency-and-solar-grants/
Energy Efficiency and Conservation Block Grant Washington State Department of Commerce	Energy audits and energy conservation planning projects including financing, infrastructure, public education	Local governments (cities, counties, federally-recognized tribes) Priority for disadvantaged communities	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** Kristen Kalbrener 360-515-8112 energyretrofits@commerce.wa.gov
Energy Retrofits for Public Buildings: Solar Grants Washington State Department of Commerce	Purchase and installation of grid-tied solar photovoltaic (electric) arrays net metered with existing facilities owned by public entities. Additional points for 'Made in Washington' components.	Washington State public entities, such as cities, towns, local agencies, public higher education institutions, school districts, federally recognized tribal governments, and state agencies. See above.	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** EPICgrants@commerce.wa.gov **Visit:** https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs/ for more information.

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Solar plus Storage for Resilient Communities Washington State Department of Commerce	The Solar plus Storage program funds solar and battery back-up power so community buildings can provide essential services when the power goes out, including both planning and installation grants.	Local governments, State governments, Tribal governments and their affiliates, Non-profit organizations and Retail electric utilities.	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** EPICgrants@commerce.wa.gov **Visit:** **https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs**
Dual Use Solar **Washington State Department of Commerce**	Constructions or planning projects that will lead to the creation of mixed use solar installation. Projects should including, but are not limited to, combining solar with: animal grazing, beekeeping, pollinator habitat, or other colocation uses.	Local governments, State governments, Tribal governments and their affiliates, Non-profit organizations, for-profit organizations, and Retail electric utilities.	Grants: EDA investment share up to $5,000,000. Cost sharing required from applicant Standard grant rate is 50% of total project cost, and up to 80%. Up to 100% for Tribal Nations	**Contact:** EPICgrants@commerce.wa.gov **Visit:** **https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs/**

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Design and/or Construction for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/ harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure, water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State.	Loans may not exceed $200,000 or 75% of the total project cost, whichever is less. Applicants given credit for documented project costs prior to receiving the loan. Interest rates at the lower of the poverty or market interest rate as published by USDA RD RUS, with a minimum of 3% at time of closing. Maximum repayment period is 10 years. Additional ranking points for a shorter repayment period. The repayment period cannot exceed the useful life of the facilities.	Submit application through EDA Grants Management Experience "EDGE" Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov
RURAL WATER REVOLVING LOAN FUND	Short-term costs incurred for replacement equipment, small scale extension of services, or other small capital projects that are not a part of regular operations and maintenance for drinking water and wastewater projects.	Public entities, including municipalities, counties, special purpose districts, Native American Tribes, and corporations not operated for profit, including cooperatives, with up to 10,000 population and rural areas with no population limits.	$55.5 million in total funds available in 2023-2025 biennium. $19.4 million specifically reserved for jurisdictions with a population of less than 150,000. $2,000,000 maximum award. Funds available as both grants and deferred loans.	Applications accepted anytime. **Contact**: Tracey Hunter Evergreen Rural Water of WA 360-462-9287 thunter@erwow.org Download application online: http://nrwa.org/initiatives/revolving-loan-fund/
Connecting Housing to Infrastructure Program (CHIP) Washington State Department of Commerce	Housing projects with at least 25% of units affordable for at least 25 years. Funding goes toward water, sewer, and stormwater infrastructure improvements for eligible projects, as well as toward system development charges and impact fees, which are waived to encourage affordable housing.	Cities, counties, and utility districts located in a jurisdiction which has a dedicated sales tax for affordable housing. The local jurisdiction will sponsor/ partner with a housing developer on the project.	$55.5 million in total funds available in 2023-2025 biennium. $19.4 million specifically reserved for jurisdictions with a population of less than 150,000. $2,000,000 maximum award. Funds available as both grants and deferred loans.	Contact: Mischa Venables 360-725-3088 Mischa.venables@commerce.wa.gov Visit www.commerce.wa.gov/CHIP

EMERGENCY Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
ECOLOGY Water Quality Emergency Clean Water State Revolving Funding Program	Projects that may result from a natural disaster or an immediate and emergent threat to public health due to water quality issues resulting from unforeseen or unavoidable circumstances. Water quality-related projects considered to be an environmental emergency that meets the WAC 173-98-030(27)5 definition and has received a Declaration of Emergency from the local Government.	Only available to public bodies serving a population of 10,000 or less. Counties, cities, and towns, federally recognized tribes, water and sewer districts, irrigation districts, conservation districts, local health jurisdictions, port districts, quasi-municipal corporations, Washington State institutions of higher education	Loan: $5,000,000 maximum Interest rates (SFY25): 10-year loan, 0.0-1.6%	Available year round. Contact: Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

EMERGENCY Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
RD – ECWAG U.S. Dept. of Agriculture Rural Development Emergency Community Water Assistance Grants	Domestic water projects needing emergency repairs due to an incident such as: a drought; earthquake; flood; chemical spill; fire; etc. A significant decline in quantity or quality of potable water supply that was caused by an emergency.	Public bodies, tribes and private non-profit corporations serving rural areas with populations under 10,000. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Grant; pending availability of funds. Water transmission line grants up to $150,000 to construct water line extensions, repair breaks or leaks in existing water distribution lines, and address related maintenance to replenish the water supply. Water source grants up to $1,000,000 for the construction of new wells, reservoirs, transmission lines, treatment plants, and/or other sources of water (water source up to and including the treatment plant).	Applications accepted year-round on a fund-available basis. **Contact:** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
DWSRF Department of Health – Drinking Water State Revolving Fund Emergency Loan Program Department of Health	Will financially assist eligible communities experiencing the loss of critical drinking water services or facilities due to an emergency.	Publicly or privately owned (not-for-profit) Group A community water systems with a population of fewer than 10,000. Transient or non-transient non-community public water systems owned by a non-profit organization. Non-profit non-community water systems must submit tax-exempt documentation. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Interest rate: 0%, no subsidy available Loan fee: 1.5% Loan term: 10 years $500,000 maximum award per jurisdiction. Time of performance: 2 years from contract execution to project completion date. Repayment commencing first October after contract execution.	To be considered for an emergency loan, an applicant must submit a completed emergency application package to the department. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

EMERGENCY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
RURAL WATER REVOLVING LOAN FUND Disaster area emergency loans	Contact staff for more information on emergency loans.	Public entities, including municipalities, counties, special purpose districts, Native American Tribes, and corporations not operated for profit, including cooperatives, with up to 10,000 population and rural areas with no population limits.	90-day, no interest, disaster area emergency loans with immediate turn-around. Download application online: http://nrwa.org/initiatives/revolving-loan-fund/	Applications accepted anytime. **Contact**: Tracey Hunter Evergreen Rural Water of WA 360-462-9287 thunter@erwow.org
HAZARD MITIGATION GRANT PROGRAM FEMA/WA Emergency Management Division	Disaster risk-reduction projects and planning after a disaster declaration in the state.	Any state, tribe, county, or local jurisdiction (incl., special purpose districts) that has a current FEMA-approved hazard mitigation plan.	Varies depending on the level of disaster, but projects only need to compete at the state level. Local jurisdiction cost-share: 12.5%	Applications will be opened after a disaster declaration. **Contact**: Tim Cook State Hazard Mitigation Officer 253-512-7072 Tim.cook@mil.wa.gov
PUBLIC ASSISTANCE PROGRAM FEMA/WA Emergency Management Division	Construction, repair to, and restoration of publicly owned facilities damaged during a disaster. Debris-removal, life-saving measures, and restoration of public infrastructure.	State, tribes, counties, and local jurisdictions directly affected by the disaster.	Varies depending on the level of disaster and total damage caused.	Applications are opened after disaster declaration. **Contact:** Gary Urbas Public Assistance Project Manager 253-512-7402 Gary.urbas@mil.wa.gov
WASHINGTON STATE DEPARTMENT OF COMMERCE ERR - Emergency Rapid Response	Projects that provide continuity of essential community services/ lifelines that become diminished during an emergency and recovery assistance after an emergency event. Projects that restore service for a limited duration or through a temporary measure. These funds are not designated for long term recovery costs associated with the full re-establishment of lifeline services.	Tribes and local governments	Grant; pending availability of funds $5,000,000- $6,000,000 Period of performance state fiscal year July-June	Applications accepted year-round until funding exhausted. $5.5 to 6 million available to award each year. **Contact:** Nicole Patrick 206-713-6997 Nicole.patrick@commerce.wa.gov For information and application visit: EmergencyRapidResponse or https://deptofcommerce.box.com/s/skmab4hq3l4z55jazzc7qlsmbrsgermv