KITSAP COUNTY

KINGSTON GENERAL SEWER PLAN UPDATE

January 2025

PREPARED BY:

Consor
Point of Contact: Erika Schuyler, PE
600 University Street, Suite 300
Seattle, WA 98101
p: 206.462.7030
e: erika.schuyler@consoreng.com

PREPARED FOR:

Kitsap County
Sewer Utility Division of Public Works Department
507 Austin Avenue
Port Orchard, WA 98366

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Kingston General Sewer Plan Update

Kitsap County

January 2025

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Consor

600 University Street
Suite 600
Seattle, WA 98101

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Acronyms & Abbreviations

A	
AAF	Average annual flow
AACE	American Association of Cost Engineers
ADA	Americans with Disabilities Act
AFD	Adjustable Frequency Drive
AKART	all known and reasonable methods of prevention, control, and treatment
ANSI	American National Standards Institute
ASIL	Acceptable Source Impact Levels
ATS	Automatic Transfer Switch
B	
BOD	Biochemical oxygen demand
C	
CARA	Critical Aquifer Recharge Areas
CBOD	Carbonaceous biochemical oxygen demand
CCTV	Closed circuit television
CFR	Code of Federal Regulations
CIP	Capital improvement plan/program
CMMS	Computerized maintenance management system
CMOM	Capacity Management Operations and Maintenance
CMU	Concrete masonry unit
COD	Chemical Oxygen Demand
CoF	Consequence of failure
County	Kitsap County
CPU	Central processing unit
CT	Current Transformer
CWA	Clean Water Act
D	
DCD	Department of Community Development
DHI	Danish Hydraulic Institute
DMR	Discharge Monitoring Report
DO	Dissolved oxygen
DOH	Washington State Department of Health
E	
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
ERU	Equivalent Residential Unit
ESA	Endangered Species Act
F	
FOG	Fats, Oils, and Grease

fps	feet per second
FTE	Full-Time Equivalent
FWPCA	Federal Water Pollution Control Act
G	
GBT	Gravity belt thickener
GIS	Geographic Information Systems
GMA	Growth Management Act
gpcd	Gallons per Capita Per Day
gpd	gallons per day
gpd/sf	Gallons per day per square foot
gpm	gallons per minute
H	
H/H	Hydraulic and hydrologic
HP	Horsepower
HPA	Hydraulic Project Approval
HVAC	Heating, ventilation, and air conditioning
I	
I&I	Infiltration and inflow
I/O	Input/output
IBC	International Building Code
IFC	International Fire Code
IMC	International Machine Code
IPS	Individual Pump Stations
ISI	Industrial Systems Inc.
K	
KCCP	Kitsap County Comprehensive Plan
KPUD	Kitsap Public Utility District
kV	Kilovolt
kVA	Kilovolt amperes
L	
LAMIRD	Limited Area of More Intense Rural Development
LEL	Lower Explosive Limit
LUV	Land Use Vision
M	
MCC	Motor control center
MG	million gallons
mg/L	Milligrams per liter
MGD	million gallons per day
mL	Milliliter
MLLW	Mean lower low water
MLSS	Mixed liquor suspended solids
MMDF	Maximum Month Design Flow

MMDWF	Maximum month dry weather flow
MMWWF	Maximum month wet weather flow
N	
NASSCO	National Association of Sewer Service Companies
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
NOC	Notice of Construction
NPDES	National Pollutant Discharge Elimination System
NSR	New Source Review
O	
O&M	operation and maintenance
OCI	Overall Condition Index
OFM	Washington State Office of Financial Management
OIT	Operator interface terminal
OPPC	Opinions of probable project cost
Orange Book	Washington State Department of Ecology's Criteria for Sewage Works Design
ORP	Oxidation Reduction Potential
Ortho-P	Orthophosphate
OSHA	Occupational Safety and Health Administration
P	
PDF	Peak day flow
PFAS	Per- and polyfluoroalkyl substances
PHF	Peak hour flow
Plan	General Sewer Plan Update
PLC	Programmable Logic Controllers
POTW	Publicly Owned Treatment Works
ppcd	pounds per capita per day
ppd	pounds per day
PSCAA	Puget Sound Clean Air Agency
PSD	Prevention of Significant Deterioration
PSE	Puget Sound Energy
psi	pounds per square inch
PSNGP	Puget Sound Nutrient General Permit
PSRC	Puget Sound Regional Council
R	
RAS	Return activated sludge
RCW	Revised Code of Washington
S	
SCADA	Supervisory Control and Data Acquisition
SCFM	standard cubic feet per minute

SCS	Soil Conservation Service
SEPA	State Environmetal Policy Act
SERP	Washington State Environmental Review Process
SF	Square feet
SHPO	State Historic Preservation Officer
SRT	Solids retention time
SSO	Sanitary Sewer Overflow
T	
TAC	Toxic air contaminants
TAZ	Traffic Analysis Zone
TIN	Total Inorganic Nitrogen
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSS	Total suspended solids
TWAS	Thickened waste activated sludge
U	
UBC	Uniform Building Code
UFC	Uniform Fire Code
UGA	Urban Growth Area
UOS	Unstable old landslides
UPC	Uniform Plumbing Code
URS	Unstable recent slides
USACE	United States Army Corps of Engineers
UV	Ultraviolet
V	
VAC	Volts of alternating current
VFD	variable frequency drive
VSS	Volatile suspended solids
W	
WAC	Washington Administrative Code
WAS	Waste activated sludge
WHGC	White Horse Golf Course
WRIA	Water Resource Inventory Area
WWTP	Wastewater treatment plant

Executive Summary

ES.1 Introduction

Since the 1950s, Kitsap County (County) has worked to protect aquifers, surface water, and the Puget Sound by providing wastewater collection, treatment, and discharge. This Kingston General Sewer Plan Update (Plan) provides a road map for the Kingston service area's long-term wastewater infrastructure needs for the next 20 years. Planning the wastewater infrastructure needs of a dynamic and fast-growing region is challenging. Expanding populations in the County will require sewer service and the County will be responsible for appropriately collecting, conveying, and treating increasing wastewater flows. Infrastructure design and implementation will be strategically planned to maximize limited fiscal resources. Federal, State, and Locate regulations all contribute to a need to be on the cutting edge of emerging technologies and require the utility to continually think ahead. Planning at this level involves weighing a complicated array of interconnected—and often conflicting—factors and variables. This Plan provides a framework for the County to continue to manage growth within the context of a countywide wastewater service network and achieve the overall goal of providing sewerage service to protect public health and the quality of Kitsap and the Puget Sound's water resources.

The State of Washington adopted the Growth Management Act (GMA) with the intent of creating a consistent and unified growth planning process. The GMA requires that the County create and enact a Comprehensive Plan to provide a 20-year blueprint for local policy, planning and capital facility investment. A Comprehensive Plan is used as a guide for local governments through the establishment of vision statements, goals, objectives, policies, and implementing actions. This Plan constitutes the sewer capital facilities element of the Kitsap County Comprehensive Plan (KCCP). At the time of adoption, this Sewer Plan is consistent with the other elements of the KCCP.

This Plan is based on planning horizons of a six-year period (2023 to 2028), and a 20-year period (2029 to 2042). An updated KCCP is currently in progress and will cover a 20-year planning period from 2024 to 2044. Therefore, the recommendations and conclusions presented in this Sewer Plan have been reviewed to confirm alignment with the 2044 planning horizon of the Comprehensive Plan.

This Plan is also aligned with the County's *Water as a Resource* policy, adopted in 2009 and reaffirmed in 2016. One of the aims of *Water as a Resource* policy is to reduce water pollution. Implementation of the projects presented in this Plan are a direct expression of the County's guiding principle to view water as a valuable resource worthy of protection and careful stewardship.

Organization of the Plan

The Plan is organized into twelve sections that cover the Kingston wastewater system:

- **Section 1: Introduction** provides an overview of the Kingston service area, ownership of the system, and contents of the Plan.
- **Section 2: Service Area Characterization** reviews the physical and administrative characteristics of the Kingston wastewater collection basin.

- **Section 3: Population, Load, and Flow Projections** estimates the current sewer system population, analyzes the impact of projected population growth, and estimates future wastewater flows and loads within the Kingston service area.
- **Section 4: Regulatory Requirements** identifies relevant federal, state, and local regulatory requirements that affect planning and operations of the wastewater system.
- **Section 5: Collection and Conveyance Existing Conditions** evaluates existing conditions of the system's gravity sewers, pump stations, and force mains based on site visits, video inspections of pipes, and discussion with County staff.
- **Section 6: Wastewater Treatment Plant Existing Conditions** evaluates existing conditions of the Kingston Wastewater Treatment Plant (WWTP) facilities, processes, and equipment based on site visits, discussion with plant operators, historical plant performance, and modeling of the plant processes.
- **Section 7: Collection and Conveyance System Analysis** analyzes sewer system capacity and alternatives for improvements to the system using a hydraulic model and evaluating system performance during a 25-year, 24-hour storm event.
- **Section 8: Wastewater Treatment System Analysis** analyzes improvements needed to maintain and upgrade the Kingston WWTP based on condition deficiencies, capacity inadequacies, and regulatory requirements.
- **Section 9: Recycled Water** evaluates opportunities for recycled water reuse so that water treated at the Kingston WWTP can be used for beneficial purposes instead of discharged to the Puget Sound.
- **Section 10: Operations and Maintenance** documents the County's management structure, details the wastewater system operation and maintenance (O&M) practices, and makes suggestions to improve utility operation practices.
- **Section 11: Capital Improvement Plan** provides a 20-year plan for implementing capital improvement plan (CIP) projects that improve the operation of the collection and conveyance system and Kingston WWTP.
- **Section 12: Financial Strategy** identifies financial approaches to fund the CIP.

General Sewer Plan Requirements

This Plan meets the Washington State Department of Ecology (Ecology) regulations for general sewer plans contained in the Washington Administrative Code (WAC) 173-240-050.

Table ES-1 summarizes the requirements and the sections in the 2024 Plan where the requirements are addressed.

Table ES-1 | WAC 173-240-050 Requirements

Section	Section Description	Location in Plan
3.a	The purpose and need for the proposed plan.	Section 1.2
3.b	A discussion of who will own, operate, and maintain the systems.	Section 1.5
3.c	The existing and proposed service boundaries.	Figure 2-1

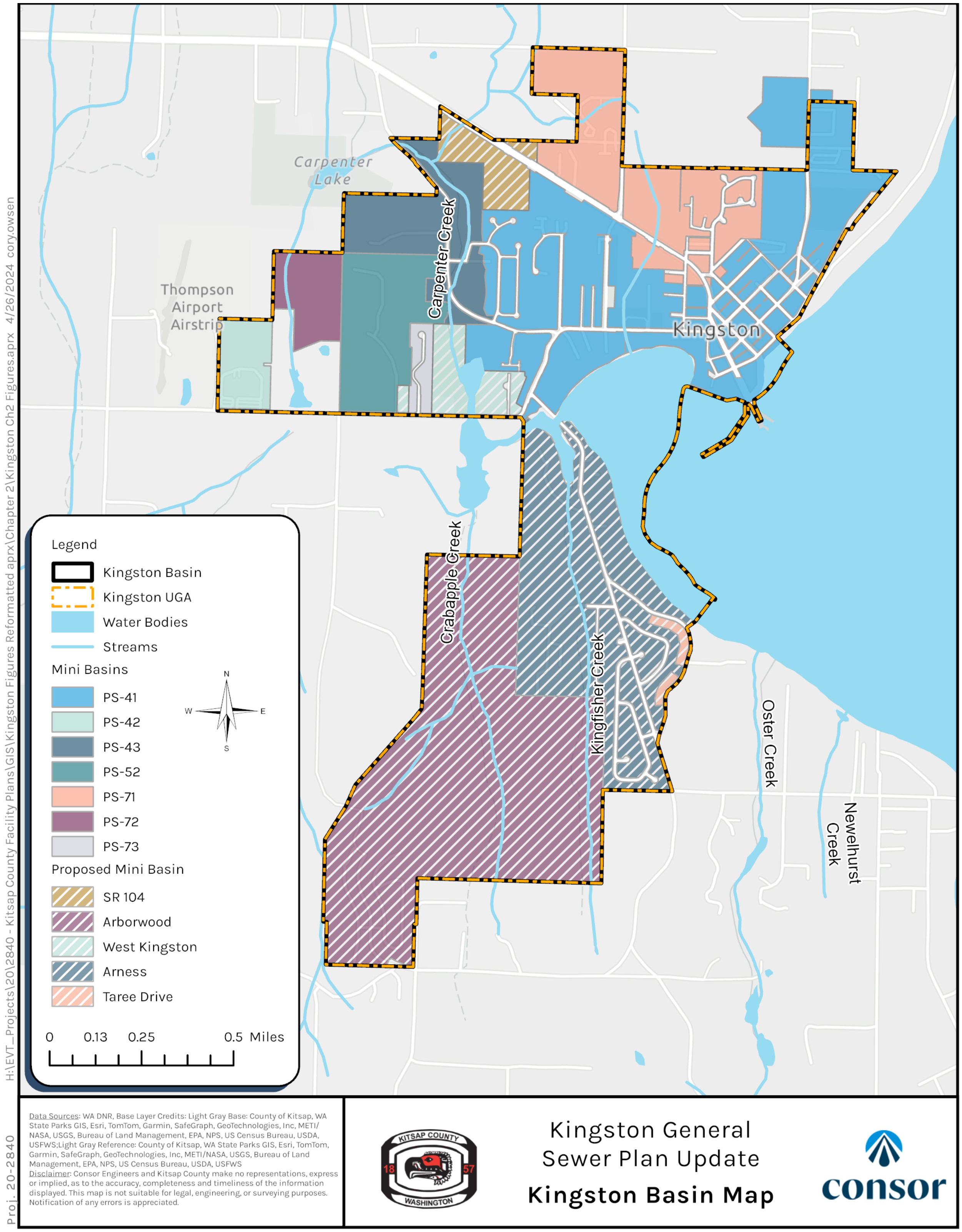
Section	Section Description	Location in Plan
3.d.i	Boundaries. The boundary lines of the municipality or special district to be sewered, including a vicinity map;	Figure 2-1
3.d.ii	Existing sewers. The location, size, slope, capacity, direction of flow of all existing trunk sewers, and the boundaries of the areas served by each;	Section 5 and Section 6
3.d.iii	Proposed sewers. The location, size, slope, capacity, direction of flow of all proposed trunk sewers, and the boundaries of the areas to be served by each;	Section 11
3.d.iv	Existing and proposed pump stations and force mains. The location of all existing and proposed pumping stations and force mains, designated to distinguish between those existing and proposed;	Section 5, Section 11
3.d.v	Topography and elevations. Topography showing pertinent ground elevations and surface drainage must be included, as well as proposed and existing streets;	Figure 2-2
3.d.vi	Streams, lakes, and other bodies of water. The location and direction of flow of major streams, the high and low elevations of water surfaces at sewer outlets, and controlled overflows, if any. All existing and potential discharge locations should be noted;	Figure 2-4
3.d.vii	Water systems. The location of wells or other sources of water supply, water storage reservoirs and treatment plants, and water transmission facilities.	Figure 2-5
3.e	The population trend as indicated by available records, and the estimated future population for the stated design period. Briefly describe the method used to determine future population trends and the concurrence of any applicable local or regional planning agencies.	Section 3
3.f	Any existing domestic or industrial wastewater facilities within twenty miles of the general plan area and within the same topographical drainage basin containing the general plan area.	Figure 1-1
3.g	A discussion of any infiltration and inflow problems and a discussion of actions that will alleviate these problems in the future.	Section 3.4.3
3.h	A statement regarding provisions for treatment and discussion of the adequacy of the treatment.	Section 6
3.i	List of all establishments producing industrial wastewater, the quantity of wastewater and periods of production, and the character of the industrial wastewater insofar as it may affect the sewer system or treatment plant. Consideration must be given to future industrial expansion.	Section 4
3.j	Discussion of the location of all existing private and public wells, or other sources of water supply, and distribution structures as they are related to both existing and proposed domestic wastewater treatment facilities.	Figure 2-5
3.k	Discussion of the various alternatives evaluated, and a determination of the alternative chosen, if applicable.	Section 7 and Section 8
3.l	A discussion, including a table, that shows the cost per service in terms of both debt service and O&M costs, of all facilities (existing and proposed) during the planning period.	Section 10, Section 11, and Section 12
3.m	A statement regarding compliance with any adopted water quality management plan under the Federal Water Pollution Control Act (FWPCA) as amended.	Section 4
3.n	A statement regarding compliance with the State Environmental Policy Act (SEPA) and the National Environmental Policy Act, if applicable.	Section 4

ES.2 Service Area Characterization

The County provides sewer service within the Kingston basin. The Kingston basin map is shown in **Figure ES-1**. The Kingston basin spans approximately 1,235 acres and is bounded by rural residential properties on three sides and Puget Sounds to the east. The basin contains small, unnamed lakes and streams in addition to several parks and neighborhood developments.

The County has established urban growth area (UGA) boundaries, land use designations, and zoning in accordance with the GMA. Urban level services, including sewer service, is not allowed outside of the UGA with limited exceptions. The County owns and maintains the sewer collection system that provides service primarily to the northern portion of the Kingston UGA, except the Kingston WWTP which is located to the west of the UGA. The system includes approximately 57,400 feet of gravity pipe, 26,000 feet of force main pipe, and 7 pump stations. All sewer flows within the basin are conveyed and treated at the Kingston WWTP.

Figure ES-1 | Kingston Basin Map



E.3 Population, Load, and Flow Projections

Current population and population growth are critical factors when considering required capacity and potential upgrades to the sewer system since sewer flows and population are closely linked.

The current sewered population in the Kingston basin was estimated based on an average of 2.5 people per equivalent residential unit (ERU). An ERU is a system specific unit of measure used to estimate wastewater volumes in the system based on the flow produced by an average single-family household.

Growth is presumed to occur within the UGA according to the land use designations and zoning in the 2016 KCCP. This plan, at the time of writing, is in alignment with the KCCP effort and is able to support the growth strategies described therein. The sewered population growth rate is estimated to be 4.04 percent based on the Puget Sound Regional Council (PSRC) and Washington State Office of Financial Management (OFM) information. The total current and projected populations for the sewered areas in Kingston basin are summarized in **Table ES-2**. Additionally, the Kitsap County Department of Community Development (DCD) prepared population projections as part of their update to the Comprehensive Plan. The population projects presented in this General Sewer Plan Update are consistent with the Comprehensive Plan update.

Table ES-2 | Kingston Basin Current and Projected Sewered Population

Year	Sewered Population
2020	2,553
2028	3,929
2042	6,337
2044	6,681*

Note:
*Extrapolated from 2042 population

Wastewater flows and loadings heavily influence WWTP facility design. Consequently, data related to wastewater characteristics and projected flows and loadings affect the selection of key criteria used to select project alternatives for further consideration. The existing flows and loads at Kingston WWTP were evaluated from January 2018 through June 2020 and correlated to current population to develop per capita values. The existing and projected flows and loads for the Kingston WWTP over the 20-year planning horizon are presented as **Table ES-3** and **Table ES-4**. Consistent with Ecology guidelines, flows are developed for average annual flow (AAF), maximum month wet weather flow (MMWWF), maximum month dry weather flow (MMDWF), peak day flow (PDF), and peak hour flow (PHF). Loads are developed for biochemical oxygen demand (BOD), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN).

Table ES-3 | Kingston WWTP Current and Projected Flows

Flow Event	2020	2028	2042
AAF (MGD)	0.11	0.17	0.27
MMWWF (MGD)	0.15	0.23	0.36
MMDWF (MGD)	0.12	0.18	0.29
PDF (MGD)	0.21	0.32	0.51
PHF (MGD)	0.57	0.87	1.41

Note:
MGD = million gallons per day

Table ES-4 | Kingston WWTP Current and Projected Loads

Parameter	2020			2028			2042		
	AA	MMWW	MMDW	AA	MMWW	MMDW	AA	MMWW	MMDW
BOD (ppd)	280	533	525	431	821	766	696	1,324	1,236
TSS (ppd)	285	429	378	438	660	550	707	1,064	887
TKN (ppd)	54	65	72	84	101	111	135	162	179

Note:
ppd = pounds per day

ES.4 Regulatory Requirements

Collection, conveyance, and treatment facilities operation, design, and construction are regulated through federal, state, County, and local regulations. The regulations are detailed in **Section 4**.

The National Pollutant Discharge Elimination System (NPDES) program, administered by Ecology, is the primary permit for Kingston WWTP, which has been issued NPDES Permit No. WA0032077. The permit went into effect in 2015, was set to expire in 2020, was administratively continued, and remains in effect as of the date of this Plan. The permit includes limits on plant capacity and treated effluent discharge, solids disposal requirements, monitoring requirements, recordkeeping and reporting criteria, and O&M requirements.

In addition, Ecology recently issued the first Puget Sound Nutrient General Permit (PSNGP), effective as of Jan. 1, 2022. The Kingston WWTP is classified as a small Total Inorganic Nitrogen (TIN) load plant and is required to implement nutrient monitoring and reporting, develop a nutrient optimization plan, prepare and submit an approvable all known, available, and reasonable methods of prevention, control, and treatment (AKART) analysis. Evaluating compliance with the new PSNGP and developing options for anticipated future nutrient permit requirements is a key focus of the Kingston WWTP condition assessment and alternative analysis.

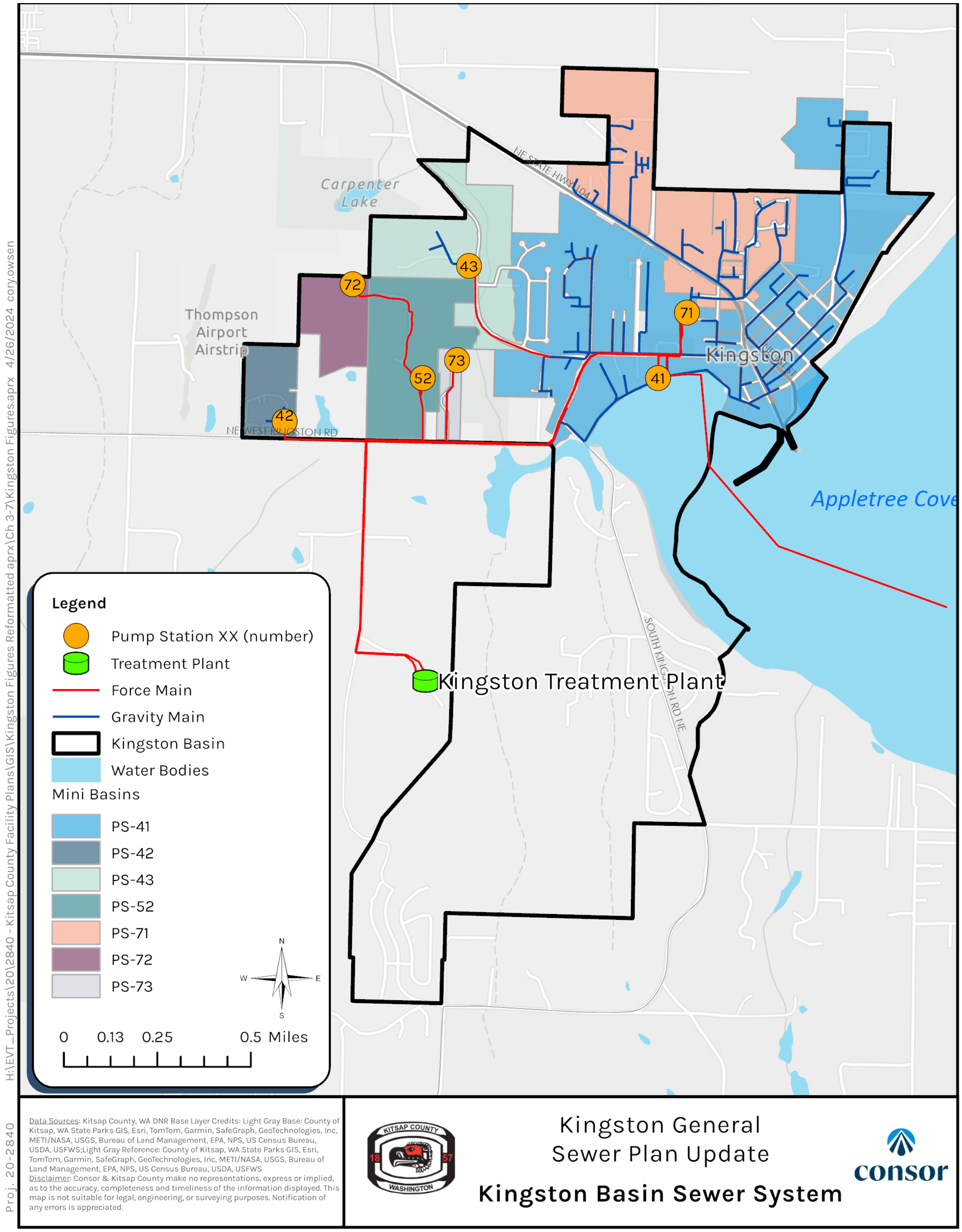
ES.5 Collection and Conveyance Existing Conditions

The Kingston basin collection and conveyance system is comprised of sewer assets owned and operated by the County within the northern portion of the Kingston UGA, except the Kingston WWTP which is located to the west of the UGA. The Kingston collection and conveyance system is shown in **Figure ES-2**. A detailed review of the existing collection and conveyance system is provided in **Section 5**.

Flows from the northern portion of the basin are routed through pump stations to the Kingston WWTP. Effluent from the WWTP is conveyed via an 18-inch diameter force main to Appletree Cove where it discharges. The Kingston basin currently contains seven mini basins: 41, 42, 43, 52, 71, 72, and 73. It is anticipated that sewer service will be eventually extended to cover the Kingston UGA.

There is approximately 57,400 feet of gravity main in the Kingston collection system. The County owns most of the pipes, which range in size from 6 inches to 12 inches in diameter. Approximately 1,000 feet of pipe are privately owned. There are approximately 26,000 feet of sewer force mains that convey pumped wastewater.

Figure ES-2 | Kingston Sewer System



There are seven pump stations within the Kingston sewer system: PS-41, PS-42, PS-43, PS-52, PS-71, PS-72, and PS-73. The firm capacity ranges from 20 gallons per minute (gpm) at PS-52 to 450 gpm at PS-71. The County classifies their pump stations as Critical, Regional, Relay, or Satellite pump stations based on how many mini-basins (or upstream pump stations) discharge into the pump station. **Table ES-5** shows the classification and number of pump stations in the Kingston basin. Pump station capacity typically increases from about 100 gpm for satellite stations to about 350 gpm for the critical pump stations.

Table ES-5 | Pump Station Type Consequence of Failure Definitions

Pump Station Type (from County)	Tributary Pump Stations	Number of Pump Stations in Kingston Basin
Satellite	0	5
Relay	1	0
Regional	2-3	0
Critical	4+	2

An evaluation of the pump stations was conducted consisting of site visits and discussions with County staff. To better inform the County's prioritization of future asset upgrades and replacements, an overall pump station "Asset Health" score was developed that synthesizes each pump station's existing likelihood of failure (condition) and consequence of failure (CoF). Each criterion is rated on a 1 to 5 scale where higher numbers indicate worse condition and high criticality, then the scores are multiplied together to get the overall Asset Health score (potential range from 1 to 25). The resulting scores ranged from 3.2 to 16, with one pump station rating higher than 10, five pump stations rated between five and 10, and one pump station rated below five.

The County has historically conducted pipeline condition assessments through video observation with the ability to examine the entire conveyance system in a 5-year cycle. This process entails inspecting pipes via closed circuit television (CCTV), storing the video in a database, reviewing the video, and assigning an Overall Condition Index (OCI) score based on the observations. The OCI score ranges from 0 to 100 with higher numbers indicating better condition.

The criteria that are scored for the OCI score are:

- Obstruction or Intrusion
- Worn Surface
- Belly or Sag in Pipe
- Crack or Fracture
- Break or Failure
- Lining or Repair Failure
- Joint Separation or Offset

The lengths of pipe in each OCI range are summarized in **Table ES-6**. Overall, the system is in good condition and none of the pipes in the Kingston basin are rated as moderate or severe condition.

Table ES-6 | Summary of Pipes OCI Scores

OCI Range	Length (ft)	Percentage of Total
0-20	-	0%
20-40	-	0%
40-60	-	0%
60-80	-	0%
80-99	3,600	6%
100	53,800	94%

ES.6 Wastewater Treatment Facilities Existing Conditions

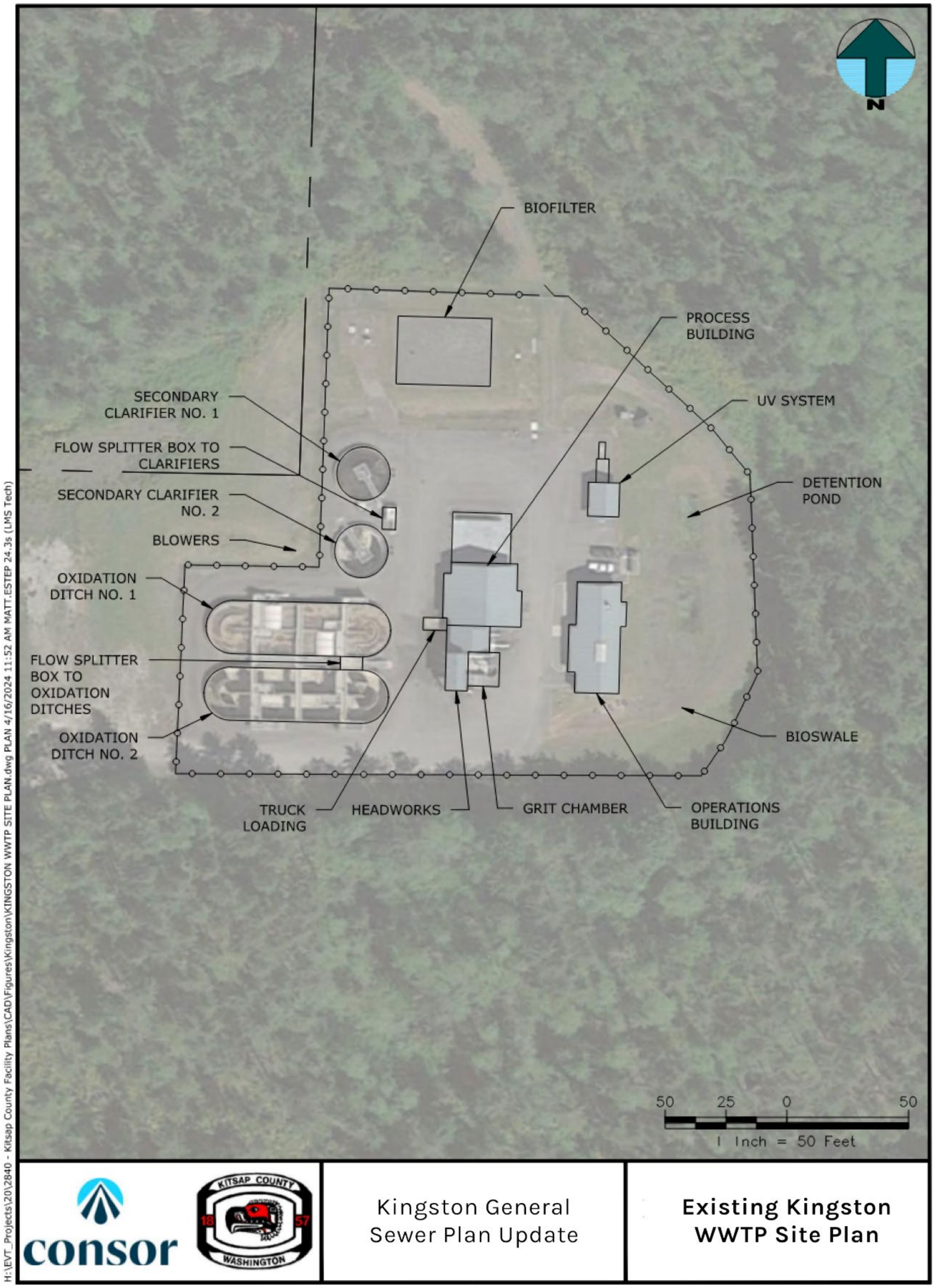
The Kingston WWTP was constructed in 2005, replacing a WWTP originally constructed in 1974. In 2006, the outfall to Appletree Cove was replaced and realigned. The Kingston WWTP is permitted to treat a maximum month design flow of 0.292 MGD. The plant is an oxidation ditch (extended aeration) type activated sludge facility. The Kingston WWTP site plan is shown in **Figure ES-3** with major structures and processes identified. The plant is located at the south end of Norman Road NE with undeveloped forested property on the east, south, and west sides, and rural residential properties to the north.

Plant processes are preliminary screening and grit removal, biological treatment in two oxidation ditches, two secondary clarifiers, and ultraviolet (UV) disinfection. Sludge removed from the secondary clarifiers is thickened with a gravity belt thickener (GBT) and sent to the County's Central Kitsap WWTP for further treatment and disposal. Treated effluent is discharged to the Appletree Cove of the Puget Sound in accordance with the NPDES Permit.

An evaluation of Kingston WWTP was conducted that consisted of a site review of equipment, facilities, processes, discussions with WWTP staff to understand operational issues, and analysis and modeling to determine capacity. Overall unit process Asset Health scores were developed, using the same method as the pump stations, to synthesize the condition and CoF. Each criterion is rated on a 1 to 5 scale where higher numbers indicate worse condition and high criticality, then the scores are multiplied together to get the overall Asset Health score (potential range from 1 to 25). All of the processes scored between 5 and 10, indicating fair to good overall condition.

A Visual Hydraulics© model was created to determine the hydraulic capacity and a Biowin© biological process model was used to evaluate the biological capacity of the existing Kingston WWTP unit processes. Model results indicated that all unit processes have sufficient hydraulic and biological capacity to handle existing and future flow and loads to meet current permit requirements.

Figure ES-3 | Existing Kingston WWTP Site Plan



ES.7 Collection and Conveyance System Analysis

The Kingston collection system was modeled using the Danish Hydraulic Institute's (DHI's) MIKE+ hydraulic and hydrologic (H/H) modeling platform to determine capacity deficiencies in the system. The projected population and increased rainfall due to climate change are the basis for establishing future system requirements. The model was developed using geographic information system (GIS) shapefiles, provided by the County, for the collection system, land use, contours, and soils in the Kingston basin. The model was calibrated to data from flow monitors installed in the collection system. The meters collected flow data from October 2020 through April of 2021. Results were compiled for the existing, 2042, and 2080 planning horizons using a 25-year 12-hour design storm.

Manholes, pipes, and pump stations were analyzed for deficiencies using the H/H model. Manholes are considered to have sanitary sewer overflows (SSOs) when the simulated water surface elevation in a manhole exceeds the rim elevation. Pipes are considered surcharged when the simulated water surface elevation in the upstream or downstream manhole connection exceeds the pipe crown. Pump stations are under capacity when the simulated flow to a pump station meets or exceeds the pump station firm capacity which is the station capacity with the largest pump out of service.

The total SSO count, surcharged gravity pipes, and velocity exceeded pipes are included in **Table ES-7**. Detailed maps can be found in **Section 7**. The results indicate that the PHF exceeds the firm capacity of PS-41 and PS-71 in all three planning horizons. These are the two largest pump stations in the Kingston basin, and PS-41 collects flow from the other stations and pumps to PS-71.

Table ES-7 | Pipe and Manhole Capacity Criteria

Scenario	Surface Sewer Overflows (SSO)	Number of Pipes Surcharged (Either end)
2022	0	10
2042	0	10
2080	0	11

ES.8 Wastewater Treatment System Analysis

The results from the WWTP Existing Conditions analysis were used to identify processes that require improvement and define feasible alternatives for WWTP improvements for the 6-year and 20-year planning horizons. Minor maintenance, repairs, and direct replacements were not subject to a full alternatives analysis due to the relatively simple nature of replacements or expansions. The recommended improvements follow.

Preliminary Treatment

All components (mechanical equipment, piping, and structures) of the preliminary treatment system are in fair or good condition and have adequate capacity through the 2042 planning period, therefore no improvements are required.

Secondary Treatment

The secondary treatment system was originally constructed in 2005 and upgrades to equipment and instrumentation in oxidation ditches were completed in 2020. The secondary clarifiers are generally in good condition. The only recommended improvement is to install ammonia and nitrate probes in the oxidation ditch to provide direct monitoring of nitrogen removal.

Disinfection

The UV equipment was installed in 2015 and is an older, basic model. Additional control and monitoring capabilities beyond what the current basic controller can offer is desired by the plant staff and will improve energy efficiency. Replacing the UV system with a Trojan UV3000Plus unit and controller is recommended but is not urgent, as the current unit works consistently and has adequate capacity.

Solids Treatment

The GBT was installed in 2005. It was observed that the GBT room had a very strong odor and operation staff confirmed this is common, indicating that the heating, ventilating, and air conditioning (HVAC) system may be underperforming. This may contribute to a more corrosive environment in the room. Maintenance and investigation of the HVAC system in the GBT room is recommended to address this issue before it creates bigger problems. Other solids treatment equipment works well and has adequate capacity, so additional upgrades are not needed.

Non-Potable Water System and Process Water Systems

Some equipment related to these systems will require in-kind replacement due to age and/or condition.

Odor Control

The odor control system was not functioning during the condition assessment visit but has since been repaired. Strong odor and corrosion were noted in the GBT room during the condition assessment. The odor should be reduced now that the odor control system is running again, but the corrosion may indicate that the HVAC system is not providing enough ventilation. Further investigation of the HVAC system is recommended to determine if upgrades are needed.

Electrical and Power Distribution System

Replacement of obsolete adjustable frequency drives (AFDs), programmable logic controllers (PLCs) and operator interface terminals (OITs) programs verification, and replacement of select electrical panels are needed.

Additionally, the County has recently completed a series of *Supervisory Control and Data Acquisition (SCADA) Master Plan technical memoranda* (HDR, 2022, Appendix F) that include an overview of the existing SCADA system, review of use and needs, selection of preferred technologies, and a project identification, estimate, and CIP.

ES. 9 Recycled Water

Recycling treated wastewater can provide numerous benefits, including conservation of limited groundwater resources, reduction of effluent discharge to the Puget Sound, and replenishment of streams and fish habitat. Use of recycled water to replace the use of potable water for non-potable purposes, such as irrigation, toilet flushing, reduces the stress on area groundwater and supports sustainable management of that limited resource. Prior County planning has resulted in the definition of a potential recycled water project. As described in the *Kingston Recycled Water Facility Plan* (Brown and Caldwell, 2020, Appendix I), the two applications deemed most feasible for recycled water use if it were produced at the Kingston WWTP are:

- Summer-time irrigation at the White Horse Golf Course (WHGC).
- Winter-time indirect groundwater recharge in an area north of WHGC, at North Kitsap Heritage Park.

The envisioned recycled water project would replace 29 million gallons (MG) per year of groundwater supply provided by the Kitsap Public Utility District (KPUD) for irrigation purposes at WHGC and infiltrate approximately 107 MG per year into the shallow aquifer that provides baseflow to Grovers Creek and its tributaries. Through this bolstering of groundwater levels, the baseflow in Grovers Creek could increase by up to 0.5 cubic feet per second, potentially providing 328 acre-feet per year to serve as an offset to consumptive impacts of new permit-exempt domestic groundwater withdrawals.

In addition to the projects described in the *Kingston Recycled Water Facility Plan,* a cursory review of other potential uses of recycled water was conducted. The County coordinated with water providers and potential stakeholders to determine if there are opportunities for irrigation use in the vicinity of the Kingston WWTP. Entities contacted were:

- Kitsap Public Utility District. KPUD has actively researched recycled water opportunities, having implemented a system in Port Gamble and considering integration into future housing developments. Additional coordination with that development group would be required to determine the level of feasibility of implementing such uses.
- Kitsap County Parks Department. A discussion was held but it was determined that there are no sites where recycled water use would be cost-effective at this time.

To produce Class A reclaimed water for the proposed irrigation and infiltration uses, upgrades to Kingston WWTP are required. *Kingston Recycled Water Facility Plan* presents a conceptual layout and sizing of facilities to produce 0.7 MGD of recycled water. The required upgrades include upgrades to the oxidation ditches, a new secondary effluent equalization tank, a tertiary filtration system, a UV and chlorine disinfection system, a recycled water pump station, and a recycled water distribution pipeline.

The capital investment to implement recycled water can be significant and is greater than what can be realistically recouped through recycled water rates. The County should seek low-interest loans or grant money from the state or federal government to support reuse implementation. Additionally, the County should continue stakeholder and public outreach and engagement and development of recycled water policies and procedures to support the program.

ES. 10 Operations and Maintenance

Section 10 includes a summary of the O&M programs for the collection and conveyance system, and the Kingston WWTP. A review of state and federal requirements that impact the County's O&M program are also included in Section 10.

The Sewer Utility Division consists of four main work groups: Utilities O&M (WWTPs and pump stations), Field Operations (collection system piping), Engineering and Administration, and Construction Management. A total of 72 staff work in the Sewer Utility Division and oversee O&M across each of the County's four wastewater systems. O&M activities include regular inspection of pump stations, cleaning and inspection of pipes, preventative maintenance of WWTP equipment, ongoing records management for all components of the system, and review and updates to the WWTPs O&M manual.

A staffing analysis was conducted for the collection and conveyance system and Kingston WWTP and determined that staffing levels and certifications are appropriate and adequate for current operations. No additional staff is expected to be required though the 20-year planning period.

Conclusions and recommendations based on a review of the County O&M practices are:

- Train and certify CCTV operators in National Association of Sewer Service Companies assessment to improve the consistency of sewer inspecting rating.
- Review spare parts inventories and assess the need for additional spare parts due to supply chain challenges.
- Institute an annual valve exercising and maintenance program.
- Develop training program to accelerate employees into Operator Certification Group III and prepare for anticipated Puget Sound Nutrient Reduction Goals and facility upgrades.
- Institute an Arc Flash Analysis and Protection program and incorporate as capital projects are designed and constructed.

ES.11 Capital Improvement Plan

The CIP projects were developed to remedy existing system deficiencies, address regulatory requirements, and provide adequate capacity for projected flows and loads. CIP projects to address immediate needs are presented in a 6-year planning horizon (from 2023 to 2028) and future CIP projects are included in the 20-year planning horizon (from 2029 to 2042). A planning level cost opinion of CIP project implementation is provided. It is assumed that minor projects will be completed with O&M budget, therefore they are not included in the CIP. CIP projects for the 6-year and 20-year planning horizons are presented in **Table ES-8**, **Table ES-9**, and **Table ES-10**. A preliminary implementation timeline of the CIP is provided in **Section 11**. There are no treatment projects proposed for the 6-year planning horizon. If funding becomes available, two proposed CIP projects, one collection and conveyance and one treatment, should be considered in the 6-year CIP.

Table ES-8 | 6-Year Kingston Collection and Conveyance Capital Improvement Projects

CIP No.	Item	Total Project Cost
CIP-K-CC-CAP-1	Replace PS-41 and Forcemain	$3,700,000
	Total	**$3,700,000**

Table ES-9 | 20-Year Kingston Collection and Conveyance Capital Improvement Projects

CIP No.	Item	Total Project Cost
CIP-K-CC-CAP-2[1]	Upgrade PS-71 and Replace Forcemain	$7,400,000
CIP-K-CC-DEV-4	Arness Pump Station and Conveyance	Expected to be paid for by developers
CIP-K-CC-DEV-5	Highway 104 Pump Station and Conveyance	Expected to be paid for by developers
CIP-K-CC-DEV-6	Taree Pump Station and Conveyance	Expected to be paid for by developers

CIP No.	Item	Total Project Cost
CIP-K-CC-DEV-7	Extend Gravity Sewer Flowing to PS-41	Expected to be paid for by developers
CIP-K-CC-DEV-8	Extend Gravity Sewer Flowing to PS-43	Expected to be paid for by developers
CIP-K-CC-DEV-9	Extend Gravity Sewers Flowing to Arborwood	Expected to be paid for by developers
CIP-K-CC-OM-10[1]	Annual Pipe Replacement	$14,000,000
	Total	**$21,400,000**

Note:
1. If funding becomes available, this project should be considered in the 6-year CIP.

Table ES-10 | 20-Year Kingston WWTP Capital Improvement Projects

CIP No.	Item	Total Project Cost
CIP-K-WWTP-OB-1[1]	Replace UV System	$880,000
CIP-K-WWTP-REG-2[2]	Nitrogen Optimization Improvements	$99,000
CIP-K-WWTP-REG-3	Reclaimed Water Improvements	$13,660,000
CIP-K-WWTP-OB-4	Replace Clarifier Drives	$480,000
	Total	**$15,120,000**

Notes:
1. If funding becomes available, this project should be considered in the 6-year CIP.
2. Future nutrient requirements and timing are unknown. Based on the current permit cycle for the PSNGP, it is assumed that effluent TIN restrictions to values below 10 milligrams per liter (mg/L) will not be implemented until 2031 at the earliest.

ES.12 Financial Strategy

Section 12 consists of the financial analysis performed by FCS group to develop a funding plan ("revenue requirement") for the County's sewer utility for the 2024 to 2042 planning horizon. The revenue requirement was identified based on operating and maintenance expenditures, fiscal policies, and the capital funding needs identified in **Section 12**.

The County sewer system has four basins, each with a treatment plant and corresponding collection system: Central Kitsap, Manchester, Suquamish, and Kingston. While a General Sewer Plan has been developed separately for each basin (this focus of this document is the Kingston basin), the County does not separate its sewer utility financial information by basin. As such, the information included in **Section 12** refers to the County sewer utility as a whole, unless explicitly stated otherwise. The result of the analysis indicates that a Countywide rate adjustment of 6.31 percent for 2025 and 6 percent per year through the remaining forecast period would be sufficient to support the capital program.

SECTION 1

Introduction

1.1 Introduction

The unincorporated area of Kingston is in Kitsap County (County), Washington. Kingston is in northwest Washington on the west side of the Puget Sound. This General Sewer Plan Update (Plan) provides the County with a 20-year plan (2022 to 2042) for the Kingston basin sewer collection, conveyance, and wastewater treatment plant (WWTP) infrastructure. The Central Kitsap, Suquamish, and Manchester basins sewer systems are covered under separate General Sewer Plan Updates.

A Kingston basin vicinity map is shown in **Figure 1-1**. The service area spans approximately 1,235 acres. Kingston is primarily residential, and the surrounding area is rural with some forested areas, including the North Kitsap Heritage Park.

The County owns, operates, and maintains the sewer facilities in the Kingston area. The system consists of approximately 57,400 feet of gravity pipe, 26,000 feet of force main pipe, seven pump stations (PS) and the Kingston WWTP.

The current sewered population in the basin was estimated by an analysis of sewer permits, indicating there are 1,021 equivalent residential units (ERU) yielding a population of 2,553 people. The sewered population is expected to grow to 3,929 in 2028 and 6,337 in 2042.

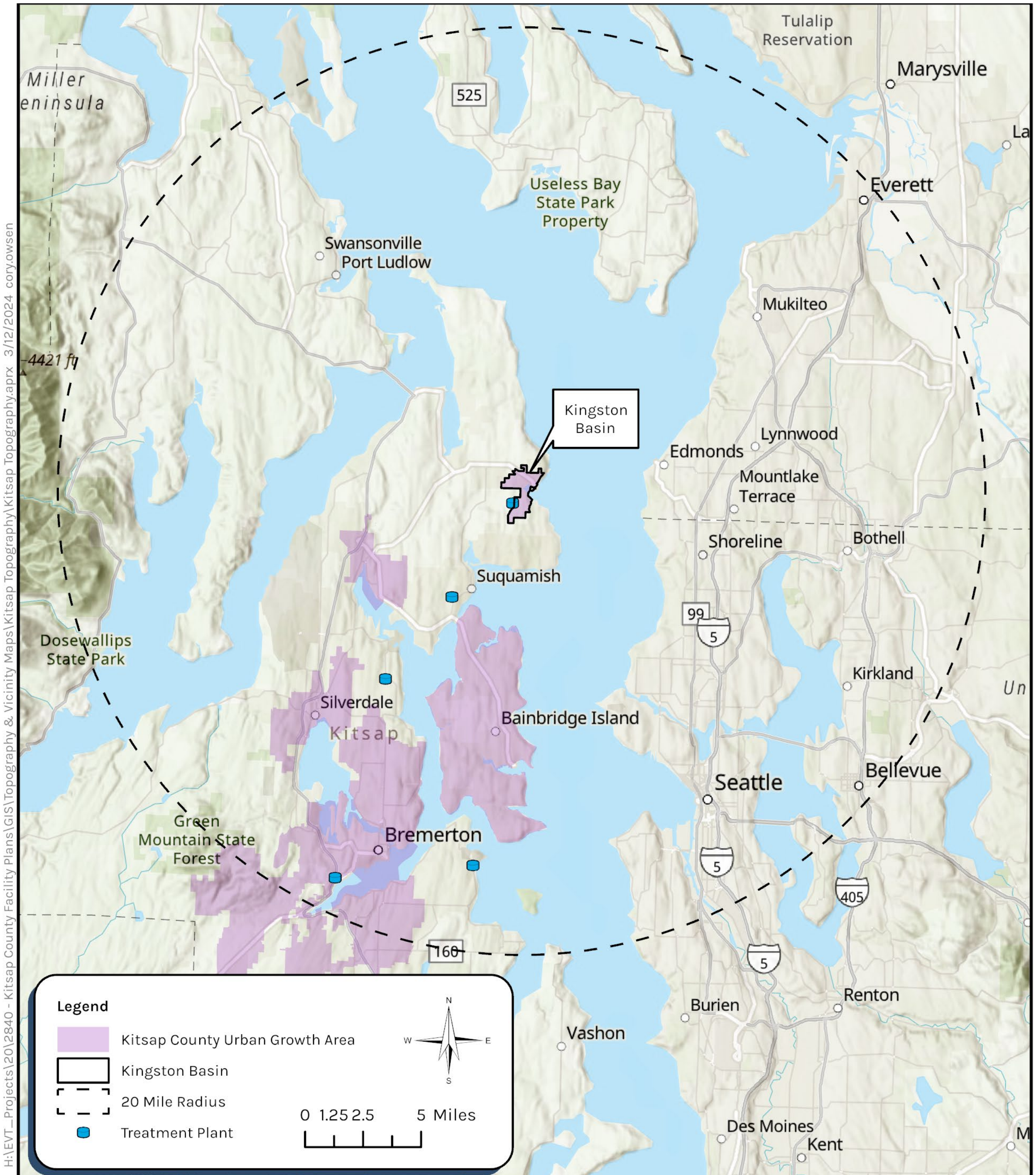
1.2 Purpose and Scope

This Plan evaluates the expected changes in the Kingston sewer service area, reports the existing condition of the collection system and Kingston WWTP, analyzes potential improvements to the system, and includes recommended and phased capital improvements that will provide service to the growing community over the planning horizon. The Plan was prepared to provide the County, the public, and regulatory agencies with information on the County's plans for maintaining, upgrading, and expanding the system. The Plan provides the roadmap for the County to continue to provide high quality service to its customers while protecting environmental quality. The Plan complies with the Washington State Department of Ecology (Ecology) regulations for general sewer plan (Washington Administrative Code [WAC] 173-240-050).

The Plan is based on planning horizons of a six-year period, 2023 to 2028, and a 20-year period, 2029 to 2042. The Plan lays out a strategy to provide wastewater services that accommodate population growth, comply with environmental regulations and permits, assess existing conditions, and maintain collection/conveyance system and treatment plant reliability and longevity. The population projections are in line with those developed by the Kitsap County Department of Community Development (DCD) over the 2044 planning horizon, which corresponds to the County Comprehensive Plan update. The recommendations presented here were made with consideration of the benefits of long-term investments that will continue to serve the community beyond the 20-year planning horizon.

Consor was contracted by the County in April 2020 to prepare the Plan and worked with the County to develop the Scope of Work, which provides guidance for decisions regarding the management and improvement of the County's wastewater treatment infrastructure.

Figure 1-1 | Kingston Basin Vicinity Map



Data Sources:Kitsap County, WA DNR Base Layer Credits: World Topographic Map: County of Kitsap, King County, WA State Parks GIS, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS;World Hillshade: Esri, CGIAR, USGS
Disclaimer: Consor Engineers and Kitsap County make no representations, express or implied, as to the accuracy, completeness and timeliness of the information displayed. This map is not suitable for legal, engineering, or surveying purposes. Notification of any errors is appreciated.

Kingston Wastewater Facility Plan and Sewer Plan Update

Kingston Basin Vicinity Map

consor

1.3 Background

The County owns and operates the Kingston wastewater system that consists of a collection and conveyance system, seven pump stations, and the Kingston WWTP with an outfall to Appletree Cove in the Puget Sound. The oldest parts of the Kingston collection system were installed in the mid-1970s. Relatively little growth in the system occurred until the early 2000s with significant growth occurring in the first half of the decade. The oldest pump station is PS-41 which was built in 1974, the remaining pump stations, PS-42, PS-43, PS-52, PS-71, PS-72, and PS-73 were installed or updated in the 1990s and 2000s. The sewer system is separate from the stormwater system and consists of gravity sewers, pump stations, and individual pump stations (IPS). Some properties within the service area have on-site septic systems that are not connected to the collection system.

The Kingston WWTP was constructed in 2005 and replaced the original WWTP that was constructed in 1974. The original plant was approximately three miles from the current plant site. The liquids treatment processes in the Kingston WWTP includes headworks with screening and grit removal, two oxidation ditches, two secondary clarifiers, UV disinfection, and an effluent Parshall Flume, and the outfall. Sludge removed from the secondary clarifiers is thickened with a gravity belt thickener (GBT) and transported to the County's Central Kitsap WWTP for further treatment and disposal. The County operates the Kingston WWTP under National Pollutant Discharge Elimination System (NPDES) Permit WA0032077 that was renewed, effective December 1, 2015, and expired on November 30, 2020. The County has submitted the permit renewal application. The current permit was administratively continued and remains in effect as of this writing.

The County has prepared several sewerage planning documents since the 1960s. The last wastewater/sewer general sewer plan for the Kingston area was prepared in 2013. Since then, the Kingston area, and the County as a whole, has grown substantially. With this growth, the need for a renewed evaluation of sewer service to the entire County became increasingly apparent. This Plan presents the findings and recommendations for the Kingston basin sewer facilities.

1.4 General Sewer Plan Requirements

The Federal Water Pollution Control Act established the requirement for a Water Quality Management Plan. Resultantly, RCW 90.71 established the need for a Puget Sound Water Quality Management Plan. The stated objective of this plan is to protect and restore Puget Sound through effective coordination among governments and private interests, and through use of an adaptive management approach.

This Plan was prepared for the County to fulfill the requirements of Chapter 173-240-050 of the WAC, Chapter 90.48 of the Revised Code of Washington (RCW), and RCW 36.70A (Growth Management Act). The Plan provides the County with a comprehensive guide for managing and operating the sewer system and coordinating expansions and upgrades to the infrastructure through buildout. The Plan serves as a guide for policy development and decision-making processes for the County. The WAC requirements are outlined in **Table 1-1**.

Table 1-1 | General Sewer Plan Requirements per WAC 173-240-050

WAC Reference Paragraph	Description of Requirement	Location in Document
3a	Purpose and need for proposed plan	Section 1.2
3b	Who owns, operates, and maintains system	Section 1.5

WAC Reference Paragraph	Description of Requirement	Location in Document
3c	Existing and proposed service boundaries	Figure 2-1
3d	Layout map showing boundaries; existing sewers; proposed sewers; existing and proposed pump stations and force main; topography and elevations; streams, lakes, and other water bodies; water systems	Figure 2-1, Figure 2-2, Figure 2-4, Figure 2-5, Section 5, Section 6, Section 7, and Section 11
3e	Population trends	Section 3
3f	Existing domestic and/or industrial wastewater facilities within 20 miles	Figure 1-1
3g	Infiltration and inflow problems	Section 3.4.1
3h	Treatment systems and adequacy of such treatment	Section 6
3i	Identify industrial water sources	Section 4
3j	Discussion of public and private wells	Figure 2-5
3k	Discussion of alternatives	Section 7 and Section 8
3l	Define construction cost and O&M costs	Section 10, Section 11, and Section 12
3m	Compliance with water quality management plan	Section 4
3n	SEPA compliance	Section 4

1.5 Ownership and Management

The County owns, operates, and maintains the sewer facilities in Kingston.

The County's Sewer Utility Division (Utility) under the Department of Public Works is solely funded through fees from sewer ratepayers. The Utility does not receive funds from County tax revenue and cannot provide any financial assistance to other public works divisions or County departments. These revenues must provide for future capital improvements and cover the maintenance, operation, and replacement of sewer systems.

The operation and maintenance (O&M) of both the sewer collection system and the County's four WWTPs is provided by the Utility. The Utility consists of four main work groups:

- Utilities Operations & Maintenance (Plant and Pump Station).
- Field Operations (Collections System).
- Engineering and Administration.
- Construction Management.

The Utilities Operation Group is responsible for running the WWTPs and laboratory. The Utilities Maintenance Group is responsible for maintaining the equipment associated with WWTPs and pump stations. The Field Operations group is responsible to maintain, repair, replace, clean, and inspect the sewer utilities collection systems. The Engineering Group manages the design of capital work. The Administration Group manages the geographic information system (GIS) database and provides review efforts for Developer proposed projects. The Construction Management Group manages the delivery of capital work.

SECTION 2

Service Area Characterization

2.1 Introduction

The Kingston wastewater system service area characteristics including geography, topography, water resources, general soil conditions, critical areas, endangered species habitats, the water supply system, and zoning designations are described in Section 2.

2.2 Growth Management Act

The State of Washington adopted the Growth Management Act (GMA) with the intent of concentrating most new development and population gains within the urban areas of the more populous and rapidly growing counties. State and local governments are required to define an urban growth area (UGA) boundary within which urban services like sewers are provided, and any new parcels created outside that boundary must be at a very low density with sufficient acreage to support on-site sewage disposal systems conforming to Washington State Department of Health (DOH) regulations.

The following exceptions to the prohibitions of sewers outside the UGA are recognized under state law (per RCW 36.70A.110(4), RCW 36.70A.070(5)(d), and WAC 365-196-320(1)(c)):

- Public schools outside the UGA can be served by sewers but are not required to be served.
- Areas of existing development outside the UGA where sufficient on-site sewage disposal systems have failed as to create a "severe public health hazard" can be served by sewers.
- Areas can be defined as a Limited Area of More Intensive Rural Development (LAMIRD), within which the development of necessary public facilities and public services, such as sewer, is allowed.

Sewers provided in either of these cases can be satellite systems limited to serving just the qualified and defined parcels, or a sewer extension can be 'tight-lined' to convey wastewater from the qualified and defined parcels into the UGA for connection to an existing sewer system.

2.3 Service Area

The Kingston service area and UGA boundaries are shown in **Figure 2-1**. The service area spans approximately 1,235 acres and is bounded to the north by the Carpenter Lake Natural Reserve, State Highway 104, and NE 272nd Street. It is bounded to the east by Appletree Cove, Taree Drive NE, and Washington Boulevard. NE. It is bounded to the south by NE Waterfront Way and NE West Kingston Road. It is bounded to the west by the Thompson Airport Airstrip and the Carpenter Lake Natural reserve. The service area contains small, unnamed lakes and streams in addition to several parks and neighborhood developments.

2.3.1 Topography

The topography of the service area is characterized as moderately hilly and sloping generally east towards Appletree Cove.

Figure 2-1 | Kingston Basin Map

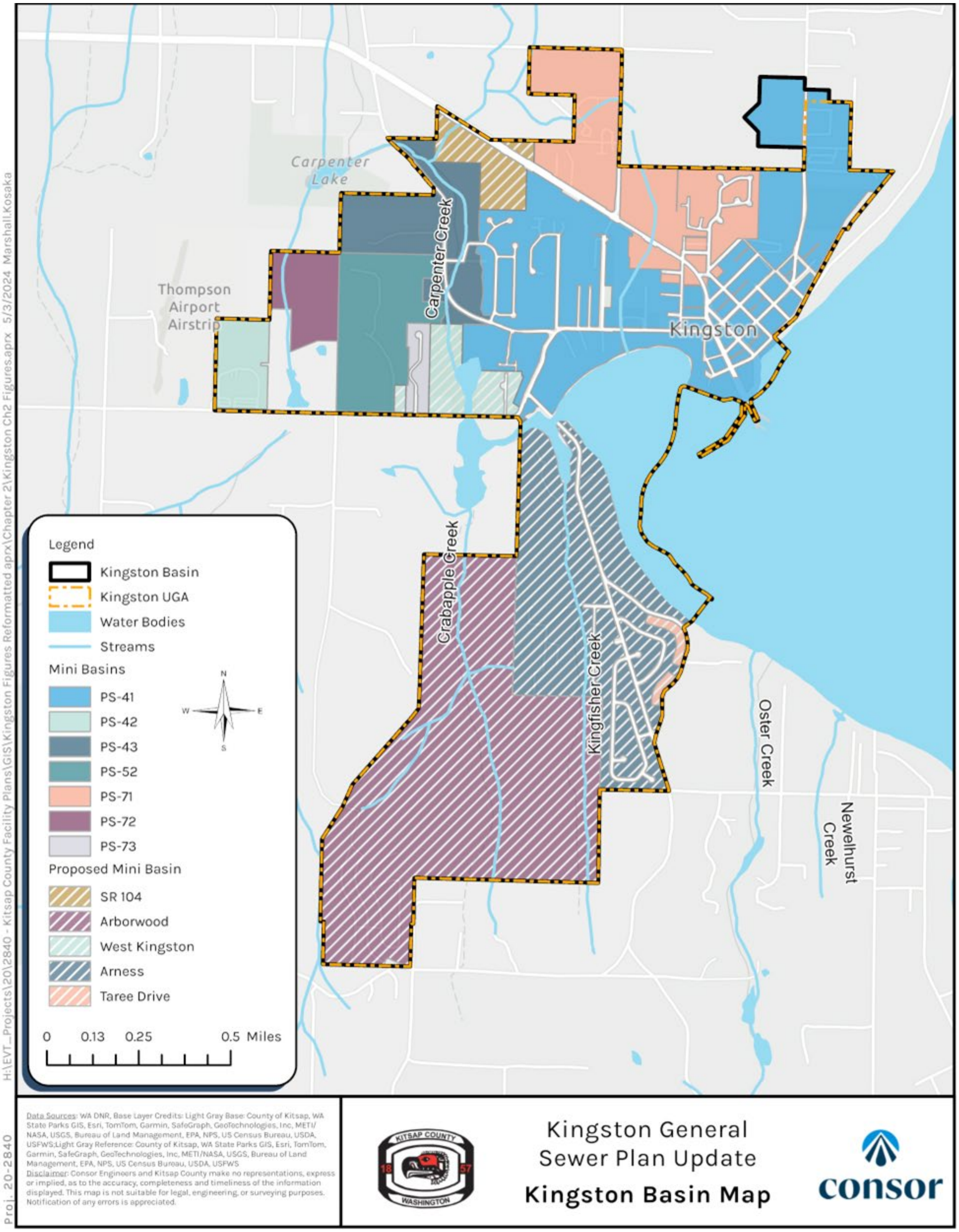
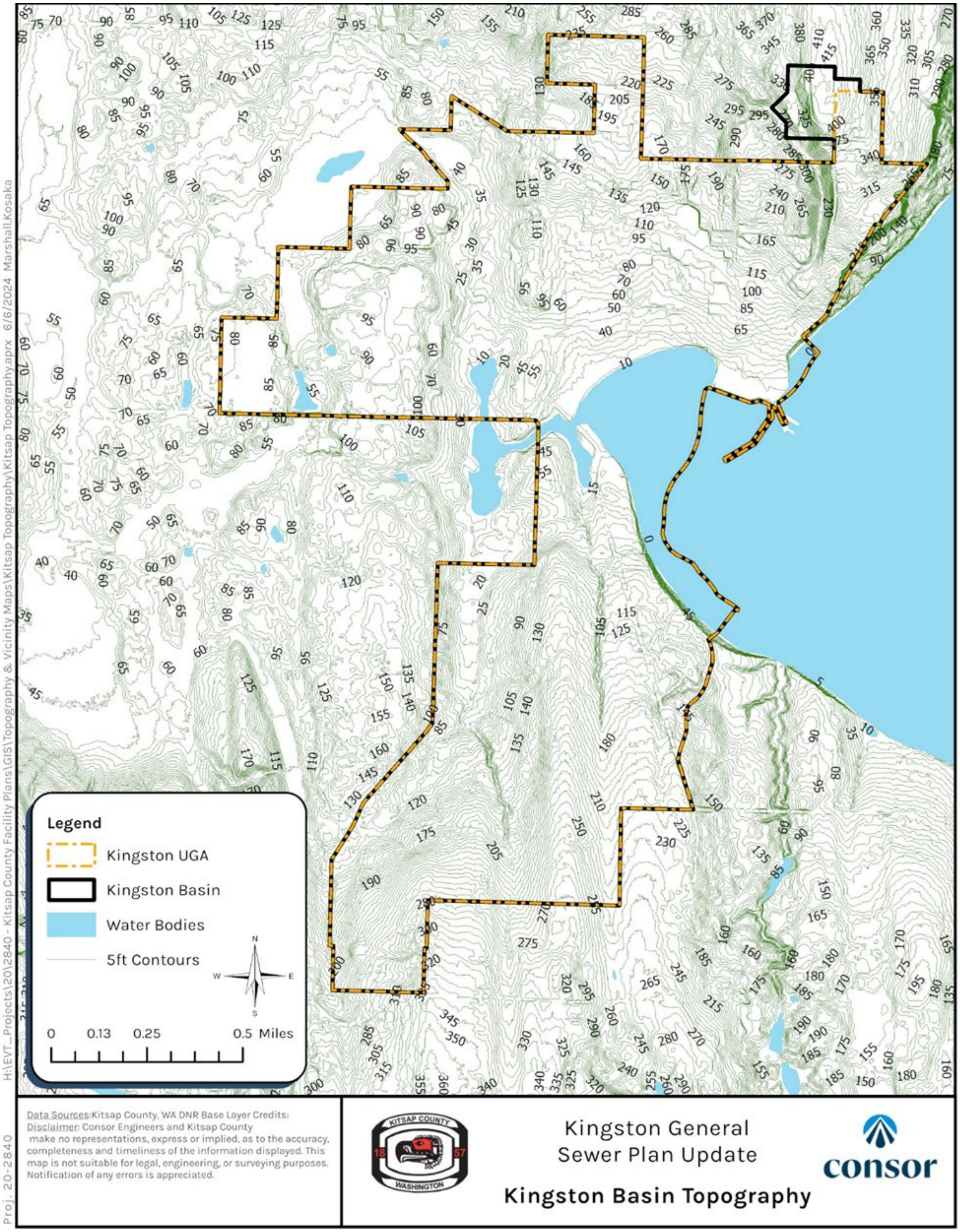


Figure 2-2 | Kingston Basin Topography



2.3.2 Water Resources

The primary water resources in the service area are Crabapple Creek, Carpenter Creek, Kingfisher Creek, and groundwater. There are several unnamed streams and surface water bodies in the service area which are shown on the map in **Figure 2-1**. Water resources in the basin are identified from the United States Geological Survey National Hydrography Dataset for Washington.

Carpenter Creek appears on Ecology's Water Quality Assessment list [303(d)] for impaired water bodies for dissolved oxygen (DO) and temperature.

2.3.3 Puget Sound Water Quality Management Plan

The Federal Water Pollution Control Act (FWPCA) established the requirement for a Water Quality Management Plan. Resultantly, RCW 90.71 established the need of a Puget Sound Water Quality Management Plan. The stated objective of this plan is to protect and restore Puget Sound through effective coordination among governments and private interests, and through used of an adaptive management approach. This Plan is consistent with the intended goals of the Water Quality Management Plan.

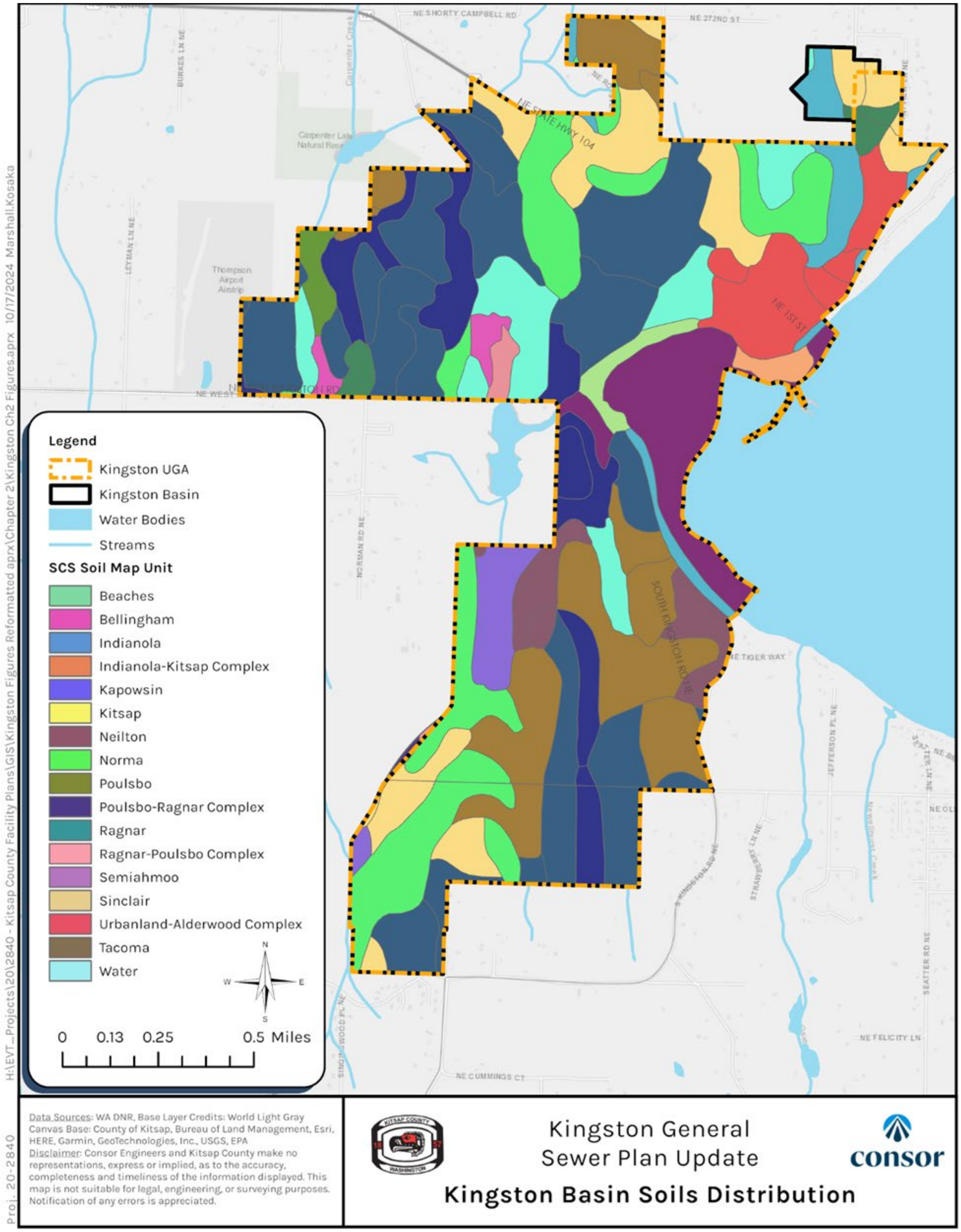
2.3.4 Geology

Soils and their aerial distribution in the basin are shown in **Figure 2-3**. The soil descriptions are referenced from the Soil Survey of Kitsap County by the United States Department of Agriculture and the Soil Conservation Service (SCS) in cooperation with the Washington State Department of Natural Resources and the Washington State University Agricultural Research Center. The aerial distribution is based on GIS data derived from the Private Forest Land Grading System and the Soil Survey of Kitsap County. Detailed descriptions in terms of SCS soil map units for the most prevalent soils are discussed below.

The Poulsbo series is the most prevalent soil type in the basin. The soil is moderately well drained and has a depth to hardpan ranging from 20 to 40 inches. Permeability is moderately rapid in the upper stratum and very slow through the hardpan. This soil is found in broad uplands and formed in glacial till.

The Kapowsin Series is the second most prevalent soil type in the basin. The soil is well drained has a depth to hardpan ranging from 20 to 40 inches. Permeability is moderate in the upper stratum and very slow through the hardpan. This soil is found in upland and terraces and formed in glacial till.

Figure 2-3 | Kingston Basin Geology



2.3.5 Critical Areas

There are critical areas throughout the Kingston Basin which will limit development, as shown on **Figure 2-4**. These areas consist of wetlands which were identified from the Department of Natural Resources 2000 Hydrology data set, the National Wetlands Inventory data set, and survey delineated wetlands from the County's parcel maps. The Critical Aquifer Recharge Areas (CARA) shown on the map are separated into Category 1 and Category 2 areas. Category 1 is defined as areas where the potential for certain land use activities to adversely affect groundwater is high. Category 2 is defined as areas that proved recharge effects to aquifers that are current or potentially will become potable water supplies and are vulnerable to contamination based on the type of land use activity. Geologic hazard areas are shown on the map and are categorized as areas of high concern and high hazard areas. High hazard areas are defined as areas with slopes greater than 30 percent and mapped by the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of the County as unstable (U), unstable old landslides (UOS), or unstable recent slides (URS). Areas of concern are classified similar to the high hazard areas but with slopes between 15 percent and 30 percent and also includes areas that are classified as highly erodible or potentially highly erodible, and seismic areas subject to liquefaction.

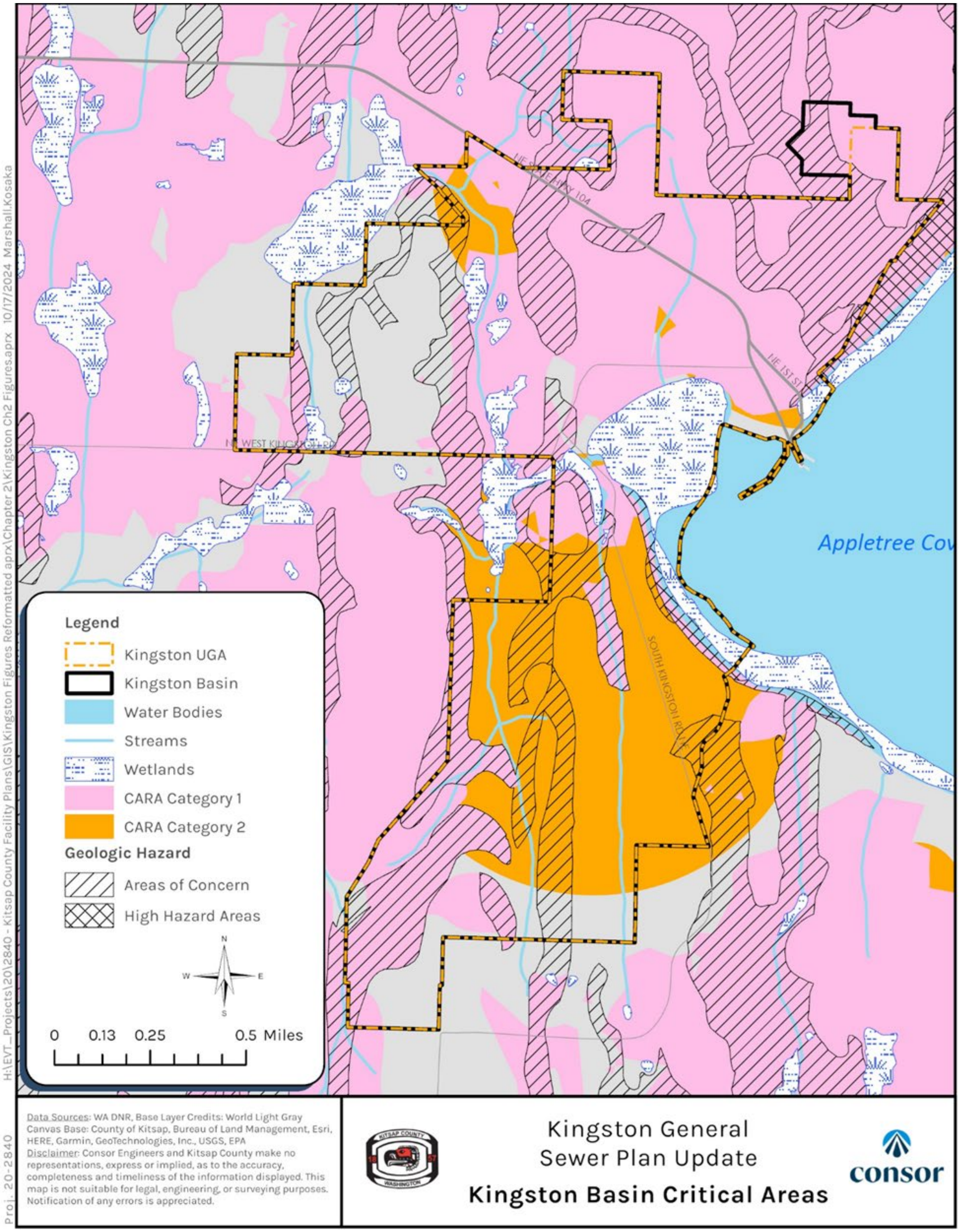
2.3.6 Endangered Species Habitat

The Washington Department of Fish and Wildlife produces a map denoting priority habitats and species throughout the state. Known species and their endangered species status for these creeks are listed in **Table 2-1**. Additionally, the basin contains numerous freshwater and marine wetlands which provide habitat for many species such as the Mountain Quail. Many of the creeks in the basin discharge to Appletree Cove which support habitat for numerous species of shellfish, waterfowl, and other fish species not listed in **Table 2-1**.

Table 2-1 | Species Present

Species	Carpenter Creek	Crabapple Creek	Kingfisher Creek	State Status	Federal Status
Coho	Yes	Yes		None	Species of Concern
Cutthroat	Yes	Yes	Yes	None	Species of Concern

Figure 2-4 | Kingston Basin Critical Areas



2.4 Water Supply System

Information regarding the basin's water system was taken from the Kitsap Public Utility District (KPUD) Water System Plan Part B, dated September 2011. The water supply system is mapped in **Figure 2-5**.

Water service for the basin is provided by KPUD's North Peninsula Water System. There are 15 operational wells in the system; eight are active production wells and 7 are reserved for emergency standby use. The system contains 17 reservoirs totaling 2.4 million gallons (MG) of usable volume. The current system is the result of consolidation of several systems over the preceding decades with further consolidation anticipated. Ultimately, it is anticipated that the North Peninsula will be connected to KPUD's Vinland System to the west and to KPUD's Miller Bay and Indianola Systems to the south. There are private wells in the basin as well as shown on **Figure 2-5**.

2.5 Land Use and Zoning

Land use and zoning within the Kingston UGA is currently established in the 2016 Kitsap County Comprehensive Plan (KCCP). Zoning in the Kingston basin is shown on **Figure 2-6**. Future growth within the Kingston basin is presumed to occur within the UGA according to the land use designations and zoning in the Comprehensive Plan.

Figure 2-5 | Kingston Water System

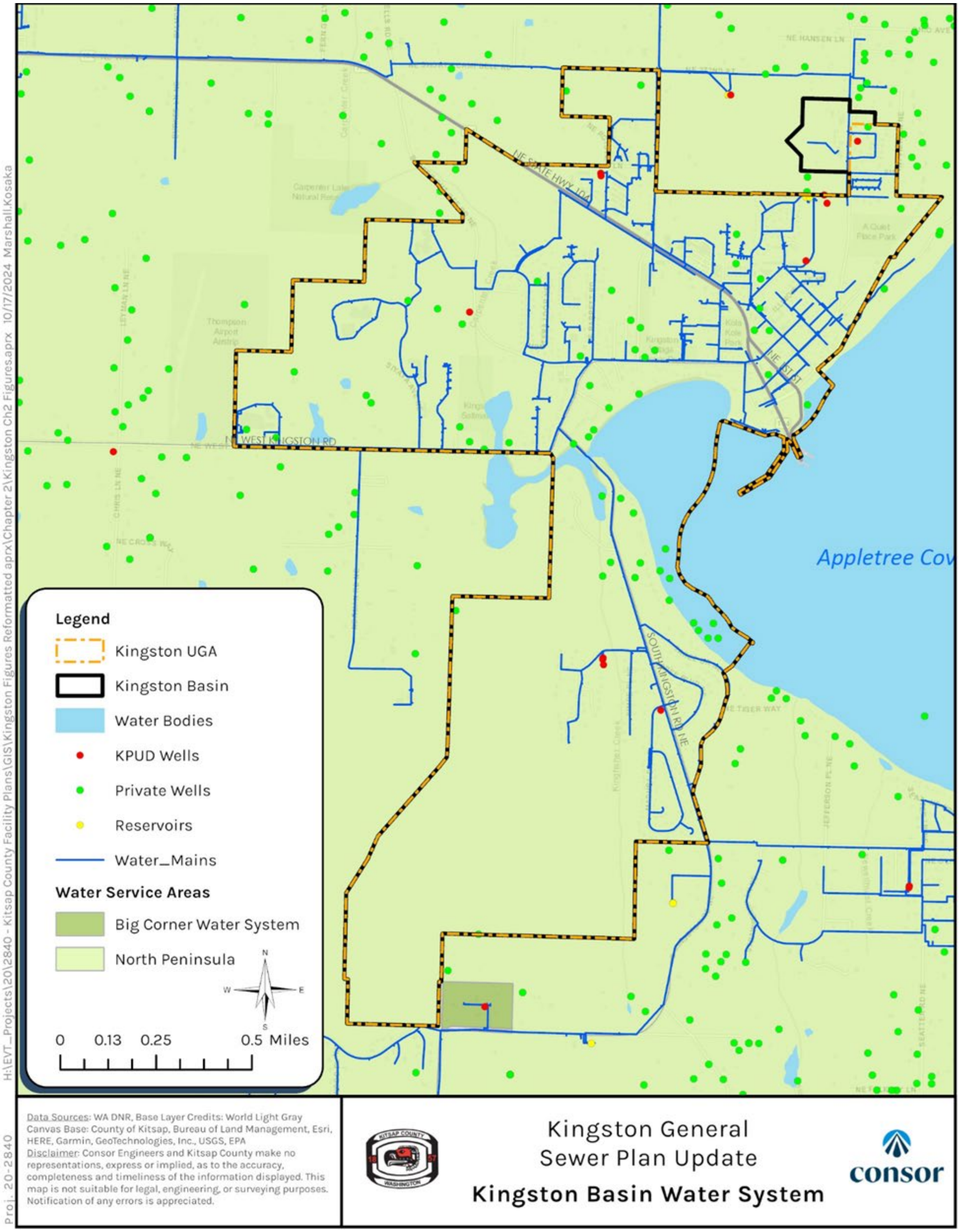
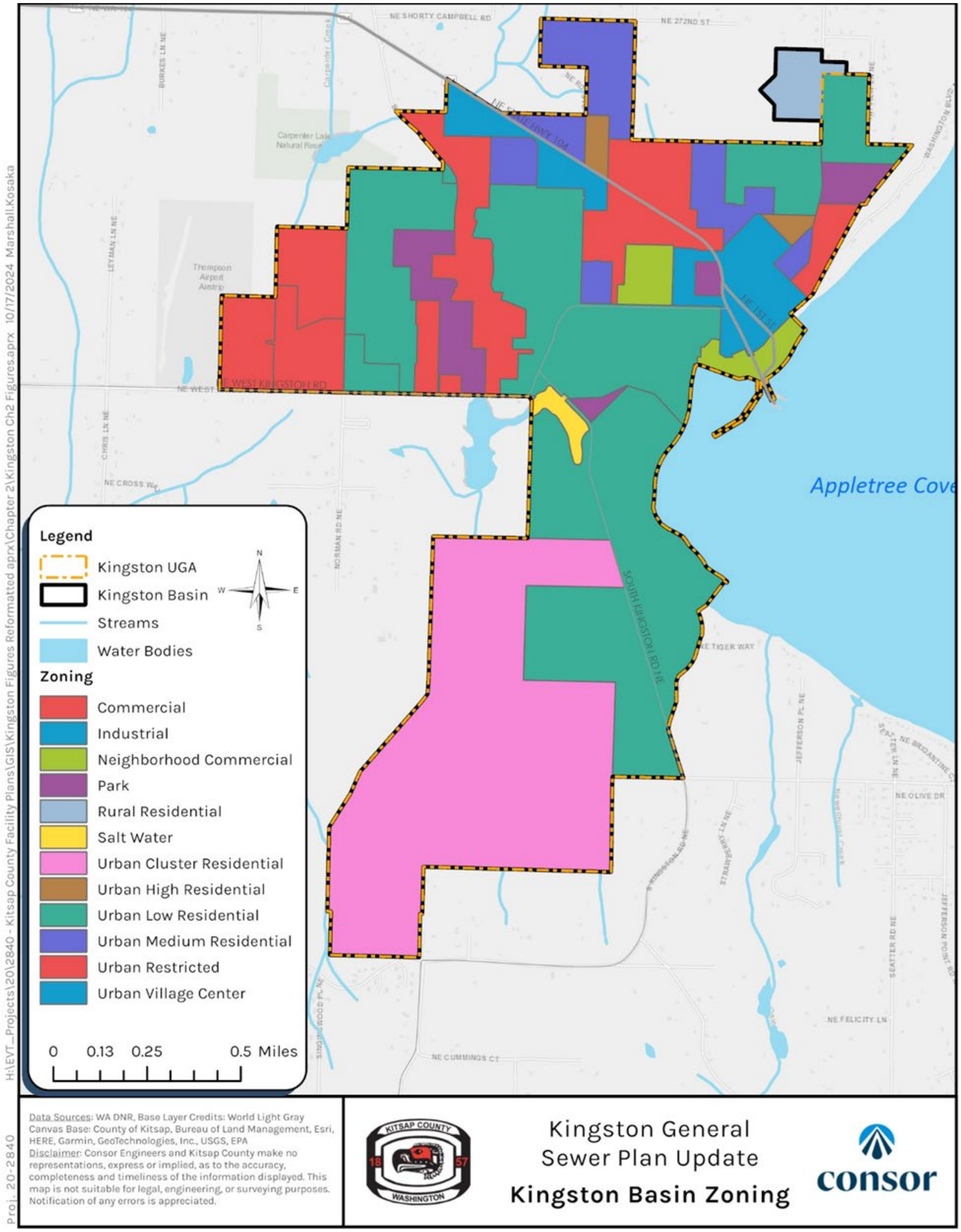


Figure 2-6 | Kingston Basin Zoning



SECTION 3

Population, Flow, and Load Projections

3.1 Introduction

The existing and projected populations and the methodology of determining the most appropriate sewered population and its growth rate to project future flows and loads for the Kingston WWTP and the collection and conveyance system are described in **Section 3**.

The projections consider existing and future customers within the Kingston basin in year 2028 (the 6-year projection) and year 2042 (the 20-year projection). With these population projections, future flows will be estimated and input into the hydraulic model to determine sewer system deficiencies and capital improvement projects the plan will estimate for the 6-year and 20-year planning horizons to improve and expand the Kingston WWTP and associated collection and conveyance system.

3.2 Definitions

Evaluation Period: The flows and loads analyzed are based on discharge monitoring reports (DMRs) from January 2018 through June 2020.

Wet Weather Season: The wet weather season is from November 1 through April 30 of the following year.

Dry Weather Season: The dry weather season is from May 1 through October 31.

Average Annual Flow (AAF): The average daily flow for the calendar year.

Maximum Month Wet Weather Flow (MMWWF): The largest volume of flow during a continuous 30-day period in wet weather season, expressed as a daily average.

Maximum Month Dry Weather Flow (MMDWF): The largest volume of flow during a continuous 30-day period in dry weather season, expressed as a daily average.

Peak Day Flow (PDF): The largest volume of flow during a one-day period, expressed as a daily average.

Peak Hour Flow (PHF): The largest flow rate during a one-hour period, over the metered time-period.

3.3 Population Projections

3.3.1 General

The population forecasts for the sewer service areas were provided by the Puget Sound Regional Council (PSRC). The PSRC is a leading source of data and forecasting for regional and local planning in the Puget Sound area, and PSRC develops policies and coordinates decisions related to regional growth and transportation and economic planning within Kitsap, King, Pierce, and Snohomish counties. The PSRC is also a leading source of data and forecasting for regional and local planning in the Puget Sound area.

The PSRC's population projections are 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 LUV dataset projects population growth for the Central Puget Sound region in five-year increments from 2020 through 2040. 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 growth on developable land. These results can then be reported for varying geographies like UGA, LAMIRD, Census Tracts, or Traffic Analysis Zones (TAZ).

The projections used for this basis of planning are based on projected growth for the portions of TAZs within the Kingston sewer service areas. The PSRC projections for residential population are defined by household population. Household population includes both single-family and multi-family units. The population was then extrapolated to 2042 based on the 2040 projection and the average yearly growth between 2035 and 2040.

As a reference, the 2019 population developed by the Washington State Office of Financial Management (OFM) was also obtained. The OFM 2019 number falls between the PSRC projection in year 2014 and 2020, and therefore is considered a valid data point in this analysis. The detailed projection for the Kingston basin is discussed in the following sections.

Additionally, population targets from the 2016 KCCP were compared with population projections received from the PSRC in five-year increments from 2020 to 2040. The targets included in the KCCP are broken down by City or UGA and areas outside of those categories are included in the broad categories of "Unincorporated UGA" and "Rural Non-UGA". The PRSC data was available at a higher resolution which was needed for the Facility and Sewer Plans because the sewer service areas do not line up with the UGA boundaries, and because the Kingston needed more granularity to geographically distribute flows throughout their respective basins for modeling of the collection and conveyance system. The overall projections are similar to the KCCP, which gives confidence that the sewer and facility planning efforts will dovetail with the overall County planning efforts described in the KCCP. The PSRC data is somewhat more conservative, which is preferrable for wastewater facility planning.

3.3.2 Residential

The OFM estimate of the residential population in the Kingston basin was 2,400 for the year 2019. The 2042 projection for population for the Kingston basin is 5,957 yielding a 148 percent increase from 2019 to 2042. The PSRC population projections for the period 2014 through 2040 in five-year increments and the 2019 OFM estimate of population and the extrapolated population in 2042 are shown in **Table 3-1**.

Table 3-1 | Kingston Service Area Population Projections

Year	Residential Population[5]
2014[1]	2,168
2019[2]	2,400
2020[1]	2,984
2025[1]	4,027
2028[3]	4,598
2030[1]	4,978
2035[1]	5,645

Year	Residential Population[5]
2040[1]	5,868
2042[4]	5,957

Notes:

1. PSRC projections
2. OFM estimates, group quarters population not reported separately
3. Interpolated from 2025 and 2030 PSRC projections
4. Extrapolated based on yearly growth between PSRC projections for 2035 and 2040
5. The total sewered population was computed using a different methodology which is described in the subsequent section

3.3.3 Current Sewered Population

The current sewer system in the Kingston basin serves the northern portion of the basin while the population estimates and projections, presented above, represent the entire Kingston basin area. The current sewered population in the basin was estimated by an analysis of sewer permits using the ERUs and assuming 2.5 people per unit. The County's sewer permit data, provided in 2020, indicated there are 1,021 ERUs in the basin yielding a current sewered population of 2,553. This sewered population estimate is larger than the 2019 OFM population for the entire UGA, but less than the 2020 PSRC projected population of 2,984. The difference is likely in the assumed 2.5 people per unit, but without a basis for modifying that ratio, the population of 2,553 will be used. It is assumed that in the future the sewered area will cover the entire UGA as population in the basin increases. The Kingston basin sewered area is shown in **Figure 3-1.** It includes some parcels that are sewered but are outside of the UGA. Although not typically allowed by the GMA, there are allowable exceptions described in **Section 2.2**, such as changes in the UGA boundary, public schools, failed septic systems that create a severe public health hazard, and LAMIRDs.

3.3.4 Sewered Population Growth Rate and Projections

Two data sources are reviewed to determine the most appropriate sewered population growth rate as the basis for the WWTP flow and load projection:

- Estimated total population projection as presented in **Table 3-1**, based on the PSRC and OFM information. This projection shows a 148 percent growth between 2019 and 2042 within the entire UGA, which averages out to be an annual growth rate of 4.04 percent.
- Estimated sewered population projection as presented in **Table 3-2**, based on extrapolated growth from the 2013 Kingston Facilities Plan Update Addendum. This extrapolated growth projection shows a 191 percent growth between 2019 and 2042 within the sewered population projections, average annual growth rate of 4.75 percent.

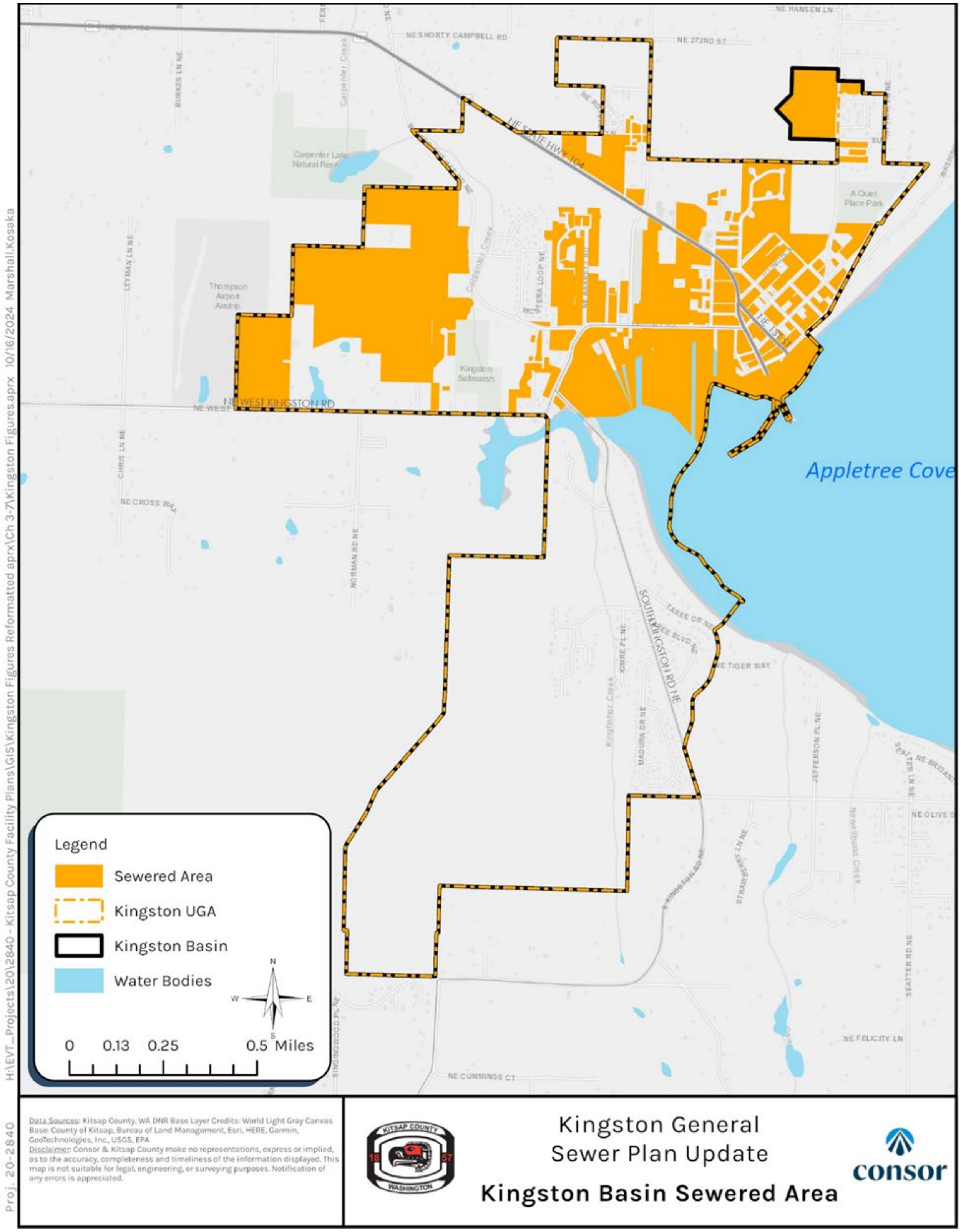
Table 3-2 | 2013 Kingston Facilities Plan Update Addendum Projected Sewered Population

Year	Projected Sewered Population
2010	823
2019[1]	3,251
2025	4,870
2042[2]	9,457

Notes:

1. 2019 data is interpolated from the 2010 and 2025 population.
2. 2042 population is extrapolated from the 2010 and 2025 population.

Figure 3-1 | Kingston Basin Sewered Area



The growth rate from the PSRC was selected as the basis for the Kingston WWTP flow and load projections since the data is based on more recent analysis of growth in the area.

Based on the estimated sewered population in **Section 3.3.3** and using the population growth rate from PSRC, the projected sewered population in 2028 and 2042 for the Kingston basin is shown on **Table 3-3**. The 2044 population projection is also presented here and aligns with those developed by the Kitsap County DCD over the 2044 planning horizon, which corresponds to the County Comprehensive Plan update.

Table 3-3 | Kingston Projected Sewered Population

Year	Projected Sewered Population
2020	2,553
2028	3,929
2042	6,337
2044	6,681*

Note:
*Extrapolated from 2042 population

3.4 Wastewater Flows

Influent flow to the Kingston WWTP is made up of primarily domestic wastewater and a small amount of light commercial and minor industrial wastewater. Flow for this plant comes in through the influent PS-71 located offsite to the northeast of the Kingston WWTP.

3.4.1 Current Wastewater Treatment Plant Flow

Daily influent flow data were evaluated using DMR reports from January 2018 through June 2020 (the evaluation period) and are shown in **Figure 3-2**. Flows increase during the rainy season due to infiltration and inflow (I&I). Inflow is stormwater runoff entering the sewer directly, typically from storm sewer connections, basement sump pumps, roof drains and submerged manholes. Infiltration occurs as groundwater leaks into the sewer system through cracked or broken pipes and manholes, or through loose joints and connections. The flow is conveyed to the WWTP through two force mains from multiple offsite pump stations.

Figure 3-2 | Daily Flowrates

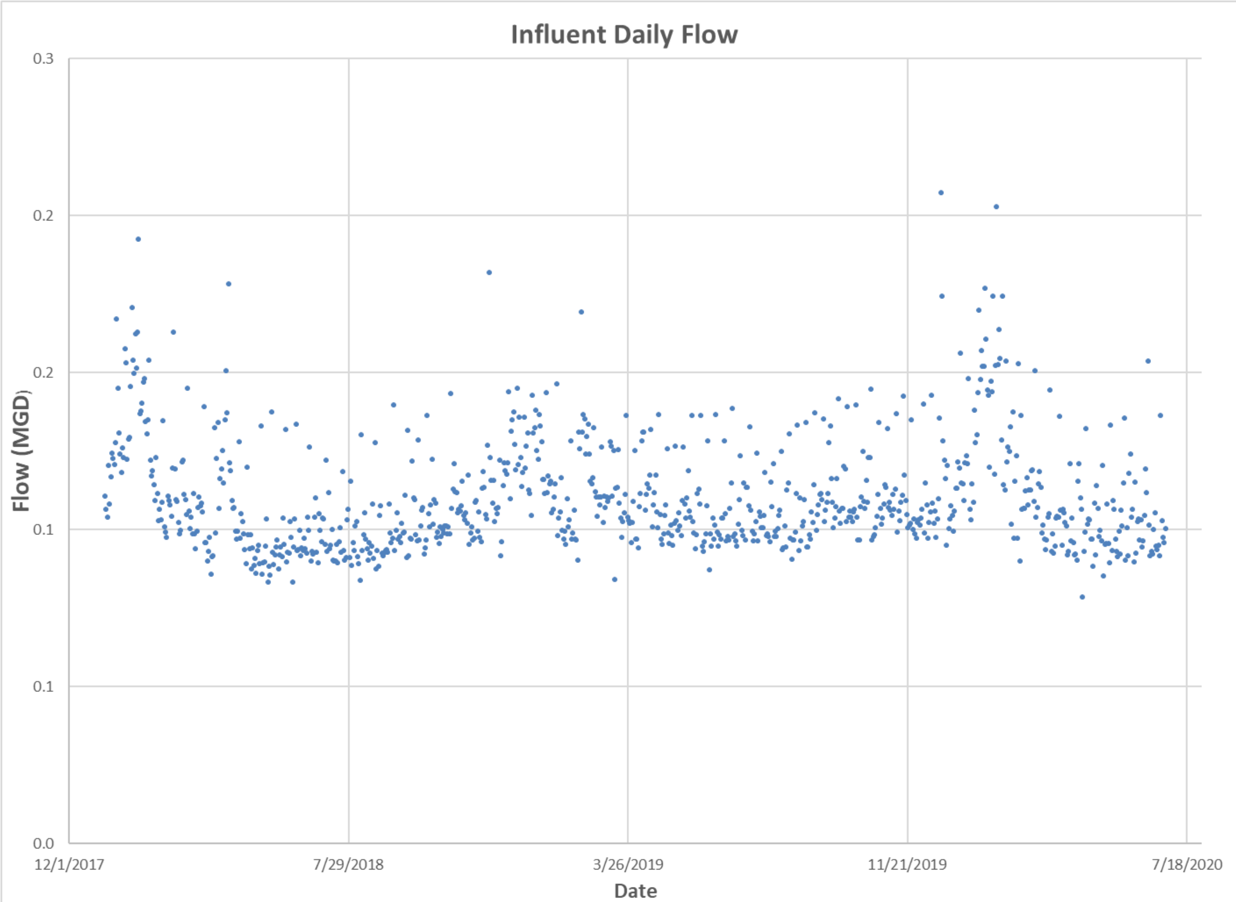


Table 3-4 summarizes the current (2020) AAF, MMWWF, MMDWF, PDF, and PHF from the plant DMR data and corresponding peaking factors and per capita values based on the estimated current sewered population of 2,553. The per capita flow values are in the normal range of most plants. Hourly flow data are not available at Kingston WWTP, so PHF was estimated based on the PS-71 discharge flow since the entire Kingston WWTP influent is pumped from PS-71. **Figure 3-3** shows the 60-minute moving average flowrate measured by the magmeter at the pump station forcemain on December 22, 2020, when the station received and pumped the highest flow during the rain event. The ratio of PHF to the average day flow on that day is 2.74. This ratio is then applied to the currently observed PDF to estimate the current PHF. The peaking factor PHF/AAF shown on **Table 3-4** is calculated by dividing the estimated PHF flow by the 2020 AAF flow.

Figure 3-3 | Pump Station 71 Discharge Flowrates on December 22, 2020

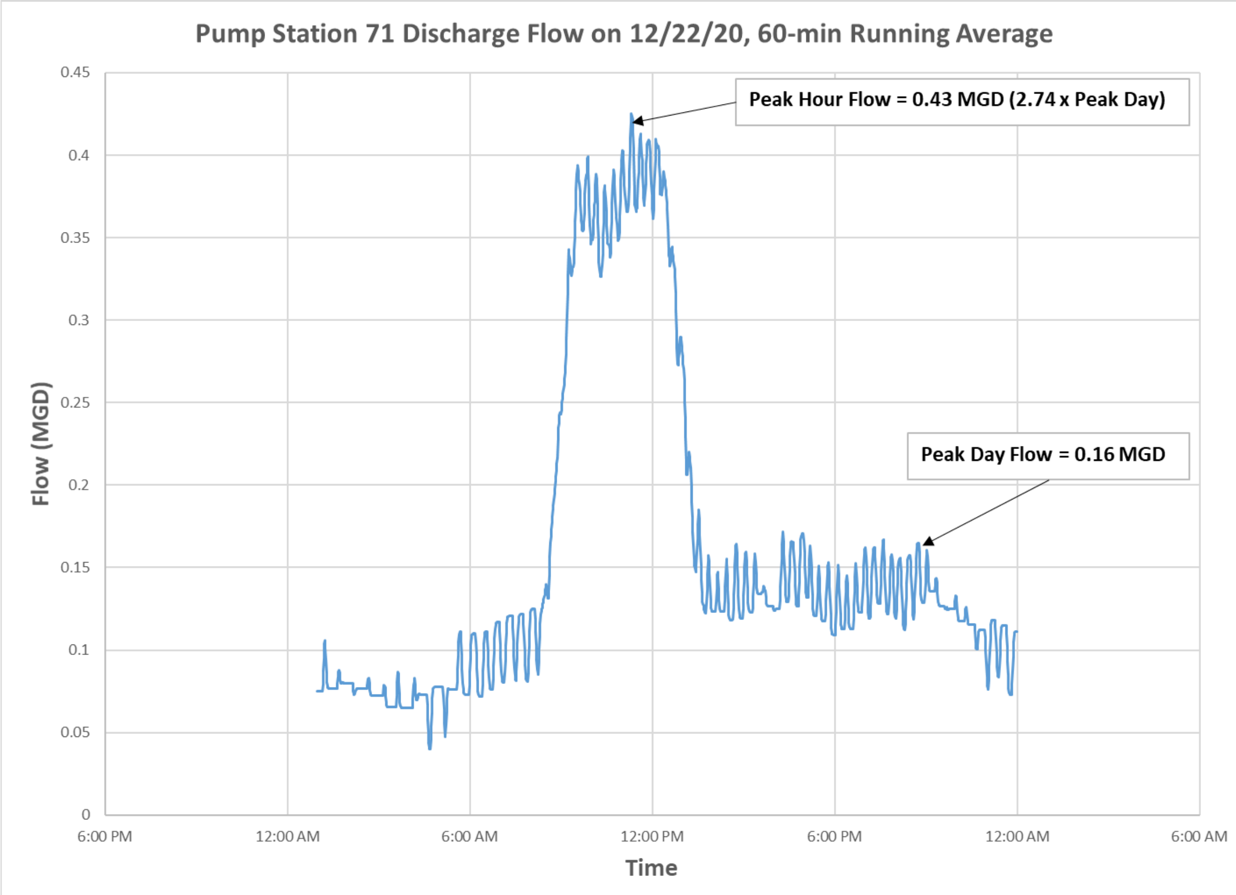


Table 3-4 | 2020 Influent Flows at Kingston WWTP

Flow Event	Current Flow (MGD)	Peaking Factor	Per Capita Flow (gpcd)
AAF	0.11	1.00	43
MMWWF	0.15	1.33	57
MMDWF	0.12	1.05	45
PDF	0.21	1.88	81
PHF	0.57	5.16	222

Notes:
MGD = million gallons per day
gpcd = gallons per capita per day

3.4.2 Wastewater Treatment Plant Flow Projection

Table 3-5 summarizes the projected flows in year 2028 (6-year projection) and year 2042 (20-year projection), based on the 2020 flows and anticipated growth rate.

Table 3-5 | Projected Influent Flows at Kingston WWTP Flows

Flow Event	2028	2042
Projected Sewered Population	3,929	6,337
AAF (MGD)	0.17	0.27
MMWWF (MGD)	0.23	0.36
MMDWF (MGD)	0.18	0.29
PDF (MGD)	0.32	0.51
PHF (MGD)	0.87	1.41

3.4.3 Infiltration and Inflow

The I&I is the wastewater component consisting of stormwater surface runoff entering the sewer system and infiltration from storm-saturated ground conditions. Inflow is runoff entering the sewer directly, typically from storm sewer connections, basement sump pumps, roof drains and submerged manholes. Infiltration occurs as groundwater leaks into the sewer system through cracked or broken pipes and manholes, or through loose joints and connections.

The I&I is important in determining the PDF and PHF through the system. They can vary significantly due to changes in groundwater tables, intensity of rainfall, duration of rainfall, and when the peak of the rain event occurs during the day.

The United States Environmental Protection Agency (EPA) publication 'Infiltration/Inflow – I/I Analysis and Project Certification' dated May 1985 was reissued as Ecology Publication No. 97-03. This publication established the following thresholds for possibly excessive I&I:

- If average dry weather flow is less than 120 gpcd, infiltration is non-excessive.
- If average wet weather flow is less than 275 gpcd, inflow is non-excessive.

The average dry weather and wet weather flows are summarized in **Table 3-6**. The average dry weather flows indicate that infiltration is non-excessive. The average wet weather flows indicate that inflow is non-excessive.

Table 3-6 | EPA/Ecology Excessive I&I Criteria

Parameter	Value
Population	2,553
Average Dry Weather Flow (MGD)	0.14
Average Dry Weather Flow (gpcd)	54
Average Dry Weather Dates[1]	1/18/2021-1/20/2021
Average Wet Weather Flow[2] (MGD)	0.22
Average Wet Weather Flow (gpcd)	86

Notes:
1. Dry weather flows are the average flow on days where no rainfall has occurred during a season of high groundwater.
2. Wet weather flows are the average of the three highest flow events from August 2020 through April 2021.

3.5 Wastewater Loads

3.5.1 Current Wastewater Loads

Wastewater loads to a treatment plant are used to evaluate different treatment alternatives and to determine the required treatment capacities. Current biochemical oxygen demand (BOD), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN) daily mass loads were derived from the 2018-2020 DMR Evaluation period data as well as monthly influent nitrogen data collected by plant staff. These daily mass loads were divided by the projected 2020 sewered population of 2,553 to calculate per capita plant loads. These 2020 total and per capita loads for BOD, TSS and TKN during annual average, wet weather and dry weather flows are shown in **Table 3-7**. The load per capita values are typical of WWTPs.

Table 3-7 | 2020 Kington WWTP Influent BOD, TSS, and TKN Loads

Population	Parameter	Annual Average		Max Month Wet Weather		Max Month Dry Weather	
		Load (ppd[1])	Load Per Capita (ppcd[2])	Load (ppd[1])	Load Per Capita (ppcd[2])	Load (ppd[1])	Load Per Capita (ppcd[2])
2,553	BOD	280	0.110	533	0.209	525	0.195
2,553	TSS	285	0.112	429	0.168	378	0.140
2,553	TKN	54	0.021	65	0.026	72	0.028

Note:
ppd = pounds per day
ppcd = pounds per capita per day

3.5.2 Influent Wastewater Loads Projection

Per capita loading factors were multiplied by projected populations in 2028 and 2042 to project future plant BOD, TSS and TKN loading during average, wet weather, and dry weather conditions. Loading projections for 2028 and 2042 are shown in **Table 3-8** and **Table 3-9**.

Table 3-8 | 2028 (6-Year) Kingston WWTP BOD, TSS, and TKN Loading Projections

Population	Parameter	Annual Average		Max Month Wet Weather		Max Month Dry Weather	
		Load (ppd)	Load Per Capita (ppcd)	Load (ppd)	Load Per Capita (ppcd)	Load (ppd)	Load Per Capita (ppcd)
3,929	BOD	431	0.110	821	0.209	766	0.195
3,929	TSS	438	0.112	660	0.168	550	0.140
3,929	TKN	84	0.021	101	0.026	111	0.028

Note:
ppd = pounds per day
ppcd = pounds per capita per day

Table 3-9 | 2042 (20-Year) Kingston WWTP BOD, TSS, and TKN Loading Projections

Population	Parameter	Annual Average		Max Month Wet Weather		Max Month Dry Weather	
		Load (ppd)	Load Per Capita (ppcd)	Load (ppd)	Load Per Capita (ppcd)	Load (ppd)	Load Per Capita (ppcd)
6,337	BOD	696	0.110	1,324	0.209	1,236	0.195
6,337	TSS	707	0.112	1,064	0.168	887	0.140
6,337	TKN	135	0.02	162	0.026	179	0.028

Note:
ppd = pounds per day
ppcd = pounds per capita per day

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SECTION 4

Regulatory Requirements

The operation and construction of wastewater collection and conveyance systems and wastewater facilities are regulated through federal, state, and local regulations. Federal, state, County, and local government regulatory requirements applicable to the Kingston collection and conveyance systems, WWTP, and other wastewater facilities are described in this section.

4.1 Federal Rules and Regulations

4.1.1 Federal Water Pollution Control Act (Clean Water Act)

The FWPCA, also known as the Clean Water Act (CWA), is a comprehensive framework for the regulating the discharge of pollutants into waters of the United States. The EPA has delegated the administration of the NPDES permit program in Washington State to Ecology. NPDES permitting is discussed in further detail below, as are Pretreatment regulations and Biosolids Management.

4.1.2 U.S. Army Corps of Engineers

The United States Army Corps of Engineers (USACE) has jurisdiction over waterways and wetlands of the United States. Modifications to the treatment plant outfall or development or construction in wetland areas may require a permit from the USACE. Permitting is reviewed by Federal, State, and local agencies as well as Tribal entities. Permits are contingent on certification from Ecology that the project is consistent with the State of Washington Coastal Zone Management Plan.

4.1.3 Endangered Species Act

The National Marine Fisheries Service is directed under Section 4(d) of the Endangered Species Act (ESA) to issue regulations conserving species listed as threatened. The Section 4(d) rules apply to ocean and inland areas as well as any entity subject to U.S. jurisdiction. Species in the basin listed as threatened under Section 4(d) are listed in **Section 2.3.6**.

Section 9 of the ESA prevents "taking" or harm of threatened species and identifies some activities with a high risk of take. These activities include urban development in riparian areas and areas susceptible to erosion destruction or alteration of habitats, and violations of discharge permits.

4.1.4 Capacity Management Operations and Maintenance Programs

Capacity Management Operations and Maintenance (CMOM) is an anticipated regulation from the EPA related to control of sanitary sewer overflows (SSO) from sewer collection and conveyance systems or treatment facilities, which are prohibited under the Federal CWA. The EPA has prepared a draft rule titled "Sanitary Sewer Overflow Control Rule" which is intended to eliminate preventable SSOs through requiring owners and operators of sewer systems to develop and implement CMOM programs.

4.1.5 Puget Sound Water Quality Management Plan

The FWPCA established the requirement for a Water Quality Management Plan. Resultantly, the RCW, section 90.71 established the need of a Puget Sound Water Quality Management Plan. The stated objective of this plan is to protect and restore Puget Sound through effective coordination among governments and private interests, and through used of an adaptive management approach.

4.1.6 EPA Plant Reliability Criteria

The Kingston WWTP is required to meet the Reliability Class I standards, as defined in EPA's Technical Bulletin "Design Criteria for Mechanical, Electrical, and Fluid System Component Reliability," EPA 430-99-74-001. A summary of plant reliability criteria and requirements and current deficiencies at Kingston WWTP are discussed in **Section 6** of this Plan.

4.1.7 National Historic Preservation Act

The National Historic Preservation Act (NHPA) established processes to assess, designate, and protect historic and cultural resources. It also established the National Register of Historic Places and the State Historic Preservation Officer (SHPO) to administer state historic preservation program and coordinate with federal agencies on their proposed actions, also known as undertakings. Section 106 of the NHPA requires coordination between federal, state, local, and tribal entities to review the impacts of any undertakings on historical properties listed or eligible for listing on the National Register.

4.2 State Rules and Regulations

4.2.1 Department of Ecology

The approval of this Plan is per Ecology. Requirements for sewer plans are listed in RCW 90.48.110 and WAC 173-240. Ecology administers numerous regulations published in the WAC which are briefly described below.

4.2.1.1 Water Quality Regulations

Ecology's water quality standards for surface waters of the State are published in WAC 173-201A which also contains the anti-degradation policy. The anti-degradation policy has goals which include restoring and maintaining the highest possible quality of the surface waters of Washington and to ensure that all human activities that are like to contribute to a lowering of water quality, at a minimum, apply all known, available, and reasonable methods of prevention, control, and treatment (AKART).

Ecology established water quality criteria for marine environments under WAC 173-201A. Under this section, standards are set for "public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife." Within this section, water quality criteria are established for aquatic life uses, Shellfish Harvesting, recreation use, and miscellaneous uses. Under aquatic life uses, target levels for temperature, DO, and bacteria, turbidity, and pH were established with different quality thresholds based on the importance of the environment and the species present. Mixing zone regulations for WWTP outfalls are also specified in this regulation.

4.2.1.2 NPDES Regulations

Ecology has been delegated authority from the EPA to enforce the CWA to regulate the discharge of treated effluent from WWTPs through the NPDES program. Washington's NPDES Permit requirements are included in WAC 173-220, whose purpose is to "establish a state individual permit program, applicable to the discharge of pollutants and other wastes and materials to the surface waters of the state, operating under state law as a part of the NPDES created by Section 402 of the FWPCA." NPDES Permit limits must comply with Washington water quality standards and biosolids management regulations included in WAC 173-201A and WAC 173- 308, respectively.

The County's Kingston WWTP NPDES Permit #WA0032077 was renewed on December 1, 2015, allowing the discharge of treated effluent to Appletree Cove, Puget Sound. A copy of the WWTP's NPDES Permit is included in **Appendix A**. The NPDES Permit expired on November 30, 2020. The County submitted the permit renewal application six months before the expiration date per the Permit requirement. The current permit was administratively continued and remains in effect.

4.2.1.3 Pretreatment Regulations & Industrial Users

Kingston WWTP is required in Special Condition S6 of the NPDES permit to enforce the discharge prohibitions, identify and report existing, new, and proposed industrial users, and conduct industrial user survey.

According to 40 Code of Federal Regulations (CFR) Part 403 (General Pretreatment Regulations for Existing and New Sources of Pollution) all "significant industrial users", which are industrial users that discharged an average of 25,000 gallons per day (gpd) or more to the Publicly Owned Treatment Works (POTW) or makes up 5 percent or more of the average dry weather hydraulic or organic (BOD or TSS) capacity of the POTW, are required to be part of the National Pretreatment Program.

The National Pretreatment Program is charged with controlling toxic, conventional, and non-conventional pollutants from non-domestic sources that discharge into sewer systems, as described in CWA Section 307(a). Ecology has been given authority by the EPA to regulate the Pretreatment Program in Washington and is required to comply with the federal provisions of the National Pretreatment Program. The Pretreatment Program requires all large POTW that have a designed treatment capacity of more than 5 million gallons per day (MGD) to establish a Local Pretreatment Program.

Kingston WWTP, with design flows less than 5 MGD, is only required to develop a formal Pretreatment Program if the nature or volume of the industrial influent are contributing to treatment process upsets, violations of NPDES Permit Limits or other circumstances that warrant the development of a program to eliminate those occurrences per 40CFR 403.8 (a).

Since majority of wastewater in the Kington basin is from domestic sewer, and no industrial or commercial discharges have been found to impact the plant performance, a Pretreatment Program is not required for Kingston WWTP.

The County conducted an Industrial User Survey in 2020. The survey is included in **Appendix B**. There is no SIU identified within the Kingston service area.

4.2.1.4 Biosolids Management

Kingston WWTP is required in Special Condition S7 of the NPDES permit to store and handle all residual solids in accordance with the requirements of applicable state water quality standards. The final use and disposal of sewage sludge from this facility is regulated by EPA under 40 CFR 503, and by Ecology under RCW chapter 70.95, WAC 173-308, Biosolids Management, and WAC 173-350, Solid Waste Handling Standards. Washington state law requires that biosolids be put to beneficial reuse unless specifically permitted otherwise. The regulations also address the monitoring, record keeping, and reporting requirements.

The current Special Condition S7 of the Kingston WWTP NPDES permit only requires the County to handle and dispose of all solid waste material in such a manner as to prevent its entry into state ground or surface water. Biosolids from Kingston WWTP are sent to the Central Kitsap WWTP for disposal; therefore, no biosolids management plan is required.

4.2.1.5 Puget Sound Nutrient General Permit

In response to areas of the Puget Sound not meeting the water quality criteria for DO, Ecology initiated the Puget Sound Nutrient Source Reduction Project to investigate the causes and extent of DO deficits. As part of the analysis, Ecology, along with several academic partners, developed a Salish Sea Model and determined the source of these exceedances of the water quality standard was the discharge of excess nutrients, especially nitrogen.

Ecology has implemented the Puget Sound Nutrient General Permit (PSNGP) for WWTPs to address the largest source of excess nutrients going into Puget Sound. They issued the first PSNGP effective as of January 1, 2022 and expiring on December 31, 2026. This PSNGP applies to the 58 publicly owned domestic WWTPs discharging into Washington waters of the Salish Sea. The WWTPs are categorized as 'Dominant (D) Total Inorganic Nitrogen (TIN) loads', 'Moderate (M) TIN loads', or 'Small (S) loads' based on their percentage of TIN load currently discharged. The dominant or moderate TIN load plants have a facility specific action level and are required to implement nutrient monitoring and reporting, develop a nutrient optimization plan, conduct a nutrient reduction evaluation, and comply with action level exceedance corrective actions if nutrient discharge limits are exceeded. Small TIN load plants do not have a facility specific action level but are also required to implement nutrient monitoring and reporting, develop a nutrient optimization plan, and conduct AKART analysis. Kingston WWTP is classified as a small TIN load plant.

Ecology is working collaboratively with Puget Sound stakeholders through the Puget Sound Nutrient Source Reduction Project and Puget Sound Nutrient Forum to find solutions for reducing other human sources of excess nutrients.

4.2.1.5.1 Monitoring and Reporting Requirements

The PSGNP requires nutrient monitoring, recording, and reporting so nutrient loading can be calculated and tracked. The requirements under this permit will supplement the information collected under Kingston WWTP's NPDES permit and is limited to analyses necessary to track nutrients in the influent and effluent. The monitoring schedule is based on of the classification of the WWTP. The dominant TIN load treatment plants are required to monitor the influent and effluent two times per week, one time per quarter, or one time per month, depending on the parameter. The moderate TIN load treatment plants are required to monitor the influent and effluent nutrient concentrations one time per week, one time per quarter or one time per month, depending on the parameter. The small TIN load treatment plants are required to monitor the influent and effluent nutrients one time per quarter, or once or twice a month depending on the parameter.

The influent and effluent sampling requirements for small TIN load plants including Kingston WWTP are shown in **Table 4-1** and **Table 4-2**.

Table 4-1 | Influent Nutrient Sampling Requirement for Kingston WWTP

Parameter	Units	Minimum Sampling Frequency
CBOD	mg/L	2/month
Total Ammonia	mg/L as N	2/month
Nitrate plus Nitrite Nitrogen	mg/L as N	1/month
TKN	mg/L as N	1/month

Table 4-2 | Effluent Nutrient Sampling Requirement for Kingston WWTP

Parameter	Units	Minimum Sampling Frequency
Flow	MGD	2/month
CBOD	mg/L	2/month
Total Organic Carbon	mg/L	1/quarter
Total Ammonia	mg/L as N	2/month
Nitrate plus Nitrite Nitrogen	mg/L as N	2/month
TKN	mg/L as N	1/month
TIN	mg/L as N	2/month
TIN	ppd	2/month
Average Monthly TIN	Lbs	1/month
Annual TIN, year to date	Lbs	1/month

Note:
mg/L = milligrams per liter
mg/L = milligrams per liter as nitrogen
ppd = pounds per day
lbs = pounds

4.2.1.5.2 Nitrogen Optimization Plan

An annual Nitrogen Optimization Plan is a required submittal for all permittees and would be submitted electronically as a permit submittal. The purpose of the Nitrogen Optimization Plan is to provide a framework for developing, implementing, and documenting nitrogen optimization strategies. The permit provided detailed requirements of the Nitrogen Optimization Plan components, which vary slightly depending on the TIN load categories.

4.2.1.5.3 AKART Analysis

Small TIN Load WWTPs are required to prepare and submit an AKART analysis by December 31, 2025. Permittees that maintain an annual TIN average less than 10 mg/L and do not document an increase in load through their DMRs do not have to submit this analysis. The AKART analysis requirements are detailed in the final permit and supporting documents. The AKART analysis must include wastewater characterization, treatment technology analysis, economic evaluation, environmental justice review, alternative selection, and implementation timelines.

4.2.1.6 Clean Water Act Section 303(d) list

Ecology conducts the water quality assessment based on Federal laws, state water quality standards, and Water Quality Assessment Policy 1-11 to track water qualities in the rivers, lakes, and marine waters in the state. The water quality assessment compares water data to requirements detailed in Policy 1-11. The assessed waters are placed into categories that describe the status of water quality, before being submitted to the EPA for approval of the category 5 listings, also called the 303(d) list. The water quality assessment divides water bodies into the following impairment categories:

- Category 1: Meets tested standards for clean waters
- Category 2: Waters of concern
- Category 3: Insufficient data
- Category 4: Impaired waters that do not require a total maximum daily load
- Category 5: Polluted waters that require a water improvement project

4.2.1.7 Infiltration and Inflow

Ecology can require reductions in I&I in situations where diluted influent affect the 85 percent BOD removal and the suspended solids minimum removal limit. State and Federal regulations also require that recipients of loan or grant money demonstrate that their sewer collections systems are not subject to excessive I&I.

4.2.1.8 Engineering Design Criteria

Ecology's "Criteria for Sewage Works Design," also known as the Orange Book, identifies engineering criteria for design, construction, and operation of public sanitary sewer systems and wastewater treatment facilities.

4.2.2 Recycled Water Use

Recycled water is regulated by Ecology and the DOH, according to WAC 173-219. Ecology and DOH are both required to review recycled water proposals to determine if proposed treatment methods and uses will protect public health and the environment while not affecting existing water rights. The regulation also provides criteria to determine the lead agency based on the type of facility recycling the water. Requirements from both the lead and non-lead agency must be met as a condition of permitting. Recycled water from the Kingston WWTP would be regulated with Ecology as the lead agency under WAC 173-219-050 as the source water is effluent from a facility permitted by Ecology.

4.2.3 State Environmental Policy Act

The Washington State Environmental Policy Act (SEPA) is intended to help state and local agencies identify environmental impacts likely to result from a range or projects or decisions. Construction of public facilities such as sewer lines or WWTPs or adopting regulations or policies such as comprehensive plans often trigger a SEPA review.

4.2.4 State Environmental Review Process

The Washington State Environmental Review Process (SERP) is regulated according to WAC 173-98-720 and states all recipients of funding for water pollution control facility projects must comply with the SERP. SERP includes all provisions of SEPA. Mitigation measures identified in documents developed through the SERP become conditions of funding.

4.2.5 Puget Sound Clean Air Agency

The Puget Sound Clean Air Agency (PSCAA) has jurisdiction in the County and is responsible for regulating and permitting air emissions in the Puget Sound Region. Construction projects are often subject to regulation under PSCAA's Notice of Construction (NOC) Program. Projects that fall under the NOC program must not be subject to provisions of the Prevention of Significant Deterioration (PSD) or the New Source

Review (NSR) programs, administered by Ecology. Determination of the regulatory pathway is dependent on the potential change in emissions resulting from the project and two categorizations: the source is either characterized as a major or non-major source and emissions from the project categorized as either significant or less than significant. Acceptable Source Impact Levels (ASIL) are defined in WAC 173-460 and regardless of regulatory pathway, toxic air contaminants (TAC) emission increases must be compared to ASILs. Point sources such as waste gas burners, open tanks, and scrubber vents must be evaluated.

4.2.6 Washington State Department of Fish and Wildlife

The Washington State Department of Fish and Wildlife administers the State Hydraulic Code (WAC 220-660) which establishes regulations for the construction of hydraulic projects or work that will impact any salt or fresh waters of the state. It also sets forth procedures for obtaining Hydraulic Project Approval (HPA). Modifications to the Kingston WWTP outfall would likely require HPA.

4.3 Kitsap County and Local Government Requirements

The Kingston sewer basin falls within unincorporated Kitsap County.

4.3.1 Kitsap County Codes

Kitsap County Code Chapter 13.12 contains regulations governing public sewer systems. This chapter describes licensing and permitting of sewers, the locations of sewers and connections, and prohibited discharges and disposal of prohibited wastes. Specifications for sewers as well as standards for excavation and trenching are also included in Chapter 13.12.

Kitsap County Code Chapter 18 contains the basic requirements that apply to the SEPA process and describes the sections of the SEPA that have been adopted by the County. Contents of Chapter 18 include, but are not limited to, designation of responsible officials and lead agency, exemptions and threshold determinations, an environmental checklist for applicants, rules for preparing environmental impact statements, rules for commenting on environmental documents under SEPA, rules governing public notices and hearings, and rules describing agency compliance with SEPA.

Kitsap County Code Chapter 19 contains the County’s Critical Areas Ordinance which identifies and protects critical areas as required by the GMA. Critical areas include but are not limited to wetlands, fish and wildlife habitat conservation areas, and geologically hazardous areas. Chapter 19 also outlines purposes and objectives for each critical area category and describes development standards, review procedures, and designation statuses.

Kitsap County Code Chapter 22 contains the County’s Shoreline Master Program which guides future development of the shorelines in the county consistent with the Shoreline Management Act. Chapter 22 describes shoreline jurisdiction and environment designations, goals and policies for the program, regulations, permit review and enforcement, and shoreline use and modification standards. This chapter also contains a section describing requirements for reports for critical areas including wetlands, habitats, geotechnical, and hydrogeological. This sections addresses when reports are required, the qualifications of those preparing the reports, and timelines and schedules for the reports.

4.3.2 Growth Management Act

The GMA is a State, County, and City planning requirement which influences City and County plans for future growth. The GMA established a series of 13 goals under RCW 36.70A.020 as well as a 14th goal (RCW

36.70A.480) which adds the goals and policies from the Shoreline Management Act to those of the GMA. The County is subject to the full requirements of the GMA which requires planning for utilities including sewer service. This includes providing a capital facilities element in Comprehensive Land Use Plans as well as forecasting future needs for these facilities, proposed locations, and capacities of new or expanded facilities, and plans to fund these facilities into the future. The 2016 KCCP was prepared to satisfy the GMA requirements and describes the planned growth within the sewer service areas as well as plans to maintain and expand services within the sewer service area.

Based on the requirements of the GMA, the County is required to review, and if necessary, revise its Comprehensive Plan by June 30, 2024, and every eight years thereafter. As part of this review and revision, the County plans to revise its population and employment growth projections, which currently are projected to 2036, out to the year 2044. This revision is planned to begin in 2022, thus revised growth projections were not available at the time of this sewer plan update.

4.3.3 Water as a Resource Policy

The County's Water as a Resource Policy directs the County to treat water as a resource and not a waste stream. The policy focuses on improving water in the County through seven main guiding principles. While the guiding principles largely focus on controlling stormwater, guiding principles concerning conserving groundwater resources impacts the sewer system through use of recycled water or non-potable water for appropriate uses. The policy also contains guiding principles aimed at continual refinement of management tools. In addition to guiding principles, the policy directs the County to consider water as a resource when developing, re-developing, retrofitting, refurbishing, maintaining, and operating public assets. The policy also directs the County to consider water as a resource when developing or revising codes and regulations.

SECTION 5

Collection and Conveyance Existing Conditions

5.1 Introduction

The Kingston basin collection and conveyance system consists of sewer assets owned by the County located primarily in the northern portion of the Kingston UGA except the Kingston WWTP which is located to the west of the UGA.

The oldest parts of the Kingston collection system were installed in the mid-1970s. Relatively little growth in the system occurred until the early 2000s with significant growth occurring in the first half of the decade. The most recent period of growth began in the early 2010s, and continues today, following a short lull in 2015 and 2016. Many pump stations in the basin were installed or updated in the 1990s and 2000s. The most recent installation occurred in 2017 with the installation of PS-73. Additional pump station proposals are under review and may be approved or under construction by the time this Plan is published. The system now serves approximately 1 square mile of residential and commercial customers within the UGA boundary. The sewer system is separate from the stormwater system and consists of gravity sewers, pump stations, and IPS. Some properties within the service area have on-site septic systems that are not connected to the collection system.

5.2 Service Areas and Sewer Basins

The Kingston collection and conveyance system is shown in **Figure 5-1**. The collection and conveyance system primarily serves the northern portion of the UGA; the southern portion of the UGA is unsewered. Wastewater within the Kingston basin is ultimately conveyed to the Kingston WWTP west of the UGA.

At the level of single pump stations, service areas are delineated as 'mini basins', defined as the area from which the collection system drains to a specified discharge point. Delineations of mini basins are based on existing sewer service and topography. Each portion of the system contributing to a pump station is delineated as a separate mini basin for this analysis.

5.2.1 Flow Routing

Flows from the northern portion of the basin are routed through PS-41, PS-42, PS-43, PS-52, PS-71, PS-72, and PS-73 to the WWTP. Effluent from the WWTP is conveyed via an 18-inch diameter force main to Appletree Cove where it discharges. **Figure 5-2** shows a flow schematic of the Kingston basin's flow routing and pump station criticalities.

The Kingston basin currently contains seven mini basins: 41, 42, 43, 52, 71, 72, and 73. It is anticipated sewer service will be extended to cover the Kingston UGA creating five additional sub-basins identified in the 2013 Kingston Wastewater Facilities Plan Update: Arborwood, Arness, SR 104, Taree Drive, and West Kingston. The existing mini basins are summarized in **Table 5-1**. The existing and anticipated mini basins are shown in **Figure 5-3**.

Figure 5-1 | Kingston Basin Sewer System

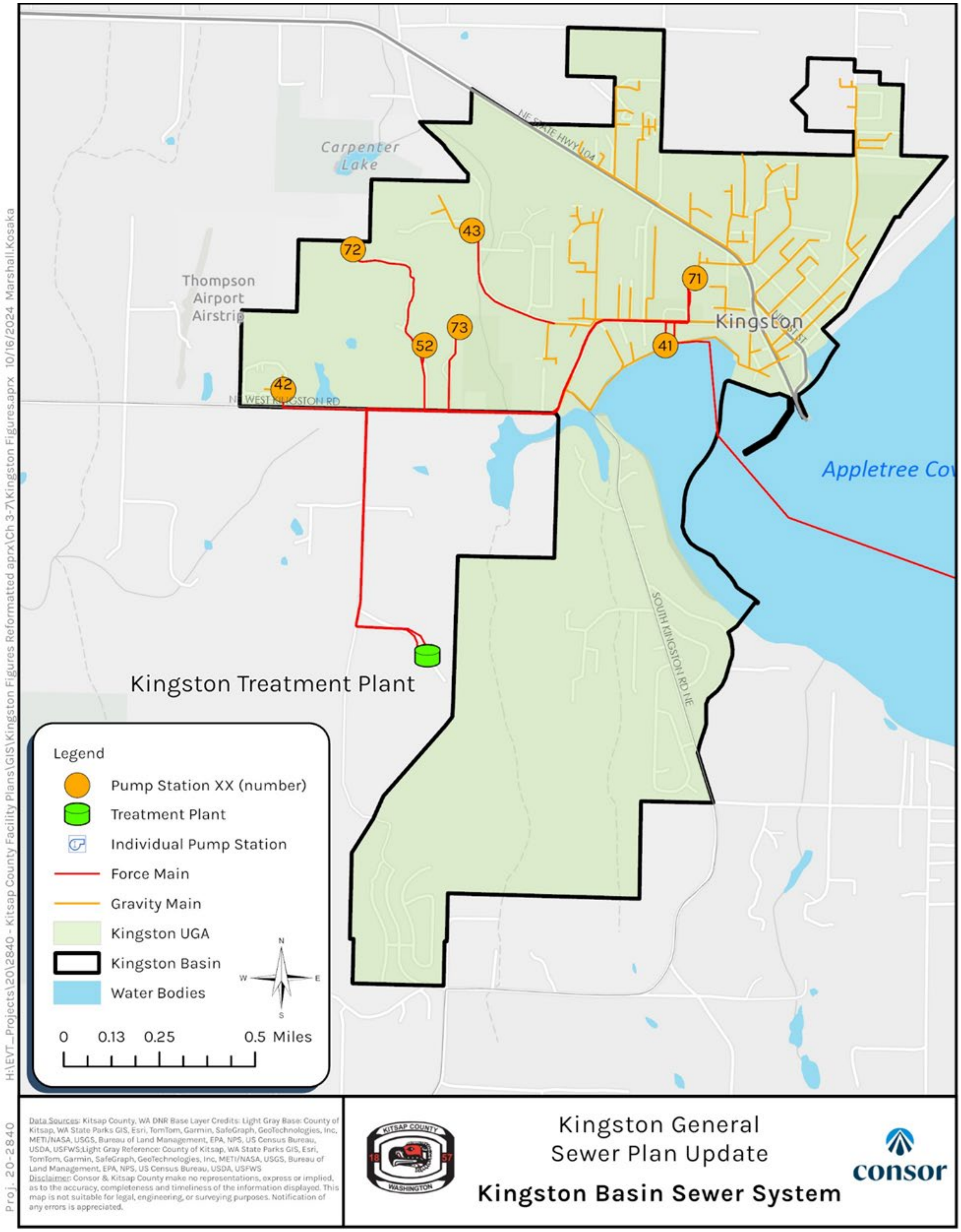
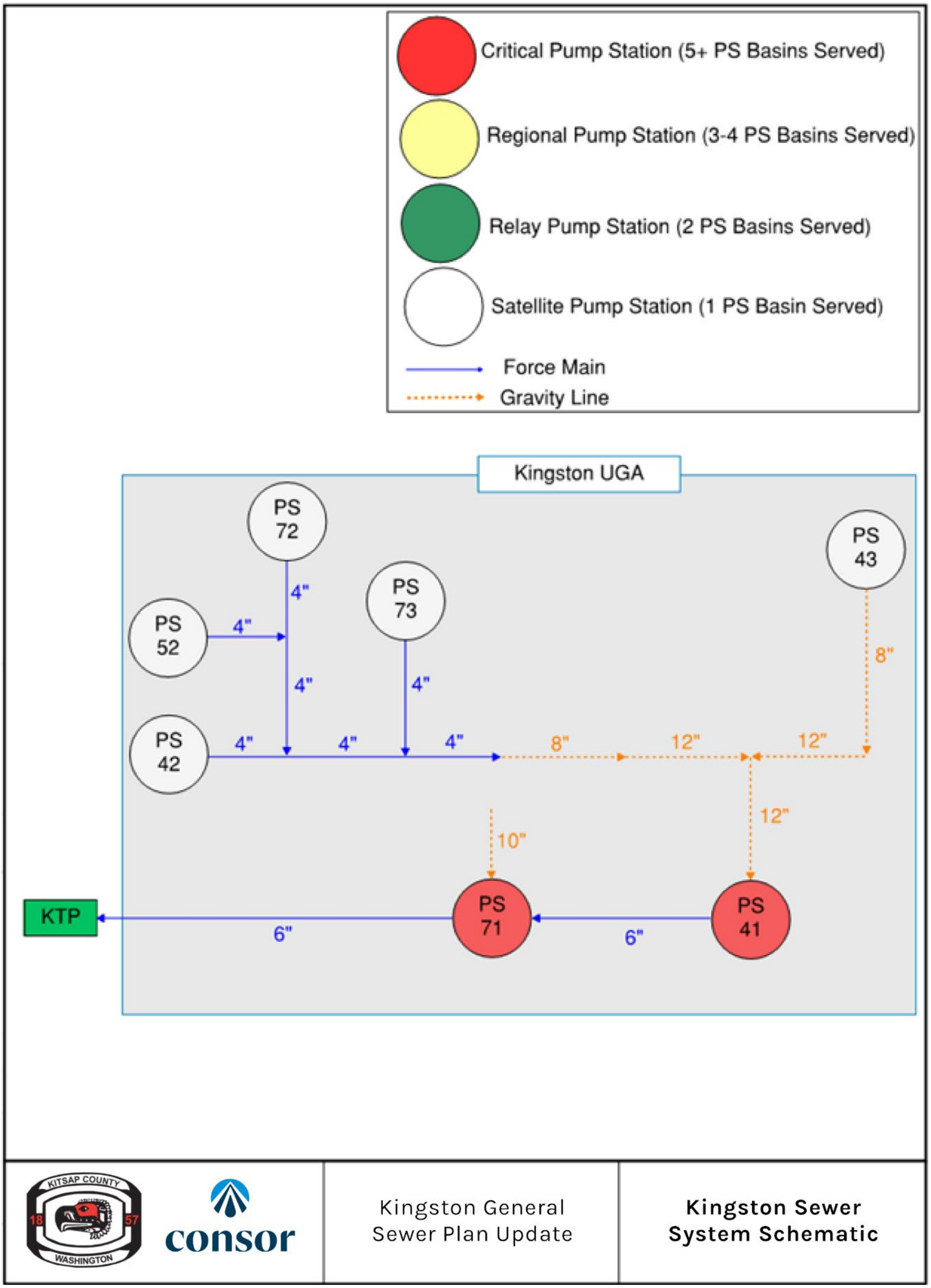


Figure 5-2 | Sewer System Schematic



DRAFT

Figure 5-3 | Kingston Mini Basins

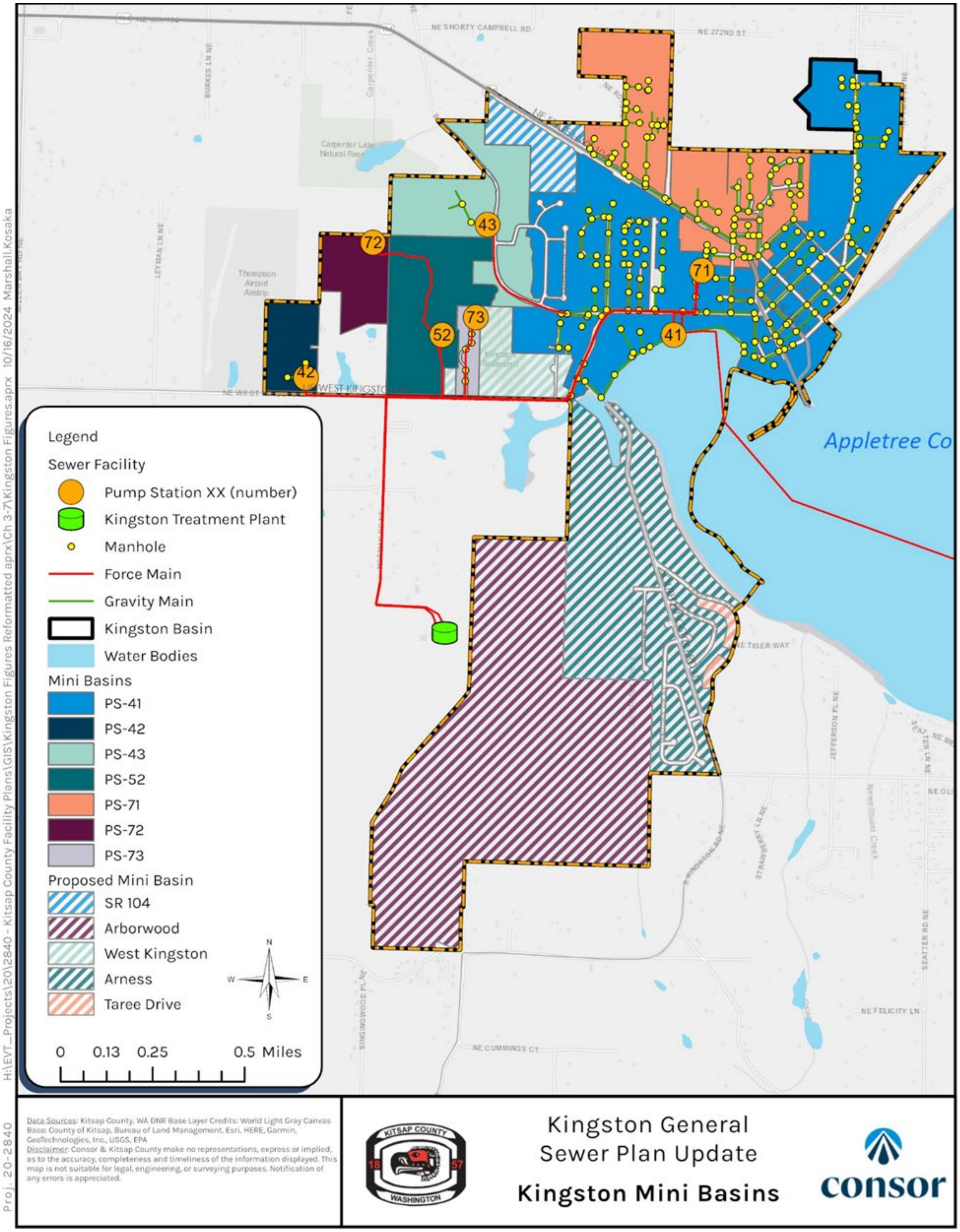


Table 5-1 | Existing Mini Basins Summary

Mini Basin	Area (ac)	Tributary Mini Basins	Downstream Mini Basins	Discharges to
PS-41	247	PS-42, PS-52, PS-72, PS-73	PS-71	6-inch dia. FM
PS-42	22	-	PS-41	4-inch dia. FM
PS-43	62	-	PS-41	4-inch dia. FM
PS-52	60	-	PS-41	4-inch dia. FM
PS-71	103	PS-41	-	6-inch dia. FM
PS-72	26	-	PS-41	4-inch dia. FM
PS-73	8	-	PS-41	4-inch dia. FM

5.2.2 Gravity Sewer

There are approximately 57,400 feet of gravity sewer pipes in the Kingston basin collection system ranging in size from 6 inches to 12 inches in diameter. The County owns most of the gravity pipe in the Kingston collection system, approximately 89 percent of which is 8 inches in diameter. The gravity sewer pipe is split roughly evenly between asbestos cement and polyvinyl chloride with approximately 50 percent and 47 percent, respectively. Ductile iron and concrete pipes comprise the remainder. An inventory of gravity sewer pipe is provided in **Table 5-2**. Pipe lengths are calculated based on GIS data provided by the County in October 2023. An updated total length was also provided by the County's sewer asset count in March 2024.

Table 5-2 | Gravity Sewer Pipe Inventory

Pipe Diameter (in)	Total Length (ft)
8	47,338
10	2,036
12	3,127
Total Gravity (2023 GIS)	**52,501**
Total Gravity Including Private (2024 Sewer Asset Count)	**57,392**

In addition to the County owned gravity sewer pipes, there is also approximately 1,000 feet of privately owned gravity pipes within the UGA boundary. Private gravity sewer pipes are summarized in **Table 5-3**.

Table 5-3 | Private Gravity Pipe Inventory

Pipe Diameter (in)	Total Length (ft)
6	158
8	975
Total Private Gravity (2023 GIS)	**1,133**

5.2.3 Force Mains

The County owns approximately 26,000 feet of sewer force mains in the Kingston basin. The force mains convey wastewater to downstream gravity conveyance or the WWTP. **Table 5-4** provides a summary of force mains in the Kingston sewer system; pipe lengths are approximated from GIS data provided by the County in May 2023. There are no privately owned force mains in the Kingston sewer system. The County provided an updated total length of forcemain in March 2024.

Table 5-4 | Force Main Summary

Force Main Diameter (in)	Total Length (ft)
4	10,612
6	11,558
Total Force Main (2023 GIS)	**22,171**
Total Force Main (2024 Sewer Asset Count)	**25,957**

5.2.4 Individual Pump Stations

Kingston basin does not have customers served by IPS.

5.2.5 Odor Control

Odor control facilities are present at several pump stations throughout the system and are summarized in **Table 5-5**.

Table 5-5 | Odor Control Inventory

Facility	Odor Control System	Operational Status
PS-41	Charcoal	Currently in use
PS-42	None	N/A
PS-43	None	N/A
PS-52	None	N/A
PS-71	Bioxide Addition	Currently in use
PS-72	None	N/A
PS-73	Passive Carbon Filter	Currently in use

5.2.6 Pump Stations

There are seven pump stations within the Kingston sewer system. The oldest pump stations were installed in the 1970s. Since then, pump stations have been added and upgraded with the most recent pump station installation occurring in 2017. The firm capacity of the pump stations in the Kingston sewer system ranges from 30 gallons per minute (gpm) at PS-52 to 450 gpm at PS-71.

The 2013 Kingston Wastewater Facilities Plan Update identified upgrades to existing pump stations in the 2013-2018 time-period. These include a full upgrade and increased capacity for PS-41 as well as higher capacity pumps, new electrical equipment, and new influent piping for PS-71. Additionally, the plan recommended installing flow meter vaults at PS-42, PS-43, PS-52, and PS-72. The 2013 Kingston Wastewater Facilities Plan Update also identified new installations of pump stations to serve the proposed mini basins identified in **Section 5.2.1** anticipated in the 2019-2025 timeline. This information was used to inform the development of CIP projects in this Plan.

On-site emergency generators have been installed at three of the seven pump stations: PS-71, PS-72, and PS-73. PS-41 receives power from PS-41.

Table 5-6 summarizes the existing pump stations based on data provided by the County including GIS data, O&M records, and draw down test records.

Table 5-6 | Pump Stations Summary[1]

Pump Station	Location	Year Built/ Upgraded	VFD	Firm Capacity (gpm)	Static Head (ft)	Total Dynamic Head (ft)	No. of Pumps	Pump HP	Individual Force Main		Mini Basins Served	Generator
									Diameter (in)	Length[2] (ft)		
PS-41	Kingston Waterfront	1974	N	240	70	85	2	15	6	1,371	PS-41, PS-42, PS-52, PS-72, PS-73	None; Power fed from PS 71; Pigtail Connection Available
PS-42	9000 NE West Kingston Road Kingston, WA 98346	1993	N	80	31	34	2	7.5	4	250	PS-42	None
PS-43	26331 Barber Cutoff Road NE Kingston, WA 98346	1990	N	400	31	34	2	5	4	2,041	PS-43	None; Pigtail Connection Available
PS-52	9918 NE West Kingston Road Kingston, WA 98346	1998	N	31	26	48	2	2	4	927	PS-52	None; Pigtail Connection Available
PS-71	Old Treatment Plant Site, Dulay Road NE	2002	N	450	-	205	2	75	6	679	PS-41, PS-71	Present; Cummins DFCC-5667357 (350 kW)
PS-72	26201 Siyaya Avenue NE Kingston, WA 98346	2006	N	95	-	180	2	10.7	4	2,325	PS-72	Present; Generator owned by Kingston High School (Type and kW Unknown)
PS-73	NE School House Place	2017	Y	-	39	127	2	17	4	1,240	PS-73	Cummins C40D6 (40 kW)

Notes:
VFD: Variable Frequency Drive
1. "-" indicates data not available at this time.
2. Length is from the pump station to the force main on NE West Kingston Road. PS-41 length is the length of force main to PS-71.

5.3 Pump Station Conditions Assessments

In September 2020 Murraysmith [now Consor] staff visited the pump stations in the Kingston basin and conducted site assessments of each facility. During these site visits, staff documented each pump station's current components and systems and their condition. Subconsultant Industrial Systems, Inc. (ISI) documented electrical equipment conditions and potential code violations. An assessment form was filled out for each pump station visited and is included as **Appendix C**.

5.3.1 Condition Summary Tables

To better organize the results of these assessments, the equipment and systems at the pump stations were arranged in several categories. While no two pump stations are identical, the stations are anatomically similar and can be characterized by a standardized set of component groupings. These component groupings are consistent with County Asset Functional Class Levels and are presented in **Table 5-7** along with definitions of the systems each comprises.

Table 5-7 | Component Group Definitions

Component Grouping	Constituent Systems and Components
Civil	Site, roadways, sidewalks, fencing
Structural	Buildings, tanks, vaults, wetwells, equipment pads, Parshall flumes
Pumping Systems	Pumps, suction, and discharge valves, check valves
Motors	Motors associated with pumps or rotating machinery.
Piping Systems	Suction piping, discharge headers, drain lines, backflushing lines, water lines, chemical dosing lines, segments of on-site force main
Valve Systems or Assemblies	Odor control system valves, washdown water valves
Support Systems	Compressed air systems, potable water, fire suppression, HVAC
Instrumentation	Level indicators, flow meters, pressure gauges, water quality analyzers, SCADA systems, network hardware, panel views
Electrical and Power Distribution	Electrical systems between MCC and main power disconnect, standby generators, transfer switches, lighting

5.3.2 Pump Station Asset Health Score

A pump station 'Asset Health Score' was developed that synthesizes each pump station's existing likelihood of failure (condition) and consequence of failure (CoF). The score was developed to better inform the County's prioritization of future asset upgrades and replacements.

For structural components like buildings and wetwells, individual condition ratings generally apply to the physical integrity of these assets in the face of material degradation due to environmental forces such as corrosion, weathering, settling, and flooding. Individual condition scores for mechanical, electrical, and instrumentation systems consider each system's physical integrity and their current ability to perform as designed. General observations and historical accounts from County O&M staff were also used to inform the condition ratings for all pump station components to incorporate phenomena not observed by Murraysmith [now Consor] staff during the site visits. Examples of this historical information from O&M staff include, but are not limited to, observed high frequencies of check valve failures, power outages, pump ragging, and pump seal failures. Individual condition ratings range from 1 to 5, with a score of 1 representing the best condition and a score of 5 representing the worst. It is important to note that condition scores are not simply reflections of age as dissimilar environmental and operational factors among the County's pump stations necessitate differing rates of condition degradation. Although age/obsolescence is not accounted for in the condition assessment, it will be a consideration for development of the 20-year CIP so that replacement of aging infrastructure is accounted for and can be budgeted. **Table 5-8** presents the definition of the component condition scores.

Table 5-8 | Component Condition Scores Definitions

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.

Individual CoF ratings for pump station components are based on a consideration of the effects of failure of each component within the context of the local pump station. Individual CoF ratings range from 1 to 5, with a score of 1 representing the lowest consequence and 5 representing the highest. **Table 5-9** presents the definition of the CoF scores.

Table 5-9 | Component Consequence of Failure Definitions

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.

To fully develop an overall pump station score, the individual condition and criticality scores of each pump station's systems and components were considered within the larger context of the Kingston basin. To accomplish this, an overall pump station CoF score (from a system-wide perspective) is applied to an overall condition score for each station. This pump station criticality score is based on County conventions for pump station CoF rankings (Sheridan, Chris M. "FKC205-20 Pump Station Criticality Map 02272019", Message to Erika Schuyler. September 10, 2020. E-mail), in which a station's CoF is defined by the number of pump stations tributary to it. **Table 5-10** presents the overall CoF scores and ranking conventions.

Table 5-10 | Station Type Consequence of Failure Definitions

Station Type (from County)	Station CoF Score	Tributary Pump Stations	Total Station Flows Handled
Satellite	2	0	1
Relay	3	1	2
Regional	4	2-3	3-4
Critical	5	4+	5+

Overall condition scores for each station are weighted by component CoF and are defined as the quotient of the sum of the products of individual component condition and CoF scores and the sum of individual component criticality scores. This scoring is represented symbolically as follows:

$$Overall\ Condition\ Score\ \equiv \frac{\sum_{Components}(Condition\ Score\ \times Criticality\ Score)}{\sum Individual\ Criticality\ Scores}$$

This overall condition score is then scaled by the station CoF score to obtain the Asset Health Score:

$$Asset\ Health\ Score\ \equiv Overall\ Condition\ Score\ \times Station\ Criticality\ Score$$

The results of the analysis described in the preceding paragraphs are summarized in **Table 5-11** and detailed in **Table 5-12**. Note that condition and CoF scores (columns 4 and 5, rows 2 through 10) are for individual components; overall condition and station CoF scores are presented in row 1 of columns 4 and 5, respectively. The Asset Health Score will be used to rank the projects in the CIP.

Table 5-11 | Station Asset Health Summary

Pump Station	Consequence of Failure	Condition	Asset Health Score
41	5	3.2	16
42	2	2.9	5.8
43	2	3.3	6.6
52	2	2.9	5.8
71	5	1.7	8.5
72	2	3.7	7.4
73	2	1.6	3.2

Table 5-12 | Pump Station Condition Assessments

Pump Station	Asset Health Score	Station Component	Condition	CoF	Year Installed/ Upgraded	Notes	Recommendations
41	16.0	Overall	3.2	5.0	1974	➢ Odor complaints have been reported during low tide conditions. ➢ Few reported issues, but the station's age makes it worth monitoring closely. ➢ Power comes from LS-71. The station has lost power on several occasions when power connection has been damaged. ➢ Station is a Smith & Loveless style dry can configuration.	
		Civil	4.0	2.0	1974		
		Structural	3.0	5.0	1974		
		Pumping Systems	2.7	5.0	1974		
		Motors[1]	2.7	3.0	1974		
		Piping Systems	3.0	5.0	1974		
		Valve Systems or Assemblies	2.0	2.0	1974		
		Support Systems	3.5	1.0	1974		
		Instrumentation	3.0	5.0	1974		
		Electrical and Power Distribution	5.0	5.0	1974		
42	5.8	Overall	2.9	2.0	1993	➢ Corrosion observed on discharge piping. ➢ Has an overflow tank. ➢ National Electrical Manufacturers Association (NEMA) 4X junction box proximity to wet well is NFPA 820 4.2.2 and NFPA 70 (NEC) article 500 violation.	➢ Relocate junction boxes outside of the wet well's Class 1 Division 2 hazardous area classification boundary in compliance with current NFPA 70 (NEC) and NFPA 820 standards
		Civil	2.0	2.0	1993		
		Structural	3.0	5.0	1993		
		Pumping Systems	3.0	3.0	1993		
		Motors	3.0	3.0	1993		
		Piping Systems	4.0	5.0	1993		
		Valve Systems or Assemblies	3.0	2.0	1993		
		Support Systems	3.0	1.0	1993		
		Instrumentation	3.0	5.0	1993		
		Electrical and Power Distribution	2.0	5.0	1993		
43	6.6	Overall	3.3	2.0	1994	➢ NEMA 4 rated enclosure starting to rust out along bottom of Starter Panel Enclosure.	➢ Recommend enclosure replacement within 5 years.
		Civil	4.0	2.0	1994		
		Structural	3.0	5.0	1994		
		Pumping Systems	3.3	3.0	1994		
		Motors	3.3	3.0	1994		
		Piping Systems	4.0	5.0	1994		
		Valve Systems or Assemblies	3.0	2.0	1994		
		Support Systems	3.0	1.0	1994		
		Instrumentation	4.0	5.0	1994		
		Electrical and Power Distribution	2.0	5.0	1994		
52	5.8	Overall	2.9	2.0	1998	➢ Breakers have been observed to trip if pumps come back online after losing power while running. ➢ NEMA 4X junction box proximity to wet well is NFPA 820 4.2.2 and NFPA 70 (NEC) article 500 violation.	➢ Relocate junction boxes outside of the wet well's Class 1 Division 2 hazardous area classification boundary in compliance with current NFPA 70 (NEC) and NFPA 820 standards
		Civil	2.0	2.0	1998		
		Structural	3.5	5.0	1998		
		Pumping Systems	3.0	3.0	1998		
		Motors	3.0	3.0	1998		
		Piping Systems	3.0	5.0	1998		
		Valve Systems or Assemblies	3.0	2.0	1998		
		Support Systems	3.0	1.0	1998		
		Instrumentation	3.0	5.0	1998		
		Electrical and Power Distribution	2.0	5.0	1998		

[1] For motors <25 hp, condition scores are considered identical to Pumping Systems condition score.

Pump Station	Asset Health Score	Station Component	Condition	CoF	Year Installed/ Upgraded	Notes	Recommendations
71	8.5	Overall	1.7	5.0	2002	➢ Rags have been observed to collect on floats near influent inlet. ➢ Pumps are prone to frequent ragging. Grease mat has been observed to accumulate quicker since Covid-19 lockdowns have gone into effect. ➢ Force main capacity is limited; second pump running adds approx. 20-40 gpm. ➢ Feeds power to LS-41. ➢ A Bioxide® odor control system is on-site. ➢ A charcoal filter is located on-site and replaced every six months.	
		Civil	1.0	2.0	2002		
		Structural	1.7	5.0	2002		
		Pumping Systems	2.3	3.0	2002		
		Motors	2.0	3.0	2002		
		Piping Systems	1.5	5.0	2002		
		Valve Systems or Assemblies	2.0	2.0	2002		
		Support Systems	2.0	1.0	2002		
		Instrumentation	2.0	5.0	2002		
		Electrical and Power Distribution	1.0	5.0	2002		
72	7.4	Overall	3.7	2.0	2006	➢ Slight corrosion observed on discharge piping. ➢ Wetwell lid is observed to collide with electrical cables upon closing.	➢ Recommendation to install electrical cable J hooks along interior wall of wet well for these cables and reroute electrical cables.
		Civil	3.0	2.0	2006		
		Structural	3.5	5.0	2006		
		Pumping Systems	3.5	3.0	2006		
		Motors	3.5	3.0	2006		
		Piping Systems	4.0	5.0	2006		
		Valve Systems or Assemblies	3.0	2.0	2006		
		Support Systems	3.0	1.0	2006		
		Instrumentation	3.0	5.0	2006		
		Electrical and Power Distribution	5.0	5.0	2006		
73	3.2	Overall	1.6	2.0	2017	➢ No significant issues noted since installation in 2017. ➢ Passive carbon filter is noted to be largely ineffective. ➢ Station does not have a sign or phone number	
		Civil	2.0	2.0	2017		
		Structural	1.0	5.0	2017		
		Pumping Systems	1.0	3.0	2017		
		Motors	1.0	3.0	2017		
		Piping Systems	1.0	5.0	2017		
		Valve Systems or Assemblies	3.0	2.0	2017		
		Support Systems	3.5	1.0	2017		
		Instrumentation	3.0	5.0	2017		
		Electrical and Power Distribution	1.0	5.0	2017		

5.4 Pipeline Conditions Assessments

The County has historically conducted pipeline condition assessments through video observation. This process entails inspecting pipe pipes via closed circuit television (CCTV), storing the video in a database, reviewing the video, and assigning an Overall Condition Index (OCI) score based on the observations. The results of these assessments have been stored in their asset management database software, Cartegraph, since 2017. They are on a five year inspection cycle with about 20 percent of the pipes inspected each year. At the time of this writing, all of the pipes have been inspected and an evaluation has been stored in Cartegraph.

The County uses consistent scoring criterion when reviewing pipeline inspection videos with several criteria, which is summarized in **Table 5-13**. Each criterion has a defined score corresponding to the severity of the observed issue, if any. Lower scores indicate more severe issues based on this scoring methodology. Note that "Roots" and "I&I" have a weighting of zero which excludes these criteria from the OCI. The County captures information so that it can be filtered and viewed in Cartegraph but other categories describe the actual pipe conditions. For example, a pipe with roots present would also be scored under the obstruction or intrusion category. The OCI is calculated by this equation:

$$OCI = \frac{\sum_{pipe}(Category\ Value\ x\ Calculation\ Weight)}{\sum_{pipe} Calculation\ Weight}$$

Table 5-13 | OCI Criteria and Weighting

Category	Value	Description	Calculation Weight
Roots	0	Blockage	0
	30	Heavy	
	50	Medium	
	80	Light	
	100	None	
I & I	40	Gushing or Spurting	0
	60	Running or Trickling	
	80	Weeping or Dripping	
	90	Stain, Possible I&I	
	100	None	
Obstruction or Intrusion	0	Severe or Impassable	1
	60	Moderate	
	80	Minor	
	100	None	
Worn Surface	40	Severe	1
	60	Moderate	
	80	Minor	
	100	None	
Belly or Sag	40	Severe (>30%)	1
	60	Moderate (10 to 30%)	
	80	Minor (<10%)	
	100	None	

Category	Value	Description	Calculation Weight
Cracks or Fractures	40	Severe Cracking	3
	60	Moderate Cracking	
	80	Minor Cracking	
	100	None	
Break or Failure	0	Collapse	5
	15	Hole Void Visible	
	30	Hole Soil Visible	
	100	None	
Lining or Repair Failure	40	Severe	1
	60	Moderate	
	80	Minor	
	100	None	
Joint Separation or Offset	40	Severe (> 1.5 Pipe Thickness)	2
	60	Moderate (1 to 1.5 Pipe Thickness)	
	80	Minor (< Pipe Wall Thickness)	
	100	None	

The County provided OCI scores for 6,609 feet of pipe in the Kingston basin where issues were found within the 60 percent in Cartegraph. This data is included as **Appendix D**. Because only pipes with noted deficiencies were input into Cartegraph, it is assumed that inspected but unscored pipes have an OCI of 100. Discussions with County staff indicate that the pipes inspected and documented in Cartegraph are representative of the system as a whole. For planning purposes, the lengths of pipe in each OCI range have been extrapolated and are summarized in **Table 5-14**. The rankings of all County-owned pipelines in the Kingston basin are not below a threshold of an OCI score of 60, so there will be no prioritizations nor projected annual costs for pipeline replacement in the CIP for this basin.

Table 5-14 | Percentage of Pipes in OCI Condition Ranges

OCI Range	Length (ft)	Percentage of Total
0-20	-	0%
20-40	-	0%
40-60	-	0%
60-80	-	0%
80-99	3,600	6%
100	53,800	94%

SECTION 6

Wastewater Treatment Facilities Existing Conditions

6.1 Introduction

A description of the existing Kingston WWTP field evaluation and condition assessment, the capacity analysis of the plant facilities and processes, and an evaluation of each process to identify any deficiencies is presented in Section 6. Recommendations are provided to address challenges impacting facility operations along with maintenance upgrades necessary to continue meeting NPDES Permit requirements.

6.2 Existing Wastewater Treatment Plant Description

The Kingston WWTP was constructed in 2005, replacing a WWTP originally constructed in 1974 that was approximately 3 miles from the current plant site. In 2006, the outfall to Appletree Cove was replaced and realigned. The Kingston WWTP is permitted to treat 0.292 MGD Maximum Month Design Flow (MMDF). The plant is an oxidation ditch (extended aeration) type activated sludge facility. Plant processes are preliminary screening and grit removal, influent flow measurement with a Parshall Flume, biological treatment in two oxidation ditches, two secondary clarifiers, ultraviolet (UV) disinfection, and effluent measurement with a Parshall Flume. Sludge removed from the secondary clarifiers is thickened with a GBT and sent to the County's Central Kitsap WWTP for further treatment and disposal. Treated effluent is discharged to the Appletree Cove of the Puget Sound through an 18-inch diameter outfall extending 5,350 feet into Appletree Cove to a depth of 169 feet below mean lower low water (MLLW) in accordance with the NPDES Permit. The Kingston WWTP site plan is shown in Figure 6-1. Figure 6-2 shows the process schematic of the current Kingston WWTP.

The Kingston WWTP is a high performing treatment plant and has received Ecology's Outstanding Performance Award every year since it was commissioned except one.

Figure 6-1 | Existing Kingston WWTP Site Plan

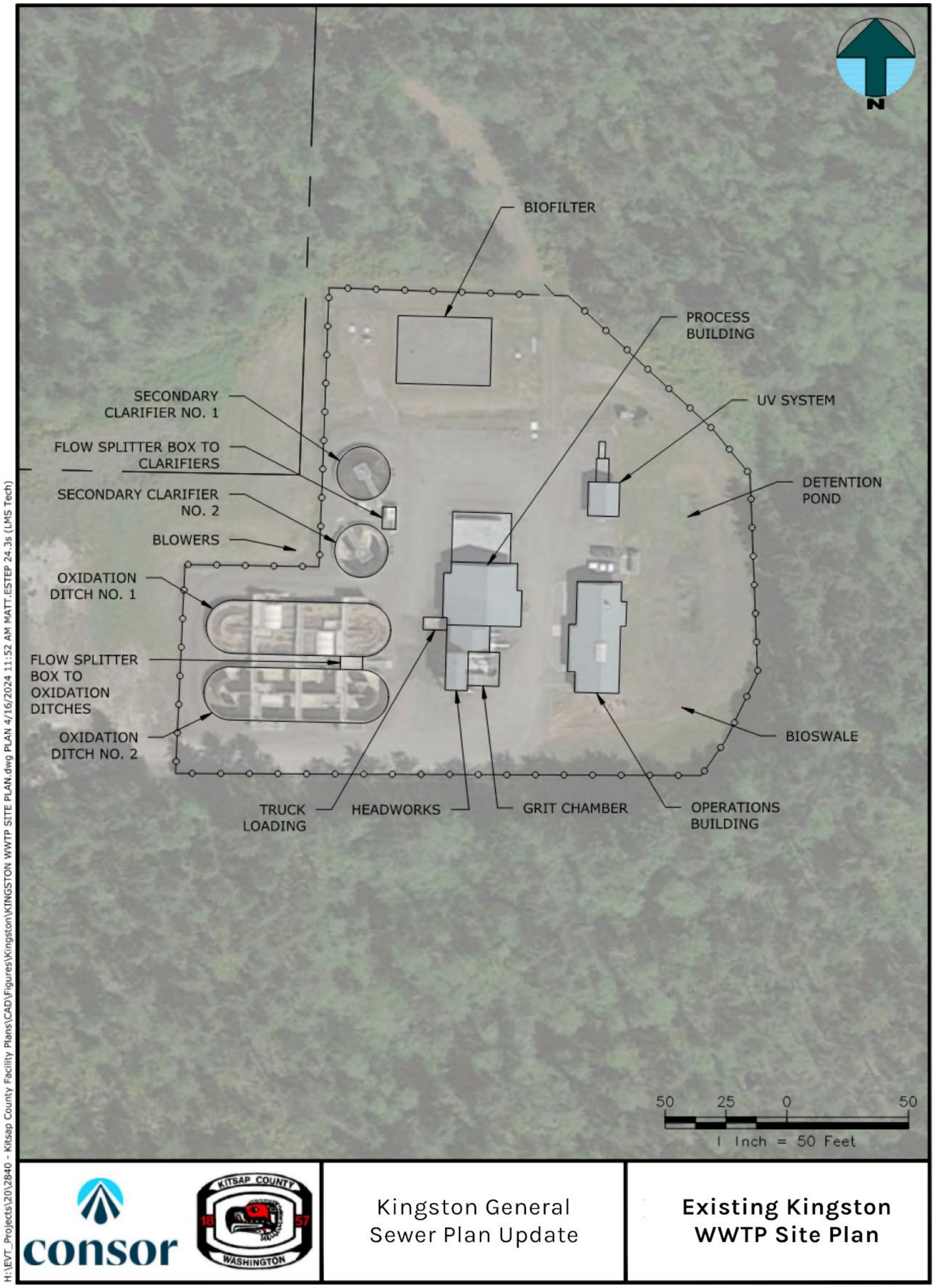
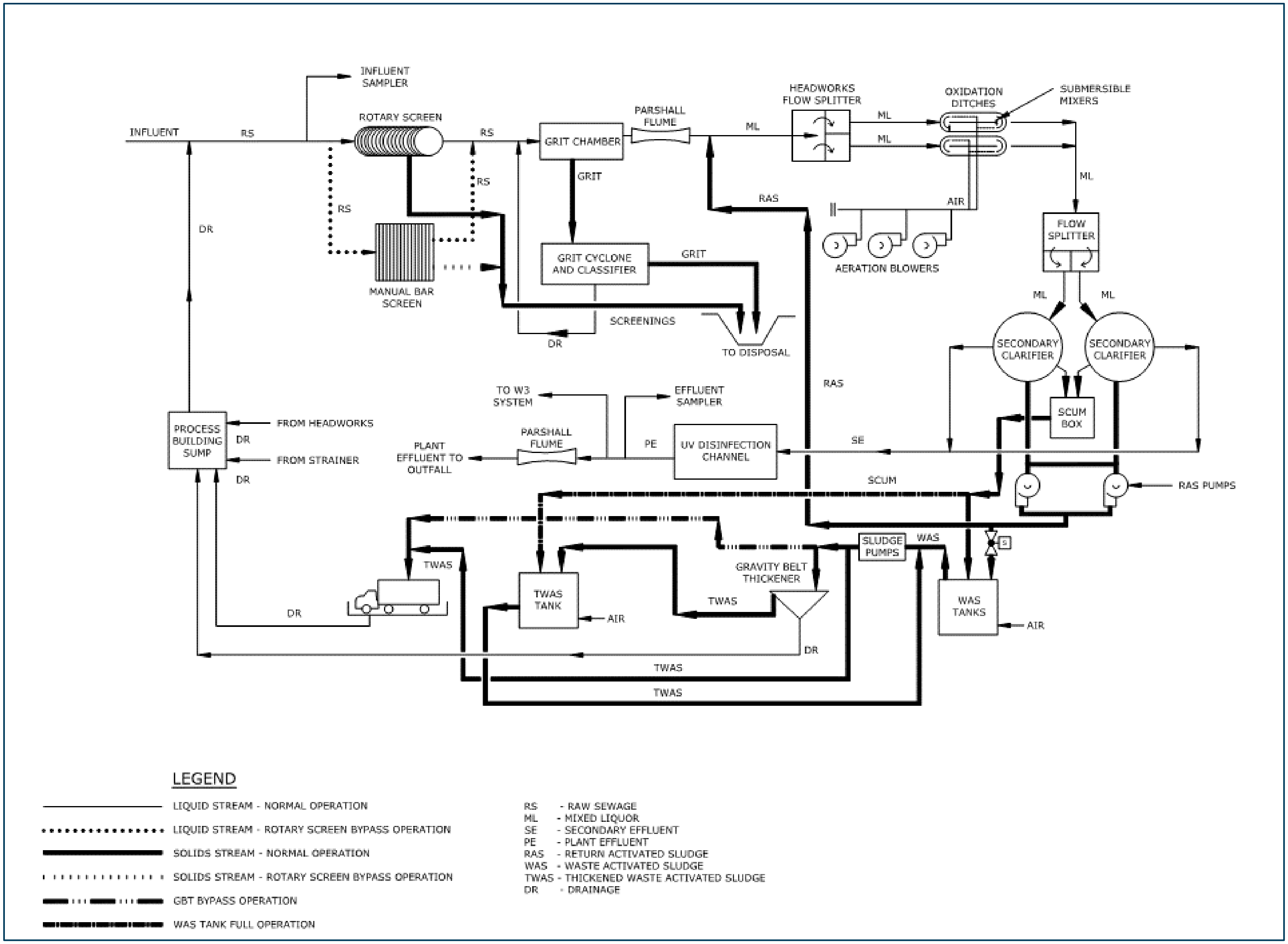


Figure 6-2 | Existing Kingston WWTP Schematic



6.3 Wastewater Treatment Plant Condition Assessment

The Murraysmith [now Consor] team visited the Kingston WWTP in September 2020 to observe and document existing plant conditions and to have discussions with plant staff regarding operational and plant performance challenges. The group investigated facilities and unit processes for the liquid streams and solids streams by walking through each process to ascertain equipment condition and manufacturing information. WWTP electrical equipment and structures were also observed. Plant staff provided information on the daily operations of the plant and past and current operational challenges. The information gathered from the assessment was used to develop a list of recommendations for maintaining plant operations and performance. The major equipment information, photos and field notes are summarized in **Appendix E**.

6.3.1 Condition Summary Tables

To better organize the results of the assessments at the Kingston WWTP, major processes were grouped as presented in **Table 6-1**.

Table 6-1 | WWTP Process Group Definitions

Process	Components
Civil	Site, site security, roadways, sidewalks, fencing
Preliminary Treatment	Screens and grit removal and associated equipment and piping
Secondary Treatment	Oxidation ditches, secondary clarifiers and associated equipment and piping
Disinfection and Effluent	UV system, effluent Parshall flume and associated piping
Solids Treatment	GBT, Waste Activated Sludge (WAS) storage tanks, Thickened Waste Activated Sludge (TWAS) storage tanks and associated equipment and piping
Support Systems	Odor control, sodium hypochlorite system, plant water system and process building sump and pumps
Power Distribution	Electrical services, transfer switches, standby generator, motor control centers and control panels

These processes were further broken down into several categories when appropriate. While no two processes are identical, the processes are anatomically similar and can be characterized by a standardized set of component groupings. These component groupings are consistent with County Asset Functional Class Levels and are presented in **Table 6-2** along with definitions. Note that the Asset Functional Class Level has nine groups: Civil, Structural, Piping Systems, Pump Systems, Valve System or Assemblies, Equipment, Support Systems, Instrumentation, Power Distribution. However, for the WWTP conditions assessments, the components are shortened to four groups, which are more directly applicable to the wastewater treatment processes. Civil, Power Distribution and Support Systems are treated as processes; Piping and Valves are grouped together; Pumps are grouped with Equipment.

Table 6-2 | Component Group Definitions

Component Grouping	Definitions
Equipment	Mechanical equipment such as screens, pumps, and blowers. Equipment and motors are treated as one piece of equipment.
Instrumentation	Electrical and measuring devices such as flowmeters, transmitters, and indicators.
Structural	Concrete structures such as buildings, basins, and tanks.
Piping	A system of pipes and valves used to convey fluids such as influent, effluent, air and sludge pipes and valves.

6.3.2 Treatment Plant Process Asset Health Score

To better inform the County's prioritization of future asset upgrades and replacements, an overall treatment plant process "Asset Health" score was developed that synthesizes each process's existing likelihood of failure (condition) and CoF.

Individual condition scores for equipment, instrumentation and piping systems consider each system's physical integrity and their current ability to perform as designed. For structural components, individual condition ratings generally apply to the physical integrity of these assets in the face of material degradation due to environmental forces such as corrosion, weathering, settling, and flooding. General observations and historical accounts from County O&M staff were also used to inform the condition ratings for all treatment plant process components to incorporate phenomena not observed by Murraysmith [now Consor] staff during the site visits. Examples of this historical information from O&M staff include, but are not limited to, challenges associated with equipment operation, lack of redundancy and lack of automation. Individual condition ratings range from 1 to 5, with a score of 1 representing the best condition and a score of 5 representing the worst. **Table 6-3** presents the definition of the condition scores. It is important to note that condition scores are not simply reflections of age as dissimilar environmental and operational factors among the Kingston WWTP necessitate differing rates of condition degradation. Although age/obsolescence is not accounted for in the condition assessment, it will be a consideration for development of the 20-year CIP so that replacement of aging infrastructure is accounted for and can be budgeted.

Table 6-3 | Component Condition Scores Definitions

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.

Individual CoF ratings for process components are based on consideration of the effects of failure of each component within the context of the local process. Individual CoF ratings range from 1 to 5, with a score of 1 representing the lowest consequence and 5 representing the highest. **Table 6-4** presents the definition of the CoF scores.

Table 6-4 | Component Consequence of Failure Definitions

Consequence of Failure Rating	Definition
1	Not Managed. Failure would not affect the treatment plant operation.
2	Not Critical. Could marginally reduce the treatment performance
3	Important (Critical but redundant). The treatment plant performance is significantly impacted without a currently-installed redundant component.

Consequence of Failure Rating	Definition
4	Critical. The treatment plant performance is significantly impacted upon failure.
5	Highly Critical. Failure will cause an immediate loss of hydraulic throughput.

To fully develop an overall treatment plant process score, the individual condition and CoF scores of each process were considered within the larger context of the Kingston WWTP. To accomplish this, an overall treatment plant process CoF score (from a plant-wide perspective) is applied to an overall condition score for each process. The definition of the overall process CoF scores are the same as the definition of the component CoF scores.

Overall condition scores for each process are weighted by component CoF and are defined as the quotient of the sum of the products of individual component condition and CoF scores and the sum of individual component CoF scores. This scoring is represented symbolically as follows:

$$Overall\ Condition\ Score\ \equiv \frac{\sum_{Components}(Condition\ Score\ \times CoF\ Score)}{\sum Individual\ CoF\ \ Scores}$$

This overall condition score is then scaled by the process CoF score to obtain the overall treatment plant process score:

$$Asset\ Health\ Score\ \equiv Overall\ Condition\ Score\ \times Unit\ Process\ CoF\ Score$$

The results of the analysis described in the preceding paragraphs are summarized in **Table 6-5** and detailed in **Table 6-6**. The Asset Health Score will be used to rank the projects in the CIP.

Table 6-5 | Treatment Plant Process Asset Health Summary

Unit Process	Unit Process CoF Score	Overall Condition Score	Asset Health Score
Civil	1	2.0	2.0
Preliminary Treatment	3	1.8	5.4
Secondary Treatment	5	1.3	6.5
Disinfection and Effluent	3	2.4	7.2
Solids Treatment	3	2.0	6.0
Support Systems	3	2.2	6.6
Power Distribution	5	2.0	10.0

The current treatment plant components are described in more detail in the following sections. Following the description of each major process component is an outline of the observations made by the Murraysmith [now Consor] team and a list of recommended improvements. The major unit process condition, capacity, and recommendations are summarized in **Table 6-19**.

Table 6-6 | Treatment Plant Unit Process Condition Assessments

Unit Process [1]	Asset Health Score	Process Component	Condition	CoF	Year Installed/Upgraded	Notes	Recommendations
Civil	2.0	Overall	2.0	1.0		➢ The fence is in good condition. ➢ The site has minimal landscaping, providing clear visibility of the site from the road.	➢ Consider adding an automatically opening gate, intrusion alarms, and video surveillance.
Preliminary Treatment	5.4	Overall	1.8	3.0		➢ The grit cyclone and classifier have moderate corrosion.	➢ General maintenance practice on grit classifier to mitigate corrosion.
		Equipment	1.8	2.0	2019, 2005		
		Instrumentation	1.3	2.7	2019		
		Structural	2.0	3.0	2005		
		Piping	2.0	4.0	2005		
Secondary Treatment	6.5	Overall	1.3	5.0		➢ The scraper drives have significant body corrosion. The scum boxes are showing moderate surface corrosion. Both of the clarifier effluent box valve stems are showing significant corrosion.	➢ Replace secondary clarifier weir caulking during clarifier downtime; clean and coat the corroded areas on the clarifier drives, scum boxes and effluent box valve stem assemblies to prevent further degradation. ➢ General maintenance practice to mitigate corrosion.
		Equipment	1.4	3.0	2020, 2005		
		Instrumentation	1.0	3.7	2020		
		Structural	1.0	3.7	2005		
		Piping	1.7	3.7	2020, 2005		
Disinfection and Effluent	7.2	Overall	2.4	3.0		➢ Plant staff are cleaning the lamps manually. ➢ The basic controller of the UV system cannot turn on or off the bank based on the flow signal.	➢ Replace entire UV system for improved control in the next 5 to 10 years.
		Equipment	3.7	3.3	2005		
		Instrumentation	2.0	3.0	2005		
		Structural	2.0	2.0	2005		
		Piping	2.0	5.0	2005		
Solids Treatment	6.0	Overall	2.0	3.0		➢ The GBT appears to be in very good condition with some minor areas of paint missing on the frame, but no rust. ➢ The GBT room had a very strong odor, indicating that the HVAC system may be underperforming.	➢ Evaluate ventilation in GBT room to minimize corrosion. ➢ General maintenance practice to mitigate corrosion. ➢ Install or repair Lower Explosive Limit (LEL) combustible gas detection system at TWAS tank. ➢ Install fire alarm system in GBT room.
		Equipment	2.0	2.9	2005		
		Instrumentation	2.3	2.3	2005		
		Structural	2.0	3.5	2005		
		Piping	2.0	5.0	2005		
Support Systems	6.6	Overall	2.2	3.0		➢ During the site visit in September 2020 the biofilter was turned off due to the media collapse. It was later dug up and recovered by the plant staff. ➢ Plant staff noted that when in use, the hypochlorite tank could not be fully drained. ➢ Pump 902 (P-902) of the W3 system has some leakage which is causing corrosion to the pump and frame. This could be a failed casing gasket.	➢ Clean the exterior of air gap tank and monitor for future overflow. ➢ Repair or replace casing gasket on pump P-902.
		Equipment	2.1	1.9	2005		
		Instrumentation	N/A	1.0			
		Structural	3.7	1.8	2005		
		Piping	2.0	2.3	2005		
Power Distribution	10.0	Overall	2.0	5.0		➢ The Adjustable Frequency Drives (AFDs) installed in MCC-01 are in good condition, however they are obsolete and no longer supported by the manufacturer. ➢ The PLC system and OIT equipment are not readily available, as each brand of PLC and OIT requires special programming. ➢ The operator interface terminal (OIT) in CP-300 plant remote I/O panel is obsolete, and the model is no longer supported. ➢ Panels LP-GBT and LP-TLP interiors were not accessed and the installation of a controller (e.g. PLC) was not verified. It is likely one or both panels contain PLCs. ➢ The local control panel for the scum pump appears to have been partially filled with water or somehow compromised. Terminals indicate rust or corrosion, and the bottom interior of the enclosure is covered with residue.	➢ Complete arc flash study. ➢ Establish replacement plan for obsolete AFDs. ➢ Verify back-up copies of all PLC and OIT programs; create and store if not created. ➢ Spare parts for the PLC should be stored by the County in case of a failure. ➢ Develop and execute a migration/replacement plan if OIT in CP-300 is used as a main point of control. ➢ Verify whether there is a PLC in the LP-GBT or LP-TLP panel. ➢ Clean and inspect the local control panel for the scum pump.
		Equipment	2.1	3.4	2020, 2005, 2004		
		Instrumentation	N/A	N/A			
		Structural	N/A	N/A			
		Piping	N/A	N/A			

Notes:
See Table 6-1 for major equipment included in each unit process

6.3.3 Evaluation of Components

The current treatment plant components are described in more detail in the following sections. Following the description of each major process component is an outline of the observations made by the Murraysmith [now Consor] team and a list of recommended improvements. The major unit process condition, capacity, and recommendations are summarized in **Table 6-19**.

6.3.3.1 Civil

The Kingston WWTP is secured by a uniform chain link fence with barbed wire. Site access is through a manual gate. There is no video surveillance onsite.

Observation: The fence is in good condition, and the site has minimal landscaping, providing clear visibility of the site from the road.

Recommendation: The County may want to consider adding an automatically opening gate, intrusion alarms, and video surveillance.

6.3.3.2 Preliminary Treatment

Raw sewage is pumped into the Headworks Facility (Headworks) from PS-71 located approximately 1.2 miles northeast of the WWTP at 26198 Dulay Road NE. The pump station provides the wastewater with enough head to flow by gravity through all the treatment processes in the WWTP. Plant drainage from the Process Building sump combines with the raw sewage forcemain prior to entering Headworks.

Headworks is a two-story above grade concrete structure that was constructed in 2005. Headworks consists of a rotary screen, manual bar screen, Parshall flume, grit removal, and influent composite sampling. The rotary screen was recently replaced with a new unit as part of the 2019 Aeration System and Oxidation Ditch Improvements project. The new rotary screen has auxiliary pressate and booster pumps for enhanced screen washing.

Raw sewage enters Headworks into a channel where an automatic sampler takes composite influent samples. This influent channel splits to two channels; one with a rotary screen and one with a manual bar screen. Raw sewage normally flows through the channel with a ¼-inch opening rotary screen. A separate channel with a 1-inch opening manual bar screen bypasses the rotary screen. Both screen channels can be isolated with manual gates for inspection and maintenance. After screening, raw sewage enters a vortex-type grit chamber. The grit removal system can be isolated with manual gates, and the plant can continue operating with flow bypassing the grit removal and directly going to the oxidation ditches. Degritted wastewater passes through a 12-inch Parshall flume with an ultrasonic level meter to monitor influent flow rate.

Influent screenings removed within the rotary screen are washed, compacted, and then discharged into a dumpster for offsite disposal. Grit collected at the bottom of the grit chamber is pumped to a grit cyclone and 12-inch inclined screw grit classifier where the grit is washed and then discharged into the same dumpster as the influent screenings. The influent screenings and grit are disposed as solid waste.

Observations and recommendations for each major headworks process component are outlined below.

6.3.3.2.1 Influent Rotary Fine Screen

Observation: The ¼-inch opening rotary screen was installed in 2019. The rotary screen is in very good condition with no visible exterior corrosion, performance issues, or maintenance concerns reported by plant staff. The screening chute and dumpster are both in good condition with no visible corrosion or leaks. Plant staff reported no issues with the rotary screen. Ancillary pressate and booster pumps for enhanced screen cleaning were also installed in 2019 and appear to be in very good condition, with no issues reported by plant staff. The influent rotary fine screen is expected to meet the typical lifespan of 25 to 30 years and have more than 27 years of life remaining.

Recommendation: None.

6.3.3.2.2 Influent Manual Screen

Observation: The 1-inch opening manual bar screen was not observed in the channel. The plant staff reported no issues with the manual screen.

Recommendation: None.

6.3.3.2.3 Grit Removal

Observation: The grit chamber was installed in 2005. The exterior concrete structure and cover plates appear to be in very good condition with no visible exterior corrosion. The grit trap equipment is in good condition with minimal surface corrosion.

The grit cyclone and classifier were installed in 2005 and are located on the upper level of Headworks. This equipment is in fair condition with the body flanges showing moderate corrosion. The feed box has been replaced with a custom fabrication indicating that corrosion has been an ongoing issue for the classifier. This corrosion will not cause grit to leak from the equipment but allows some gas to escape the equipment and will eventually cause the equipment to leak and malfunction.

The grit pump was installed in 2005. The grit pump and piping appear to be in good condition with no visible exterior corrosion.

Plant staff reported that the grit removal system is operating well, with no outstanding performance or maintenance issues. The grit equipment is 16 years old with no noted performance issues or significant visible degradation; therefore, it is expected to exceed its typically expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years) but may require rehabilitation to maintain performance prior to replacement.

Recommendation: The corrosive area on the grit classifier should be repainted to mitigate further corrosion and odor.

6.3.3.3 Primary Treatment

There is no primary treatment at the Kingston WWTP. Effluent from Headworks flows directly to the oxidation ditches.

6.3.3.4 Secondary Treatment

Headworks effluent is split to two oxidation ditches. Return activated sludge (RAS) combines with the flow prior to the flow splitter into the oxidation ditches, which were originally constructed in 2005. Upgrades to equipment and instrumentation in both oxidation ditches were completed in 2020 and 2021. The brush aeration system originally installed in the oxidation ditch in 2005 was replaced with submersible mixers and an aeration system with blowers and fine bubble air diffusers. DO and oxidation reduction potential (ORP) probes are in the recycle turn zone downstream of the effluent weirs and upstream of the aerators.

Air is supplied to the oxidation ditches by three new variable-speed, 15-Horsepower (HP) positive displacement blowers (two duty, one standby) installed in 2020. The blowers were installed north of the oxidation ditches and west of Secondary Clarifier No. 2, in sound-attenuating enclosures. The blowers were commissioned to be controlled by ORP, however, after some difficulties with the plant operation, operators switched back to time-based aeration and plan to troubleshoot ORP-based operation when peak winter flows have receded.

From the oxidation ditches, flow is conveyed to a flow splitter located east of the secondary clarifiers. The flow splitter divides the flow to the two 35-foot diameter secondary clarifiers. The flow splitter and secondary clarifiers were constructed in 2005. Each of the secondary clarifiers has a side wall depth of 13 feet and a total surface area of 1,924 square feet. The clarifiers each have a central drive unit, center column and feed well, spiral rake arm, scum scraper, scum box, scum pit, effluent weirs, and inboard launder. Process water is sprayed onto the surface of the secondary clarifiers along the walkway to reduce foaming. Mixed liquor separates in the clarifier, and the active biomass settles to the bottom of the clarifier while treated secondary effluent flows over the v-notch effluent weir.

The biomass is concentrated and withdrawn from the bottom of the clarifiers as RAS or WAS. The sludge from the clarifiers is pumped by the two RAS pumps located in the Process Building. Both RAS pumps can pump from either clarifier. Flow from each RAS pump is metered and returned to the mixed liquor influent into the oxidation ditches. According to the plant Operations Manual, the variable speed RAS pumps normally operate automatically on a lead/lag basis and can be controlled in one of three modes: Ratio, RAS flow, or Manual. In Ratio mode, the speed of RAS pumps is automatically regulated to maintain a fixed RAS return ratio, i.e., the ratio between the recycle flow rate as measured by the RAS flow meters less the WAS flow meter value and effluent flow rate as measured by the effluent Parshall flume. In RAS flow mode, the speed of a given RAS pump is automatically regulated to maintain a constant flow rate as measured by the respective flow meter. In Manual mode, the speed of a given RAS pump is automatically regulated to maintain a constant speed.

WAS is periodically diverted from the discharge of the RAS pumps to the selected WAS tank via a motorized flow control valve downstream of the WAS flowmeter. Although the flow control valve could be manually opened or closed locally, it is normally automatically controlled by the SCADA in Time or Volume modes. In Time mode, the WAS valve opens when the operator opens it via the remote control and remains open for the duration of the time setpoint before automatically closes. In Volume mode, the WAS valve opens when the operator opens it via the remote control and remains open until the wasted sludge volume, as measured by the WAS flow meter, equals the volume setpoint. Based on the plant operation data in the last two years, the Volume mode has been used at the plant to waste approximately 3,000 to 7,000 gallons per day of sludge on each of five weekdays. The volume wasted is calculated based on mean cell residence time and TSS concentration.

The secondary clarifiers are equipped with a scum scraping mechanism that removes scum from the surface of the clarifiers. The scum is pushed into a scum trough that drains into a common scum pump station adjacent to the clarifiers. From the scum wetwell, a submersible scum pump normally pumps scum into the TWAS tank and can also pump scum into the WAS tanks if the TWAS tank is full or out of service. The scum pump must be turned on manually and will turn off based on a low-level switch in the scum wetwell.

Observations and recommendations for each major process component are outlined below.

6.3.3.4.1 Oxidation Ditches

Observation: The oxidation ditches concrete structures, walkways, and associated equipment and instrumentation all appear to be in very good condition. The oxidation ditches currently have sufficient capacity to be operated one at a time, and operation is alternated once per year. Two submersible mixers are moved between the oxidation ditches when they are rotated. Each oxidation ditch is equipped with two aeration diffuser grids with air supplied by the new blowers. During the site visit in September 2020, Oxidation Ditch No. 2 was operating with the new aeration blowers, diffusers and mixers, and Oxidation Ditch No. 1 still has old equipment and was drained. The upgrade to Oxidation Ditch No. 1 was substantially completed by the end of 2020. Staff reported no performance or maintenance issues with the new oxidation ditch equipment or other secondary process structures or equipment.

Recommendation: None.

6.3.3.4.2 DO/ORP probes

Observation: New DO and ORP probes were installed at Oxidation Ditch No. 2 during the Aeration System and Oxidation Ditch Improvements project. Similar to the submersible mixers, the DO and ORP probes will be shared between two oxidation ditches and installed in the operational ditch. The probes were not visible.

Recommendation: None.

6.3.3.4.3 Aeration Blowers

Observation: Three Aerzen blowers were installed in 2020 and appear to be in very good condition. The blowers have variable frequency drives. Three blowers share a common stainless-steel discharge air header which later splits into two piping to the two oxidation ditches. Air flow is measured by the thermal mass flow meter at each oxidation ditch. The blowers are currently operated on a time basis, typically 4 hours on and 2 hours off. DO is continuously monitored.

Staff reported that the blowers function well and the oxidation ditches are effective at nitrogen removal.

Recommendation: None.

6.3.3.4.4 Flow Splitter

Observation: The flow splitter box was constructed in 2005. It could not be drained for observation but appears to be in good condition. Plant staff reported that the flow splitter has no operational or maintenance issues and provides an even split between secondary clarifiers.

Recommendation: None.

6.3.3.4.5 Secondary Clarifiers

Observation: The secondary clarifiers were constructed in 2005. The concrete structures and walkways are in very good condition. Secondary Clarifier No. 1. was operating the day of the site visit, and Clarifier No. 2 was empty. The clarifier center column, scraper, and weir components appeared to be in good condition. The weir caulking is showing minor wear. The scraper drives are in fair condition, with significant body corrosion. The scum boxes are showing moderate surface corrosion. Both of the clarifier effluent box valve stems show significant corrosion.

The clarifier drive equipment is 16 years old and is expected to meet its typically expected lifespan of 25 to 30 years. It is expected that the equipment may have half of its expected serviceable life remaining (12 to 15 years) but will likely require rehabilitation to maintain performance prior to replacement.

Recommendations: Replace secondary clarifier weir caulking during clarifier downtime. Clean and coat the corroded areas on the clarifier drives, scum boxes and effluent box valve stem assemblies to prevent further degradation. Plan for increased maintenance requirements for the next 12 to 15 years, and then replace the equipment.

6.3.3.4.6 RAS/WAS Pumping

Observation: The RAS pumps located in the Process Building were installed in 2005 and appear to be in good condition. The exposed piping, valves and two RAS magnetic flow meters (magmeter) appear to be in very good condition. The WAS magmeter and flow control valve appear to be in very good condition.

Plant staff reported no performance or maintenance issues with operating the RAS/WAS pumping system. The RAS pumps are 16 years old with no noted performance issues or significant visible degradation; therefore, they are expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: None.

6.3.3.4.7 Scum Pump and Wetwell

Observation: The scum wetwell, pump, and piping were constructed in 2005. The wetwell concrete and hatch are in good condition. The submersible pump rail system, scum piping, and float were observed to be in good condition. Plant staff reported no performance or maintenance issues with the scum pumping system. The scum pump is 16 years old with no noted performance issues or significant visible degradation; therefore, it is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: None.

6.3.3.5 Disinfection and Effluent

Secondary effluent is discharged to the UV disinfection channel located east of the secondary clarifiers. Flow enters the UV disinfection channel with two banks of UV lamps that alternate in lead/lag operation. The UV system is a Trojan UV3000B system configured in two banks equipped with 56 low pressure bulbs each. One of the two banks is usually energized to handle the normal flows. The second bank is brought online to deliver required UV dose during high flows. The system records the lamp life and can automatically alternate the banks for equal wear and time off to minimize bank cycling. The UV channel is built to provide extra width for additional lamp modules in the future if the capacity needs to be increased. The UV channel level is controlled by fixed level control finger weirs. There are high-level and low-level switches downstream of UV bank and upstream of the level control weirs. If the UV channel level drops below the set point, the UV system will generate a low level alarm to alter the operator to manually shut down the system to prevent the lamp overheating.

Following UV disinfection, effluent flow is measured with a 6-inch Parshall flume equipped with an open channel ultrasonic level sensor. Between the UV channel and the flume, there is a withdrawal point for plant water system. An automatic composite flow sampler collects samples upstream of the Parshall flume. Following metering, the effluent flows by gravity to the outfall.

Observations and recommendations for each major process component are outlined below.

6.3.3.5.1 UV Disinfection System

Observation: The concrete channel, grating, Parshall Flume and UV equipment were installed in 2005. The channels, grating and flume are in good condition. Plant staff clean the lamps manually. The Trojan UV-3000B system was installed in 2005 and has the basic controller which can only automatically alternate the lead and lag UV banks, monitor the bank run time, bank On/Off status, a common alarm and UV intensity. The basic controller can turn on but cannot turn off the tank based on the flow signal from the Parshall flume.

Recommendation: The Trojan UV-3000B system is an old model using the manufacturer's low-pressure high output open channel technology. Although there were no performance or maintenance issues observed, additional control and monitoring capabilities beyond what the current basic controller can offer, e.g., tracking the individual lamp status and the UV transmittance, are desired by the plant staff. The basic controller can be replaced with the touch smart controller and a new UV transmittance probe can be installed to meet most of the monitoring requirement, except the individual lamp failure status. If the individual lamp failure status needs to be monitored, the entire Trojan 3000B UV system needs to be upgraded. The Trojan UV-3000B system life is typically 20 to 25 years, therefore the UV system at Kingston WWTP is in poor condition and has about 2-10 years of remaining life. It is recommended to upgrade the entire UV system to provide those monitoring capabilities.

6.3.3.5.2 Parshall Flume and Effluent Sampling

Observation: The Parshall Flume was constructed in 2005 and is in good condition. The automatic sampler was installed in 2005 and is in fair condition. Plant staff reported no issues with effluent metering and sampling.

Recommendation: None.

6.3.3.5.3 Outfall

The plant effluent is discharged through an outfall in Appletree Cove in the Puget Sound by gravity through an 18-inch diameter pipe with seven 3-inch diameter diffuser ports 50 feet apart at the downstream end of the outfall pipe. The outfall was replaced and realigned in 2006 and inspected in 2019. The last diffuser port was not found during the inspection and the inspectors were able to confirm flow through only one of the diffuser ports.

Observations and recommendations for the outfall are outlined below.

Observation: The outfall components were not observed.

Recommendation: None.

6.3.3.6 Solids Treatment

Sludge is thickened and stored at the Kingston WWTP and then transported to the Central Kitsap WWTP for further treatment and ultimate disposal under the County's Class B biosolids program. The Process Building and solids handling processes were constructed in 2005. Sludge collected from the secondary clarifiers is pumped by two RAS pumps in the Process Building. RAS and WAS are metered and WAS flow is diverted from the RAS loop via a flow control valve and flow meter.

WAS is pumped to the Process Building, where it is stored in two below-grade 25,000-gallon aerated WAS tanks. The WAS tanks also accept scum from the secondary clarifiers. The WAS tanks are equipped with coarse bubble diffusers to mix and aerate the sludge and prevent septic conditions. Plant staff estimate the WAS quantity to be wasted on the daily basis to maintain a desired aeration basin sludge retention time and utilize the WAS control valve and flow meter to waste the target WAS volume. Sludge is currently wasted at the rate of approximately 3,000 to 7,000 gallons each weekday, so each WAS tank provides 3.3 to 8.0 days of storage. WAS tanks are filled and emptied simultaneously.

From the WAS tanks, sludge is pumped by one of the two sludge pumps to the GBT. WAS can bypass the GBT system and be pumped directly from the WAS tanks to tanker trucks if necessary. GBT is only run about one day a week when the plant does not collect composite samples. GBT drainage flows to the Process Building sump for discharge to Headworks. The GBT was installed in 2005. It has a 200 gpm capacity and is run to thicken sludge to 5.0 to 5.5 percent solids concentration. Operators have found that sludge thicker than 5.5 percent is difficult to get out of the tanker trucks. The GBT has one polymer mixing and dilution system to enhance sludge thickening in the GBT. The polymer dilution system dilutes neat polymer from delivered drums and injects the dilute polymer into the influent sludge stream entering the GBT.

TWAS is stored in a below-grade 16,000-gallon aerated TWAS tank in the Process Building, then pumped to the solids loading station on the south side of the Process Building. TWAS from the Kingston WWTP is transported by tanker trucks to the Central Kitsap WWTP for further processing. The tank is equipped with coarse bubble diffusers to mix and aerate the sludge and prevent septic conditions.

Two 15-HP variable speed, progressive cavity sludge pumps in the Process Building are used to feed WAS from the WAS tanks to the GBT, and TWAS from the TWAS tanks to the solids loading station. Piping is also configured so the pumps can pump TWAS back through the GBT or WAS directly to the tanker truck loading station. Three 15-HP positive displacement blowers provide continuous aeration to the WAS and TWAS tanks. The blowers were installed in 2005. Headspace air from the GBT room and the WAS and TWAS tanks is sent to the biofilter odor control system.

Observations and recommendations for each major process component are outlined below.

6.3.3.6.1 WAS Storage Tanks

Observation: The WAS storage tanks were constructed in 2005. The WAS tank interiors could not be observed, but a portion of the tank exterior surfaces is visible outside the Process Building. Both tanks appear to be in good condition. Tank Level Indicating Transmitters and gas monitors also appeared to be in good condition.

Plant staff did not report operational or performance issues with the WAS storage tanks. When staff observe reduced mixing in a WAS tank, the tank is emptied and sprayed down with a firehose, and the diffusers are replaced with a backup set of cleaned diffusers. A set of standby diffusers is kept onsite to accommodate this process as it happens several times per year.

Recommendation: None.

6.3.3.6.2 Gravity Belt Thickener

Observation: The GBT was installed in 2005 and appears to be in very good condition with some minor areas of paint missing on the frame, but no rust. The sludge feed piping and fittings are in good condition. It was observed that the GBT room had a very strong odor and operation staff confirmed this is common, indicating that the heating, ventilating, and air conditioning (HVAC) system may be underperforming. This may contribute to a more corrosive environment in the room.

The GBT is 16 years old with no noted performance issues or significant visible degradation; therefore, it is expected to exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendations: Clean and repaint areas of GBT where paint is chipped or missing to prevent corrosion. Test and rebalance HVAC system in the GBT room to achieve the required air changes.

6.3.3.6.3 GBT Polymer System

Observation: The polymer system is a Polyblend system that was installed in 2005 and appears to be in good condition. Plant staff reported no operational issues with the GBT thickening polymer system. The polymer system is 16 years old with no noted performance issues or significant visible degradation; therefore, it is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: None.

6.3.3.6.4 TWAS Storage Tank

Observation: The TWAS storage tank was constructed in 2005. The TWAS tank interior could not be observed. Plant staff reported no maintenance or operational issues with the TWAS storage tank. When staff observe reduced mixing in the TWAS tank, the tank is emptied and sprayed down with a firehose, and the diffusers are replaced with a backup set of cleaned diffusers. A set of standby diffusers is kept onsite to accommodate this process as it happens several times per year.

Recommendation: None.

6.3.3.6.5 Sludge Tank Blowers

Observation: The sludge tank blowers were installed in 2005 and appear to be in good condition. Plant staff reported no maintenance or operational issues with the blowers. The blowers and low-pressure stainless-steel air piping appear to be in good condition.

The sludge tank blowers are 16 years old with no noted performance issues or significant visible degradation; therefore, they are expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: None.

6.3.3.6.6 Sludge Pumps

Observation: The sludge pumps, piping, and valves in the Operations Building were installed in 2005 and appear to be in good condition. The plant staff reported no performance or maintenance issues with the sludge pumps.

Recommendation: None.

6.3.3.6.7 Truck Loading

Observation: The truck loading station and installed in 2005 and appears to be in good condition. Plant staff reported no operational or maintenance issues with the truck loading station.

Recommendation: None.

6.3.3.7 Support Systems (Odor Control, Sodium Hypochlorite System, and Plant Water and Drainage Systems)

Kingston WWTP's odor control system was constructed in 2005 and consists of a biofilter with associated fan, humidifier, and heater. Foul air is pulled from Headworks, the WAS and TWAS tanks, and the GBT room into the humidifier and heater for conditioning. Then the air is sent to the biofilter, where it is treated then released to atmosphere. Equipment associated with the biofilter (fan, humidifier, and heater) is located adjacent to Headworks. The biofilter and associated sump is at the north end of the site.

Kingston WWTP's sodium hypochlorite system was constructed in 2005. It consists of a 2,000-gallon storage tank located between Headworks and the Process Building, and three metering pumps. The system, originally intended to feed sodium hypochlorite to Headworks, the secondary clarifiers and the W3 system, is unused.

The Kingston WWTP diverts various sources of plant drainage to the Process Building sump. The Process Building sump collects drainage from the GBT, truck sludge loading area, W3 system automatic strainer, and Headworks. There are two 5-HP Process Building sump pumps that operate automatically on level floats to return plant drainage to Headworks. The Process Building sump and pumps were constructed in 2005.

Kingston WWTP has a W2 nonpotable water system to supply water for polymer dilution, seal water for the sludge pumps, water for the odor control humidifier and biofilter, and interior hose bibs. The W2 system was constructed in 2005. It is supplied by the potable water system and consists of an air gap tank, two pumps and a hydropneumatic tank.

The W3 water system consists of two pumps operating in lead/lag, a third flush pump, and an automatic strainer. The lead/lag system normally operates automatically, drawing water from plant effluent between the UV system and the effluent Parshall flume and pumping it in a circulation loop to provide plant water on demand to various plant processes. The W3 system provides plant effluent to plant processes including the GBT, rotary screen, grit classifier, oxidation ditches, secondary clarifier spraydown, and exterior hose bibs. Some W3 water is separately and manually pumped by a third pump to feed a flush water connection for the influent raw sewage pipe at Headworks. This flush water does not go through the automatic W3 strainer.

6.3.3.7.1 Odor Control

Observation: During the site visit in September 2020 the biofilter was turned off due to the media collapse. It was later dug up and recovered by the plant staff. Kingston WWTP receives no odor complaints, but it was observed that the GBT room had a strong odor, indicating that the HVAC system may be underperforming. This may contribute to a more corrosive environment in the room. The fan, duct heater and humidifier are in good condition, therefore, they are expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: Investigate the HVAC system in the GBT room of effectiveness and capacity.

6.3.3.7.2 Sodium Hypochlorite System

Observation: The sodium hypochlorite system is not used. Plant staff noted that when in use, the hypochlorite tank could not be fully pumped out or drained, therefore it is not functional and its condition is rated as very poor.

Recommendation: None. Not needed.

6.3.3.7.3 Process Building Sump

Observation: The Process Building sump and pumps were constructed in 2005. The condition of the Process Building sump and pumps was not observed but plant staff reported no performance or maintenance issues.

Recommendation: None.

6.3.3.7.4 W2 System

Observation: All components of the W2 system were installed in 2005 and appear to be in good condition. The air gap tank appeared to have had overflow events. Plant staff did not report performance or maintenance issues with the W2 system. The W2 system is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: Clean the exterior of the air gap tank and monitor for corrosion around the base of the tank.

6.3.3.7.5 W3 System

Observation: The W3 system has three pumps and an automatic strainer that were installed in 2005. The W3 system components appear to be in good condition. The W2 system is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years). Pump 902 (P-902) has some leakage which is causing corrosion to the pump and frame. This could be a failed casing gasket.

Recommendations: Repair or replace casing gasket on P-902. Clean and recoat corroded areas of the P-902 to prevent further degradation.

6.3.3.8 Power Distribution

6.3.3.8.1 Utility Service Entrance

The utility service entrance is owned and provided by Puget Sound Energy (PSE). Electrical power service to the facility is provided from a 12,470-volt, 3-phase distribution line running underground to a 750 kilovolt amperes (kVA) three phase pad-mounted transformer located in the northeast area of the facility property just north of the generator fuel tank. The three-phase transformer steps the 12.47-kilovolt (kV) transmission primary voltage down to 480-volt secondary utilization voltage for the facility. The utility service entrance secondary conductors continue underground from the pad-mounted transformer to the utility current transformer (CT) enclosure and then onto the main circuit breaker located inside the Operations Building. The utility revenue metering equipment and CT enclosure is located outside of the

Operations Building on the east wall of the electrical room. The utility transformer, service conductors and power metering equipment are owned and maintained by PSE.

Observation: The utility service entrance equipment (transformer, service conductors, power metering equipment, etc.) was installed in 2005 and is in good condition. The equipment is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Recommendation: None.

6.3.3.8.2 Main Power Distribution

The facility is served by a 480-volt, 3-phase, 3-wire electrical power distribution system. The main service and distribution equipment were installed in early 2005 and are located in the main electrical room in the Operations Building. The facility power distribution system consists of the utility service entrance, standby generator, main circuit breaker, automatic transfer switch (ATS), metering, two motor control centers (MCCs), various 480-volt power panels, 480: 120/208 volts of alternating current (VAC) distribution transformers and 120/208 VAC lighting and power panels.

Observation: The main power distribution system including the service entrance rated 800 ampere main circuit breaker, distribution transformers, power panels, and MCCs is in good condition. The system is expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

No arc flash labeling was observed on any of the electrical equipment in this facility.

Recommendation: A complete arc flash study for the electrical infrastructure should be performed to comply with Occupational Safety and Health Administration (OSHA) standard 1910.269 which was made mandatory and put into effect on July 10, 2014.

6.3.3.8.3 Generator and Automatic Transfer Switch

Standby emergency power is supplied by a Cummins 350-kW diesel engine-generator. It is a non-enclosed generator located in the generator room in the Operations Building. The standby generator was installed in 2005 and has a 600-ampere circuit breaker and is fueled by an external diesel fuel storage tank on the northeast area of the facility. The standby generator engine was last serviced in 2019 according to labeling on the installed filters.

The 3-pole, 800-ampere, 480-volt, 3-phase, 3-wire ATS is located on the north wall in the main electrical room just south of the generator room in the Operations Building. It is fed from the 800-ampere service entrance main breaker (normal side) and standby generator (emergency side). The ATS load side connects to MCC-01 600-ampere main breaker and has a tap to the 480V, 225-ampere power panel DPP-01.

Observation: The generator and ATS were installed in 2005 and are in good condition.. The ATS and generator are sized to provide enough back-up power for all essential functions for the facility to continue operation in the event of a prolonged power outage.

Recommendation: None.

6.3.3.8.4 Motor Control Centers

There is a total of two MCCs in the plant, MCC-01 and MCC-01A. MCC-01 has a 600-ampere main breaker and is fed from the ATS. MCC-01A has a main lug connection and is fed from a circuit breaker in MCC-01. MCC-01 was installed in 2005 and MCC-01A was installed in 2020 as part of a plant upgrade. **Table 6-7** below shows the MCCs, their location, model, and rating.

Table 6-7 | MCC Locations, Models, and Rating

MCC	Location	Model	Rating [Amps]
01	Process Building Electrical Room	Cutler-Hammer Freedom Series 2100	600
01A	Process Building Electrical Room	Cutler-Hammer Freedom Series 2100	600

Observation: MCC-01A is new, in very good condition, and should have over 90 percent of its 25 to 30 year expected lifespan. MCC-01 was installed in 2004 and is in good condition. MCC-01 is expected to exceed the typical expected lifespan of 25 to 30 years. It is expected that the equipment may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years).

Most of the components in the MCC's individual buckets are consistent with industry standard and are readily available or could be replaced with similar manufacturer's devices.

The AFDs installed in MCC-01 are in good condition, however they are obsolete and no longer supported by the manufacturer.

Recommendation: A replacement plan for the obsolete AFDs should be established in the event of failure. A newer model is available, and a similar manufacture's AFD could be used, depending on physical space and options.

6.3.3.8.5 Control Panels

Control panels are located throughout the facility. The main plant controller is located in the office area of the Operations Building and the main remote input/output (I/O) rack is located in the Process Building electrical room. The control panels are comprised of Industry standard equipment including programmable logic controllers (PLCs), operator interface terminals (OITs), uninterruptable power supply (UPS), small digital readouts, and typical components including circuit breakers, relays, wiring, fuses, terminals, indicator lights, selector switches, etc. **Table 6-8** below shows the panels, their location, PLC and central processing unit (CPU) models and of an OIT is present. Local pushbutton, selector switch, and or indication stations are not listed.

Table 6-8 | Panel Locations and Models

Panel	Location	PLC Model	CPU Model	OIT
CP-200 Main CP	Operations Building Office Area	Allen-Bradley Compactlogix	1769-L33ER	N/A
CP-300 Rem. I/O for MCC-01	Process Building Electrical Room	Allen-Bradley Compactlogix	1769 Remote I/O	Y
FCP-201 Fine Screen	Headworks Area	Allen-Bradley Micrologix	1400 Series	Y
LP-200 Grit Collection	Headworks Area	N/A	N/A	N/A

Panel	Location	PLC Model	CPU Model	OIT
LP-710 Bio Filter Sump Pump	Bio-swale area	N/A	N/A	N/A
LP-920 Proc. Bldg Sump Pump	Process Building Lower Level	N/A	N/A	N/A
LP-TLP Truck Loading	Process Building near truck loadout	N/A	N/A	N/A
LP-TCP Thickening	Process Building Thickening Room	N/A	N/A	N/A
LP-GBT Gravity Belt	Process Building Thickening Room	See observation and recommendation	N/A	N/A
LP-Scum Pump	Clarifier Area	N/A	N/A	N/A

Observation: Most of the control panels installed appear to be operating adequately and are generally in good condition. The control panels are expected to meet or exceed the typical expected lifespan of 25 to 30 years. It is expected that the panels may have 50 to 90 percent of its expected serviceable life remaining (13 to 27 years). Components installed are consistent with industry standard and are readily available or could be replaced with similar manufacturer's devices. The exception to this is the PLC system and OIT equipment, as each brand of PLC and OIT requires special programming.

The main PLC system for the facility with equipment located in the CP-200 and CP-300 panels was upgraded by Quality Controls Corp. in 2020 as part of facility modifications.

Communication between the main and remote I/O panel is achieved via an ethernet link. The connection to the fine screen panel as well as connection to SCADA is also via an ethernet link.

CP-300 plant remote I/O panel has an OIT that is in good condition and functional, however it is obsolete, and the model is no longer supported.

Panels LP-GBT and LP-TLP interiors were not accessed and the installation of a controller (e.g. PLC) was not verified. It is likely one or both panels contain PLCs.

The local control panel for the scum pump appears to have been partially filled with water or somehow compromised and is in fair condition. Terminals indicate rust or corrosion, and the bottom interior of the enclosure is covered with residue. The scum pump panel is expected to have less than 50 percent of its expected serviceable life remaining (2 to 10 years).

Recommendations:

Verify back-up copies of all PLC and OIT programs have been created, and if not, have them created and stored in a safe place as soon as possible. Spare parts for the PLC system including a CPU, power supply, communication module, and a minimum of 1 spare I/O module per type should be stored by the County in case of a failure.

If the OIT in CP-300 is used as a main point of control and its function has not been replaced by the overall plant SCADA system, then a migration/replacement plan should be developed and executed as soon as possible.

Verify whether there is a PLC in the LP-GBT or LP-TLP panel. If a PLC exists, verify if it is still supported and if a back-up of its program has been saved. Given the apparent age of these panels, if a PLC exists it is likely outdated so we recommend a migration/replacement plan should be developed and executed as soon as possible.

The local control panel for the scum pump should be thoroughly cleaned and inspected. The source of the water infiltration should be identified and corrected.

6.3.3.9 SCADA System

SCADA system condition assessment and evaluation have been conducted as part of the County-wide SCADA master plan project. See *Kitsap County Sewer Utility SCADA Master Plan Technical Memoranda* (Murraysmith [now Consor] /HDR, 2021) in **Appendix F** for the details.

6.4 Code Review

Code requirements for the Kingston WWTP are summarized in **Section 6.4.1**. **Section 6.4.2** includes discussion of general code requirements that would be triggered should major upgrades be completed at the WWTP. Code requirements summarized in this report include:

- Washington State Building Code, including the following adopted codes. The 2021 versions of the code went into effect March 15, 2024 and are expected to be updated in approximately 2027.
    - International Building Code (IBC)
    - International Machine Code (IMC)
    - International Fire Code (IFC)
    - National Electrical Code (NEC) 70
    - National Fire Protection Association (NFPA) 820
    - NFPA 24
    - Uniform Plumbing Code (UPC)
- Americans with Disabilities Act (ADA)
- CFR

6.4.1 Summary of Existing Buildings and Use

The Kingston WWTP Site Plan is shown in **Figure 6-1**. There are two main buildings onsite, which are the Operations Building and the Process Building.

6.4.1.1 Operations Building

The Operations Building, located on the east side of the plant site, is a multipurpose building with the following functions:

- Administrative office space and control room
- Laboratory working space
- Garage/shop
- Bathroom, shower, and lockers
- Backup Generator room
- Electrical room

The Operations Building is a one-story above grade building. It has one roll up door for the garage/shop, and four man-doors. The Operations Building was constructed in 2005.

- Floor Area:
  - B (Office/Control Room, Electrical Room) Approximately 700 square feet (SF) (Allowable 8,000 SF).
  - S-3 (Garage/Shop, Generator Room) Approximately 900 SF (Allowable 8,000 SF).
- Height: 20 feet (Allowable 2 stories, 40 feet).
- Construction Type: 1997 Uniform Building Code (UBC) and Uniform Fire Code (UFC) Type V-N, constructed of non-combustible, non-fire rated materials. The building is constructed of a concrete slab, load-bearing concrete masonry unit (CMU) walls, and wood truss roof framing covered with sheet metal roofing.
- Occupancy Group:
  - Office/Control Room, Electrical Room - Group B per UBC 1997, where Section 304.1 defines Group B as occupancies consisting of business functions.
  - Garage/Shop, Generator Room – Group S-3 per UBC 1997, where Section 311.1 defines Group S-3 as occupancies consisting of repair garage functions.
- Calculated Occupancy Load:
  - B (Office/Control Room, Electrical Room) - 7 persons per IBC Table 1004.1.2 - occupant load factor of 100 gross for business areas.
  - S-3 (Garage/Shop, Generator Room) - 9 persons per IBC Table 1004.1.2 - occupant load factor of 100 gross for industrial areas.
- Fire Sprinklers: Not required per IBC Section 903.
- Safety features: Tepid eyewash/shower station required where the eyes or body of any person may be exposed to injurious corrosive materials per 29 CFR 1910.151 and the American National Standards Institute (ANSI) Z358.1.

6.4.1.2 Process Building

The Process Building, located east of the oxidation ditches and secondary clarifiers in the middle of the site, houses the following solids processing equipment:

- Dewatering room with GBT, associated polymer system and piping (upper level)
- Electrical room (upper level)
- Mechanical/Service room with W2 system (upper level)
- Solids handling including RAS pumps, aerated WAS and TWAS tanks, sludge tank blowers, sludge transfer pumps, W3 system, and Process Building sump (lower level)

The Process Building is two story building with one story below grade. It has two roll up doors for the GBT room and two man-doors. The Process Building was constructed in 2005.

- Floor Area:
  - S-2 Approximately 3,085 SF (Allowable 12,000 SF). GBT room is approximately 500 SF and Solids Handling area in basement is approximately 860 SF.
- Height: 23 feet (Allowable 2 stories, 40 feet).
- Construction Type: 1997 UBC and UFC Type V-N, constructed of non-combustible, non-fire rated materials. The building is constructed of a concrete slab, reinforced concrete walls below grade, load-bearing CMU walls, and wood truss roof framing covered with sheet metal roofing.
- Occupancy Group:
  - Group S-2 per UBC 1997, where Section 311.1 defines Group S-2 as occupancies consisting of low-hazard storage functions.
- Calculated Occupancy Load:
  - S-2 - 30 persons per IBC Table 1004.1.2 - occupant load factor of 100 gross for industrial areas.
- Fire Sprinklers: Not required per IBC Section 903. Fire detection and portable fire extinguishers required per NFPA 820, see **Section 6.4.2.3**.
- Safety Features: Tepid eyewash/shower station required where the eyes or body of any person may be exposed to injurious corrosive materials per 29 CFR 1910.151 and ANSI Z358.1.

6.4.2 General Code Requirements

6.4.2.1 Accessibility

Any new building anticipating personnel occupancy is required to comply with the accessibility requirements of Chapter 11 of the IBC. In general, this means that the building shall have an accessible parking stall and accessible path of travel from the accessible stall to the Operations Building entrance. Doors shall have lever hardware and accessible rooms shall meet the design and dimensional requirements of Chapter 11. Per the IBC, accessibility is not required for mechanical and process spaces as described in Section 1103.2.9 Equipment Spaces.

Existing buildings are governed by the Existing Building Code Section 305. Generally, any portions of the building that are altered, should comply as if it is a new building, including accessibility. But the entire building does not necessarily need to be upgraded. For example, if the alternation of the existing space does not include the toilet/locker area, then that area will not have to be upgraded to meet the accessibility requirement in the IBC.

Although the Operations Building at Kingston WWTP does not comply with the latest IBC code on the accessibility requirement, it is grandfathered in from the code when it was constructed. If the building is to be upgraded or modified, it will need to meet the current accessibility requirements. The Process Building at Kingston WWTP could be categorized as the equipment spaces in Chapter 11 Section 1103.2.9 therefore is exempt from the accessibility requirement.

6.4.2.2 Means of Egress

The Washington State Building Code mandates in Chapter 10 that in all buildings the means of exit discharge shall meet the following requirements:

- Illumination Required: Means of exit discharge shall be always illuminated by not less than 1-foot-candle (11 lux) at the walking surface per IBC 1008.2.
- Egress Sizing: The minimum width of each door opening shall be a minimum width of 32 inches and height of 80 inches, as well as sufficient for the occupant load thereof per IBC 1010.1.1.

6.4.2.3 NFPA 820

The NFPA 820 provides requirements for ventilation, electrical classification, materials of construction, and fire protection measures for the Collection Systems (Table 4.2.2), Liquid Stream Treatment Process (Table 5.2.2), and the Solid Stream Treatment Process (Table 6.2.2). Applicable locations have been summarized in the **Table 6-9** below.

6.4.2.4 NFPA 24

Fire suppression hydrants shall be installed in accordance with NFPA 24. Chapter 7 of NFPA 24 references the local jurisdiction for hydrant spacing requirements. The County fire code mandates hydrants to be located between 50 and 150 feet of the buildings to be protected. The closest fire hydrants are 55-feet from the northwest corner of the Process Building and 15-feet from the southeast corner of the Operations Building. Section C.4.1.3 of NFPA 24 generally recommends a minimum residual pressure of 20 pounds per square inch (psi) should be maintained at hydrants when delivering fire flow. Fire flow scenarios were not modeled as part of this planning effort.

6.4.3 Summary of Code Requirements

No code violation has been observed at the Kingston WWTP. Although the Operations Building does not comply with the latest IBC code on the accessibility requirement, such as the accessible parking stall, path from the accessible stall to the entrance, ADA bathroom, etc., it is grandfathered in from the code when it was constructed. If the building is to be upgraded or modified, it will need to meet the current accessibility requirements. It is recommended to install the fire alarm system in the GBT room and make sure functional fire extinguishers are available at all the locations listed in **Table 6-9**.

The following conditions require additional comprehensive analysis as they were beyond the scope of this review:

- HVAC compliance
- Seismic Anchoring

Table 6-9 | NFPA 820 Requirements Pertinent to the Kingston WWTP

Location	Fire and Explosion Hazard	Ventilation[1]	Extent of Classified Area	NEC Area Electrical Classification (All Class I, Group D)	Materials of Construction	Fire Protection Measures
Screen Channels	Possible ignition of flammable gases and floating flammable liquids	Continuously ventilated at 12 changes per hour	Enclosed – entire space	Division 2	Noncombustible, limited combustible, or low flame spread index material	Portable fire extinguisher and hydrant protection in accordance with NFPA 820 7.2.4.
Grit Removal Tank	Possible ignition of flammable gases and floating flammable liquids	Continuously ventilated at 12 changes per hour	Enclosed – entire space	Division 2	Noncombustible, limited combustible, or low flame spread index material	Portable fire extinguisher and hydrant protection in accordance with NFPA 820 7.2.4
Oxidation Ditches (not preceded by primary clarifier)	Possible ignition of flammable gases and floating flammable liquids	No ventilation, not enclosed	Interior of the tank from the water surface to the top of the tank wall. Envelope includes 18 inches above the top of the tank and extending 18 inches beyond the exterior wall; envelope 18 inches above grade extending 10 ft horizontal from the exterior tank walls	Division 2	Noncombustible, limited combustible, or low flame spread index material	Hydrant protection in accordance with NFPA 820 7.2.4
Secondary Clarifiers	N/A	No ventilation, not enclosed	N/A	Unclassified	Not required	Hydrant protection in accordance with NFPA 820 7.2.4
UV Disinfection	N/A	No ventilation	N/A	Unclassified	Not required	Hydrant protection in accordance with NFPA 820 7.2.4
Scum Pumping Area – secondary clarifiers scum pump station	Buildup of vapors from flammable or combustible liquids	No ventilation	Entire enclosed scum wetwell	Division 1	Noncombustible	Portable fire extinguisher and hydrant protection in accordance with NFPA 820 7.2.4
WAS and TWAS Storage Tanks	Possible generation of methane gas in explosive concentrations; carryover of floating flammable liquids	Continuously ventilated at 12 air changes per hour	Enclosed – entire space	Division 2	Noncombustible, limited combustible, or low flame spread index material	Portable fire extinguisher and hydrant protection in accordance with NFPA 820 7.2.4. Combustible gas detection system.
GBT Room	Accumulation of methane gas	Continuously ventilated at 6 air changes per hour	Entire room	Unclassified	Noncombustible, limited combustible, or low flame spread index material	Portable fire extinguisher, hydrant protection in accordance with NFPA 820 7.2.4, and fire alarm system.
Odor Control	Leakage and ignition of flammable gases and vapors	Not enclosed, open to the atmosphere	Areas within 0.9 m (3 feet) of leakage sources such as fans, dampers, flexible connections, flanges, pressurized unwelded ductwork, and odor-control vessels	Division 2	Noncombustible, limited combustible, or low flame spread index material	Portable fire extinguisher
			Area beyond 3 feet leakage sources	Unclassified		

Note:
1. Ventilation rates are the intended design values. Testing is needed to verify the actual ventilation during operation.

6.5 Existing Wastewater Treatment Plant Performance

The performance of the existing WWTP in terms of NPDES permit compliance, EPA's reliability requirement, and future nutrient removal requirement are summarized in this section.

6.5.1 Compliance to NPDES Permit

The County's Kingston WWTP NPDES Permit #WA0032077 was renewed December 1, 2015, allowing the discharge of treated effluent to Appletree Cove, Puget Sound. A copy of the WWTP's NPDES Permit is included as **Appendix A**. The NPDES Permit expired on November 30, 2020. The County has already submitted the permit renewal application six months before the expiration date per the Permit requirement.

Table 6-10 is a summary of waste discharge limitations for the Kingston WWTP Outfall 001 to Puget Sound as contained in Section S1 of the NPDES Permit.

Table 6-10 | Outfall 001 NPDES Waste Discharge Limits[1]

Effluent Limits: Outfall 001		
Parameter	**Average Monthly**	**Average Weekly**
CBOD	25 mg/L	40 mg/L
	61 ppd	98 ppd
	85% removal of influent BOD	
TSS	30 mg/L	45 mg/L
	73 ppd	110 ppd
	85% removal of influent TSS	
Parameter	**Daily Minimum**	**Daily Maximum**
pH	6.0	9.0
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria	200/100 mL	400/100 mL

Notes:
1. From current Kingston WWTP NPDES Permit # WA0032077
mg/L = Milligrams per liter
ppd = Pounds per day
mL=milliliter

The plant design criteria listed in Section S4 of the current permit set the upper limits for the influent flow, CBOD, and TSS loads, as following:

- Maximum month design flow is 0.292 MGD
- Influent CBOD loading for maximum month is 585 lb/day
- Influent TSS loading for maximum month is 585 lb/day

The County is required to 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 above design criteria for three consecutive months.

2. The projected plant flow or loading will reach design capacity within five years.

Figure 6-3 through **Figure 6-6** show the 7-day and the 30-day rolling average concentrations and loads for both effluent CBOD and TSS between January 2018 and June 2020. The corresponding NPDES permit limits are shown for comparison. These figures indicate Kingston WWTP has not exceeded the permit effluent CBOD and TSS limits during this period. In addition, the plant has not exceeded pH or Fecal Coliform limits during this same period based upon review of the monthly DMRs.

Figure 6-3 | 7-day Rolling Average Effluent CBOD and TSS Concentrations

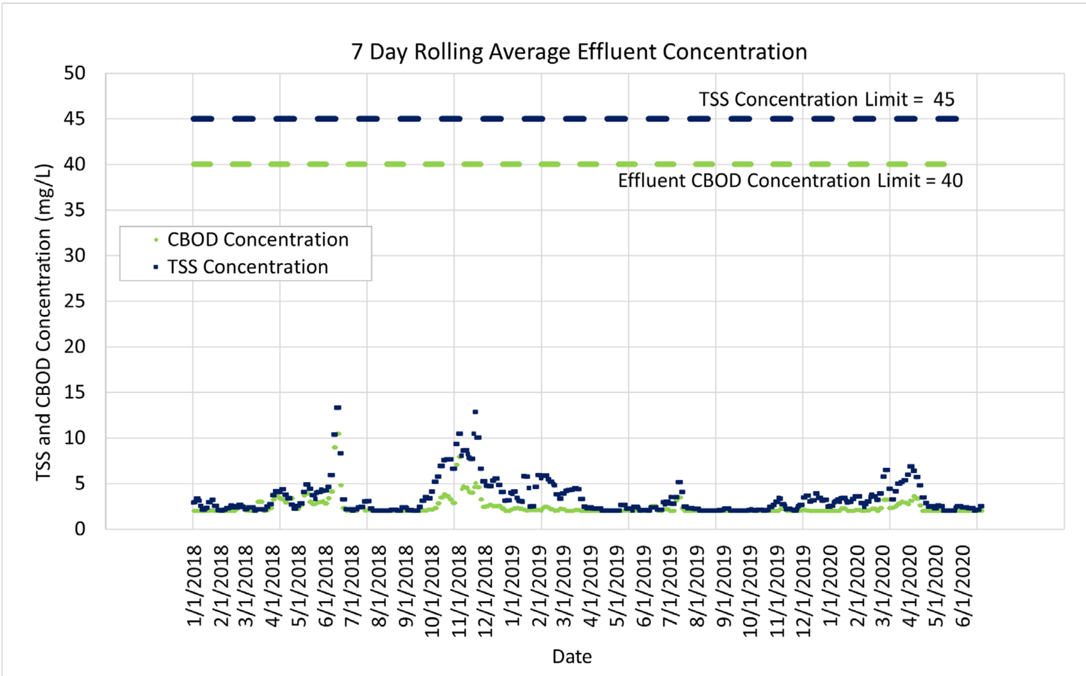


Figure 6-4 | 30-day Rolling Average Effluent CBOD and TSS Concentrations

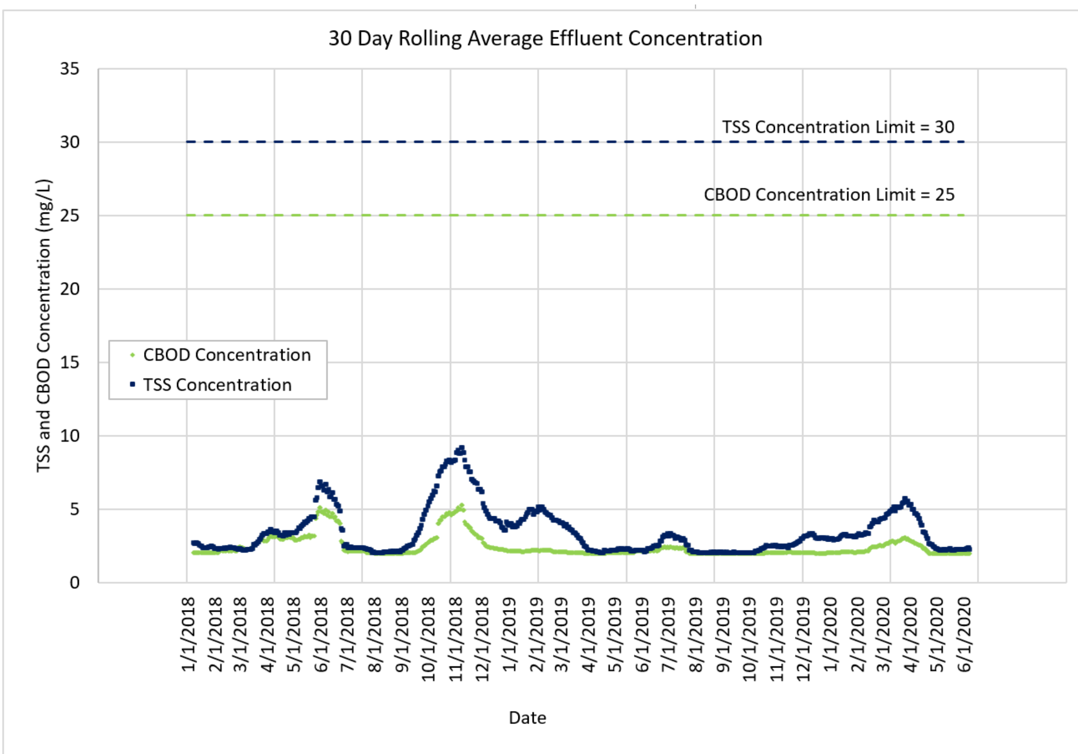


Figure 6-5 | 7-day Rolling Average Effluent CBOD and TSS Loads

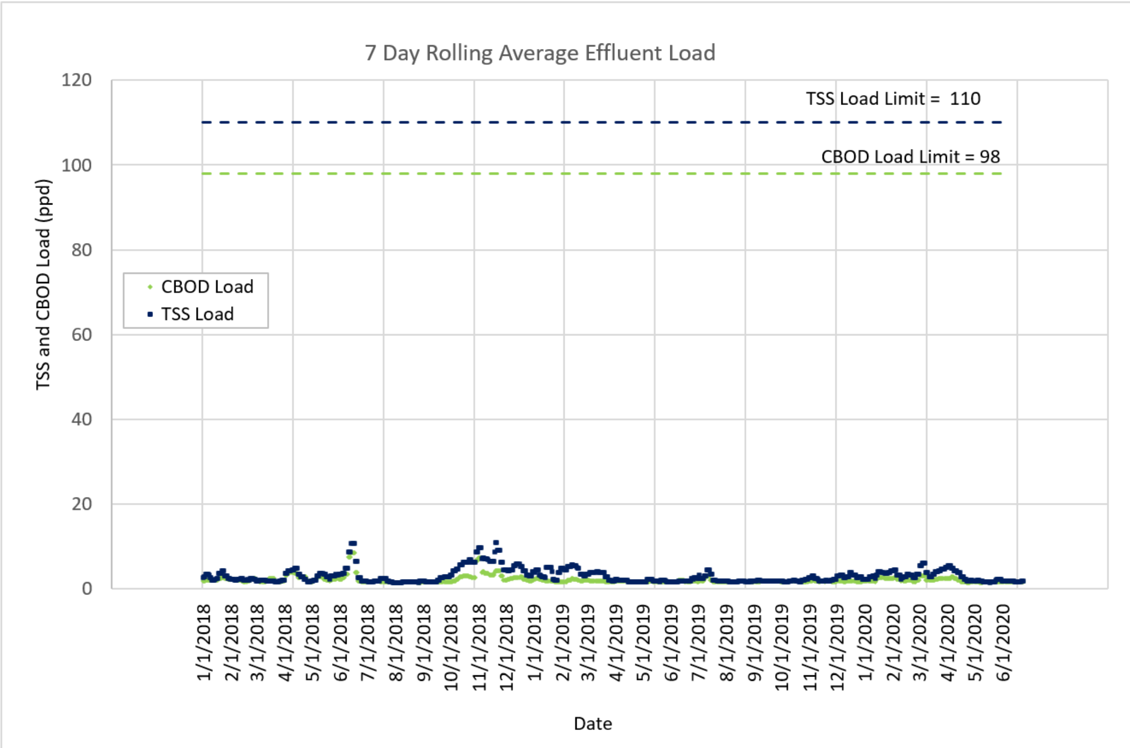


Figure 6-6 | 30-day Rolling Average Effluent CBOD and TSS Loads

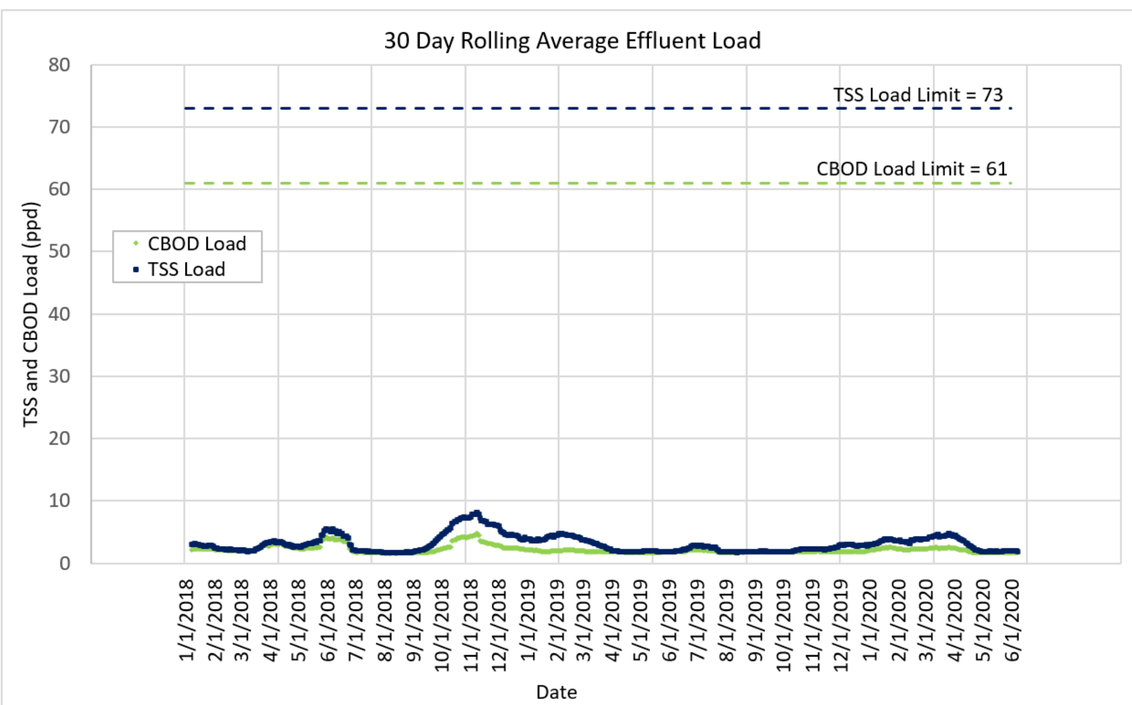


Figure 6-7 and **Figure 6-8** show the plant 30-day rolling average influent flow and BOD and TSS loads to compare with the design criteria in the permit. Both influent flow and loads are well below 85 percent of the designed values.

Figure 6-7 | 30-day Rolling Average Influent Flow

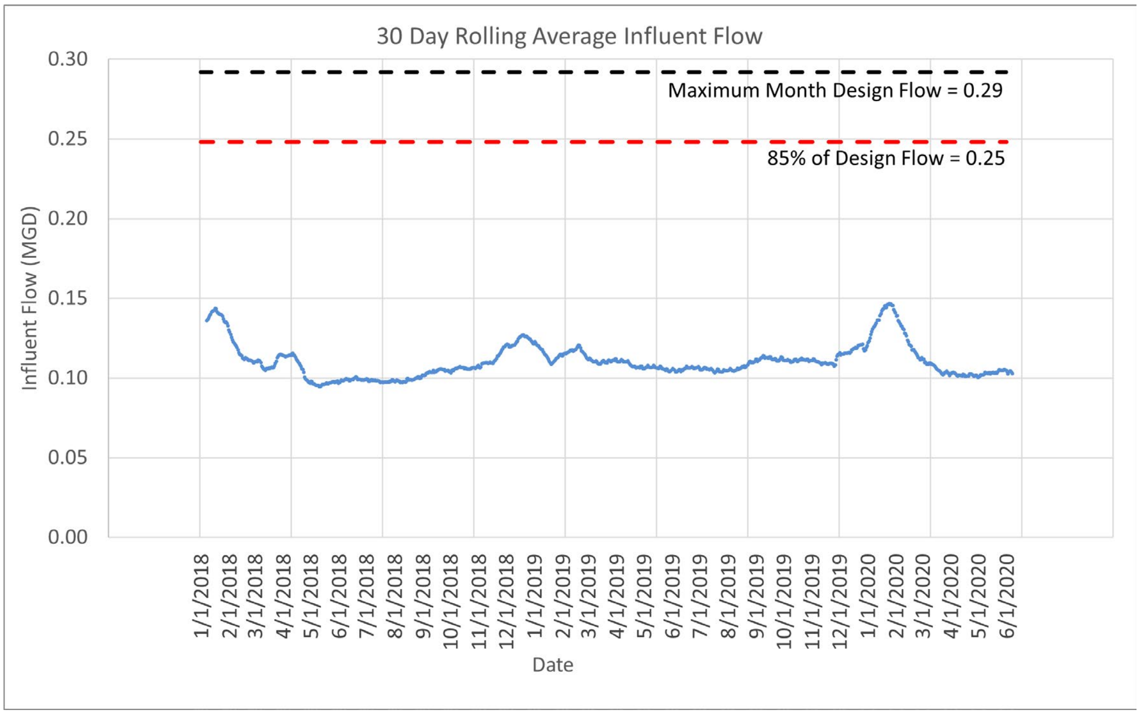
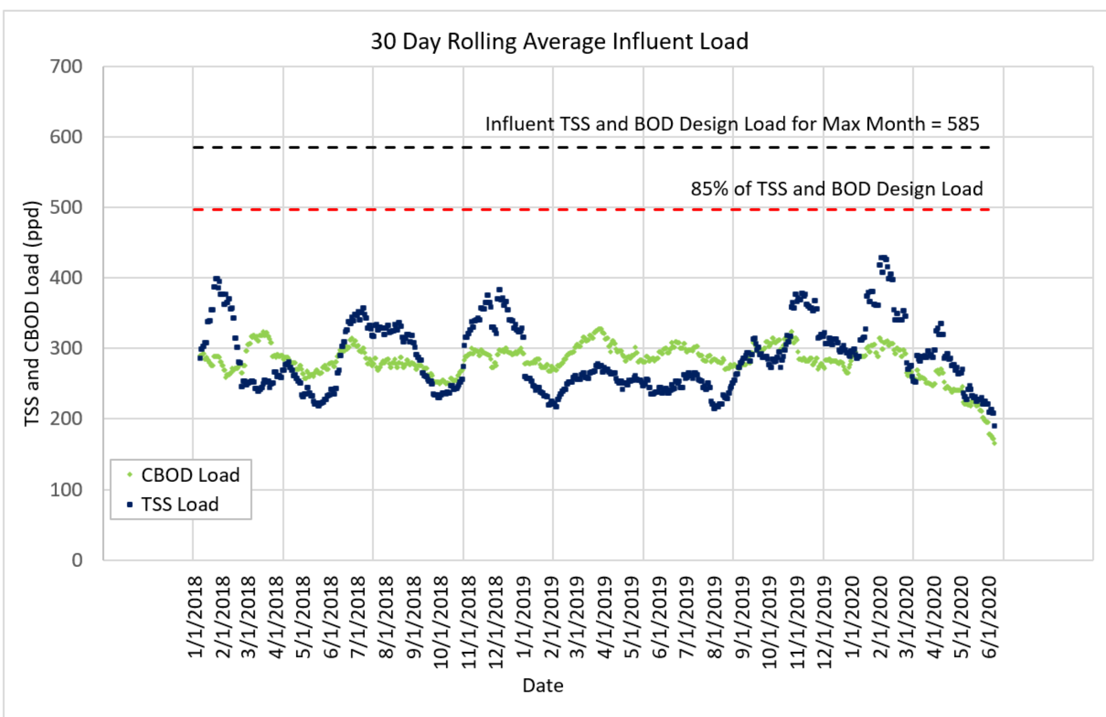


Figure 6-8 | 30-day Rolling Average Influent CBOD and TSS Loads



6.5.2 EPA Plant Reliability Criteria

The Kingston WWTP is required to meet the Reliability Class I standards, as defined in EPA's Technical Bulletin "Design Criteria for Mechanical, Electrical, and Fluid System Component Reliability," EPA 430-99-74-001. **Table 6-11** includes a summary of the reliability criteria and requirements to be considered as part of the Alternatives Evaluation and Recommended Plan.

Table 6-11 | EPA Class I Reliability Criteria

Treatment Unit Process	Reliability Class I Requirements	Current Deficiencies
Influent Screening	A backup bar screen designed for mechanical or manual cleaning shall be provided. Facilities with only two bar screens shall have at least one bar screen designed to permit manual cleaning.	None. A manual screen is provided to back up the mechanical screen.
Pumps (Liquids, Solids & Chemical Feed)	A backup pump shall be provided for each set of pumps performing the same function. The capacity of the pumps shall be such that, with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow.	None. Backup is provided to RAS pumps and sludge transfer pumps.
Secondary Clarification	The units shall be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining units shall have a design flow capacity of at least 75% of the total design flow.	None. One of two secondary clarifiers will be able to handle 75% of the total flow.
Aeration Basin	A backup basin will not be required; however, at least two equal-volume basins shall be provided.	None. Two oxidation ditches are provided.
Aeration Blowers and/or Mechanical Aerators	There shall be a sufficient number of blowers or mechanical aerators to enable the design oxygen transfer to be maintained with the largest-capacity-unit out of service. It is permissible for the backup unit to be an uninstalled unit, provided that the installed units can be easily removed and replaced. However, at least two units shall be installed.	None. Aeration blowers are designed to provide design airflow with one backup.
Air Diffuser Systems	The air diffusion system for each aeration basin shall be designed so that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.	None. Two grids of diffusers are provided in each oxidation ditch. Isolation of any will not impair the oxygen transfer capability of the system
Disinfection	The units should be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining units should have a design flow capacity of at least 50 percent of the total design flow.	None. The UV channel has two banks. One of two UV banks will be able to handle more than 50% of the total design flow.
Sludge Storage Tanks	Holding tanks are permissible as an alternative to component or system backup capabilities for components downstream of the tank provided the volume of the holding tank shall be based on the expected time necessary to perform maintenance and/or repair and the capacity of sludge treatment processes downstream can handle the combined flow from the storage tanks and the working sludge treatment system	None. WAS storage tanks and TWAS storage tank are provided to back up the GBT and sludge pump.

Treatment Unit Process	Reliability Class I Requirements	Current Deficiencies
Sludge Disposal	An alternative method of sludge disposal shall be provided for each sludge treatment unit process without installed backup.	None. If GBT is down, WAS storage tanks could store sludge for at least a week. Or un-thickened sludge could be trucked to Central Kitsap WWTP.
Electrical Power Supply	Two separate and independent power sources, either from two separate utility substations or from a single substation and an on-site generator. The backup power supply shall be sufficient to operate all vital components during peak wastewater flow conditions, including critical lighting and ventilation.	None. An on-site generator is provided.

6.5.3 Preliminary Nutrient Loading at Kingston WWTP

Although the small TIN load plants do not have a facility specific action level in the first PSNGP, the proposed action level TIN load limits that Ecology presented in the Preliminary Draft Nutrient General Permit for Kingston WWTP provide a useful basis for evaluating performance and may be relevant again in the future. The load limits are shown in **Table 6-12**.

Table 6-12 | Kingston WWTP Preliminary Draft Nutrient General Permit Load Limits

Action Level	TIN Load Limit (lbs-N/year)	Maximum Average Annual Concentration[1] (mg/L)
Baseline (AL_0)	3,660	10.93
Secondary Threshold (AL_1)	7,555	22.56

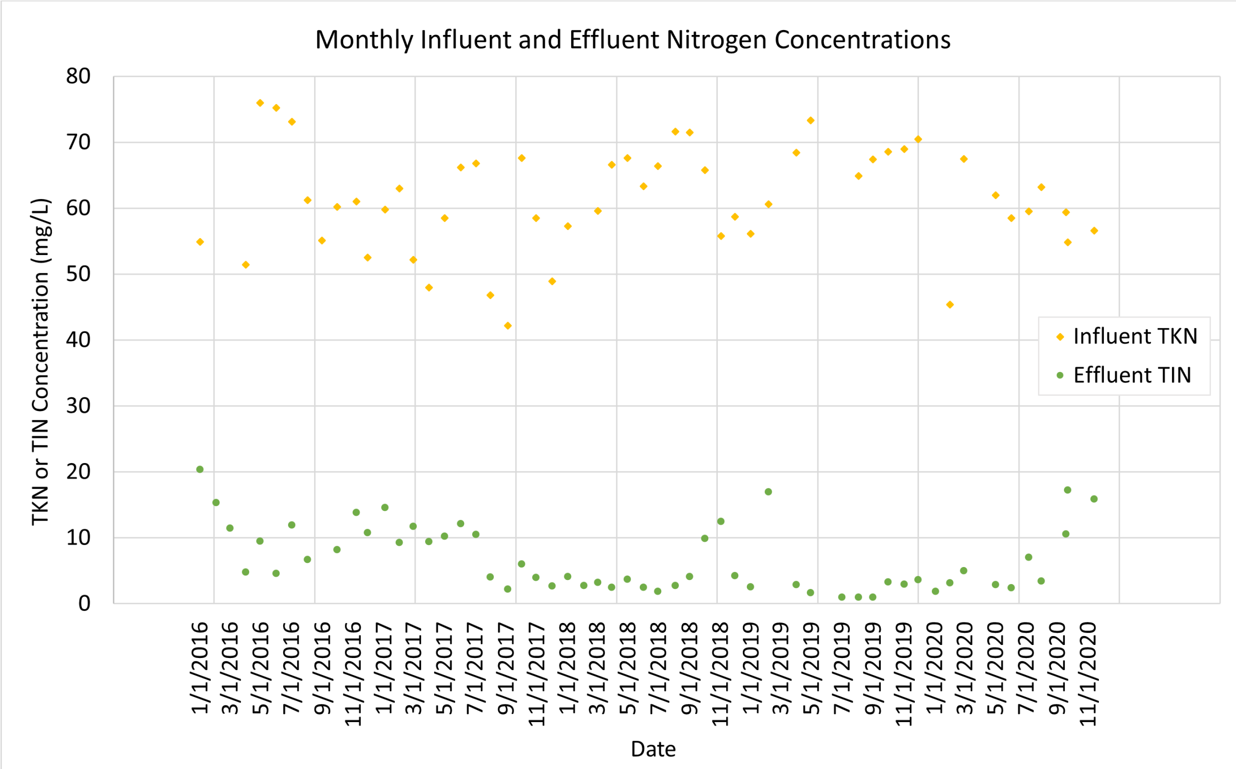
lbs-N/year: pounds of nitrogen per year

Note:

1. Maximum Average Annual Concentration is the load limit divided by the current AAF

Since 2016, Kingston WWTP staff have been conducting monthly testing of the influent and effluent for nitrogen species, shown in **Figure 6-9**. Average influent TKN concentration was 61.4 mg/L, while effluent TIN concentrations ranged from 1.0 to 20.4 mg/L, with an average concentration of 6.8 mg/L.

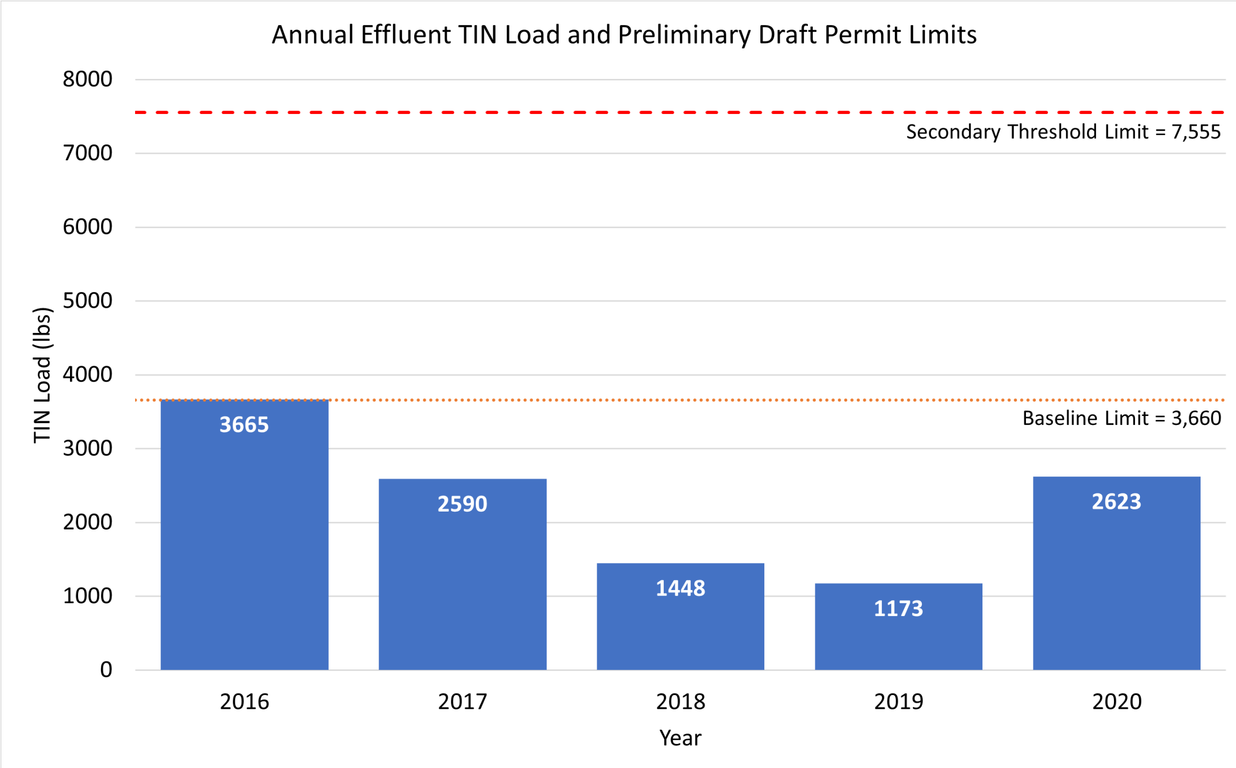
Figure 6-9 | Kingston WWTP Influent and Effluent Nitrogen Concentrations



The preliminary nutrient data was used in conjunction with effluent flow data to estimate annual TIN loading for comparison with the preliminary permit TIN load action levels in **Figure 6-10**. In a few instances, monthly data was not collected, and the effluent TIN concentration was interpolated to estimate the load for that month. In 2016, the estimated TIN load of 3,365 lbs just slightly exceeded the secondary threshold due to high Nitrate + Nitrite effluent concentration in the first few months of the year. In all other years, the TIN load was well below the load limits.

It may be feasible to further reduce TIN loading to the Puget Sound by implementing a recycled water program to divert effluent from the outfall. Kingston WWTP does not currently produce effluent that meets reuse requirements or have a recycled water permit. The potential for a water reuse program is discussed in **Section 9**.

Figure 6-10 | Kingston Annual Effluent TIN Loads



The data indicates that Kingston WWTP has the capacity to meet the originally proposed load limits and may be able to consistently achieve low TIN loading if load limits are implemented in the future.

6.6 Existing Wastewater Treatment Plant Capacity Evaluation

This section of the Plan documents the capacity of the existing WWTP. Capacity at the treatment plant consists of equipment capacity, hydraulic capacity, and process capacity. The Kingston WWTP is required to treat the design flow and waste loads according to the NPDES permit, as well as hydraulically pass the PHF rate without being flooded. Current and projected flows were developed in **Section 3** and are shown in **Table 6-13**, below.

Table 6-13 | Existing and Projected Kingston WWTP Flows (MGD)

Flow Description	Current Flows (Years 2018-2020)	2028 Projected flows	2042 Projected flows
Annual Average Flow (AAF)	0.11	0.17	0.27
Max Month Wet Weather Flow (MMWWF)	0.15	0.23	0.36
Max Month Dry Weather Flow (MMDWF)	0.12	0.18	0.29
Peak Daily Flow (PDF)	0.21	0.32	0.51
Peak Hour Flow (PHF)	0.57	0.87	1.41

Based on 2005 Kingston WWTP design documents, the plant was designed and constructed to handle the PHF of 2.26 MGD except for the UV equipment. The existing UV channel can pass 2.26 MGD hydraulically but requires additional UV bank to provide sufficient disinfection to 2.26 MGD or more.

6.6.1 Mechanical Equipment Capacity

The capacity of each existing major unit process is listed in **Table 6-14**.

Table 6-14 | Design Capacity of Unit Processes at Kingston WWTP

System	Data/Type
Mechanical Fine Screen	
Quantity	1
Capacity, each	2.6 MGD
Grit Chamber	
Type	Vortex
Quantity	1
Diameter	7 feet
Capacity flow	2.26 MGD
Oxidation Ditch	
Quantity	2
Volume (each)	274,000 gallons (36,600 square feet)
Average Sidewater Depth	10’-4”
Secondary Clarifier	
Quantity	2
Diameter	35 feet
Depth	13 feet
UV System	
Type	Low Pressure
Quantity	2 banks in 1 channel; 56 lamps per bank
Dosage	37 milliwatt sec/sq cm
Capacity	1.60 MGD with two banks in service
WAS Storage Tank	
Quantity	2
Volume, each	25,000 gallons
TWAS Storage Tank	
Quantity	1
Volume, each	16,000 gallons
Gravity Belt Thickener	
Quantity	1
Size	1-meter belt
Capacity	200 gpm

6.6.2 WWTP Liquid Stream Hydraulic Capacity

6.6.2.1 Hydraulic Capacity Analysis

To evaluate the hydraulic capacity of the existing WWTP, the treatment plant was modelled using Visual Hydraulics© based on the design and record drawings.

The hydraulic capacity was evaluated for flows up to the 2042 PHF of 1.41 MGD to identify how the existing plant hydraulics can be expected to perform during future flowrates. The model was run under two different flow scenarios, 2042 PHF and 2042 AAF. Under both scenarios two oxidation ditches are put into service since no redundant oxidation ditch is required per Ecology's reliability requirement. Under 2042 PHF scenario two sub-scenarios were modeled to simulate operation with one or two secondary clarifiers in service, since a redundant secondary clarifier is required per Ecology's reliability requirement. As part of the analysis, hydraulic limitations were identified when the water level reached within 12-inches of freeboard below the top of a containment structure. The hydraulic profile at the 2042 AAF and PHF is shown in **Figure 6-11** below. The RAS flowrate recycle fraction (RAS/Influent) was assumed to match the average design of 0.1 MGD/0.27 MGD for the AAF and was assumed to be 0.50 of the MMWWF for flows at or higher than the MMWWF. A detailed summary of the input parameters used in the Visual Hydraulics Model is included as **Appendix G**.

6.6.2.2 Headworks Facility Hydraulic Capacity

All components (mechanical equipment, piping, and structures) in Headworks have hydraulic capacity in excess of the 2042 PHF of 1.41 MGD per the model results and equipment design criteria.

6.6.2.3 Secondary Treatment Hydraulic Capacity

From Headworks, screened sewage is piped through a single 14-inch diameter pipe to a flow splitter control box between the two oxidation ditches which controls the sewage flow into the oxidation ditches. Effluent from the oxidation ditches is collected in parallel pipes that combine and redistribute flows in the secondary clarifier splitter box clarifiers. Parallel 14-inch diameter pipes send activated sludge from the splitter box to each of the secondary clarifiers. Effluent from the secondary clarifiers is collected in a common 14-inch diameter pipe that connects to the UV channels. All components of the secondary treatment system have hydraulic capacity in excess of the 2042 PHF of 1.41 MGD per the model results and equipment design criteria.

6.6.2.4 UV Channel and Effluent Basin Hydraulic Capacity

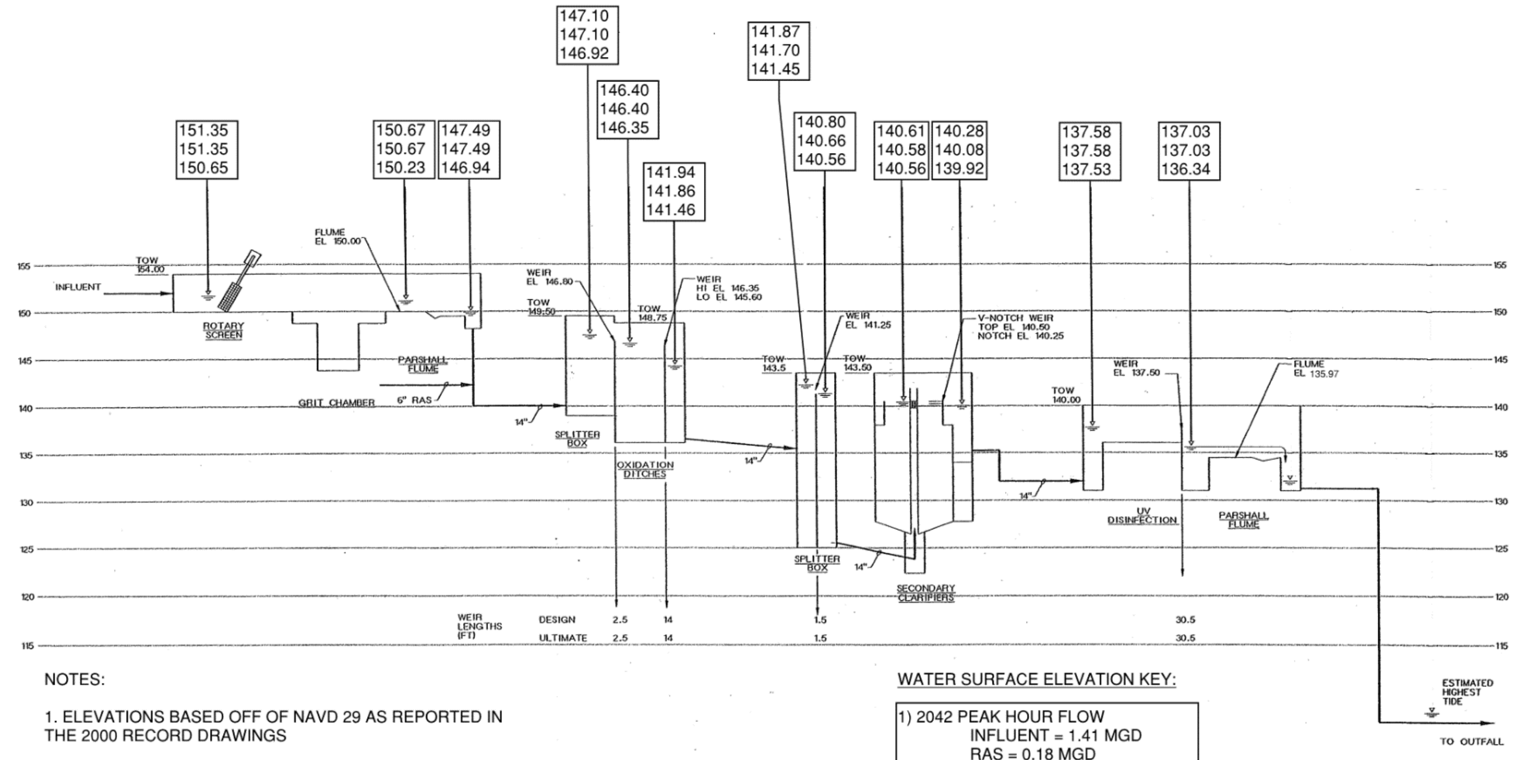
Following the secondary clarifiers, effluent flows through a UV disinfection channel and a Parshall flume before leaving the site in the 18-inch diameter effluent pipe. All components of the disinfection and effluent flow measurement structure have a hydraulic capacity that exceeds the 2042 PHF of 1.41 MGD per the model results. The outfall piping downstream of the Parshall flume and the outfall structure were not modeled.

The existing UV disinfection system has two UV banks with a total rated capacity of 1.60 MGD. The existing channel could be widened to accommodate additional UV lamps, which will increase the total capacity to greater than 2.54 MGD.

6.6.2.5 Summary

The hydraulic analysis indicates that all components of the Kingston WWTP have sufficient capacity to convey flows throughout the entire 20-year design period.

Figure 6-11 | Kingston WWTP Hydraulic Profile



NOTES:

1. ELEVATIONS BASED OFF OF NAVD 29 AS REPORTED IN THE 2000 RECORD DRAWINGS

2. OXIDATION DITCH WEIR ASSUMED AT HIGH POSITION FOR HYDRAULIC CALCULATIONS

WATER SURFACE ELEVATION KEY:

1) 2042 PEAK HOUR FLOW
INFLUENT = 1.41 MGD
RAS = 0.18 MGD
2/2 OXIDATION DITCHES
1/2 CLARIFIERS

2) 2042 PEAK HOUR FLOW
INFLUENT = 1.41 MGD
RAS = 0.18 MGD
2/2 OXIDATION DITCHES
2/2 CLARIFIERS

3) 2042 AVERAGE ANNUAL FLOW
INFLUENT = 0.27 MGD
RAS = 0.10 MGD
2/2 AERATION BASINS
1/2 CLARIFIERS

6.6.3 Secondary Treatment System Process Capacity

6.6.3.1 BioWin™ Model Development

The existing oxidation ditches and secondary clarifiers were modeled using BioWin™ software to determine the existing secondary process treatment capacity. The oxidation ditches, secondary clarifiers, and WAS storage tanks were sized in the model based on record drawings as summarized in earlier sections. BioWin™ does not have a process element for an oxidation ditch, so a loop of reactors is used with high recycle to simulate one instead. The process model was evaluated under both current and future AAF, MMWWF, and MMDWF conditions.

6.6.3.2 Influent Wastewater Characterization

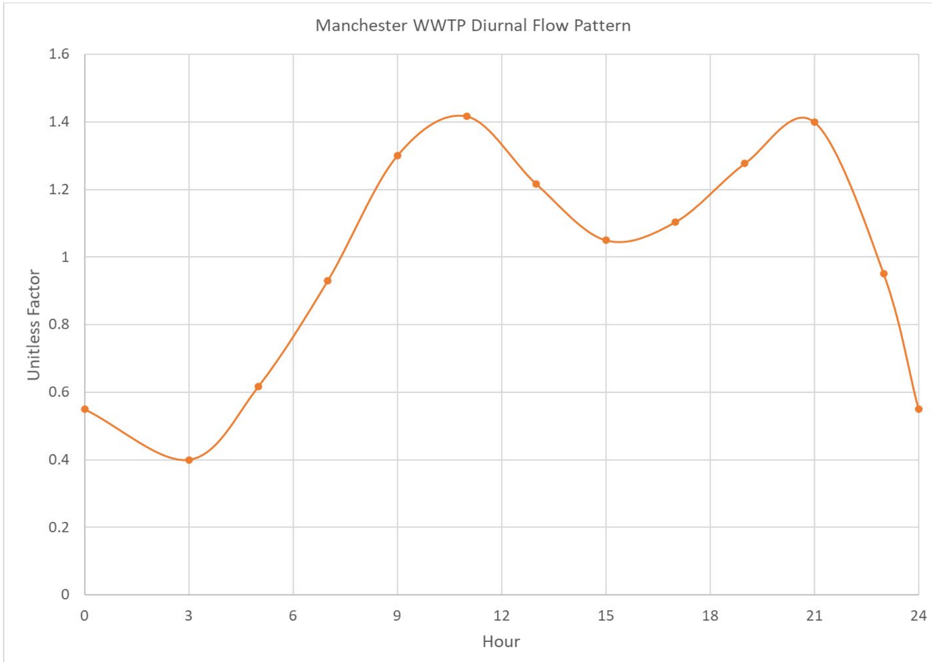
Following the sampling plan developed by Murraysmith [now Consor], County staff collected three wastewater characterization of influent and effluent composite samples in September 2020 including one on a weekend. The results of the wastewater characterization (**Table 6-15**) were included to develop the influent characteristics for the process model.

Table 6-15 | Average Influent Wastewater Characteristics

Parameter	Average Influent Value	Average Effluent Value
Total Chemical Oxygen Demand (COD) (mg/L)	614	Not Determined
Filtered COD (mg/L)	223	30
Flocculated and Filtered COD (mg/L)	112	Not Determined
Carbonaceous Biochemical Oxygen Demand (CBOD) (mg/L)	276	Not Determined
Filtered CBOD (mg/L)	72	Not Determined
TSS (mg/L)	298	2.9
Volatile Suspended Solids (VSS) (mg/L)	264	2.7
NH_3-N (mg/L)	37	0.4
NO_3-N & NO_2-N (mg/L)	2.67	14
TKN (mg/L)	57	1.9
Total Phosphorus (TP) (mg/L)	9.4	8.2
Orthophosphate (Ortho-P) (mg/L)	5.9	7.9
Alkalinity (mg/L)	326	169
Calcium (mg/L)	52	Not Determined
Magnesium (mg/L)	18	Not Determined
pH	7.46	7.39
DO (mg/L)	0.1	6.6

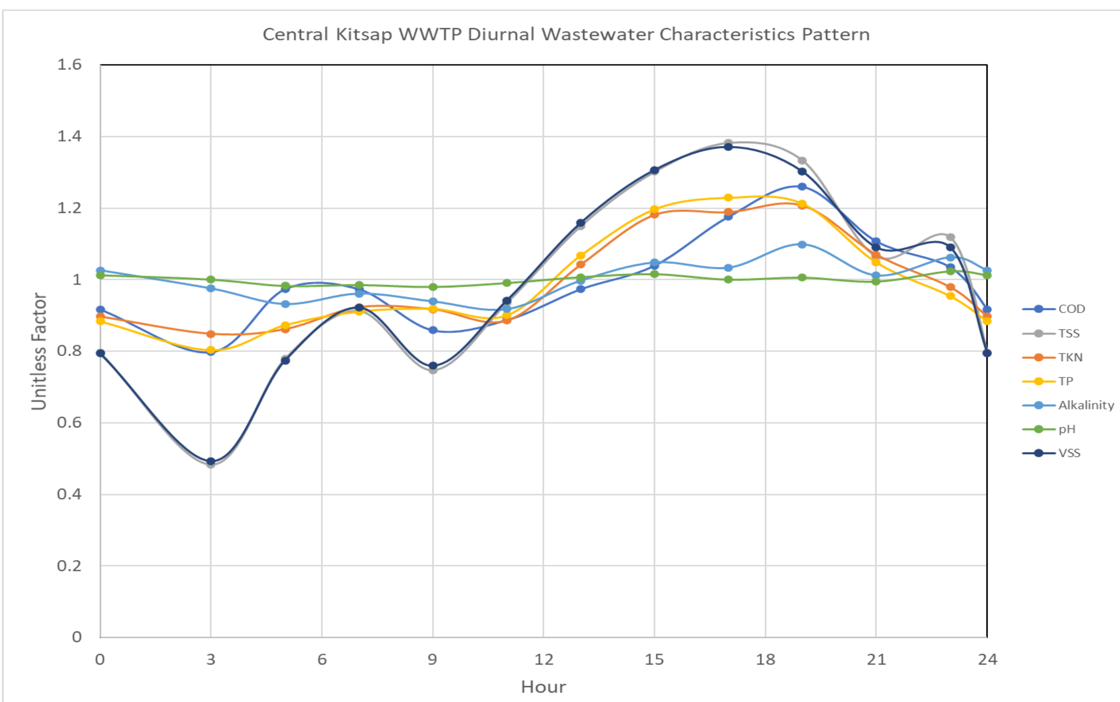
Since no hourly influent flow is recorded, the diurnal flow data from Appendix C of the 2014 Manchester Sewer Facilities Strategy Plan (BHC Consultants, October 2014) was used to simulate diurnal influent flow patterns. The County also operates the Manchester WWTP and it has a similar service area as the Kingston WWTP. The diurnal influent flow pattern is shown on **Figure 6-12.** In addition, diurnal influent wastewater sampling for COD, TSS, VSS, TKN, TP, Ortho-P, Alkalinity, and pH was performed at Central Kitsap WWTP on October 21, 2020 and were used as the basis of Kingston WWTP diurnal influent concentration pattern as shown on **Figure 6-13**. Both diurnal flow and concentration information was used in the process model dynamic simulations.

Figure 6-12 | WWTP Influent Flow Diurnal Flow Pattern



Source: 2014 Manchester Sewer Facilities Strategy Plan

Figure 6-13 | WWTP Influent Characteristics Diurnal Pattern



Source: Central Kitsap WWTP Wastewater Sampling Results, 2020

6.6.3.3 Treatment Requirements

Although Kingston WWTP is currently only required to meet the CBOD and TSS removal requirement and effluent CBOD and TSS concentration and load limits, and effluent pH and fecal coliform limits, the nutrient removal requirement will be applied soon. As part of the capacity evaluation for the plant, besides trying to meet the current permit requirements for CBOD of 25 mg/L and TSS of 30 mg/L on a monthly average basis, the plant was also evaluated for meeting a potential TIN concentration of 10 mg/L. It is anticipated the Nutrient General Permit will become more stringent with potential effluent TIN limit of 3 to 10 mg/L in the future. Potential alternatives to achieve as low as 3 mg/L will be discussed in the following section.

6.6.3.4 Oxidation Ditch Capacity

The results of various simulations at AAF, MMWWF, and MMDWF in 2020, 2028 and 2042 are shown in Table 6-16.

Under current 2020 flow and loads, one oxidation ditch with the current operation procedure can meet all the treatment goals on BOD, TSS, and annual TIN load. Although the mixed liquor suspended solids (MLSS) will get as high as 3,500 mg/L during the maximum month condition when 20-day of solids retention time (SRT) is maintained to promote nitrification and denitrification, the secondary clarifier settleability analysis (state point analysis in BioWin) indicates this high MLSS will not deteriorate the clarifier performance. This is supported by historical operational data that shows that the MLSS reached 3,000 mg/L and the effluent TSS was less than 15 mg/L.

As flow and loads increase over time, a second oxidation ditch will likely be required in the next six to eight years to maintain the same level of nitrification and denitrification to meet the same TIN cap. With two oxidation ditches in operation, the plant will have to drop the solids retention time down to 15 days by 2042 to account for the additional load and not overload the secondary clarifiers. In summary, the existing oxidation ditches have sufficient capacity to treat the projected 2042 TSS and BOD loads to meet the current NPDES permit limits and remove the projected nitrogen load to meet the potential TIN action level in the next 20 years. More detailed analysis on optimizing the oxidation ditches to meet more stringent nitrogen requirement will be discussed in the next section.

Table 6-16 | BioWin™ Process Model Simulation Results

Parameter	2020			2028			2042		
	AAF	MMWWF	MMDWF	AAF	MMWWF	MMDWF	AAF	MMWWF	MMDWF
Flow (MGD)	0.11	0.15	0.12	0.17	0.23	0.18	0.27	0.36	0.29
Temperature (°C)	15	11	22	15	11	22	15	11	22
Influent Alkalinity (mg/L)	330	330	330	330	330	330	330	330	330
No of AB Trains	1	1	1	2	2	2	2	2	2
DO Cycle (hrs)	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF
DO Target during ON Cycle (mg/L)	2	2	2	1.5	2	2	1.5	2	2
SRT (days)	38	20	20	30	20	13	15	15	18
MLSS (mg/L)	3,300	3,500	3,000	2,100	2,700	2,400	2,000	3,500	3,500
Effluent TSS (mg/L)	0.92	1.25	0.97	1.41	1.9	1.49	2.28	3.25	2.52
Effluent BOD (mg/L)	1.17	1.64	1.5	1.3	1.78	1.62	1.7	2.34	1.88
Effluent Ammonia (mg/L)	1	3.1	1.4	1	1.9	1.1	2	6.5	1.7
Effluent Nitrate and Nitrite (mg/L)	4.75	3.35	0.43	2.2	0.55	1.0	1.3	0.1	0.4
Effluent TIN (mg/L)	5.8	3.4	1.8	3.2	2.5	2.1	3.3	6.6	2.1
Annual Effluent TIN Load (ppd)	5			5			7		
Effluent pH	6.7	6.9	6.9	6.8	7.0	6.8	6.9	6.9	6.9
Effluent Alkalinity (mg/L)	119	219	167.5	139	217	158	178	220.5	168
WAS Solids (ppd)	172	362	309	276	548	483	500	969	802
WAS Tank Storage Capacity (days)	19	9	11	12	6	7	7	3	4
Thickened Biosolids (% solids)	5.1	5.4	5.1	5.4	5.4	5.4	5.4	5.4	5.4
Thickened Biosolids (ppd)	135	265	231	220	426	378	388	745	617
TWAS Storage Tank Storage Capacity (days)	50	27	29	33	17	19	19	10	12

6.6.3.5 Secondary Clarifier Capacity

Secondary clarifier capacity is mainly assessed based on the surface overflow rate. The typical secondary clarifier surface overflow rate under average flows is 400 to 700 gallons per day per square foot (gpd/sf). The typical secondary clarifier surface overflow rate under peak flows is 800 to 1,600 gpd/sf.

Ecology design criteria requires the secondary clarifiers to have sufficient capacity to pass 75 percent of the design flow when the largest unit is out of service. **Table 6-17** summarizes the surface overflow rate under various operating conditions. Modeling results indicate that one clarifier will be able to treat average flows through 2042. Both clarifiers will be required to handle the peak flows for reliable performance. The existing two clarifiers meet Ecology's redundancy requirement.

Table 6-17 | Secondary Clarifier Surface Overflow Rate

Parameter	AAF	MMWWF	PHF	75% of PHF	AAF	MMWWF	PHF	75% of PHF
Design Year	2028	2028	2028	2028	2042	2042	2042	2042
Flow (MGD)	0.17	0.23	0.87	0.65	0.27	0.36	1.41	1.06
No. of Secondary Clarifiers in service	1	1	2	1	1	1	2	1
Surface Overflow Rate (gpd/sf)	176	235	452	678	285	380	733	1,099

6.6.4 Solids Stream Capacity

The following sections discuss the capacity of each major component in the solids handling system.

6.6.4.1 WAS Tanks Storage Capacity

Sludge is currently wasted to the two 25,000 gallon WAS tanks at a rate of 3,000 to 7,000 gallons per day. At 5,000 gallons per day of wasting, WAS tanks currently have 10 days of storage capacity. At 2042 maximum month flows, the storage duration of the WAS tanks is reduced to three days based on BioWin™ model results presented in **Table 6-10**. The WAS tank storage duration could potentially be extended by slowing down the RAS pump speed and hence feeding a higher concentration of sludge to the WAS tanks. The TWAS storage could also be further utilized prior to building additional WAS storage by operating the GBT more frequently, i.e., every three days, to empty WAS tanks.

6.6.4.2 Gravity Belt Thickener Loading Rate

According to the 2005 design drawings for the Kingston WWTP, the GBT is designed for a hydraulic loading rate of 200 gpm. Once per week the GBT is run to empty the WAS tanks. **Table 6-18** summarizes the projected WAS production by the process model and the anticipated GBT operating hours each week when run at 200 gpm. The GBT has sufficient capacity to meet existing and future flow and loads.

Table 6-18 | Projected GBT Operation

Parameter	AAF	MMWWF	AAF	MMWWF	AAF	MMWWF
Design Year	2020	2020	2028	2028	2042	2042
WAS Solids (ppd)	172	362	276	548	500	969
Assumed WAS Concentration (mg/L)	8,000	8,000	8,000	8,000	8,000	8,000
WAS Flow (gpd)	2,600	5,400	4,100	8,200	7,500	14,500
GBT Operating Hours (hours per week)	1.5	3.2	2.4	4.8	4.4	8.5

6.6.4.3 TWAS Tank Storage Capacity

Sludge from the WAS tanks is thickened one day per week and sent to the 16,000-gallon TWAS tank. WAS concentration can range from 4,000 ppm to 9,000 ppm and is thickened from about 5 percent up to 6 percent solids. Current TWAS storage duration is approximately 50 days. In 2042, the BioWin™ model projects TWAS storage capacity of approximately 12 days. Therefore, TWAS storage capacity is not a limiting factor at the Kingston WWTP and is adequate for future flows.

6.7 Summary of Deficiencies and Recommendations

Table 6-19 provides a summary of the main findings for each unit process based on the condition assessment, code review, hydraulic analysis, and treatment capacity analysis described above.

Table 6-19 | Overall Unit Process Capacity and Deficiencies

Unit Process	Physical Condition[1]	Capacity	Recommendation
Preliminary Treatment			
Fine Screen	Very Good	2.6 MGD, peak	None
Grit Removal	Good	2.26 MGD, peak	None
Parshall Flume	Good	10.4 MGD, peak	None
Grit Pump and Classifier	Good	220 gpm	General maintenance practice on grit classifier to mitigate corrosion
Secondary Treatment			
Oxidation Ditches	Very Good	Over 0.36 MGD, maximum month	None
Oxidation Ditch Blowers	Very Good	528 scfm, firm	None
Oxidation Ditch Effluent Piping	Unknown	Over 1.62 MGD, peak	None
Flow Splitter to Clarifiers	Good	Over 1.62 MGD, peak	None
Secondary Clarifiers	Fair	Over 1.62 MGD, peak	General maintenance practice to mitigate corrosion
Secondary Clarifiers Effluent Piping	Unknown	Over 1.62 MGD, peak	None
RAS and WAS Pumps	Good	275 gpm, firm	None
Disinfection and Effluent			
UV System	Poor	1.6 MGD, peak	Replace entire system for improved control in the next 5 to 10 years
Effluent Parshall Flume	Good	2.5 MGD, peak	None
Solids Treatment			
Gravity Belt Thickener	Good	200 gpm	Evaluate ventilation in GBT room to minimize corrosion. General maintenance practice to mitigate corrosion Install fire alarm system in GBT room
WAS Storage Tanks	Good	50,000 gallons. WAS tanks' capacity could be a limiting factor in 2042.	System control to draw higher concentration WAS if needed.

Unit Process	Physical Condition[1]	Capacity	Recommendation
TWAS Storage Tank	Good	16,000 gallons	Install or repair LEL combustible gas sensors
Sludge Tank Blowers	Good	400 scfm, firm	None
Support Systems			
Odor Control	Good	N/A	None
W2 Water	Good	N/A	Clean the exterior of air gap tank and monitor for future overflow
W3 Water	Good	N/A	Repair or replace casing gasket on pump P-902
Power Distribution			
Electrical Service	Good	750 kVA service/800 amp main circuit breaker	None
Generator	Good	Generator has the capacity to fully power the plant during outages	None
MCCs	Good	N/A	Establish replacement plan for obsolete AFDs
Control Panels	Poor to Good	N/A	Complete arc flash study Verify back-up copies of all PLC and OIT programs; create and store if not created Spare parts for the PLC should be stored by the County in case of a failure Develop and execute a migration/replacement plan if OIT in CP-300 is used as a main point of control Verify whether there is a PLC in the LP-GBT or LP-TLP panel Clean and inspect the local control panel for the scum pump
Buildings			
Operations Building	Good	N/A	None
Process Building	Good	N/A	None

Notes:
SCFM: standard cubic feet per minute
1. Component condition rating based on **Table 6-3**

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SECTION 7

Collection and Conveyance System Analysis

7.1 Introduction

The Kingston collection system was modeled using the Danish Hydraulic Institute's (DHI's) MIKE+ hydraulic and hydrologic (H/H) modeling platform to determine capacity deficiencies in the system. Results were analyzed for the existing, 2042, and 2080 planning horizons using a 25-year 12-hour design storm. Selection of the design storm and other model information is included in the technical memorandum *Kingston and Suquamish Design Storm, Model Loadings, and Future Condition Parameters* (Murraysmith [now Consor], February 2022), included as **Appendix H**.

7.2 Capacity Criteria

The following criteria were used to determine if a collection and conveyance facility was capacity limited and in need of upsizing:

- Manholes are considered to have SSOs when the water surface elevation in a manhole exceeds the rim elevation. SSOs at manholes and pump stations are public health hazards and a source of contaminants that adversely impacts the water quality of streams, lakes, marine waters, and groundwater.
- Pipes are considered surcharged when the water surface elevation in the upstream or downstream manhole connection exceeds the pipe crown. This condition indicates that the sewer has reached flow capacity and hydraulic flow characteristics have worsened.
- Pipes with velocities exceeding 7 feet per second (fps) are considered capacity limited. High velocities cause increased scouring, wear of pipe materials, and shorten the useful life of pipe. High velocities also cause turbulent flow conditions and higher energy requirements for pumping equipment. This is primarily a factor for force mains.
- Pump stations are under capacity when the flow to a pump station meets or exceeds the pump station firm capacity. The firm capacity of a pump station is the pumping capacity of the station when the largest pump is out of service.

7.3 Analysis Results

The results of the modeling analysis are summarized in this section. Assets that were modeled as failing the criteria for the planning horizons are shown in **Figure 7-1**, **Figure 7-2**, and **Figure 7-3** and the total counts of SSOs and surcharged gravity pipes are included in **Table 7-1**. The pipe surcharge shown in **Table 7-1**, in **Figure 7-1**, and **Figure 7-2** flags any gravity pipe whose end node has a water surface elevation greater than the crown of the pipe at that node connection. Force mains are only considered under capacity if they fail the velocity criteria. Force mains and gravity pipes that fail the velocity criteria are shown in **Figure 7-3**.

Table 7-1 | Pipe and Manhole Capacity Criteria

Scenario	Surface Sewer Overflows (SSO)	Number of Pipes Surcharged (Either end)	Velocity Exceeding 7fps
2022	0	10	0
2042	0	10	3
2080	0	11	3

The model simulated PHF for each pump station in the Kingston basin is shown in **Table 7-2**. These results indicate that PS-41 and PS-71 exceed the firm capacity in all three planning horizons. Capital improvement projects will be recommended to increase the capacity at these stations. The pipe deficiencies shown in pipes in **Figure 7-1** and **Figure 7-2** immediately upstream of these two pump stations are due to the pump stations backing up, and not because the pipes cannot convey peak flows without the restriction at the pump station.

Table 7-2 | Pump Station Capacity and Peak Hour Inflows

Pump Station	Firm Capacity (gpm)	2022 Peak Flow (gpm)	2042 Peak Flow (gpm)	Build-Out Peak Flow (gpm)
PS-41	240	[441]	[562]	[596]
PS-42	80	35	43	47
PS-43	400	47	65	69
PS-52	31	19	27	29
PS-71	450	[609]	[792]	[840]
PS-72	95	35	43	46
PS-73	84	30	35	38

Note:
Flows exceeding the firm capacity are bracketed and in bold italics.

Deficiencies at pipes B28-3007-B28-3006 and B28-3006-B28-4090 are minor with approximately 6-inches of surcharge in the build-out scenario. B28-4064-B28-4TEE surcharges because the downstream invert of this 6-inch pipe is at the bottom of the downstream 12-inch pipe, so pipe flow greater than 50-percent in the 12-inch pipe can cause surcharging in the 6-inch pipe. Capital improvements to increase pipe conveyance capacity will not be recommended at this time based on these model results. Rather, it is recommended that the County continue to monitor these areas for evidence of surcharge.

7.4 Capital Improvement Plan Model Runs

Model runs were performed with improvements to both pump stations and pipe sizes to remove minor flow restrictions and to size improvements. These improvements are described in **Section 11**.

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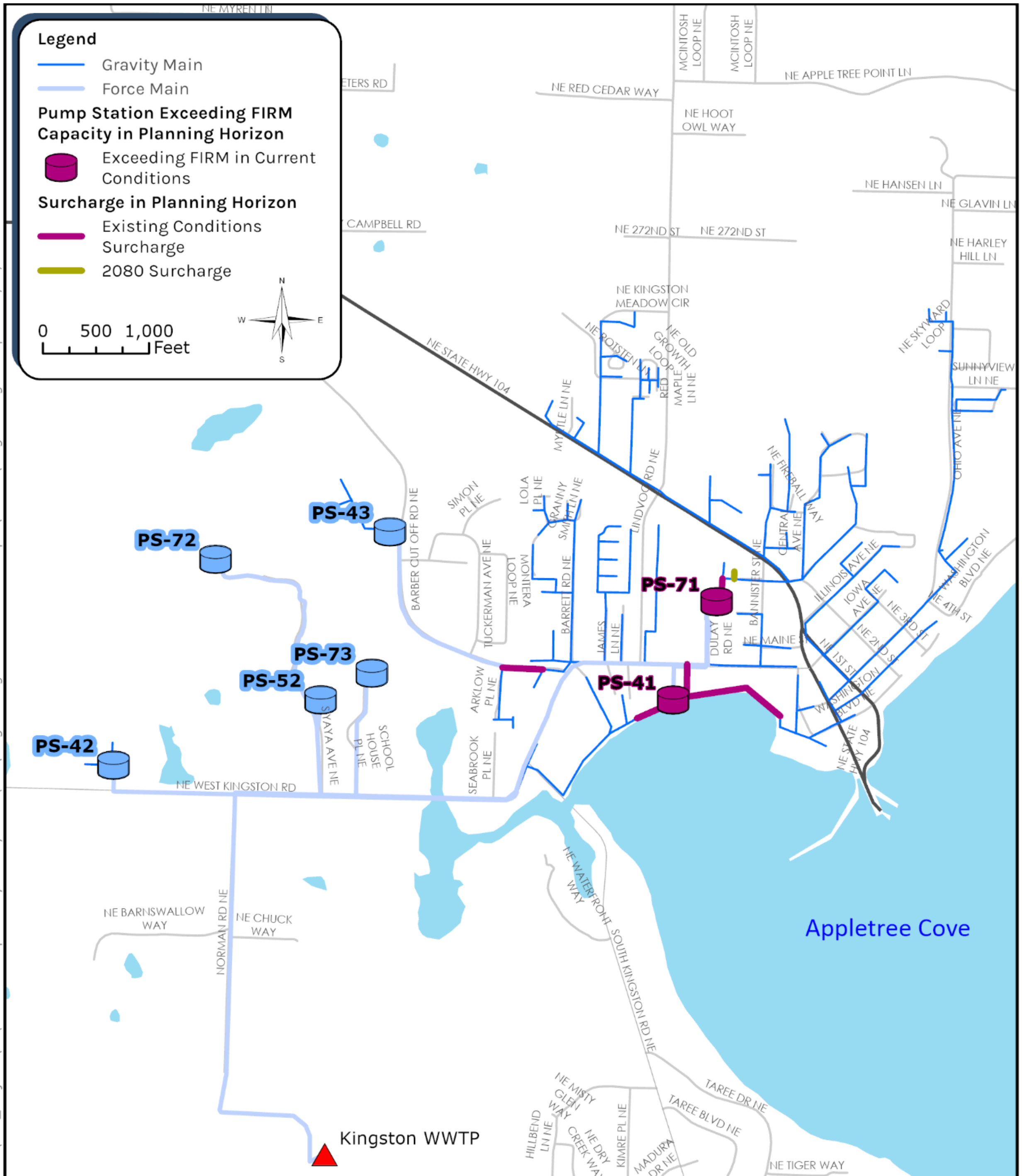
Figure 7-1 | Kingston Capacity Deficiencies



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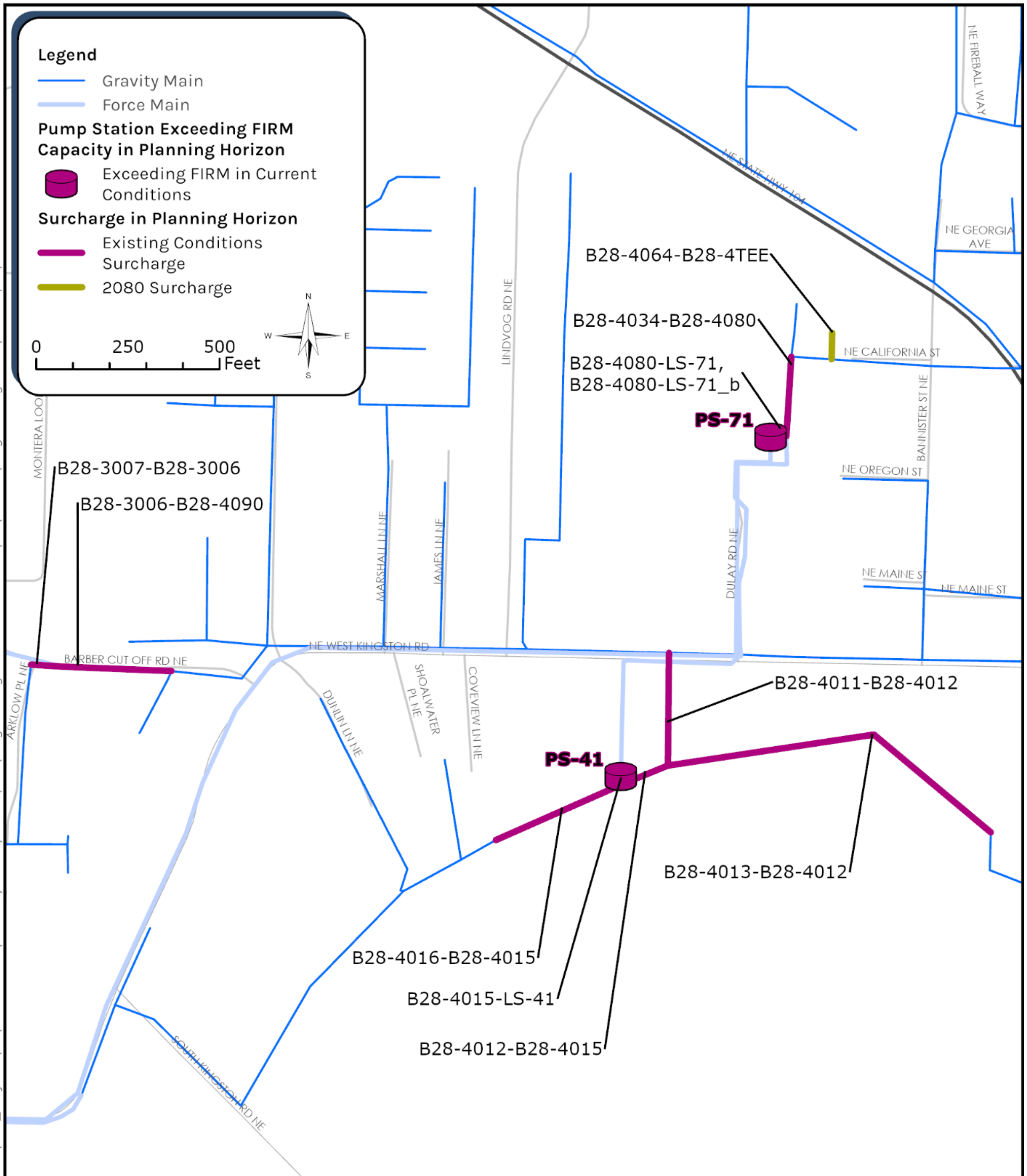
Kingston General Sewer Plan Update

System Analysis Results

consor

Figure 7-2 | Kingston Capacity Deficiencies Detailed Map



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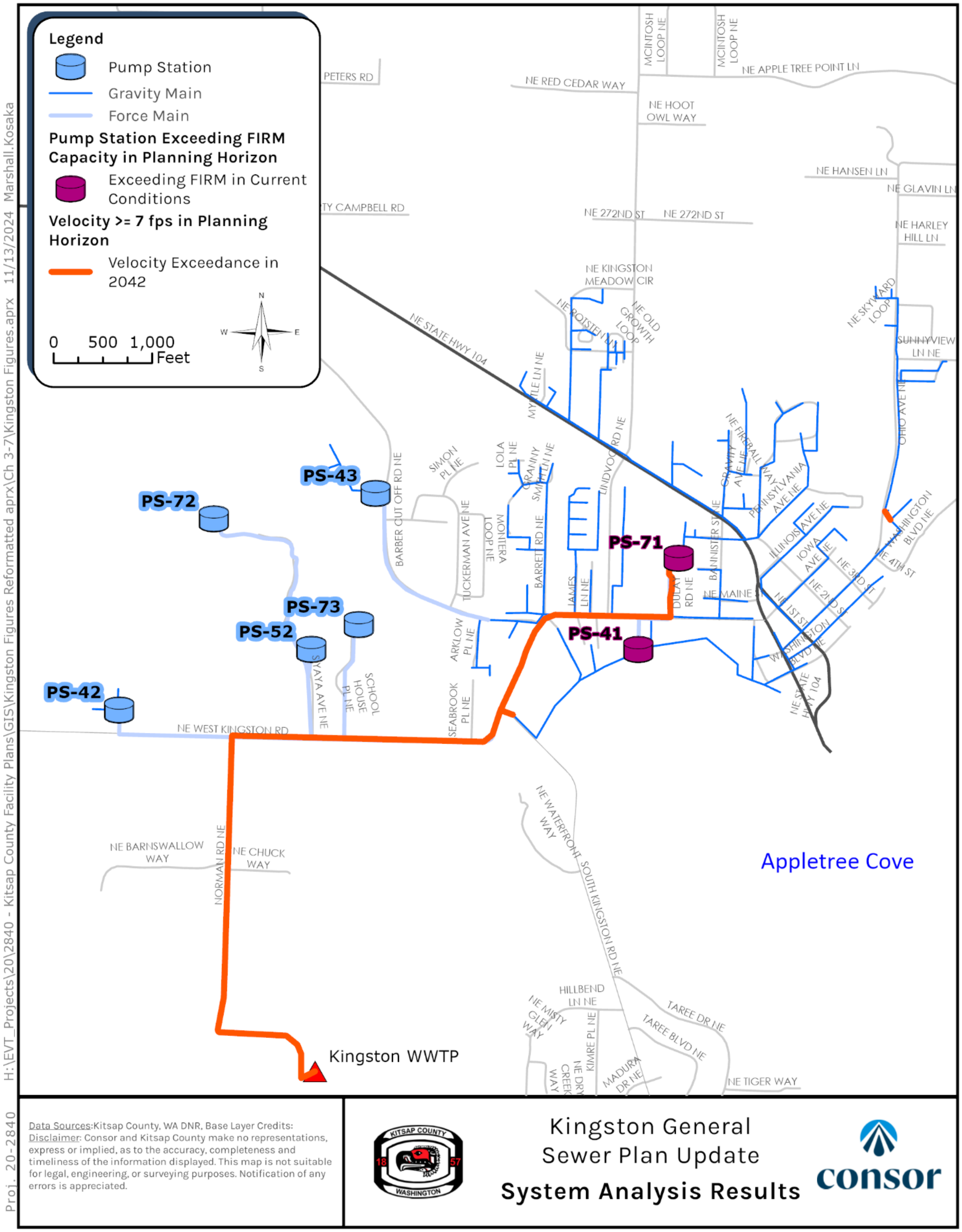
Kingston General Sewer Plan Update
System Analysis Results Detailed Map

consor

Figure 7-3 | Kingston Velocity Deficient Pipes



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SECTION 8

Wastewater Treatment System Analysis

The Kingston WWTP liquid stream improvement alternatives considered to improve the plant for the 6-year and 20-year planning horizons are described in this Section. Projected increases in flow and loading to the WWTP and aging equipment are the primary drivers for the improvements to allow the plant to consistently achieve the required effluent quality. The evaluation takes into consideration current deficiencies and the upgrades required, develops potential alternatives to achieve the expected treatment performance, and evaluates capital and life cycle costs.

The results of the condition assessment, capacity analysis, regulatory requirements, and projected flows and loadings, were used to identify processes that require improvement and define feasible alternatives for WWTP improvements. Minor maintenance, repairs, and direct replacements identified in the condition assessment **Table 6-19** are discussed briefly herein, but are not subject to a full alternatives analysis. These items as well as the preferred alternatives identified in this section will be included in the Capital Improvement Plan (CIP) in **Section 11**.

8.1 Overview of Improvements

Preliminary treatment components at Kingston WWTP include the Headworks Facility, a mechanical rotary screen, manual bar screen, and grit removal system. These components are generally in good or very good condition and have sufficient capacity, so no upgrades are required, and further analysis of alternative processes is not considered in this section. Kingston WWTP does not have any primary treatment processes.

Secondary treatment components at Kingston WWTP include two oxidation ditches, two secondary clarifiers, and associated support systems. The secondary clarifiers are in fair condition and require some general maintenance. Other components are in good or very good condition. All the secondary treatment components currently have sufficient capacity; however, implementation of the PSNGP has introduced new secondary treatment requirements and further changes the permit system are expected. Therefore, the capacity of the secondary treatment system will be examined more closely in this section.

The UV disinfection system condition is in poor condition and was identified in the condition assessment, **Section 6**, as the primary process requiring improvement. The process was reviewed, and two alternatives were identified and analyzed to select a preferred alternative to address the observed problems.

Each alternative is designated with a code identifying the location and alternative number as DIS (Disinfection)-#. Optimization and improvements will occur in the UV Facility.

- **Alternative DIS-1 Trojan UV3000B and Controller** replaces the existing Trojan UV3000B with a new version of the same system.
- **Alternative DIS-2 Trojan UV3000Plus and Controller** replaces the existing system with the upgraded Trojan 3000plus system which allows for greater operational control and monitoring.

No other UV manufacturers were considered in this analysis because the existing UV system is by Trojan. Replacing the existing UV system with Trojan system will require none to minimal modification to the existing UV channel.

Solids treatment at Kingston WWTP is provided by a GBT and includes WAS and TWAS storage tanks as well as blowers for the tanks. Some maintenance is needed in the GBT room to fix ventilation, address corrosion, and repair sensors, but otherwise all components are in good condition and have sufficient capacity, so further analysis of alternative processes is not considered in this section.

The odor control system was not functioning during the condition assessment visit but has since been repaired and may require further investigation. This will be discussed briefly in this section, but analysis of process alternatives is not necessary.

The non-potable water, process water, and power distribution systems are in good condition and have sufficient capacity, so no upgrades are required. Some equipment related to these systems will require in-kind replacement, but analysis of alternative processes is not considered in this section.

Figure 8-1 shows the site plan of WWTP with the unit process requiring improvement identified. **Table 8-1** provides a summary of the alternatives.

Table 8-1 | Treatment Improvement Alternatives Summary

Alternative Number	Alternative Name	Alternative Description	Deficiency Addressed
DIS-1	UV Disinfection – Trojan UV3000B and Controller	Replace the existing Trojan UV 3000B with a new unit; replace the basic controller with the touch smart controller; install a UV transmittance probe	Disinfection
DIS-2	UV Disinfection – Trojan UV3000Plus and Controller	Replace the existing Trojan UV 3000B with an upgrade version – Trojan UV 3000Plus with touch smart controller and UV transmittance probe	Disinfection

Figure 8-1 | Overview of Improvement Alternatives at the Kingston WWTP

8.2 Opinions of Probable Project Costs

Class 5 opinions of probable project costs (OPPC) for the 20-year planning period were developed for each alternative. The Class 5 OPPCs were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering International (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.*

The OPPCs were developed using RSMeans Heavy Construction Cost Data, recent County project bid tabs, County input, industry 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 Consumer Cost Index for use in project budgeting. The OPPC includes both construction and project costs. The construction costs include construction work and materials plus markups for mobilization, general contractor markups, overhead, and profit, taxes, and a construction contingency of 30 percent. The project costs account for a markup of 25 percent for engineering, legal, and administration costs associated with project delivery.

The O&M costs and the 20-year net present values were also developed based on the following assumptions:

- Labor cost: $60/hour
- Electricity Cost: $0.10/kWh
- Discount rate: 3 percent
- Inflation rate from 2023 to 2024: 12 percent
- Inflation rate from 2025 to 2026: 8 percent
- Long term inflation: 5 percent

8.3 Secondary Treatment Improvements

8.3.1 Existing Condition Description

Two oxidation ditches provide secondary treatment at Kingston WWTP. Aeration is accomplished by a fine bubble diffuser system. Air is supplied by three positive displacement blowers (two duty, one standby) in the adjacent Blower Building. DO probes and ORP probes are used to assist in process monitoring.

According to the assessment in **Section 6**, the secondary treatment structures are in very good condition and will last for at least another 50 years. The oxidation ditches currently have sufficient capacity to be operated one at a time, and operation is alternated once per year. Two submersible mixers and the monitoring probes are moved between the oxidation ditches when they are rotated. The blowers are currently operated on a time basis and function properly. However, the process control could be improved by adding ammonia and nitrate probes to directly measure these constituents.

8.3.2 Nitrogen Removal Criteria

Ecology issued the PSNGP on December 1, 2021. The permit is effective on January 1, 2022, and expires on December 31, 2026. Kingston WWTP is categorized as a small TIN load plant. Though the permit does not specify an action level of TIN load for small TIN load plants, an AKART analysis is required for permittees who cannot maintain an annual average TIN of less than 10 mg/L. Thus, staying below the existing TIN load and achieving an annual average TIN of 10 mg/L through optimization is the goal for the secondary treatment process.

Future nutrient limits beyond the 2026 expiration of the permit have not been determined, but Ecology has indicated the target for future permits will likely be between 3 and 10 mg/L, and the permit requires a "Nutrient Reduction Evaluation" which includes consideration of technologies capable of achieving 3 mg/L seasonally for Dominant and Moderate load WWTPs.

As detailed in **Section 6** and shown in **Table 8-2** below, Kingston WWTP is capable of meeting an annual average TIN concentration below 10 mg/L both currently and under projected 2028 and 2042 flows and loads. With an expected 2042 average annual effluent TIN of 3.3 mg/L, the expected capacity of the plant is very close to the lower limit of target TIN concentrations identified by Ecology. Implementation of a reclaimed water program would also reduce effluent TIN loading and is discussed in **Section 9**.

Table 8-2 | Secondary Treatment Process Model Simulation Results

Parameter	2028			2042		
	AAF	MMWWF	MMDWF	AAF	MMWWF	MMDWF
Flow (MGD)	0.17	0.23	0.18	0.27	0.36	0.29
Temperature (oC)	15	11	22	15	11	22
Influent Alkalinity (mg/L)	330	330	330	330	330	330
No of AB Trains	2	2	2	2	2	2
DO Cycle (hrs)	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF	4 ON/2 OFF
DO Target during ON Cycle (mg/L)	1.5	2.0	2.0	1.5	2.0	2.0
SRT (days)	30	20	13	15	15	18
MLSS (mg/L)	2,100	2,700	2,400	2,000	3,500	3,500
Effluent TSS (mg/L)	1.41	1.90	1.49	2.28	3.25	2.52
Effluent BOD (mg/L)	1.30	1.78	1.62	1.70	2.34	1.88
Effluent Ammonia (mg/L)	1.0	1.9	1.1	2.0	6.5	1.7
Effluent Nitrate and Nitrite (mg/L)	2.2	0.55	1.0	1.3	0.1	0.4
Effluent TIN (mg/L)	3.2	2.5	2.1	3.3	6.6	2.1
Annual Effluent TIN Load (ppd)	5	-	-	7	-	-

Since Kingston WWTP already has the capacity to meet the 10 mg/L TIN AKART trigger throughout the planning period and the capacity to provide TIN treatment near the lowest future proposed limits, an analysis of secondary treatment alternatives is not necessary and is not included in this section.

8.4 UV Disinfection Alternatives

8.4.1 Existing Condition Description

According to the assessment in **Section 6**, the existing UV system is a two-bank Trojan UV3000B installed in 2005 and has about 2 to 10 years of remaining life. This model has a basic controller which can automatically alternate the lead and lag UV banks and monitor the bank run time, bank on/off status, a common alarm, and UV intensity. However, the basic controller cannot turn off the bank based on the flow signal. Plant staff cleans the UV lamps manually. It is recommended to replace the entire UV system with a new system that has additional monitoring and control capabilities, and cleaning capabilities.

8.4.2 DIS-1 UV Disinfection – Trojan UV3000B and Controller

For DIS-1, the existing Trojan UV3000B will be removed and replaced with a new UV3000B system (**Figure 8-2**), the basic controller will be replaced with a touch smart controller, and a new UV transmittance probe will be installed. This alternative will be able to monitor and control several operational parameters requested by operators including tracking bank lamp life, switching banks/bringing them on and off, tracking and alarming on UV intensity, and monitoring UV transmittance. However, the UV3000B unit can only be controlled based on flowrate, not UV dose, and the touch smart controller of UV3000B does not monitor the individual lamp On/Off status.

The manufacturer Trojan provided the recommended system design based on the 2042 peak flow condition and the state disinfection requirements of one bank shall handle 50 percent of the design PHF. A new UV3000B system will have two banks in a lead/lag operation with a total 64 lamps. The new UV banks can be placed in the existing UV channel without any modification to the UV channel.

Figure 8-2 | DIS-1 Trojan UV3000B System

8.4.3 DIS-2 UV Disinfection – Trojan UV3000+ and Controller

For DIS-2, the existing Trojan UV3000B system will be replaced with an upgraded model, the Trojan UV3000Plus (**Figure 8-3**). This alternative will provide all the monitoring control functionality of alternative DIS-1 and will provide flow rate adjustable intensity and additional monitoring capability including individual lamp failure status. It has a knob to adjust intensity and has an option of automatic cleaning system. With the touch smart controller, the system will be able to monitor the individual lamp status and dose pacing.

The manufacturer Trojan provided the recommended system design based on the 2042 peak flow condition and the state disinfection requirements of one bank shall handle 50 percent of the design PHF. Under the

2042 peak flow design condition, two banks will be installed in the existing channel with three UV modules per bank and six lamps per UV module, equating to 36 lamps. The new UV banks can be placed in the existing UV channel with minor modifications to the baffles to adjust the channel width.

Figure 8-3 | DIS-2 Trojan UV3000Plus System

The comparison of the existing basic controller, touch smart controller for UV 3000B and touch smart controller for UV 3000Plus are summarized in **Table 8-3**.

Table 8-3 | UV System Controller Capability Comparison

Capabilities	Current: Basic Controller for UV 3000B	DIS-1: Touch Smart Controller for UV 3000B	DIS-2: Touch Smart Controller for UV 3000Plus
Configuration			
Max. # of Channels	1	2	2
Max. Modules/bank	20	20	32
Max. Banks/channel	3	3	3
Control			
Flow Pacing	Yes	Yes	No
Dose Pacing	No	No	Yes
Individual Lamp Status	No	No	Yes
Lead Bank Rotation	Automatic	Automatic or Manual	Automatic or Manual
Redundant Bank Logic	No	Yes	Yes
Multiple Lamp Failure	No	No	Yes
Module Failure Alarm	No	No	Yes
Bank Communication Alarm	No	No	Yes
USB Data Logging	No	Yes	Yes
Remote Control Capabilities			

Capabilities	Current: Basic Controller for UV 3000B	DIS-1: Touch Smart Controller for UV 3000B	DIS-2: Touch Smart Controller for UV 3000Plus
Force System On/Off	No	Yes	No
Turn On Additional Bank (if available)	No	Yes	No
Remote Monitoring Capabilities			
SCADA	No	Yes	Yes
Bank Status	Yes	Yes	Yes
Common Alarm	Yes	Major, Minor	Critical, Major, Minor
Low UV Intensity Alarm	No	Yes	Yes
Bank UV Intensity Alarm	No	Yes	Yes
Average UV Intensity	No	Yes	No

8.4.4 UV Disinfection Cost Analysis

Class 5 OPPCs for the UV disinfection alternatives were developed as described in **Section 8.2** and are summarized in **Table 8-4**. The total project cost for the UV3000B system is lower than the UV3000Plus system because the equipment is less expensive, however, the annual operating costs are higher, so over the 20-year lifecycle the UV3000Plus system will cost approximately $25,000 less.

Table 8-4 | UV Disinfection Alternatives Cost Estimate

Alternative Number	Alternative Name	Project Cost	O&M 20-year Net Present Cost	Total 20-year Net Present Cost
DIS-1	UV Disinfection – Trojan UV3000B	$ 594,000	$ 445,000	$1,039,000
DIS-2	UV Disinfection – Trojan UV3000Plus	$ 809,000	$ 205,000	$1,014,000

8.5 Odor Control Improvements

8.5.1 Existing Condition Description

The odor control system consists of a biofilter with a fan, humidifier, and heater to provide appropriate filter conditions. The biofilter provides odor control for the entire WWTP, including the headworks, WAS tank, TWAS tank, and GBT room. The biofilter and associated equipment is in good condition but was turned off during the condition assessment because the media had collapsed. The County has since excavated and recovered the filter media and report that the filter is running well again.

8.6 Recommendations

This section provides a recommendation for each process based on the performance and cost analysis of alternatives which includes both capital costs and long-term O&M costs.

8.6.1 Secondary Treatment

Kingston WWTP already has the capacity to meet the 10 mg/L TIN AKART trigger throughout the planning period and to provide TIN treatment near the lowest future proposed limits, so major improvements to the secondary treatment process are not needed. The County should complete the Nitrogen Optimization Plan and implement low-cost improvements to assist in optimization as required by the PSNGP, including installing ammonia and nitrate probes in the oxidation ditch. These probes will provide direct monitoring of nitrogen removal processes and will assist operators in making well informed adjustments to process operation.

8.6.2 Disinfection

Alternative DIS-2 is recommended as the disinfection alternative because it provides greater functionality and efficiency. Although the capital cost is higher, the 20-year net present value is less than DIS-1, and the increased efficiency and reduced maintenance makes this alternative more favorable.

8.6.3 Odor Control

During the condition assessment strong odor and corrosion was noted in the GBT room. The odor should be reduced now that the odor control system is running again, but the corrosion may indicate that the HVAC system is not providing enough ventilation. Further investigation of the HVAC system is recommended to determine if upgrades are needed.

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SECTION 9

Recycled Water

Recycled water provides multiple potential benefits from wastewater management, water supply, and environmental enhancement perspectives. Because of these benefits, the County identified recycled water as a key strategy in its *Water as a Resource* policy, adopted in 2009 and reaffirmed in 2016, which aims to conserve groundwater resources, restore the natural hydrologic flow in local streams and creeks, and reduce water pollution. In short, implementation of recycled water efforts would be a direct expression of the County's guiding principle to preserve water as a resource rather than treating it as a waste stream. This section summarizes the County's assessment to date of the potential for developing and implementing a recycled water program involving the Kingston WWTP.

9.1 Recycled Water Regulatory Framework

Wastewater that is reused for beneficial purposes in a municipal context must meet certain regulatory and water quality requirements. In Washington, recycled water (also referred to as reclaimed water) is defined in WAC 173-219 as: "water derived in any part from a wastewater with a domestic wastewater component that has been adequately and reliably treated to meet the requirements of WAC 173-219, so that it can be used for beneficial purposes." As such, recycled water is no longer considered a wastewater once it is put to use.

WAC 173-219 defines the requirements and constraints pertaining to the use of recycled water for a wide range of purposes. Recycled water permits are issued by Ecology and DOH. Ecology is generally the lead permitting agency, with the primary exception being when the source water is generated by an on-site sewage system with a design flow of less than or equal to 100,000 gpd.

There are three classes of recycled water defined in WAC 173-219: Class B, Class A, and Class A+. These are defined by varying degrees of treatment and water quality, and are each applicable for various uses, as summarized below.

- Class B (meets oxidation and disinfection requirements) recycled water can be used for some construction and industrial purposes, and certain irrigation uses where access to the general public is restricted.
- Class A (meets Class B requirements, plus coagulation and filtration, or use of membrane filtration) recycled water can be used for a wide range of commercial uses (such as toilet/urinal flushing and street sweeping) and irrigation of areas that have open access to the public. This can also be used for groundwater recharge, assuming additional requirements are met, such as nitrogen limits.
- Class A+ (meets Class A requirements, plus additional needs to be health protective, as defined on a case-by-case basis) is required for direct potable reuse (i.e., drinking or direct ingestion).

The public access restriction requirements for Class B are typically difficult to meet for a municipal entity like the County, whereas Class A does not require access restriction, so Class A has a wider range of potential uses. Therefore, it is water of this quality that is considered in this Plan when evaluating potential reuse opportunities. While opportunities for use of lower quality water may exist, they are anticipated to be few in number with very limited benefit being received, based upon the experience of other Puget Sound utilities.

9.2 Prior Recycled Water Planning Efforts

In 2003, the County began assessing opportunities for using recycled water that could be produced at Kingston WWTP to meet an array of long-term water resource management objectives. Multiple studies have been conducted over the two decades since then, culminating in the development of a conceptual plan for how a recycled water program could be implemented in the Kingston area. The recent County recycled water planning efforts include:

- Kingston Reclaimed Water Environmental Feasibility Study (September 2010).
- Kingston Recycled Water Project Report (February 2016).
- *Kingston Recycled Water Facility Plan* (Brown and Caldwell, March 12, 2020), see **Appendix I**. This document, building upon the previous efforts, was prepared in part with federal funding through the United States Bureau of Reclamation WaterSMART Title XVI Water Reclamation and Reuse Program to satisfy the requirements for a Title XVI Feasibility Study. This is referred to hereafter as the 2020 Feasibility Study.

In addition, the concept of generating and using recycled water in Kingston was included in a watershed planning effort facilitated by Ecology for Water Resource Inventory Area (WRIA) 15, as directed by the Streamflow Restoration Act (RCW 90.94). This activity is documented in the *WRIA 15 Watershed Restoration and Enhancement Plan* (March 1, 2022). The evaluation presented in that document is based on the technical work conducted by the County and builds upon the broader water resource management benefits that a recycled water program could provide in this geographic area.

9.3 Benefits and Potential Uses

Recycled water can provide numerous benefits. Specific environmental benefits associated with the envisioned recycled water program at Kingston are summarized below.

- **Conserve limited groundwater resources**. Water use in the Kingston area is sourced from groundwater pumped primarily from the sea-level aquifer. This is a limited resource, with aquifer levels susceptible to decline as local water demand increases. In addition, saltwater intrusion can occur if groundwater levels are withdrawn below certain thresholds. Use of recycled water to replace the use of potable water for nonpotable purposes, especially during peak use times (i.e., summer irrigation season), reduces the stress on area groundwater and supports sustainable management of that limited resource.
- **Reduce marine water discharge**. Recycled water is being increasingly explored around Puget Sound as a means to reduce wastewater discharge (and therefore reduce nitrogen loading) to marine waters and comply with more restrictive wastewater discharge permit requirements, such as those established by the recently enacted PSNGP. Such actions serve to protect and improve marine water quality, which in turn improves fish and shellfish habitat by reducing the overpopulation of phytoplankton and zooplankton and avoiding development of algal blooms.

- **Restore and replenish streams and fish habitats**. Recycled water can be used to directly augment streams and wetlands and can be used to indirectly influence them through recharge of groundwater that supports such features.

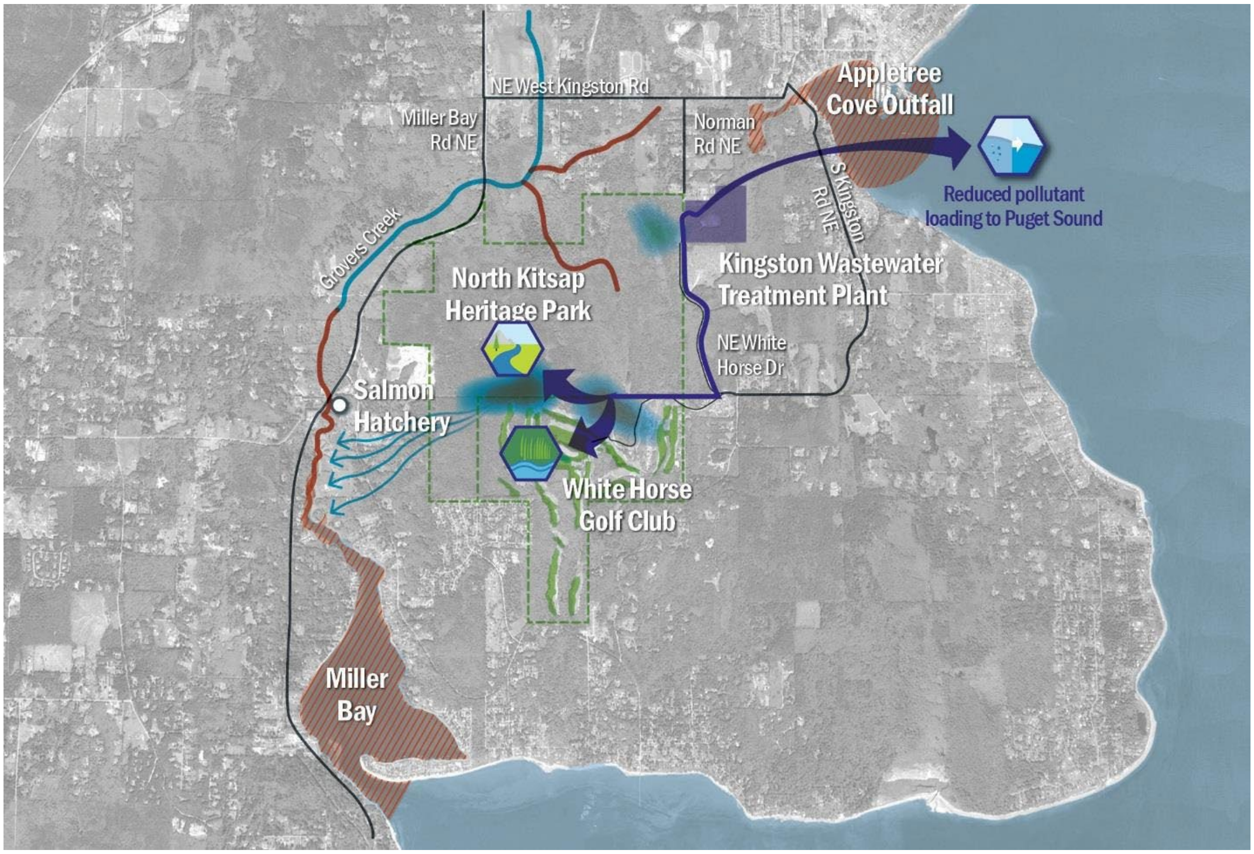
Prior County planning has resulted in the definition of a potential recycled water project that would realize all the above benefits. As described in detail in the 2020 Feasibility Study, the two applications deemed most feasible for recycled water use if it were produced at the Kingston WWTP are:

- Summer-time irrigation at the White Horse Golf Course (WHGC).
- Winter-time indirect groundwater recharge in an area north of WHGC, at North Kitsap Heritage Park.

The envisioned recycled water project would replace 29 MG per year of groundwater supply provided by KPUD for irrigation purposes at WHGC, which is owned and operated by the Suquamish Tribe. The golf course uses water mostly during May through September, with average water demands in the peak month of July being approximately 300,000 gallons per day.

In addition, the project would involve infiltration of approximately 107 MG per year into the shallow aquifer that provides baseflow to Grovers Creek and its tributaries. Through this bolstering of groundwater levels, the WRIA 15 Watershed Plan estimates that baseflow in Grovers Creek could increase by up to 0.5 cubic feet per second, potentially providing 328 acre-feet per year to serve as an offset to consumptive impacts of new permit-exempt domestic groundwater withdrawals. **Figure 9-1** provides a conceptual view of the proposed project.

Figure 9-1 | Conceptual-Level Map of Kingston Recycled Water Project



(Source: Figure 1-1 of 2020 Feasibility Study)

As part of development of this Plan, a cursory review of other potential uses of recycled water in the Kingston area was conducted. An investigation was made into the possibility of irrigation of other turf/landscaped areas. The County coordinated with water providers and other potential stakeholders to determine if there were any such opportunities for this type of recycled water use in the vicinity of the Kingston WWTP. Entities contacted were:

- Kitsap Public Utility District. The County discussed recycled water potential uses with KPUD staff in March 2023. KPUD has actively researched recycled water opportunities throughout portions of its service area and has implemented a system in Port Gamble. Key benefits of this resource to KPUD are the potential to relieve stresses on groundwater supplies during peak use periods and provide a tool for water rights mitigation efforts. In addition to the potential for irrigating the WHGC (as noted previously) and other sites examined in previous studies, KPUD staff noted that there are new housing developments occurring in this area, such as Arborwood, where there may be potential for integrating recycled water as a source of irrigation water into the planning of future phases. Additional coordination with that development group would be required to determine the level of feasibility of implementing such uses.

- Kitsap County Parks Department. A discussion was held with Kitsap County Parks Department staff in January 2022, regarding the possibility of irrigation of turf/landscaped areas managed by the County. It was determined that, based on locations of other irrigable areas and their relatively small amount of associated water consumption, there are no sites where recycled water use would be cost-effective.

Further investigation into other uses was not conducted, due to the comprehensive nature of the previous efforts already completed.

9.4 Capital Improvements

To produce Class A reclaimed water for the proposed irrigation and infiltration uses described in **Section 9.3**, upgrades to Kingston WWTP are required. Key components, the details of which are provided in the 2020 Feasibility Study, are:

- Modifications to the existing oxidation ditch, including upgrades to the aeration and mixing components of the oxidation ditch, are needed to provide for greater nitrogen removal to support groundwater infiltration. Some of these improvements were made to the WWTP in 2020, including installation of fine bubble diffusers and submersible mixers. Therefore, with additional improvements such as ammonia and nitrate probes, nitrogen removal should be achievable to levels required for groundwater infiltration.
- A secondary effluent equalization tank, to hold flows that exceed the design capacity of the recycled water disinfection and conveyance systems.
- A filter feed pump station, to direct flow from the biological process to tertiary filtration.
- Tertiary filtration, comprised of upflow sand filtration.
- UV light disinfection, followed by chlorination to provide for a chlorine residual.
- A recycled water pump station to introduce recycled water into the distribution system.
- A recycled water pipeline to convey the finished product to WHGC and the infiltration site.

The 2020 Feasibility Study presents a conceptual layout and sizing of facilities to produce 0.7 MGD of recycled water, based on predicted 2040 PDF rates considered in that analysis. Total capital costs associated with these improvements are estimated at approximately $13.7 million.

These projects are included in the CIP in **Section 11**, to continue to advance the project and support the County's efforts to obtain funding for the recycled water program.

9.5 Future Steps

As the County continues advancing the proposed recycled water project at Kingston WWTP, key implementation considerations that will be taken into account, beyond technical feasibility, costs, and water quantity/quality benefits, include those described briefly below. These items will be explored in greater depth as the County advances in its planning process.

- **Regulatory Requirements**. One of the more rapidly changing elements that will shape future recycled water programs are water quality requirements related to currently unregulated chemicals. In particular, the water industry's current focus on per- and polyfluoroalkyl substances (PFAS) will likely yield State or federal drinking water limits that are lower than the State Action Levels established for five PFAS compounds in 2021. This may lead to certain additional forms of treatment being required to produce recycled water suitable for purposes such as groundwater recharge or streamflow augmentation.

- **Funding**. The capital investment to implement reuse can be significant and is greater than what can be realistically recouped through recycled water rates. Most utilities seek low-interest loans or grant money from the State or federal government to support reuse implementation. At the State level, this includes funding through the Centennial Clean Water Fund, while at the federal level this can include funding through the WaterSMART Title XVI program.

- **Stakeholder and Public Outreach**. The County has had extensive coordination with the Suquamish Tribe during development of the proposed recycled water project. Continued collaboration with the Tribe, along with general public involvement, is critical to the success of this effort, largely in relation to the above two topics of water quality and funding. The public will want assurance that proposed reuse practices are protective of public and environmental health. In addition, the full range of benefits must be articulated so that the community can truly assess costs versus benefits, and understand how investment in reuse relates or compares to other priorities the County is facing.

- **Implementation Policies and Procedures**. Recycled water programs require much more than the upfront capital infrastructure. County policies will be needed to establish when, where, and how recycled water can be used and what the applicable rates are for customers who would use the resource. Depending on the extent of infrastructure that may be needed in the future, development standards may be required, including maintenance procedures specific to purple pipe distribution systems, water quality monitoring/reporting, and backflow prevention.

SECTION 10

Operations and Maintenance

10.1 Introduction

The County's Kingston sewer collection and conveyance system, WWTP O&M program, and review of State and Federal requirements that impact the County's O&M program are summarized in this section. Current department organization and staffing is presented, and future staffing needs are also discussed. Comments, observations, and recommendations to improve the efficiency and effectiveness of the County's O&M program are provided at the end of this section. Key O&M elements that have the potential to impact the CIP are carried forward and further discussed in the following sections.

10.2 Utility Management and Structure

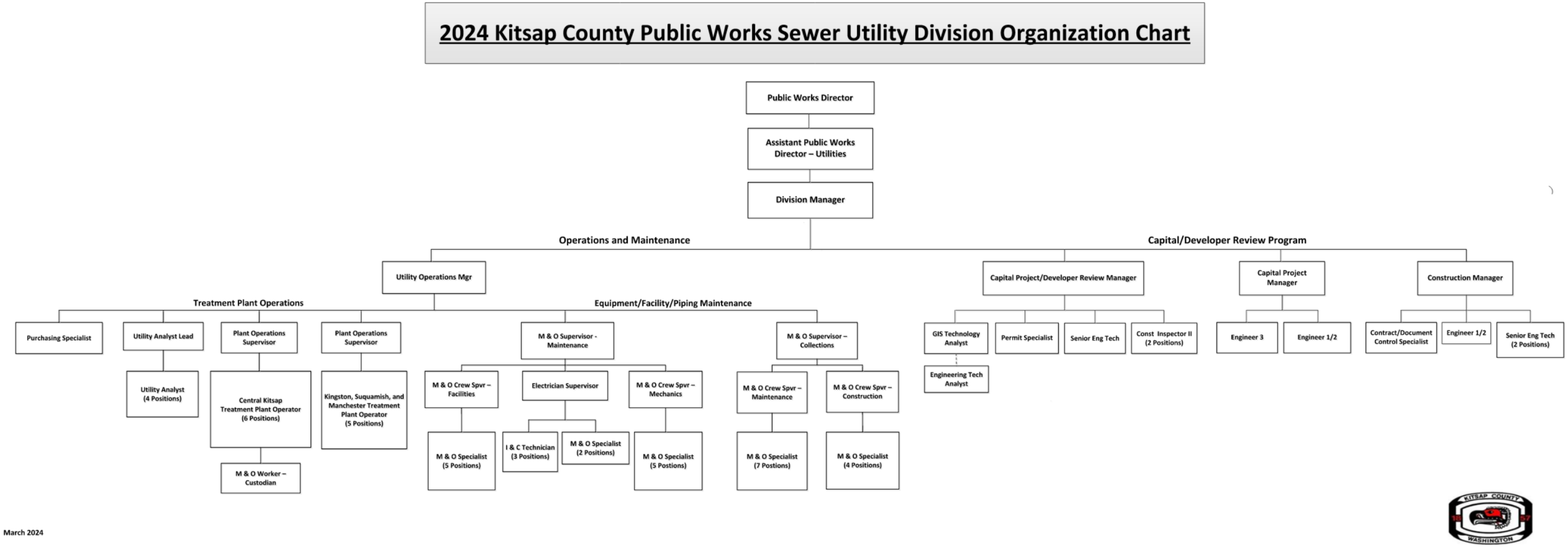
The County is managed by a three-person Board of County Commissioners, who are elected officials that represent one of three geographical districts. The Kitsap County Department of Public Works is responsible for management of County roads, recycling and solid waste, sewer, and stormwater, with separate Divisions for each. The Sewer Utility Division is responsible for O&M of both the sewer collection system and the County's four WWTPs. The organizational chart for the Sewer Utility Division is shown as **Figure 10-1**.

The Sewer Utility is led by the Sewer Utility Senior O&M Manager, who reports to the Public Works Assistant Director. A total of 72 staff currently work in the Sewer Utility Division. The Sewer Utility Division consists of four main work groups: Utilities (Plant and Pump Station) O&M, Field (Collection) Operations, Engineering and Administration, and Construction Management.

The Utilities (Plant and Pump Station) O&M is led by the Utilities Operations Manager. The pump station O&M of the plants and pump stations is run by the Sewer Utility O&M Supervisor who oversees two Maintenance Crew Supervisors, each with a five-person crew, and an Electrical Supervisor with a 5-person crew. The four WWTPs are managed by the two Plant Operations Supervisors: Outlying Plant Supervisor and Central Kitsap Treatment Plant Supervisor. The three smaller WWTPs, including Kingston, each have a lead operator and share two additional operators who work on all plants as needed. Central Kitsap WWTP is run with six plant operators, and one worker. The County cross-trains operations staff so that they can fill in for other staff during absences or emergencies.

The Field (Collection) Operations is responsible to maintain, repair, replace, clean, and inspect the sewer utilities collection systems. It is managed by the Sewer Collections O&M Supervisor who oversees two O&M Crew Supervisors. Engineering efforts are managed by both the Sewer Utility Engineering and Construction Management Groups. The Construction Management Group manages the delivery of capital work while the Engineering Group manages the design, both groups consult the Facilities and Conveyance operation groups for project specific challenges that will impact day to day or future operations. The Administration portion of the Engineering Group manages the GIS database utilized by the Operations groups and provides review efforts for Developer proposed projects.

Figure 10-1 | Kitsap County Public Works Sewer Utility Organizational Chart



10.3 Operation and Maintenance Requirements

10.3.1 Regulatory Compliance

Ecology has the authority to permit WWTPs through the NPDES program, which includes Kingston WWTP. Ecology has issued NPDES Permit WA0032077 to the County for Kingston WWTP, which includes operator certification and O&M requirements for both the WWTP and the collection system.

10.3.2 Operation and Maintenance Program

As required by the NPDES permit, the County has instituted an O&M program which consists of maintenance records for all major mechanical and electrical components for the WWTP, collection system, pump stations, and any other major facilities. The County uses a computerized maintenance management system (CMMS) to schedule and record all maintenance activities for plants and pump stations. The system identifies the frequency and type of maintenance recommended by the manufacturer and records the frequency and types of maintenance performed. The CMMS is available to all relevant County staff for review, update, and inspection. The County also uses a GIS system to inventory and record all maintenance and inspections of the conveyance pipe systems and is also used to populate downloadable asset layers accessible to the public.

10.3.3 Operation and Maintenance Manual

The Kingston WWTP O&M Manual provides basic information for the plant in accordance with the NPDES permit, WAC 173-240-080, and Ecology's Orange Book. It describes the treatment process in sufficient detail to familiarize personnel with both the normal operation of the plant as well as the alternate methods of operation that are available. In addition, it provides an overview of all miscellaneous components and management systems in use at the plant. The intent of the manual is to assist operators and other personnel with learning the overall operation of the plant, to serve as a basic reference for operating any of the system's components and provide emergency response and safety guidelines.

Pump station specific O&M information is located on the County's Electronic O&M website. This includes information on critical pieces of equipment such as pumps, electrical, instrumentation, controls equipment, valves, and odor control systems. Newer stations have more complete O&M data than older stations.

10.4 Supervisory Control and Data Acquisition

The County employs a Supervisory Control and Data Acquisition (SCADA) system to monitor and record the status of the pump stations and treatment plants. The SCADA system uses Aveva (previously known as Wonderware) software. The County recently completed a Sewer Utility SCADA Master Plan that evaluated the existing SCADA system, identified operational needs, determined preferred hardware and software, and presented recommended improvement projects. The Sewer Utility SCADA Master Plan is included as **Appendix F**. All the County pump stations are connected to the SCADA system, and new pump stations include force main pressure monitoring to provide greater remote insight into operating conditions.

The pump stations and treatment plants have a number of alarms that are linked to the County SCADA system that alert staff if a problem is occurring via either very high frequency licensed radio network or 4G cellular network. These alarms include high wet well level alarms, intrusion alarms, pump fail alarms, and others. The alarm functionality at pump stations designated as 'critical' is checked weekly to ensure they are operational.

10.5 Collection System Operation and Maintenance Activities

10.5.1 Collection System Overview

The Kingston collection and conveyance system primarily serves the northern portion of the Kingston UGA; the southern portion of the UGA is unsewered. Wastewater within the Kingston basin is ultimately conveyed to the WWTP west of the UGA. The Kingston collection and conveyance system is shown in **Figure 10-2**.

10.5.2 Pump Stations

County crews visit and inspect each pump station regularly to check on equipment, test alarms, and perform maintenance as needed. The inspection and testing frequency is determined by the criticality of the pump station and is completed as shown in **Table 10-1**. Criticality is determined by how many drainage basins (or upstream pump stations) discharge to the pump stations. A schematic of the conveyance system showing the pump station criticality is shown in **Figure 10-3**. Physical location of a pump station in relation to a water body or location that is difficult to access, may drive a higher criticality definition independent of number of contributing basins. Generator load exercise is completed with the pump station load at all critical stations and regional stations with loads greater than 200 kW. Stations with loads less than 200 kW are exercised with mobile load banks. Stations will be checked if alarms are indicated.

Table 10-1 | Pump Station Inspection & Testing Frequency

Pump Station Type[1]	Threshold for Designation	Inspection Frequency	Alarm Check Frequency	Generator Load Exercise[2]
Critical	5+ Basins Served, or if specifically identified	1x per week	Bi-weekly	Annually
Regional	3-4 Basins Served	1x per week	Bi-weekly	Annually
Relay	2 Basins Served	1x per week	Bi-weekly	Annually
Satellite	1 Basin Served	1x per week	Bi-weekly	Annually

Notes:
1. Certain pump stations may serve fewer basins, yet the selection of type is driven by location.
2. Generators are run monthly, however load tested annually.

10.5.3 Sanitary Sewers

Gravity sanitary sewer pipes and manholes are regularly cleaned to clear them of debris, settled solids, and grease buildup and inspected with video equipment to evaluate pipe condition. Sewer cleaning and inspection are vital to maintaining a well working sewer collection system. Over time, deterioration, solids build-up, and blockages can cause collapse and other pre-mature failures. Proactive maintenance through cleaning and inspection keeps the sewer collection system working efficiently and avoids many serious service disruptions from occurring.

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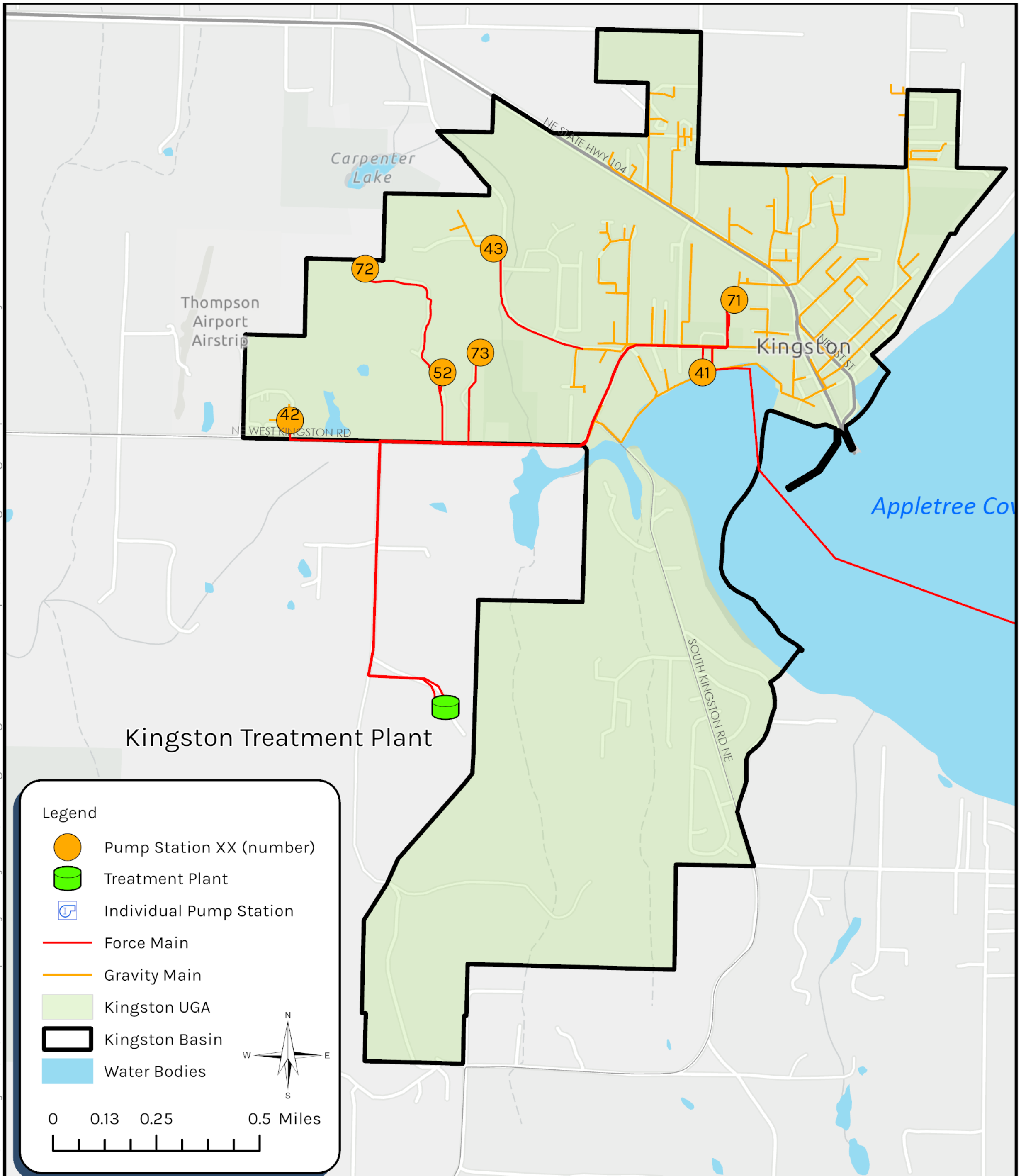
Figure 10-2 | Kingston Basin Sewer System



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Data Sources: Kitsap County, WA DNR Base Layer Credits: Light Gray Base: County of Kitsap, WA State Parks GIS, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS;Light Gray Reference: County of Kitsap, WA State Parks GIS, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS

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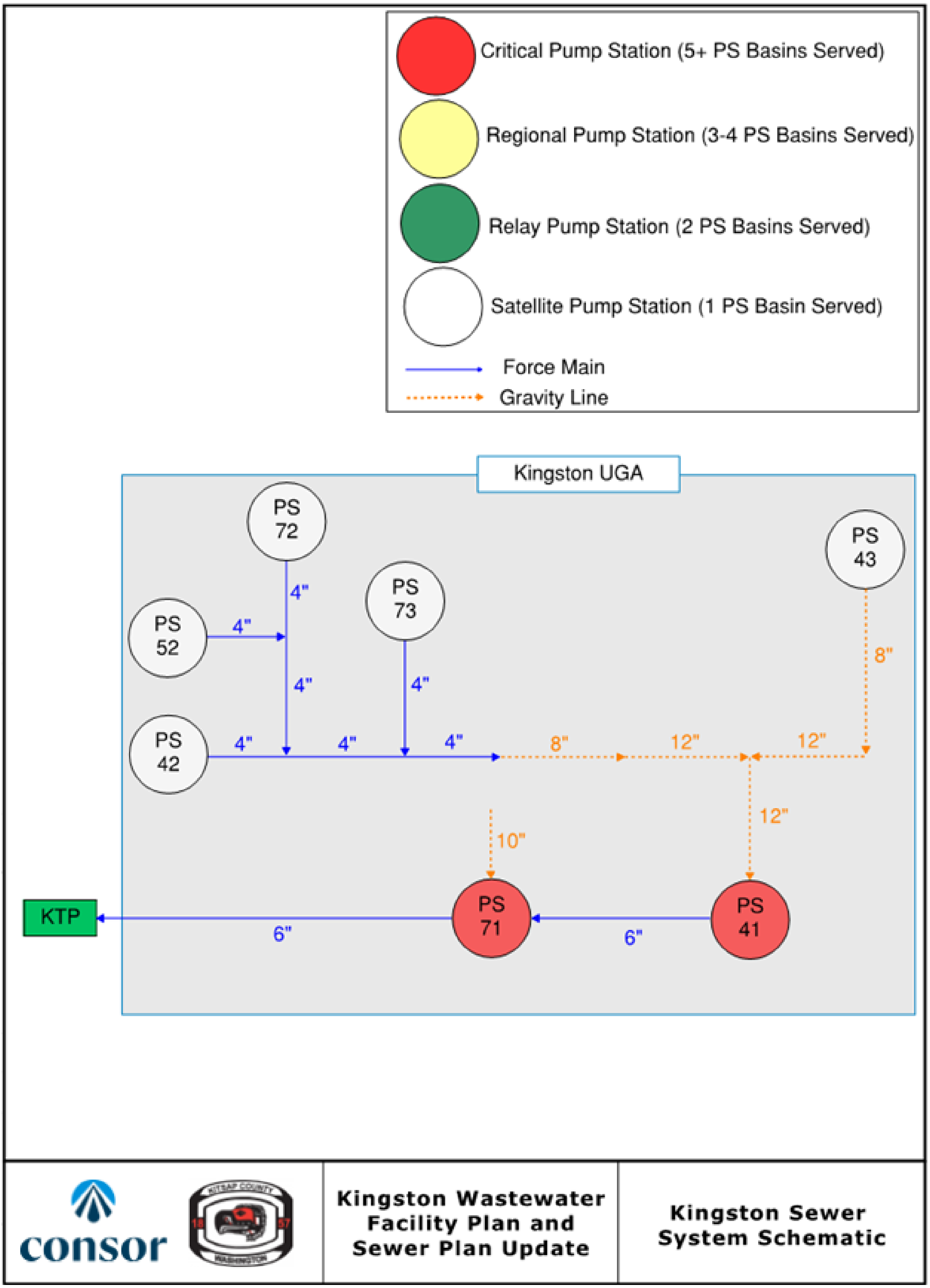
Kingston Wastewater Facility Plan and Sewer Plan Update

Kingston Basin Sewer System

consor

Figure 10-3 | Kingston Sewer System Schematic



The County performs pipe cleaning/jetting and CCTV inspection in-house. Reasons for inspection include routinely scheduled inspections, warranty inspections, new construction inspections and other special project inspections. The system is jetted prior to inspections to improve visibility by removing grease, roots by foaming, sand, grit, and debris, helping reduce blockages and odor issues.

The County process consists of inspecting pipes via CCTV, storing the video in a database, reviewing the video, and assigning an OCI score based on the observations. Pipe condition is evaluated based on operator experience and flagged for further investigation if needed. The County does not currently use a condition rating system such as the National Association of Sewer Service Companies (NASSCO) standards to evaluate and record observed conditions. It is recommended that the County consider having CCTV operators trained and certified in NASSCO assessment to improve the consistency of sewer inspecting rating.

The results of these assessments have been stored in their asset management database software Cartegraph since 2017. The County has a target metric to complete inspection of all pipes in the system on a five-year cycle (approximately 20 percent of the pipes inspected each year). According to Standard Operating Procedure, in addition to CCTV every five years, flushing is performed annually unless identified as a hot spot and frequency is then location dependent. At the time of this writing, all of the pipes have been inspected and an evaluation has been stored in Cartegraph.

The force mains and siphons are cleaned when needed. The County's force mains are designed to achieve scouring velocities that self-clean under normal system operation. If pipe conditions allow, pigging is performed annually. Destructive testing is only performed when lines are suspected of failure.

The Kingston WWTP outfall is inspected by divers following the procedures required by the NPDES permit.

10.5.4 Pretreatment Program

The County is required by the NPDES permit to enact a pretreatment program to ensure all commercial and industrial customers comply with the pretreatment regulations in 40 CFP Part 403 through 471. The program is required to take continuous and routine measures to identify all existing, new, and proposed significant industrial users. The County does not have any significant industrial users within the Kingston service area. Refer to **Section 4** for more information.

10.5.5 Odor and Corrosion Control Program

The County has several calcium nitrate (Bioxide™) solution dosing systems in the collection system to remove and prevent formation of hydrogen sulfide. The systems are located upstream of areas where odor complaints are common. These systems are set to dose automatically and are not connected to SCADA. Operators visit each system regularly to check on operation and refill on-site solution containers.

The County also utilizes hypochlorite dosing, charcoal filters, and organic biofilters at specific stations. Uses are prescribed based upon individual pump station characteristics.

10.5.6 Fats, Oils, and Grease Program

County Code 13.12.160 prohibits discharge of pollutants that will cause obstructions in the County sewer system. Businesses producing fats, oils, and grease (FOG) are required to have and maintain a grease removal system. Depending on the type and size of business, this may be a small grease trap maintained by employees or a large oil/water interceptor that is pumped out regularly by a permitted waste hauler.

The County accepts hauled FOG waste at the Central Kitsap WWTP and is currently designing a dedicated FOG receiving station to improve ease of disposal for FOG haulers.

The County is considering implementing code through the use of inspection, enforcement, or other financial penalties to ensure FOG compliance.

10.6 WWTP Operations and Maintenance Activities

10.6.1 Preventative Maintenance

The County maintains the Kingston WWTP to keep critical components in good operating condition. This includes inspecting machinery, cleaning tanks, and maintaining equipment. Maintenance is performed in accordance with the manufacturer's recommendations during the warranty period for equipment and maintenance intervals are adjusted based on operator experience after the warranty period expires. Spare parts for all equipment are tracked in the CMMS with critical spare parts identified. Key parts are kept on hand in instances where the part cannot be readily obtained from local suppliers.

It is recommended that the County develop a valve exercise program to minimize issues with infrequently used valves seizing as they age, and also review spare parts inventories and assess the need for additional spare parts due to supply chain challenges.

10.6.2 Laboratory Operation and Accreditation

The County maintains an accredited laboratory at the Central Kitsap WWTP (W660-21A) to provide analysis of a broad range of water quality parameters including those for reporting or permit monitoring data. The laboratory at the Kingston WWTP is not certified, so samples required for reporting purposes are analyzed at the Central Kitsap WWTP lab. The County must maintain accreditation in accordance with WAC 173-50. Ecology's *Procedural Manual for the Environmental Laboratory Accreditation Program* provides details on requirements, fees, recommended practices, proficiency testing, and audit procedures.

In addition to completing water quality testing, the laboratory is responsible for recalibrating and maintaining process probes and mobile testing instruments.

10.7 Sewer Collection System Staffing Needs

The County operates and maintains all four of their sewer basins as a single utility, and all sewer collection staff work in all the basins. A comparison of County sewer collection operations staff with similar utilities in the area is shown in **Table 10-2**. The County numbers reflect all County owned sewer collection and conveyance facilities from all County basins. The County has slightly less staff per mile of pipe, and fewer staff per pump station than the average of the other utilities.

Table 10-2 | Sewer System Staffing Comparison

Agency	Personnel (FTE)	Miles of Pipe	Personnel per Mile of Pipe	No. of Pump Stations	Personnel per Pump Station
Kitsap County	18	215[1]	0.09	64[2]	0.3
City of Bellevue	25	520	0.05	36	0.7
City of Enumclaw	4	142	0.03	7	0.6
City of Kent	13	211	0.06	7	1.8
City of Kirkland	24	123	0.19	6	4.0

Agency	Personnel (FTE)	Miles of Pipe	Personnel per Mile of Pipe	No. of Pump Stations	Personnel per Pump Station
City of Lacey	14	236	0.06	48	0.3
City of Port Orchard	6.5	75	0.09	21	0.3
Silver Lake Water and Sewer District	33	207	0.16	22	1.5
West Sound Utility District	15	45	0.33	12	1.3
Alderwood Water and Wastewater District	11	440	0.03	12	0.9
Average			**0.11**		**1.25**

Notes:

1. Total miles of gravity sewer pipe and force main pipe in Central Kitsap, Kingston, Manchester, Suquamish, and Navy Yard City, provided by the County's sewer asset count in 2024.
2. Number of pump stations in Central Kitsap, Kingston, Manchester, Suquamish, and Navy Yard City.

10.8 WWTP Staffing Needs

Kingston WWTP is classified by Ecology as a Class II facility, therefore, the operator in responsible charge must have a Group II operator certification. Additionally, a Group I operator must be in charge during all regularly scheduled shifts. Kingston WWTP shares the operators with the other three WWTPs. Operator certification of all four WWTPs is shown in **Table 10-3**. In addition to the plant operators, there are 5 laboratory staff who are required to obtain an operator certification within two years of being hired.

Table 10-3 | Operator Certifications

Operations Certification	Number of Staff
Operator in Training	0
Group I	4
Group II	5
Group III	3
Group IV	4
TOTAL	**16**

Current staffing at Kingston WWTP facility consists of one Lead Plant Operator specifically assigned to Kingston and one Plant Operations Supervisor and two Rover Plant Operators who oversee operations at Suquamish WWTP, Manchester WWTP and Kingston WWTP. Thus, the total full-time equivalent (FTE) for Kingston is approximately 2.0, with 1.0 FTE by the Lead Plant Operator and 1/3 FTE each by the Plant Operations Supervisor and Rover Plant Operators. During off hours, critical SCADA alarms from the plant are configured to ring through to an on-call operator. Maintenance at Kingston WWTP is conducted by the Sewer Utility O&M group which is shared across all of the County's WWTPs and collection and conveyance systems.

As flows and loads increase at the facility and as improvements are undertaken, staffing levels may change. **Table 10-4** identifies potential staffing needs at existing and future planning horizon based on *Estimating Staffing for Municipal Wastewater Treatment Facilities* (EPA, 1973) and *The Northeast Guide for Estimating Staffing at Publicly and Privately-Owned Wastewater Treatment Plants* (New England Interstate Water Pollution Control Commission, Nov 2008). These estimates include supervisory, administrative, clerical, laboratory, yard work, site maintenance, and unit process O&M. All methods assume 1,500 working hours per employee after holidays, time off, training, etc. These estimates are intended to be guidelines only;

specific staffing levels must be determined by the County and reviewed regularly to adequately operate and maintain the facility.

Table 10-4 | Kingston WWTP Staffing Comparison and Projection

Condition	Average Annual Flow (MGD)	Current Staffing	EPA Method Staffing[1]	Northeast Guide Method Staffing
Staff at 2020 *(additional staff needed)*	0.11	2.00	1.02 *(0)*	2.57 *(0.57)*
Staff at 2042[2] *(additional staff needed)*	0.27	-	0.85 *(0)*	2.41 *(0.41)*

Notes:

1. The minimum plant capacity covered in the EPA Method is 0.5 MGD, therefore a flow of 0.5 MGD was used as the basis for staffing determinations.
2. Staff required in 2042 is lower for both methods due to the replacement of aging equipment and improved automation and controls as recommended in the CIP.

Based on both the EPA and Northeast Guide methods, the County's current approach of having one dedicated staff person for Kingston with one additional FTE of shared support staff appears to be appropriate and adequate for current operations. There is a deficiency in staff using the Northeast Guide method. It is expected that if some additional effort is required it can be covered with assistance from other operating staff on an as-needed basis. There is little expected increase in flows and improvements at the plant are expected to improve staff efficiency, so no additional staff is expected to be required though the 20-year planning period. It is recommended that the County continue executing the Sewer Utility Plant Operator Qualification Program and additional external classroom training to accelerate employees into Operator Certification Group III and prepare for anticipated Puget Sound Nutrient Reduction Goals and facility upgrades.

10.9 Conclusions and Recommendations

Conclusions and recommendations based on a review of the County O&M practices are:

- Consider having CCTV operators trained and certified in NASSCO assessment to improve the consistency of sewer inspecting rating.
- Consider reviewing spare parts inventories and assessing the need for additional spare parts due to supply chain challenges.
- Institute and annual valve exercise and maintenance program.
- Consider developing additional classroom training to accelerate employees into Operator Certification Group III and prepare for anticipated Puget Sound Nutrient Reduction Goals and facility upgrades.
- Institute an Arc Flash Analysis and Protection program to identify deficiencies that can be mitigated through coordinated CIP projects.

SECTION 11

Capital Improvement Plan

11.1 Introduction

This section identifies CIP projects and O&M projects for the Kingston collection system and WWTP. These improvements are required to remedy deficiencies identified in Section 5, Section 6, Section 7, Section 8, and to implement a recycled water program as described in Section 9.

11.2 Capital Improvement Plan Criteria

CIPs are presented on a 6-year basis from 2023 to 2028 for immediate needs; and, for the 20-year planning horizon (from 2029 to 2042) for improvements that are anticipated but not pressing. A planning level cost opinion and a preliminary timeline of CIP project implementation is provided. It is assumed that minor projects will be completed with O&M budget and are listed separately. The methodologies for funding the CIP projects will be discussed in Section 12.

The Asset Health Scores discussed in Section 5 and Section 6 were used to identify the most critical projects across the County's system based on asset condition and the CoF. The CIP projects were prioritized based on the Asset Health Scores and factors including the extent and type of deficiency, customers impacted, environmental impacts, and capital and O&M costs.

In conjunction with the facility planning effort, the County has been working on a series of SCADA Master Plan technical memoranda which include project identification, estimates, and capital improvement planning in Technical Memorandum No. 5. SCADA system improvements are not incorporated into this CIP because they are generally implemented across the entire sewer division, and not specifically to process improvements at the Kingston WWTP. SCADA improvements were also included in a separate CIP.

Drivers of improvements are considered for five categories:

1. Capacity: An asset no longer has sufficient capacity when it cannot or is modeled in the future to not be able to meet the equipment, hydraulic, or process capacity requirements, as detailed in Section 6 for the WWTP and Section 7 for the collection and conveyance system. The proposed firm capacity for pump stations is determined through H/H model simulations considering increased population for the 2042 planning horizon and a 25-year storm event. Capacity driven improvements are assigned the maximum asset health score of 25 as these projects are considered the most critical. Capacities are defined as follows:

    a. A gravity sewer pipe no longer has sufficient capacity when the flow in the pipe is greater than or equal to 80 percent of pipe flowing full ($d/D \geq 0.8$).

    b. A force main no longer has sufficient capacity when the velocity in the pipe is greater than 7 feet per second.

    c. A pump station is over capacity if the largest pump is out of service and the remaining pump(s) is (are) unable keep up with the inflow.

   d. An equipment/treatment process no longer meets the equipment, hydraulic, or process capacity requirements, discussed in detail in **Section 6**.

2. O&M: County staff indicate the asset requires excessive maintenance, using valuable time and money. O&M issues are primarily driven by condition. The project goal will be to improve reliability and reduce maintenance call outs.

3. Obsolescence: The asset is reaching the end of its service life. Life expectancy of piping, structures, and mechanical/electrical equipment varies depending on the treatment processes and is discussed in **Section 6**. For the collection system, life expectancy of pipes are 100 years, structures are 50 years, and mechanical/electrical equipment is 25 years.

4. Developer: A new development in the County necessitates new or upgraded infrastructure that would not be needed by the existing customers and would be funded and constructed by a developer.

5. Regulatory: Regulatory projects will address facilities that are currently out of compliance or expected to become incompliant with existing, pending, or anticipated regulations set by the State and Federal agencies, such as Ecology or the EPA.

Projects for the County's sewer systems are identified with a code that identifies the basin, system, driver of improvements, and a project number using the following identifiers (note that basin identifiers are used as General Sewer Plan Updates for the three other service areas are being completed concurrent to this Plan):

- Project Category:
  - Capital Improvement Plan = CIP
  - Operation and Maintenance = O&M
- Basin Abbreviations:
  - Central = CK
  - Kingston = K
  - Suquamish = S
  - Manchester = M
- System:
  - Collection and Conveyance = CC
  - Wastewater Treatment Plant = WWTP
- Driver:
  - Capacity = CAP
  - Op and Maintenance = OM
  - Obsolescence = OB
  - Developer = DEV
  - Regulatory = REG

AACE International Class 5 OPPCs with an anticipated accuracy range of -50 percent to +100 percent were developed using RSMeans Heavy Construction Cost Data, recent County project bid tabs, County input, industry experience, and local contractor and supplier costs. The total project costs include construction costs for work and materials plus markups for mobilization, general contractor markups, overhead and profit, taxes, and a construction contingency of 50 percent plus an additional markup of 50 percent for engineering, legal, administration costs, and construction management associated with project delivery. The OPPCs were developed in 2023 dollars.

There is a five-year moratorium on pavement excavation and trenching following the completion of a new road or road overlay. This requirement restricts all road trenching except in the event of an emergency repair or if all trenching is outside of the paved area. Projects should be coordinated with road paving projects to avoid this moratorium and reduce paving costs.

11.3 Kingston Collection and Conveyance System Improvements

The collection and conveyance system includes pump stations, force mains, and gravity sewers. Proposed CIP projects address identified deficiencies for these assets. Projects are frequently combined for efficient project delivery. The projects components are broken down into pump stations, which include force mains, and pipeline projects, which include gravity sewers.

11.3.1 Recently Completed and Ongoing Kingston Collection and Conveyance CIP

There are no known current capital projects in the Kingston collection and conveyance system at the time of this writing.

11.3.2 6-Year Collection and Conveyance CIP (2023 to 2028)

Each of the projects identified for the Kingston collection and conveyance system 6-year CIP are summarized in **Table 11-1**. The location of the 6-year CIPs are shown in **Figure 11-1.** The conveyance sizes and PS firm capacities were determined considering increased population for the 2042 planning horizon and a 25-year storm event. A CIP is also included for annual gravity main replacement due to aging infrastructure or other unforeseen system needs. See OPPCs for individual projects in **Appendix J** for more detail.

11.3.2.1 CIP-K-CC-CAP-1 – Replace PS-41 and Forcemain

This project will replace the existing PS-41 and forcemain that connects this station to PS-71. It Is projected that wet weather flows to this station during a 25-year storm will exceed the exiting firm capacity within the near-term planning horizon. The existing station is near the shoreline at the south end of a private drive south of NE West Kingston Rd between Dulay Road NE and Lindvog Rd NE and is proposed to remain in this location. The station was originally constructed in 1974, making it the oldest station in the Kington area. This CIP is primarily driven by capacity, however, this station also had the highest (e.g. poorest rated) Asset Health Score based on condition assessment of the seven stations in the basin. The proposed firm capacity is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. See **Table 11-1** for project details.

Table 11-1 | 6-Year Kingston Collection and Conveyance Capital Improvement Projects

CIP No	Asset Health Score	Project Name	Replacement[1]	Upgrade[2]	Capacity Increase[3]	Total Project Cost	Project Description
CIP-K-CC-CAP-1	25.0[4]	Replace PS-41 and Forcemain	X			$3,700,000	➢ Replace the pump station to increase firm capacity to 630 gpm ➢ Construct new 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 ➢ Replace 1,400 LF forcemain with 8-inch diameter pipe. Station upgrade will trigger forcemain replacement.
					TOTAL	**$3,700,000**	

Notes:

1. Replacement projects will construct a new facility.
2. Upgrade projects will replace components of the facility.
3. Capacity Increase projects will increase hydraulic capacity and can include system expansion.
4. An Asset Health Score of 25 has been assigned to this project overriding the condition assessment asset health score. PS-41 previously had an asset health score of 16.0.
5. An asset health score of 20 was selected to prioritize projects on an annual basis.

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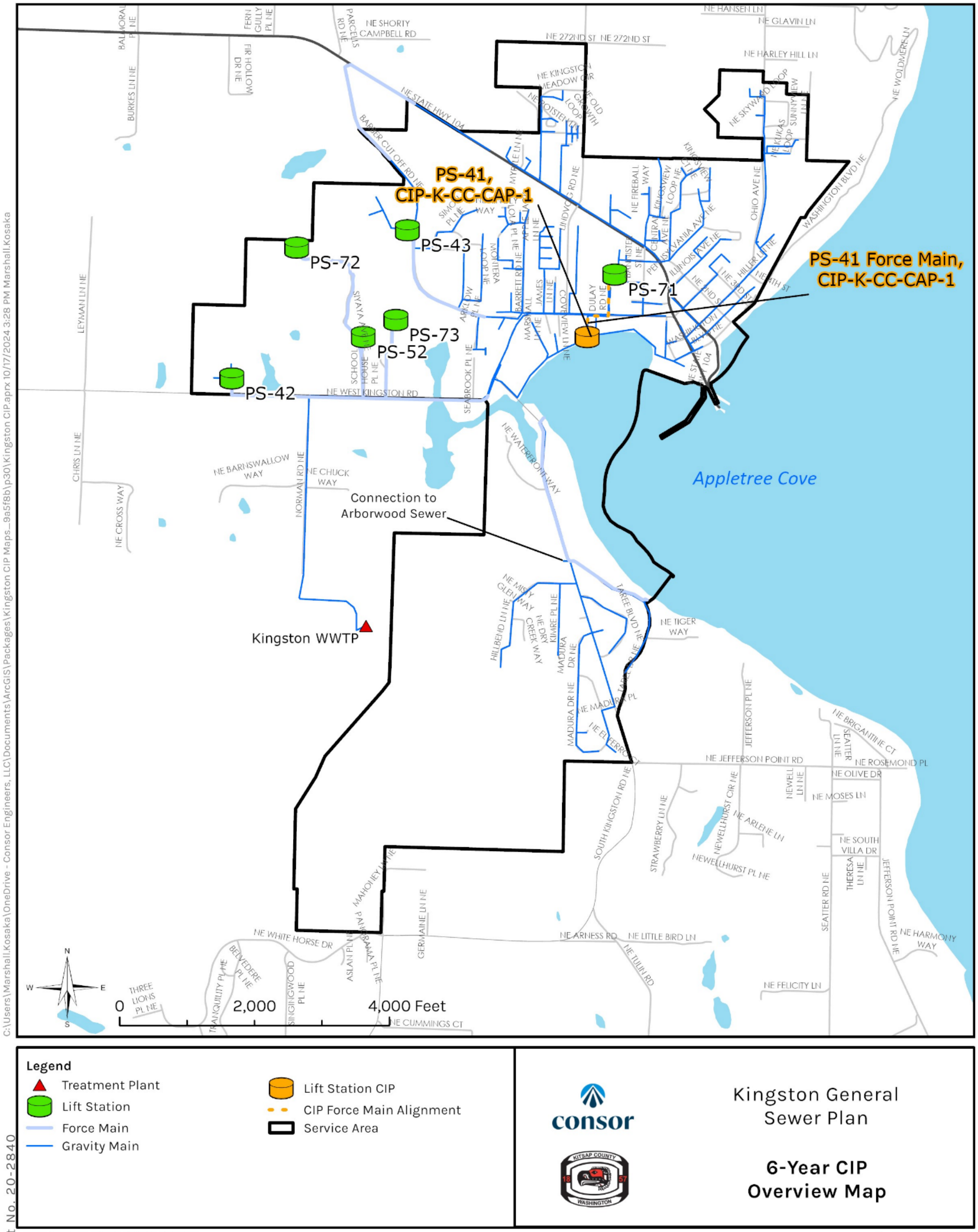
Figure 11-1 | 6-year Collection and Conveyance CIP (2023-2028)



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Project No. 20-2840

Data Sources: Kitsap County, WA DNR.
Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet
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11.3.3 20-Year Kingston Collection and Conveyance CIP (2029 to 2042)

Each of the projects identified for the Kingston collection and conveyance system 20-year CIP are summarized in **Table 11-2**. These projects are related to system expansion to new development or septic conversion. It is assumed that developer projects will be significantly funded by the developer and will be excluded from the financial analysis. The conveyance sizes and LS firm capacities were sized considering increased population for the 2042 planning horizon and a 25-year storm event. The location of the 20-year CIPs are shown in **Figure 11-2**. See OPPCs for individual projects in **Appendix J** for more detail.

11.3.3.1 CIP-K-CC-CAP-2 – Upgrade PS-71 and Replace Forcemain

This project will increase the pumping capacity of PS-71 and replace the existing forcemain that connects this station to the Kingston WWTP. It is projected that wet weather flows to the station during a 25-year storm will exceed the existing firm capacity in the near-term planning horizon. Forcemain replacement is required with increased pumping capacity in the near term. The existing station is located at the old treatment plant site on Dulay Road NE just north of the Village Green Community Center. The station was constructed in 2002 and is in relatively good condition based on the results of the condition assessment presented in **Section 5**. The proposed firm capacity is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. See **Table 11-2** for project details.

*If funding becomes available, this project should be considered in the 6-year CIP.

11.3.3.2 CIP-K-CC-DEV-4 - Arness Pump Station and Conveyance

This project will include constructing new gravity sewer, a new PS, and associated forcemain in the Arness area in the south Kingston sewer service area. Development in this area or septic conversion will trigger the need for this project. The proposed Arness PS will discharge to the Arborwood development currently planned (portions are currently under construction). The proposed firm capacity and gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.3 CIP-K-CC-DEV-5 – Highway 104 Pump Station and Conveyance

This project will include constructing new gravity sewer, a new PS, and associated forcemain near Highway 104 in the northeast Kingston sewer service area. Development in this area or septic conversion will trigger the need for this project. The proposed Highway 104 PS will discharge to the existing collection system tributary to PS-41. The proposed firm capacity and gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.4 CIP-K-CC-DEV-6 - Taree Pump Station and Conveyance

This project will include constructing new gravity sewer, a new PS, and associated forcemain in the Taree area in the south Kingston sewer service area. Development in this area or septic conversion will trigger the need for this project. The proposed Taree PS will discharge to the Arborwood development currently planned (portions are currently under construction). The proposed firm capacity and gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.5 CIP-K-CC-DEV-7 – Extend Gravity Sewers Flowing to PS-41

This project will include installing additional gravity sewers tributary to PS-41. Development in this area or septic conversion will trigger the need for this project. The proposed gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.6 CIP-K-CC-DEV-8 - Extend Gravity Sewers Flowing to PS-43

This project will include installing additional gravity sewers tributary to PS-43. Development in this area or septic conversion will trigger the need for this project. The proposed gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.7 CIP-K-CC-DEV-9 - Extend Gravity Sewers Flowing to Arborwood

This project will include installing additional gravity sewers tributary to the Arborwood sewer system. Development in this area or septic conversion will trigger the need for this project. The proposed gravity main sizing is determined through H/H model simulations for the 2042 planning horizon and a 25-year storm event. It is assumed that this project would be funded by development. See **Table 11-2** for project details.

11.3.3.8 CIP-K-CC-OM-10 – Annual Pipe Replacement.

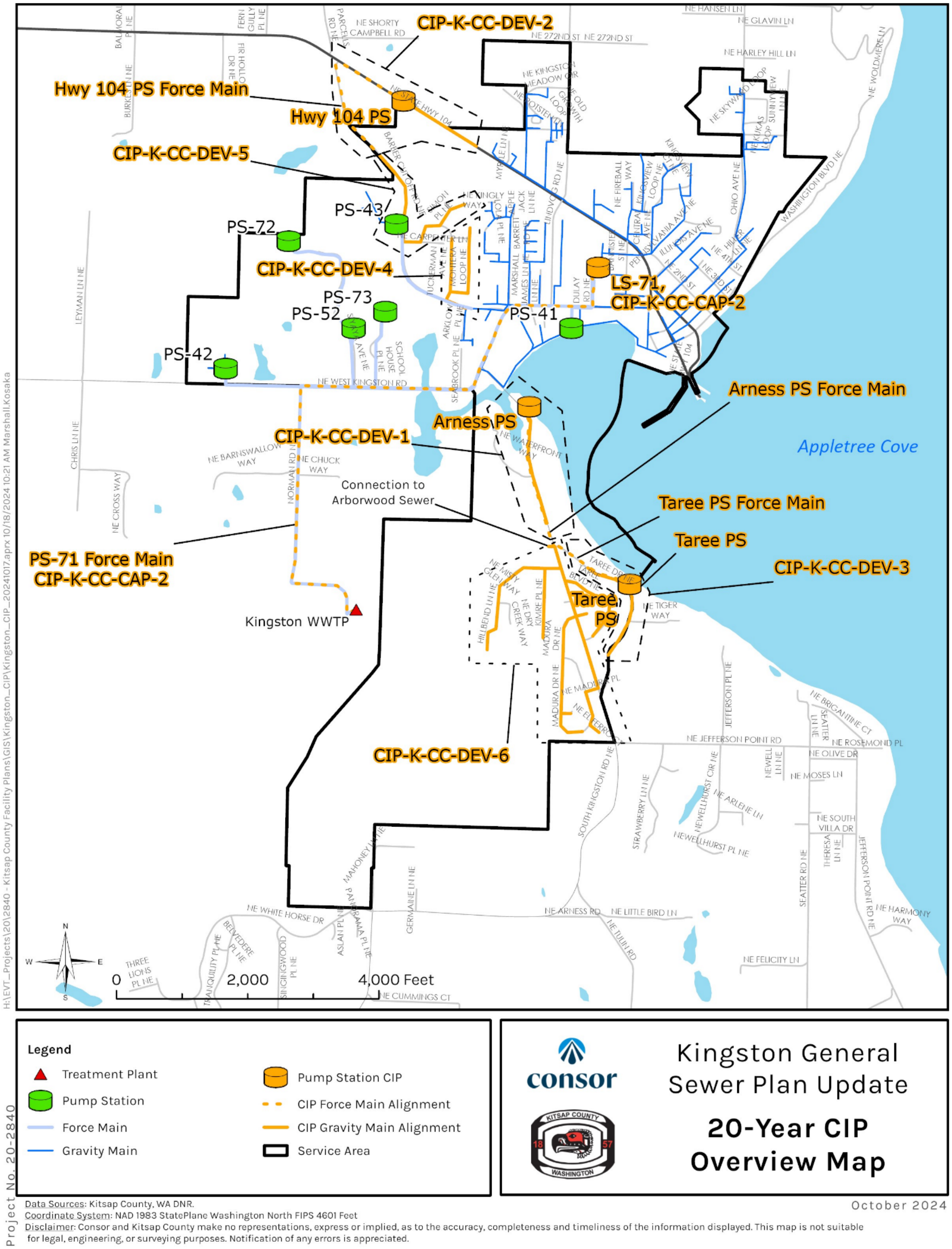
This project will be an annual program that the County will develop to provide ongoing funding to replace aging and deficient pipes not identified in other capital improvement projects. These pipes may include deficiencies related to root intrusion, high rates of I&I, deflected joints, cracked pipes, insufficient slopes, and high rates of O&M call outs. It assumes that half of one percent of the pipe in the Kingston basin would be replaced each year. See **Table 11-2** for project details.

Table 11-2 | 20-Year Kingston Collection and Conveyance Capital Improvement Projects

CIP No	Asset Health Score	Item	Replacement[1]	Upgrade[2]	Capacity Increase[3]	Total Project Cost	Project Description
CIP-K-CC-CAP-2[6]	25.0[7]	Upgrade PS-71 and Replace Forcemain	X			$7,400,000	➢ Upgrade station to increase pump capacity of LS-71 to 790 gpm ➢ Replace pumps ➢ Replace electrical, instrumentation, and control equipment ➢ Replace 9,500 LF forcemain with 8-inch diameter pipe. Station upgrade will trigger forcemain replacement
CIP-K-CC-DEV-4	n/a[4]	Arness Pump Station and Conveyance			X	$0	➢ Construct 1,850 LF of new 8-inch diameter gravity sewer. ➢ Construct new 20 gpm PS and 2,200 LF associated 4-inch diameter forcemain. ➢ Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction). ➢ Project expected to be paid for by developers. Estimated project cost is $5,700,000.
CIP-K-CC-DEV-5	n/a[4]	Highway 104 Pump Station and Conveyance			X	$0	➢ Construct 1,300 LF of new 8-inch diameter gravity sewer. ➢ Construct new 61 gpm PS and 2,800 LF associated 4-inch diameter forcemain. ➢ Project would expand the area served by PS-41 ➢ Project expected to be paid for by developers. Estimated project cost is $5,000,000.
CIP-K-CC-DEV-6	n/a[4]	Taree Pump Station and Conveyance			X	$0	➢ Construct 1,830 LF of new 8-inch diameter gravity sewer ➢ Construct new 26 gpm PS and 1,300 LF associated 4-inch diameter forcemain. ➢ Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction). ➢ Project expected to be paid for by developers. Estimated project cost is $6,100,000.
CIP-K-CC-DEV-7	n/a[4]	Extend Gravity Sewer Flowing to PS-41			X	$0	➢ Construct 2,540 LF of new 8-inch diameter gravity sewers to expand the area served by PS-41 ➢ Project expected to be paid for by developers. Estimated project cost is $3,800,000.
CIP-K-CC-DEV-8	n/a[4]	Extend Gravity Sewer Flowing to PS-43			X	$0	➢ Construct 2,500 LF of new 8-inch diameter gravity sewers to expand the area served by PS-43 ➢ Project expected to be paid for by developers. Estimated project cost is $4,400,000.
CIP-K-CC-DEV-9	n/a[4]	Extend Gravity Sewers Flowing to Arborwood			X	$0	➢ Construct 10,140 LF of new 8-inch diameter gravity sewers. ➢ Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction). ➢ Project expected to be paid for by developers. Estimated project cost is $15,900,000.
CIP-K-CC-OM-10	20[5]	Annual Pipe Replacement			X	$14,000,000	➢ Replace deteriorated and aging pipe. ➢ Project costs assume $1,000,000 per year totaled over 14 years (CIP years 7-20). ➢ Replacement assumes 0.5 percent of total system (225 LF) is replaced per year.
					TOTAL	$21,400,000	

Notes:
1. Replacement projects will construct a new facility.
2. Upgrade projects will replace components of the facility.
3. Capacity Increase projects will increase hydraulic capacity and can include system expansion.
4. Asset health score is not applicable for these projects that are development driven and do not exist.
5. An asset health score of 20 was selected to prioritize projects on an annual basis.
6. If funding becomes available, this project should be considered in the 6-year CIP.
7. An Asset Health Score of 25 has been assigned to this project overriding the condition assessment asset health score. PS-71 had an asset health score of 8.5.

Figure 11-2 | 20-year Collection and Conveyance CIP (2029-2042)



11.4 Kingston WWTP Improvements

The Kingston WWTP has an oxidation ditch (extended aeration) type activated sludge that works well and can continue to provide treatment through the 20-year planning period. Much of the plant was installed or upgraded in 2005. Some additional repairs, replacements, and improvements will be required to ensure continuing operation. Additionally, implementation of the PSNGP has added additional TIN removal optimization requirements, which will require some upgrades to the secondary treatment process.

11.4.1 Kingston WWTP Alternatives Analysis

The alternatives analysis in Section 8 evaluated different treatment technologies for key processes and recommended UV disinfection system upgrades. In addition, several minor maintenance, repairs, and direct replacements are identified in Section 6 and will be required to keep the Kingston WWTP operating reliably over the next 20 years. The urgency of each of these projects has been assessed to develop a project list of short-term CIP projects that should be addressed in the next 6-years and a long-term project list for those CIP projects that are not urgent but will need to be executed later in the 20-year planning period. The remaining projects that can be completed by the plant staff are categorized as O&M projects. These project lists, project descriptions, and costs are presented in the sections that follow.

11.4.2 Recently Completed and Ongoing Kingston WWTP CIP

There are no known current capital projects at the Kingston WWTP at the time of this writing.

11.4.3 6-Year Kingston WWTP CIP (2023 to 2028)

There are no projects at Kingston WWTP for the 6-year CIP. If funding becomes available, projects identified for potential near term implementation in previous Plan sections should be considered in the 6-year CIP.

11.4.4 20-Year Kingston WWTP CIP (2029 to 2042)

Each of the projects for the 20-year CIP are described below and are summarized in Table 11-3. See OPPCs for individual projects in Appendix J for more detail.

11.4.4.1 CIP- K-WWTP-OB-1: Replace UV System

The existing UV system is approaching the end of its expected lifespan. Various alternatives for replacement were analyzed in Section 8 and replacement with the Trojan UV3000Plus was selected as the preferred alternative. Replacing the UV system with this upgraded model will provide a system with advanced monitoring and control functionality which will reduce operating costs and O&M requirements.

*If funding becomes available, this project should be considered in the 6-year CIP.

11.4.4.2 CIP- K-WWTP-REG-2: Nitrogen Optimization Improvements:

Kingston currently has one set of DO and ORP probes that are manually moved between the two oxidation ditches depending on which one is in operation. Adding and additional DO probe will eliminate the need to move the probes between basins, and adding a ammonia-nitrate probes will provide direct measurement of nitrogen to assist in TIN optimization as required to meet permit requirements. As noted in Section 8, Kingston WWTP is expected to be capable of achieving TIN of less than 7 mg/L throughout the 20-year planning horizon if optimization upgrades are implemented.

11.4.4.3 CIP-K-WWTP-REG-3: Class A Reclaimed Water Improvements:

Section 9 introduces the benefits of recycled water and the following required upgrades to Kingston WWTP to produce Class A reclaimed water for the purpose of irrigation and infiltration uses. This project will reduce effluent TIN loading at the WWTP outfall by providing an alternative end use and can be implemented if TIN treatment requirements become more restrictive. This project will include the following elements:

- A secondary effluent equalization tank
- A filter feed pump station
- Tertiary filtration
- UV disinfection, followed by chlorination
- A recycled water pump station
- A recycled water pipeline

11.4.4.4 CIP-K-WWTP-OB-4: Replace Clarifier Drives:

The secondary clarifier drive equipment is expected to reach the end of their service life towards the end of 20-year planning horizon. This project will replace the drives, collection mechanisms, walkway and platform, and weirs with new equipment.

Table 11-3 | 20-Year Kingston WWTP Capital Improvement Projects

CIP No	Asset Health Score	Item	Replacement[1]	Upgrade[2]	Capacity[3]	Total Project Cost	Project Description
CIP-K-WWTP-OB-1[4]	7.2	Replace UV System		X		$880,000	➢ Replace obsolete UV system with new, more advanced model to reduce operating cost and O&M requirements
CIP-K-WWTP-REG-2[5]	6.5	Nitrogen Optimization Improvements		X		$99,000	➢ Project will improve TIN monitoring and control to ensure effluent TIN can be consistently reduced to below 10 mg/L ➢ Install additional DO probe ➢ Install ammonia and nitrate probes in each basin
CIP-K-WWTP-REG-3	6.6	Reclaimed Water Improvements		X		$13,660,000	➢ Use reclaimed water for irrigation at WHGC and indirect groundwater recharge at North Kitsap Heritage Park ➢ Construct secondary effluent equalization tank ➢ Construct filter feed station and tertiary filtration ➢ Add additional UV disinfection ➢ Construct recycled water pump station and pipeline ➢ Implement CIP-K-WWTP-CAP-3 if not already completed ➢ Project will reduce effluent TIN loading at the WWTP outfall by providing an alternative end use.
CIP-K-WWTP-OB-4	6.5	Replace Clarifier Drives		X		$480,000	➢ Replace secondary clarifier drives, collection mechanism, walkway, platform, and weirs
					Total	$15,120,000	

Notes:

1. Replacement projects will construct a new facility.
2. Upgrade projects will replace components of the facility.
3. Capacity Increase projects will increase hydraulic capacity.
4. If funding becomes available, this project should be considered in the 6-year CIP.
5. Future nutrient requirements and timing are unknown. Based on the current permit cycle for the PSNGP, it is assumed that effluent TIN restrictions to values below 10 mg/L will not be implemented until 2031 at the earliest.

11.4.5 O&M Projects

Each of the O&M projects are summarized in **Table 11-4**. Costs and drivers of improvements are not included for O&M projects since these are relatively minor projects implemented by County staff and not included in the CIP budget.

Table 11-4 | O&M Projects

O&M Project No	Asset Health Score	Item	Project Description
O&M-K-WWTP-1	5.4	Grit Classifier Recoating	➢ Repaint the corroded areas of grit cyclone and classifier to mitigate further corrosion and odor problems.
O&M-K-WWTP-2	6.5	Secondary Clarifier Cleaning, Coating, and Re-caulking	➢ Replace weir caulking, clean and coat the corroded areas to prevent further degradation.
O&M-K-WWTP-3	6.6	Replace GBT Fire Alarm and WAS/TWAS LEL Sensors	➢ Repair the Was/TWAS lower explosive limit sensors and replace the GBT room fire alarm system to improve safety.
O&M-K-WWTP-4	6.0	Rebalance GBT Room HVAC and Repaint GBT Room Mechanical Equipment	➢ Test and rebalance the GBT room HVAC system to provide better ventilation. ➢ Testing may determine that new equipment is required. ➢ Once the HVAC system is functioning better, equipment should be cleaned and repainted where paint is chipped or missing to prevent further corrosion.
O&M-K-WWTP-5	6.6	Monitor W2 Overflow	➢ Clean the exterior of the air gap tank and install an overflow logger to monitor the overflow and prevent corrosion around the base of the tank.
O&M-K-WWTP-6	6.6	Replace W3 Pump P-902 Casing Gasket	➢ Clean and recoat the corroded areas of P-902 and replace the casing gasket to prevent further degradation.
O&M-K-WWTP-7	10.0	Replace AFDs and Complete Control Panels Housekeeping	➢ Verify back-up copies of PLC and OIT programs for CP-300. A migration/replacement plan for OIT in CP-300 will be developed and executed if it is not functional. ➢ Verify the existence of the controller (PLC) in panels LP-GBT and LP-TLP and develop and implement a migration/replacement plan if the controller is outdated. ➢ Clean and inspect the scum pump local control panel and identify and correct the source of the water infiltration to prevent future corrosion. ➢ Replace the AFD's in MCC-01 with a newer model provided by a similar manufacturer to ensure it is functional if/when needed.
O&M-K-WWTP-8	10.0	Complete WWTP Arc Flash Study	➢ Complete arc flash study and install signage as needed ➢ May be combined with similar projects at other WWTPs
O&M-K-CC-1	6.4	Miscellaneous LS Improvements	➢ Minor improvements to LS-42: relocate junction box to comply with NFPA 820, install new canopy ➢ Minor improvements to LS-43: replace electrical enclosures, new canopy ➢ Minor improvements to LS-52: relocate junction box to comply with NFPA 820, new canopy ➢ Minor improvements to LS-72: install cable hooks inside wet well and reroute electrical cables, new canopy

11.5 Wastewater System 20-Year CIP

The 20-Year CIP is summarized in **Table 11-5** along with the consultant proposed spend plan over the 20-year planning horizon.

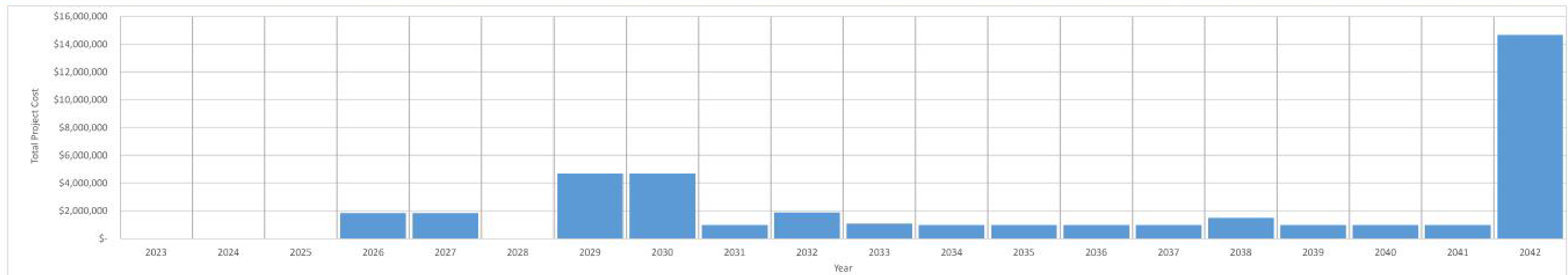
Table 11-5 | Recommended Capital Improvement Program Summary

Kingston Basin CIP Plan

consor

6 or 20 Year CIP	CIP No.	Asset Health Score	Project Name	Total Project Cost	6-Year CIP 2023	2024	2025	2026	2027	2028
6	CIP-K-CC-CAP-1	20	Replace PS-41 and Forcemain	$ 3,700,000				$ 1,850,000	$ 1,850,000	
20	CIP-K-CC-OM-10	20	Annual Pipe Replacement	$ 14,000,000						
20	CIP-K-CC-CAP-2	25	Upgrade PS-71 and Replace Forcemain*	$ 7,400,000						
20	CIP-K-WWTP-OB-1	7.2	Replace UV System*	$ 880,000						
20	CIP-K-WWTP-REG-2	6.5	Nitrogen Optimization Improvements	$ 99,000						
20	CIP-K-WWTP-OB-4	6.5	Replace Clarifier Drives	$ 480,000						
20	CIP-K-WWTP-REG-3	6.6	Class A Reclaimed Water Improvements	$ 13,661,000						
			Total Project Cost (2023)	$ 40,220,000	$ -	$ -	$ -	$ 1,850,000	$ 1,850,000	$ -
			Assumed Inflation Rate			12%	8%	8%	5%	5%
			Inflation Multiplier		1	1.12	1.21	1.31	1.37	1.44
			Future Value Cost		$ -	$ -	$ -	$ 2,416,781	$ 2,537,620	$ -

Project Name	20-Year CIP 2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Replace PS-41 and Forcemain														
Annual Pipe Replacement	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Upgrade PS-71 and Replace Forcemain*	$ 3,700,000	$ 3,700,000												
Replace UV System*				$ 880,000										
Nitrogen Optimization Improvements					$ 99,000									
Replace Clarifier Drives										$ 480,000				
Class A Reclaimed Water Improvements														$ 13,661,000
Total Project Cost (2023)	$ 4,700,000	$ 4,700,000	$ 1,000,000	$ 1,880,000	$ 1,099,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,480,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 14,661,000
Assumed Inflation Rate	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Inflation Multiplier	1.51	1.59	1.67	1.75	1.84	1.93	2.03	2.13	2.23	2.35	2.46	2.59	2.72	2.85
Future Value Cost	$ 7,107,736	$ 7,463,123	$ 1,667,293	$ 3,291,237	$ 2,020,172	$ 1,930,101	$ 2,026,606	$ 2,127,936	$ 2,234,333	$ 3,472,153	$ 2,463,352	$ 2,586,519	$ 2,715,845	$ 41,807,858



SECTION 12

Financial Strategy

12.1 Introduction

This chapter documents the Sewer Financial Plan, which shows how the investments in the CIP can be funded by the County sewer utility.

This Sewer Financial Plan was written by FCS, a Bowman company, under subcontract with Consor, the County's consulting engineers who have prepared the other required elements of this Plan.

12.1.1 Four Basins, One Financial Entity

The County sewer system has four basins, each with a treatment plant and a corresponding collection system: Central Kitsap, Manchester, Suquamish, and Kingston. The capital planning has been performed separately for each basin. However, the County does not separate its sewer utility financial information by basin, so all information shown in this Sewer Financial Plan document—unless explicitly stated otherwise—refers to the County sewer utility as a whole.

This sewer financial plan document has been written so it can be included with each of the Wastewater Facilities and Sewer Plan documents: Central Kitsap, Manchester, Suquamish, and Kingston. At the end of this chapter, a table showing the allocation of costs and revenues across the four basins is included, so that the Plan documents will each contain the required elements needed for submission to Ecology.

12.1.2 Sequence of Topics

After reviewing the historical performance of the sewer utility, we describe the methodology and key assumptions underlying the financial forecast. The key assumptions address the assumed fiscal policies, economic assumptions, and data sources. This section also summarizes the CIP, expressing total project costs in both constant 2023 dollars and future inflated dollars.

After the key assumptions and data sources, this chapter then shows the results of the revenue requirement forecast. This is a two-step process. First, the capital funding strategy describes how the capital costs can be financed over time, using both debt and non-debt sources. The debt issues lead to annual debt service costs. The second step is the annual forecast, which incorporates the debt service and other annual costs into a forecast that is balanced against projected revenues. The forecast is tested assuming existing rates. If either the projected cash balances are insufficient or the required bonded debt service coverage is not achieved, then rates are adjusted until the forecast is balanced. In this forecast, the forecast can be balanced with overall rate increases of 6.31% in 2025 (already adopted by the County) and 6% per year from 2026 through 2042.

This document then shows the implications of these rate increases on several metrics and policy targets: reserve fund balances, rate-funded capital investment, bonded debt service coverage, outstanding debt as a percentage of total assets, annual debt service as a percentage of total revenue ("debt service load"), and the average single-family bill as a percentage of median household income.

The next section of this document allocates the forecast results to the four basins. Finally, Appendix K contains a list of loan and grant programs administered by State agencies.

12.2 Financial History

This section is a summary of historical financial performance as reported on the County sewer utility income statements.

Table 12-1 shows comparative financial statements for the six-year period 2018 through 2023. These statements summarize the revenues, expenses, and ending reserves for each year.

Table 12-1 | Sewer Utility Income Statement Summary

Kitsap County Sanitary Sewer Statement of Revenue, Expenses, and Changes in Fund Net Position	2018	2019	2020	2021	2022	2023
Operating Revenues						
Charges For services	$ 29,148,750	$ 22,655,426	$ 22,463,052	$ 29,309,413	$ 29,874,573	$ 33,131,359
Miscellaneous	8,186	1	1,830	(952)	29,607	26,281
Total Operating Revenue	29,156,936	22,655,427	22,464,882	29,308,461	29,904,180	33,157,640
Operating Expenses						
Personnel services	6,300,329	6,279,287	5,685,451	4,687,211	7,096,959	7,204,619
Contractual services	2,457,856	1,139,373	2,005,189	3,274,795	1,526,763	1,677,788
Utilities	1,730,524	1,572,611	1,629,789	1,658,245	1,829,897	2,031,543
Repair and maintenance	363,500	206,538	124,609	276,907	67,014	383,963
Other supplies and expenses	822,068	2,411,869	2,904,338	24,091	3,522,734	3,624,846
Insurance claims and other benefits	23,206	41,016	48,593	36,905	55,869	71,221
Depreciation	8,067,911	8,229,732	7,938,653	7,936,876	7,798,372	7,564,530
Amortization	-	-	-	-	18,185	43,554
Total Operating Expense	19,765,394	19,880,426	20,336,622	17,895,030	21,915,793	22,602,064
Operating Income (loss)	9,391,542	2,775,001	2,128,260	11,413,431	7,988,387	10,555,576
Nonoperating Revenues (Expense)						
Interest and investment revenue	557,566	992,414	501,061	(108,225)	(514,379)	1,599,427
Grant Revenue	-	-	-	-	12,077,611	1,617,967
Miscellaneous revenue	7,995,466	974,624	-	-	-	11,521
Interest expense	(2,332,621)	(2,574,476)	(1,774,693)	(1,663,145)	(1,534,251)	(1,592,572)
Miscellaneous expense	(2,362)	-	-	-	-	-
Total Nonoperating Revenue (Expense)	6,218,049	(607,438)	(1,273,632)	(1,771,370)	10,028,981	1,636,343
Income (loss) Before Contributions & Transfers	15,609,591	2,167,563	854,628	9,642,061	18,017,368	12,191,919
Capital contributions	1,746,374	1,079,087	3,304,592	358,850	8,815	3,378,392
Transfers in	133,903	2,116,097	-	-	-	-
Transfer out	(167,214)	(364,731)	(139,181)	(47,868)	(47,940)	(78,250)
Transfer to Fiscal Agent	-	(2,066,310)	-	-	-	-
Change in Net Position	17,322,654	2,931,706	4,020,039	9,953,043	17,978,243	15,492,061
Net Position - Beginning	92,589,114	109,914,129	104,363,824	108,683,150	118,636,193	136,614,438
Prior period adjustment	-	(8,482,011)	299,286	-	-	-
Net Position - Ending	109,911,768	104,363,824	108,683,149	118,636,193	136,614,436	152,106,499

Following are some observations about the sewer utility's historical financial performance:

- "Charges for services" revenue varies from year to year, with the total ranging from $22.4 million to $33.1 million over the past six years. While population growth and retail rate increases account for a general upward trend over time, the "up and down" variability from year to year is largely driven by changes in capital cost sharing from contract customers.

The three primary contract customers are the City of Poulsbo, U.S. Navy Keyport, and Bangor. All three contract customers pay for ongoing service at the commercial rate. Poulsbo and U.S. Navy Keyport have separate cost-sharing agreements for capital costs. In the County's accounting system, capital cost-sharing is included in the "charges for services" revenue category.

- In 2018, the County received $7,995,466 in miscellaneous revenue, with a smaller amount ($974,625) received the following year. The County's annual report showed this revenue in the "operating grants and contributions" category. While we did not determine the source, it is clearly a non-recurring revenue.
- Total operating expenses have increased over time, with an average increase of 2.3% per year. There was a temporary decrease from 2020 to 2021 followed by a rebound in 2022. This pattern may have been influenced by the COVID-19 pandemic.
- The County received approximately $13.7 million in grants over the last two years with the majority ($12.1 million) being accounted for in 2022.
- The financial statements suggest that the County utility has been drawing down its balance of outstanding debt through the six-year period, since interest expense decreased from $2.3 million in 2018 to $1.6 million in 2023.
- In the annual report, the term "net position" refers to the utility's total assets minus total liabilities. (It is analogous to "owner's equity" in private sector financial statements.) The Kitsap County sewer utility's net position has increased by $59.5 million (64%) from the beginning of 2018 to the end of 2023. This equates to an average increase of 8.6% per year during the period.

12.3 Methodology and Assumptions

12.3.1 Revenue Requirement Forecast Methodology

The revenue requirement forecast identifies the total revenue needed to fully fund the utility on a stand-alone basis considering current and future financial obligations. For this analysis, the resulting rate increases are assumed to be applied "across-the-board" to all customer classes; no rate design changes are proposed in this financial plan.

Table 12-2 shows that the forecast is a two-step process. The first step is the capital funding strategy, shown in the left column. We begin with the total capital program provided by Consor as part of the General Sewer Plan Updates for each of the County's four wastewater basins. We then subtract all of the non-debt funding sources. The remainder is the amount of borrowing needed. The number at the bottom of the first column—the debt needed to fund the remainder of the capital program—determines the amount of new debt service, which is an annual cost.

The second step is the annual forecast, shown in the column to the right. The fiscal policy targets include the minimum reserve balances that must be maintained in the forecast. To that number we add each year's projected operating costs, existing and new debt service, and the amount of current rate funding used for capital expenditures. After deducting non-retail revenue, we now know how much money is needed each year from rates.

Table 12-2 | Revenue Requirement Overview

	Capital Funding Strategy
	Total Capital Projects
-	Grants
-	Wholesale Contributions
-	Newcomer Fees
-	Rate-Funded Capital
-	Cash Reserves
=	Debt Funding (Loans or Bonds)

	Annual Forecast
	Fiscal Policy Targets
+	Operating Costs
+	Existing & New Debt Service
+	Rate-Funded Capital
=	Revenue Requirement
-	Offset Revenues
=	Revenue Required from Retail Rates

The rate revenue requirement is next compared with the revenue projected to be generated by current rates. In addition, we test the current rates against required “debt service coverage,” which is an important fiscal policy explained below. If the current rates are insufficient—either because they do not generate enough cash or because the debt service coverage target is not met—then the forecast rates are adjusted to the degree necessary to balance the cash flow requirements and ensure that the coverage target is achieved.

12.3.2 Fiscal Policies

The fiscal policies that affect a rate forecast include the target operating reserve, minimum capital reserve, minimum operating and capital cash, debt service coverage, rate-funded capital reinvestment. Each type of policy is discussed below.

12.3.2.1 Target Operating Reserve

“Reserves” are another word for fund balance. An operating reserve is a liquidity cushion; it protects the utility from the risk of short-term variation in the timing of revenues or expenses.

For operating reserves, we often characterize the target with both a minimum and a maximum. For any given year, if the forecast shows an ending fund balance below the minimum, then rates need to be raised higher to replenish the reserve. If the forecast shows the ending balance above the maximum, then the excess cash is re-characterized as a capital reserve.

The most common operating reserve target for sewer utilities is between 45 days and 60 days (12%-16%) of annual operating expenses. However, Kitsap County sewer rates include a volume charge for non-residential and contract customers, which introduces more revenue variability. We therefore suggest a larger cushion—an operating reserve target of 90 days (25%) of annual operating expenses.

Recommended Policy: Achieve a year-end operating fund balance of <u>90 days (25%)</u> of total annual operating expenses. <u>Results</u>: For 2024, this amount is forecasted to be about $4.1 million; it increases throughout the forecast period as operating costs increase with inflation.

12.3.2.2 Minimum Capital Reserve

The capital fund balance fluctuates naturally because it serves two functions. First, capital reserves are a capital funding tool, the means by which a utility saves up in advance of major capital projects and avoids overreliance on debt. Utilities tend to go through waves of capital investment, so the reserve balance tends to grow over time and then drop suddenly after a large capital project.

There is also a second function of a capital reserve. It also serves as a risk reserve just like the operating reserve, giving the utility the flexibility to respond to unanticipated needs. Such needs could include a capital cost overrun, or an unexpected failure of a major asset. It could be an unexpected regulatory requirement or simply an opportunity-driven capital improvement. A cash cushion gives the utility flexibility to address unforeseen capital needs in a logical way.

That cash cushion is achieved by having a minimum capital fund balance in the projections. In other words, when we forecast capital spending and the fund balance naturally goes up and down, we only allow it to go down so far—only as far as the target minimum—not all the way to zero.

The target minimum capital fund balance could be defined as a certain percentage of the average CIP, or as the projected replacement cost of specified high-value assets. However, a simple and common way to set a target minimum capital reserve is to define it as 1% of the original cost of fixed assets in the system. This minimum naturally increases over time since future capital investment leads to a growing inventory of assets. That is the approach we recommend in this financial plan.

Recommended Policy: Achieve a year-end minimum capital balance target of 1% of the original cost of plant-in-service. Results: This equates to roughly $2.9 million for year-end 2024 and increases to $9.0 million in 2042 as capital is constructed.

12.3.2.3 Minimum Operating and Capital Cash

In recent years, bond rating agencies have focused on the combined operating and capital cash balance. A favorable indicator is when a utility maintains a combined year-end cash reserve of at least 180 days (50%) of annual operating expenses. That is the policy target we recommend here.

Recommended Policy: Maintain a minimum year-end operating and capital balance of 180 days (50%) of annual operating expenses. Results: This equates to roughly $8.2 million for year-end 2024 and increases thereafter. In this forecast, the 180-day target is achieved in all years.

12.3.2.4 Debt Management

The sewer utility currently has three revenue bonds, two Public Works Trust Fund (PWTF) loans, and four Department of Ecology (DOE) state loans. Additionally, the County is in the process of selling additional revenue bonds and securing another DOE loan. In 2024, debt service is about $5.2 million. With existing debt and the new debt arrangements already underway, debt service will rise above $7 million per year for 2027-2040, dropping off after 2040. In addition, to address the capital needs identified in this plan, additional revenue bonds are forecasted to be issued in future years. Each bond issue is assumed to have a 20-year term, issuance cost of 1%, and an interest rate of 5%.

12.3.2.4.1 Debt Service Coverage

Debt service coverage is a requirement typically associated with revenue bonds and some state loans. It is also a useful benchmark to measure the riskiness of a utility's capital funding plans. Coverage is best understood as a factor applied to annual debt service. A typical requirement in selling revenue bonds is that bonded debt service coverage must be at least 1.25 throughout the life of the bonds. That means the County agrees to collect enough revenue each year to meet operating expenses and not only pay debt service but also an additional 25% above bonded debt service. This cushion makes bondholders more confident that debt service will be paid on time. The extra revenue can be used for capital expenditures, to build reserves, or for debt service on subordinate debt.

While the County's contractual minimum coverage is 1.25, achieving coverage greater than the minimum is a positive signal that bond rating agencies notice, and it can result in more favorable terms for future borrowing. For that reason, many utilities set a policy target higher than 1.25.

Recommended Policy: Set rates to achieve bonded debt service coverage of at least 1.50. Results: The utility is forecasted to achieve this policy in all years except 2032 and 2034, when coverage decreases to 1.38 and 1.49. That is still safely above the legal minimum of 1.25.

12.3.2.5 Rate-Funded Capital Investment

To avoid overreliance on debt, it is useful to have a target for the amount of capital investment that is funded by rates ("pay-as-you-go"). A common benchmark is to aim for rate-funded capital of at least 100% of original cost depreciation by the end of the forecast period. We recommend that approach.

Recommended Policy: Rate revenue should fund 100% of original cost depreciation expense by the end of the forecast period. Annual depreciation is $7.5 million in 2023, growing to $19.8 million by 2042. Results: In this forecast, rate-funded capital at 100% of depreciation is first achieved in 2039 and continues through the remainder of the forecast.

Table 12-3 provides a summary of the recommended fiscal policies for the sewer utility.

Table 12-3 | Summary of Fiscal Policies

Policy	Recommended Target
Operating Reserve	90 days (25%) of annual O&M expenses (initially, $4.1 million)
Minimum Capital Reserve	1% of original cost of plant-in-service (initially, $2.9 million)
Minimum Operating & Capital Cash	180 days (50%) of annual O&M expenses (initially, $8.2 million).
Debt Service Coverage	A policy target of at least 1.50 for bonded debt, which is higher than the contractual minimum of 1.25
Rate-Funded (Pay-as-You-Go) Capital Reinvestment	Rate-funded capital should equal 100% of original cost depreciation by the end of the study period ($19.8 million per year by 2042)

12.3.3 Key Assumptions and Data Sources

12.3.3.1 Economic & Inflation Factors

The operating expenditure forecast relies primarily on the County's 2024 adopted budget. The line items in the budget are then adjusted each year by one of the following factors:

- General Cost Inflation – After conversations with staff, we assumed 4% in 2024 followed by 3% per year thereafter.
- Construction Cost Inflation – Unless otherwise mentioned, all project costs were given in 2023 dollars, then escalated for construction inflation of 8% in 2024, 4% per year thereafter.
- Labor Cost Inflation – Assumed at 10% for 2025 to reflect the County's compensation study adjustments, followed by 3% per year based on the Employment Cost Indices for wages.

- Benefits Cost Inflation – Assumed at 5% per year, based on the Employment Cost Indices for benefits.

- Taxes – The State excise tax rate is 3.852%, the State Business and Occupation (B&O) tax rate is 1.75%. The State excise tax applies to rate revenue allocated to the collection system. The B&O tax applies to rate revenue allocated to treatment and transmission, as well as to system development charges and other miscellaneous fees.

- Fund Earnings – Assumed to be 4% in 2024 and decreasing one percentage point per year until 2027 and then remaining at 1% for the forecast period. Based on market conditions as well as historical Local Government Investment Pool (LGIP) returns.

- Customer Growth – Conservatively assumed to be 0.5% per year, based on discussion with staff. The assumed growth rate in sewered population varies for each of the County's four service areas, which are projected to be between 0.6%/yr and 4.8%/yr. Therefore, a 0.5%/year customer base growth rate represents a conservative estimate for the purposes of financial planning in the event assumed sewered population growth rates are not realized.

- Operating Budget Execution Factor – 95% in 2024 followed by 90% for all other years, based on discussions with staff and historical data on actual vs. budgeted spending.

12.3.3.2 Fund Balances

The County manages both an operating and capital fund related to the sewer utility. For the purpose of showing funds restricted for debt service repayment, the forecast contains a third category: debt reserves. These funds are assumed to come from the operating fund. **Table 12-4** shows the updated allocated cash balance for 2024 between operating, capital, and debt purposes for the financial modeling. It also shows the projected beginning fund balance for 2024, the beginning of the forecast period.

Table 12-4 | Cash Balances

Description	2024 Beginning Cash Balances
Operating Fund	$11,560,996
Capital Fund	$369,483
Debt Reserves	$6,827,376
Total Fund Balance	**$18,784,376**

While the capital fund reserves are below the initial target of $2.9 million for 2024 beginning balance, the operating fund balance more than covers the difference. In our forecast, any excess operating reserves are re-categorized as available for capital purposes.

12.3.3.3 Existing Debt

As stated previously, current outstanding debt for the sewer utility includes three revenue bonds, two Public Works Trust Fund (PWTF) loans, and four Ecology loans. Annual debt service payments are about $5.2 million in 2024. The County has opted to time the bonded debt service payments to smooth out year-to-year fluctuations in total debt service. The 2015 bond is retired in 2027 while the 2010C QECB loan is retired in 2028. Starting in 2028, the 2010B refunding bond starts to require principal payments. The two outstanding PWTF loans are fully repaid in 2031 and 2041. Two of the DOE loans are fully repaid in 2025 while the others are repaid gradually through 2038.

12.3.3.4 Near-Term Future Debt Obligations

Although not currently making payments on them, the County has begun the process of obtaining two additional debt issues. The first is a 20-year revenue bond which assumes repayment starting in 2025. The bond proceeds (including a bond premium) are assumed to be $32.5 million, requiring annual payments of $2.5 million once principal repayment begins in 2027.

The second loan in process is a $3.78 million DOE loan for the Capital Facility Plans update. Remaining draws on this loan are assumed to occur in 2024. Repayment starts in 2025, with annual payments of about $200,000 per year.

As of the time of writing, the County has also applied for other low-cost loans from State agencies. These additional loans will be described later in this document, under “Capital Funding Strategy.”

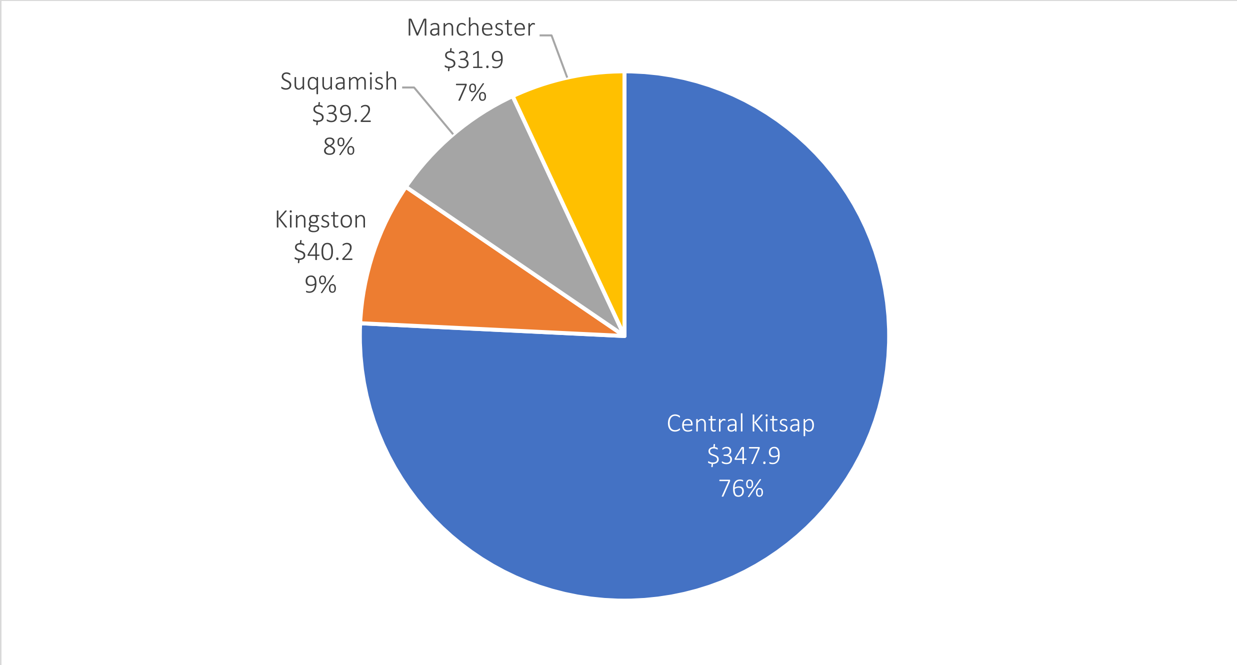
12.3.3.5 Capital Expenditure Forecast

12.3.3.5.1 Capital Projects Before Escalation

Capital project costs and timing were developed by Consor with County staff input. The resulting 2024-2042 capital improvement plan (CIP) shows estimated spending of about $459.2 million in 2023 dollars. Total capital costs in 2023 dollars by basin is shown in **Figure 12-1**. Central Kitsap is the largest treatment plant, and the Kitsap basin has 76% of the capital requirements.

The largest project in the early part of the CIP is the Solids and Liquid Hauled Waste Upgrades at the Central Kitsap treatment plant. Design for this project is currently underway, and its construction schedule is assumed to continue through 2028. (For convenience, it is sometimes referred to as the “digester project,” even though it actually includes other elements besides new digesters.) Its total remaining cost (in escalated dollars) is assumed to be $140 million, and it dominates the early years of the forecast—much of the borrowing and resulting rate increases in the next few years are focused on financing the digester project. Because of the size of the project and the fact that its engineering is well advanced, its cost estimate is given in escalated dollars — no further inflation factor is applied to the $140 million cost. For the other projects, however, **Figure 12-1** shows cost estimates in 2023 dollars.

Figure 12-1 | Unescalated Capital Spending (Millions) 2024-2042



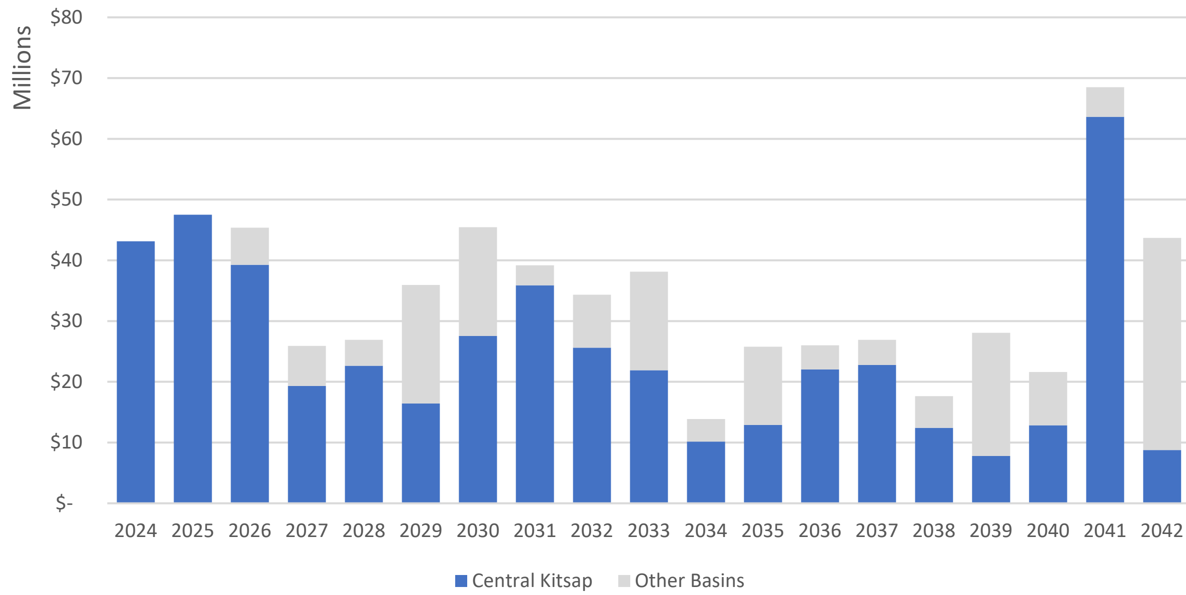
12.3.3.5.2 Projected Capital Expenditures after Cost Escalation

Figure 12-2 shows the year-by-year funding needs after applying the assumed inflation factors.

The digester project has expenditures extending from 2024 through 2028. After 2028, many of the identified capital projects are focused on the collection systems—the pipes and pumps that deliver wastewater to the four treatment plants. The 2029-2040 projects include needed improvements in the Kingston, Suquamish and Manchester basins in addition to the Central Kitsap basin.

In 2041, the CIP shows a major project ($50.3 million, in escalated dollars) to construct Aeration Basins 5 and 6 at the Central Kitsap plant, based on assumed requirements from the State. In 2042, a major upgrade (Class A Reclaimed Water Improvements, costing $29.9 million in escalated dollars) is shown for the Kingston plant. For these 2041 and 2042 projects, the nature of the regulatory requirements from the State are uncertain, but these estimates serve as a placeholder to flag the need for additional major investments in future years.

Figure 12-2 | Capital Expenditure Forecast 2024-2042 (escalated dollars) – Central Kitsap vs All Other Basins



The dark part of each column represents the Central Kitsap basin capital cost needs. The total escalated cost of capital improvements for the Central Kitsap basin is $472.6 million, about 72% of the total $654 million in escalated capital needs for the County.

12.4 County-Wide Revenue Requirement Results

The County currently has an adopted sewer rate increase for 6.31% in 2025. Following the adopted rate increase, the forecast shows that 6.0% annual rate increases would be necessary to continue to cover operations as well as fund the capital plan through a mix of cash funding and debt financing.

12.4.1 Capital Funding Strategy

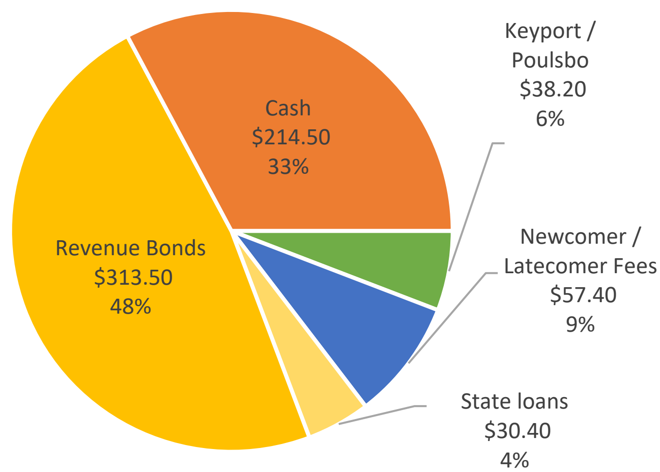
Over the full 19-year period from 2024 through 2042, the capital expenditure forecast (including inflation) contains $654 million of projects. In the capital funding strategy, our task is to identify where that $654 million will come from.

Figure 12-3 shows the forecasted sources of funding for this capital program.

- First is the capital cost sharing from U.S. Navy Keyport and Poulsbo. County staff provided estimates for 2024-2029, totaling $28.1 million for the 6-year period. We assumed that the cost share for 2029 ($778,000) continues in future years, so the total through 2042 is $38.2 million.
- Second, any available Newcomer or Latecomer revenue is applied to the capital program. The forecast assumes about $3,000,000 per year in revenue assuming no changes to the charge, or a total of $57.4 million.
- Next, we assume the low-interest loans that the County is currently pursuing from both Public Works and Department of Ecology. The assumed total is $30.4 million.

- The remaining capital funding need is balanced with a mix of cash vs. revenue bond debt. Each type of funding works to complement the other to fill the remaining funding gap. This includes:
  - Revenue bonds: issued in two-year cycles as needed, to cover capital costs for the year of issuance and the following year. Total debt proceeds are $313.5 million (48% of the total) through 2042. Except for the 2024/25 bond issue, we assumed 20-year bonds at 5% interest.
  - Cash funding: The covers the remaining $214.5 million (33% of the total). It is generated by the rate increases needed to repay revenue bonds and fund the remaining capital needs.

Figure 12-3 | Capital Funding Sources 2024 – 2042



12.4.1.1 Planned Low Interest Loans

The County has applied for low-interest State loans in the short term. The forecast assumes that the County receives the maximum $10 million in both 2025 and 2026 from the Public Works Trust Fund as well as an additional $9.85 million from the Department of Ecology. The total forecasted debt service on these loans is $1.8 million dollars.

12.4.1.2 Planned Revenue Bond Debt Issues

The first bond issue is currently in process as of 2024, but funding may not be available until 2025. After the first revenue bond debt issuance, additional issues are forecasted every two years as needed through 2041. **Table 12-5** shows the timing and magnitude of the bonded debt proceeds assumed in the financial plan, along with the annual debt service associated with each issue.

Table 12-5 | Planned Revenue Bond Issues in the Financial Plan

Year	Net Proceeds	Annual Debt Service
2024/2025	$32.5 million*	$2.5 million*
2026	$22 million	$1.9 million
2028	$42 million	$3.7 million
2030	$70 million	$5.9 million
2032	$58 million	$4.9 million
2034	$19 million	$1.6 million

Year	Net Proceeds	Annual Debt Service
2036	$25 million	$2.1 million
2039	$5 million	$0.4 million
2041	$40 million	$3.4 million
Total	**$313.5 million**	**$26.5 million**

Note:
*2024/2025 issue includes approximately $2.5m premium. Debt service is planned to have two years of interest-only payments in 2025 and 2026

12.4.1.3 Potential Grants and Other Low Cost State Loans

Due to the reliance on revenue bond funding for the capital program, the County should continue to pursue additional low-cost State loans. Grants and state loans provide two benefits. The first is the cost savings compared to the assumed alternative of issuing revenue bonds. In addition, by reducing its reliance on revenue bonds, the County improves its bonded debt service coverage calculation.

The following document is a helpful summary of the funding, eligibility, and contact details for water and sewer infrastructure assistance programs (both grants and low-cost loans) in Washington State: http://www.infrafunding.wa.gov/resources.html. This summary is updated each year by the Department of Commerce. The most recent version (September 17, 2024) is included as **Appendix K** to this report.

12.4.2 Annual Forecast

Figure 12-4 graphically represents the annual forecast through 2042. Total operating revenues are about $31.0 million in 2024 and $90.4 million in 2042. These figures exclude revenue restricted to capital purposes—debt proceeds, capital cost sharing from contract customers, or newcomer charges.

The stacked columns represent the costs of the utility, such as operating expenses, existing debt service, new debt service, and annual cash funding used for capital projects. The solid black line represents revenue at existing rates and the dashed line shows forecasted revenue with rate increases.

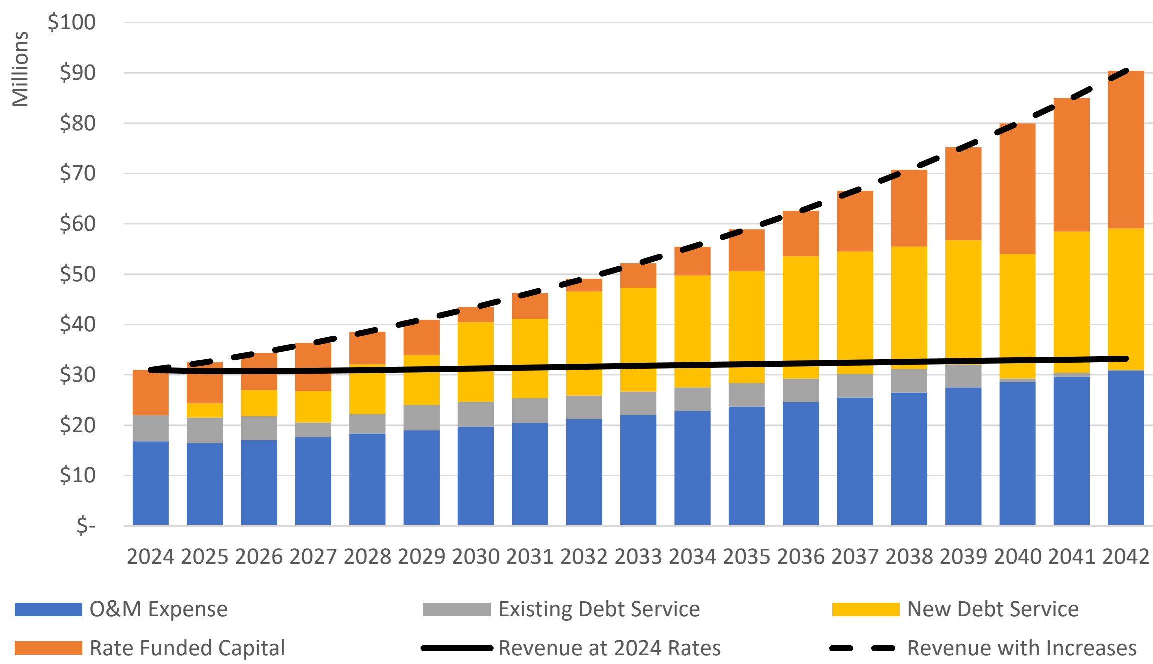
Below are further observations about these variables.

- Solid line: Revenue at existing rates.
  - Revenue is projected to increase with customer growth, even without future rate adjustments.
- Dashed line: Revenues with rate increases.
  - After the recommended rate increases, revenue is expected to grow to $90.4 million by 2042.
- Blue bar: Operating expenses.
  - Operating expenses increase with the annual cost escalation assumptions described earlier.
- Grey bar: Existing debt service.
  - Annual payments of about $5.2 million in 2024, declining to $214,000 by 2042.
- Yellow bar: New debt service.
  - New debt service begins in 2025. By 2042, it is about $28.1 million per year.

➢ Orange bar: Rate revenue available for capital projects.

  ○ This amount fluctuates year to year as the debt issues impact the difference between revenue collected and total other obligations.

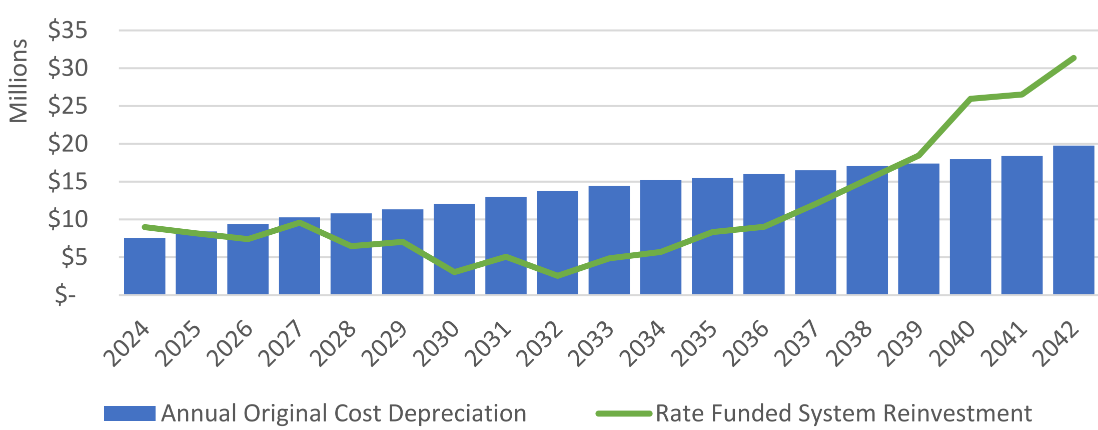
Figure 12-4 | Revenue Requirement Forecast



12.4.2.1 Rate-Funded Capital Investment

The green line in **Figure 12-5** shows the sewer utility's projected annual level of rate-funded capital investment in relation to annual depreciation.

Figure 12-5 | Annual Rate-Funded System Reinvestment



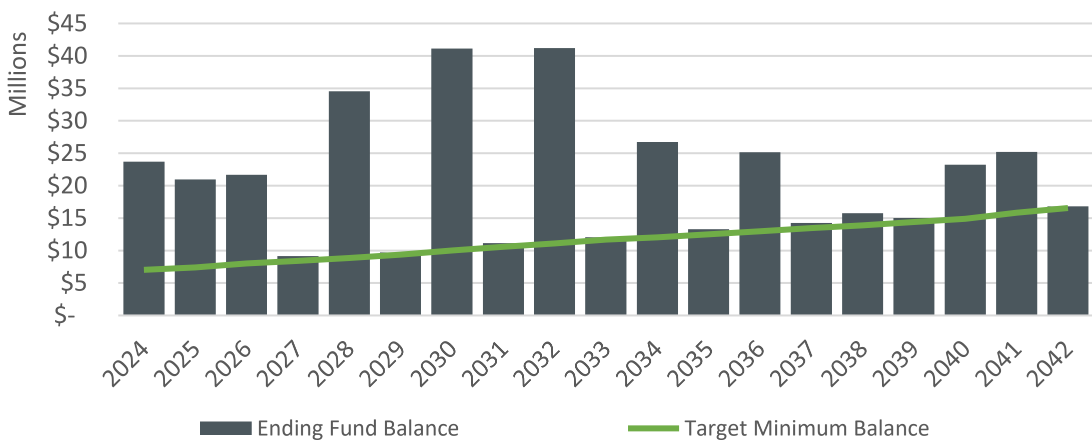
Over the forecast period, annual depreciation cost increases as the County completes capital projects. The blue line represents the same amount as the light green bar in **Figure 12-4**. Over this period, rate-funded system reinvestment reaches a low of 9% of annual depreciation in 2032. This coincides with the lowest bonded debt coverage (1.38) in the forecast. Beginning in 2039, rate-funded capital is projected to achieve the assumed policy target of at least 100% of annual depreciation cost.

12.4.2.2 Operating and Capital Reserve Level

The recommended minimum operating fund balance is 90 days of total annual operating expenses, and the recommended minimum capital fund balance is 1% of the original cost of assets. The sum of these two targets represents the combined minimum reserve balance—about $7.0 million in 2024. It grows to $16.6 million in 2042 as operating costs increase and the County adds assets to the system.

Figure 12-6 shows projected unrestricted fund balances through 2042 in relation to the reserve target (the green line). The utility is projected to achieve the reserve target each year.

Figure 12-6 | Operating and Capital Reserve Forecast

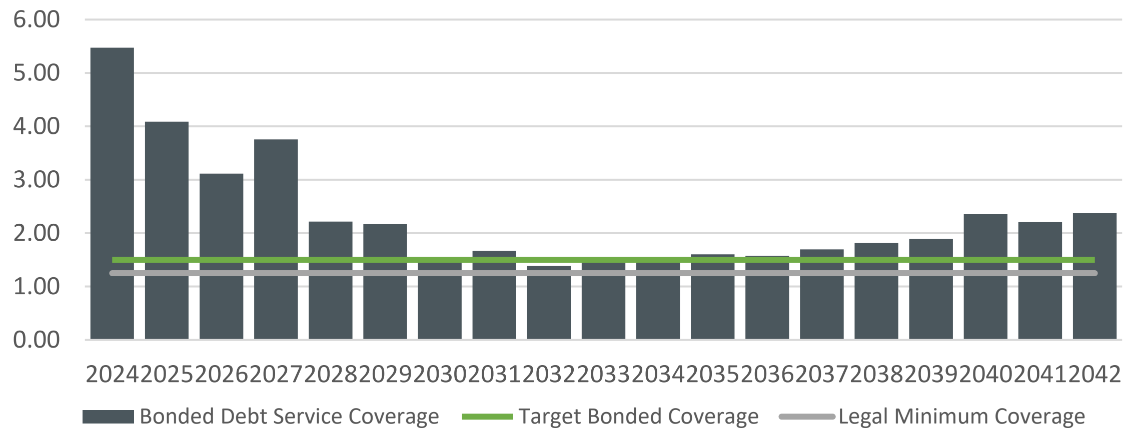


12.4.2.3 Bonded Debt Service Coverage

The legal minimum for revenue bond debt service coverage is 1.25 in each year in which bonds are outstanding. To enhance creditworthiness, many utilities set a policy target that is higher than the legal minimum. In this forecast, assumed a policy goal of at least 1.50 for bonded debt service coverage. However, we allowed exceptions to keep planned rate increases from going above 6% per year.

Figure 12-7 shows projected bonded debt service coverage through 2042 in relation to the assumed policy target of 1.50 and the legal minimum of 1.25. The utility is projected to achieve the policy target each year except for 2032 and 2034, when coverage drops to 1.38 and 1.49. The forecast stays above the legal minimum of 1.25 throughout the forecast period.

Figure 12-7 | Projected Bonded Debt Service Coverage in Relation to Target and Legal Minimum



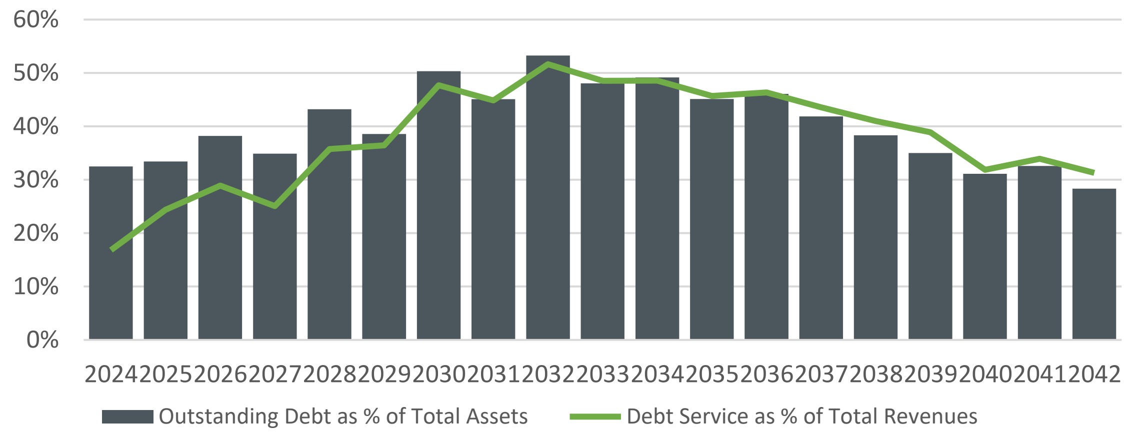
12.4.2.4 Analysis of Outstanding Debt and Debt Service Load

Because the County will need to borrow heavily to fund this CIP, two other debt-related metrics are relevant: the level of outstanding debt in relation to total assets ("debt-to-total assets ratio"), and the projected debt service as a percentage of total revenues ("debt service load"). Debt is a useful component in the capital funding toolbox, but it should not be overused. The cumulative effect of a series of borrowing decisions can be assessed by looking at these two metrics.

Figure 12-8 shows the projected debt-to-total assets ratio and the debt service load throughout the 2024-2042 forecast period. There is not a formal policy target to compare with, but we are aiming to keep both metrics below 50%. In this forecast, both metrics stay at or below 50% except in 2032, when outstanding debt is 53% of total assets and debt service is 52% of total revenue.

Based on these results, we observe that this forecast relies heavily on debt during the next 19 years, and we do not suggest greater borrowing. The significance of this finding comes from the fact that there is a tradeoff between rate increases and the level of borrowing. Higher rate increases allow more "pay-as-you-go" rate-funded capital funding (in lieu of debt), while higher levels of borrowing allow the rate impact to be pushed into future years. In this forecast, the recommended rate increases—6% per year after 2025—should not be ameliorated by more borrowing.

Figure 12-8 | Projected Debt-to-Total Assets Ratio and Debt Service as % of Total Revenue



12.4.2.5 Affordability

Since the inception of the Clean Water Act, the US Environmental Protection Agency (EPA) has provided some guidance on how to measure financial burdens. Called the residential indicator (RI), the EPA measure is the annual residential cost of utility service divided by the median household income (MHI) of the relevant service area. An RI of 2.0% or higher indicates a "high burden" according to the EPA standard for sewer utilities.

The median household income for Kitsap County is estimated to be $103,593 as of 2024. This is based on a survey from the Census Bureau 2023 American Community Survey plus one year of inflation.

Table 12-6 presents an average single-family sewer bill with projected annual rate increases for the forecast period, tested against the affordability threshold. We assumed that median household income increases at the same rate as general inflation, which after 2023 is 3.0% per year. Applying the 2.0% test, Kitsap County's sewer rates are forecasted to remain within the EPA affordability range through 2042. Note that the median income benchmark does not measure the impact on low-income households; the forecasted rates could be a significant burden on households at the lowest income levels.

Table 12-6 | Affordability Table

Year	Inflation	Median HH Income	Projected Monthly Bill	Projected Annual Bill	% of Median HH Income
2023		$99,609	$92.24	$1,107	1.11%
2024	4.00%	$103,593	$98.06	$1,177	1.14%
2025	3.00%	$106,701	$104.25	$1,251	1.17%
2026	3.00%	$109,902	$110.51	$1,326	1.21%
2027	3.00%	$113,199	$117.14	$1,406	1.24%
2028	3.00%	$116,595	$124.17	$1,490	1.28%
2029	3.00%	$120,093	$131.62	$1,579	1.32%
2030	3.00%	$123,696	$139.52	$1,674	1.35%
2031	3.00%	$127,407	$147.89	$1,775	1.39%
2032	3.00%	$131,229	$156.76	$1,881	1.43%
2033	3.00%	$135,166	$166.17	$1,994	1.48%

Year	Inflation	Median HH Income	Projected Monthly Bill	Projected Annual Bill	% of Median HH Income
2034	3.00%	$139,221	$176.14	$2,114	1.52%
2035	3.00%	$143,397	$186.71	$2,241	1.56%
2036	3.00%	$147,699	$197.91	$2,375	1.61%
2037	3.00%	$152,130	$209.78	$2,517	1.65%
2038	3.00%	$156,694	$222.37	$2,668	1.70%
2039	3.00%	$161,395	$235.71	$2,829	1.75%
2040	3.00%	$166,237	$249.85	$2,998	1.80%
2041	3.00%	$171,224	$264.84	$3,178	1.86%
2042	3.00%	$176,361	$280.73	$3,369	1.91%

12.5 Basin-Specific Revenue Requirement Forecasts

While the previous section discussed the overall financial obligations of the County's sewer utility, this section focuses on the obligations as allocated to individual basins. Because the County provides system-wide rates rather than area-specific rates, all customers share the same level of support for funding the Countywide sewer utility. The capital planning is performed for individual basins, but the funding of capital projects—including all debt obligations—and the subsequent rate changes are applied to the County sewer utility as a whole, not for individual basins.

However, this financial plan is one chapter within a set of larger General Sewer Plan Updates documents, and those documents are specific to each basin. In order to meet the Department of Ecology requirements for the planning documents, this section provides information about costs and revenues as they are allocated for each of the four basins: Central Kitsap, Manchester, Suquamish, and Kingston.

12.5.1 Allocating Costs Across Basins

As part of the financial forecast, the County provided an estimated number of Residential Billing Equivalents served by each basin. A Residential Billing Equivalent is used as a metric to estimate the proportion of revenue each basin generates and is based on how much a non-single family residential customer pays compared to a residential customer. For example, based on the County's current billing structure, a multi-family customer bill is approximately 80% of a single-family bill and would be treated as 0.8 Residential Billing Equivalent. Of the approximately 28,000 equivalents, the Central Kitsap area serves the vast majority of customers, representing 89.5% of the revenue. Accordingly, we allocated 89.5% of the overall costs to the Central Kitsap Basin. The same approach is taken to the other basins—the cost of O&M, capital, debt service, and required reserves are allocated in proportion to each basin's share of the system-wide total Residential Billing Equivalents. The Residential Billing Equivalents and resulting allocation percentages are shown in **Table 12-7**.

Table 12-7 | Allocation to Basins

Basin	Residential Billing Equivalents	Percentage
Central Kitsap	25,011	89.46%
Manchester	1,026	3.67%
Suquamish	970	3.47%
Kingston	950	3.40%
Total	**27,957**	**100%**

12.5.2 Results by Basin

The allocation of the revenue requirement to individual basins is shown in **Table 12-8**. For simplicity in presentation, we show the allocated revenue requirement only for the years 2025 and 2030, but the same percentage allocations can be applied to any of the forecast years.

Table 12-8 | Projected Revenue Requirement by Basin – 2025 and 2030

	Total	Central Kitsap	Manchester	Suquamish	Kingston
Allocation Percentage		89.46%	3.67%	3.47%	3.40%
2025					
Revenues					
Rate Revenue after Rate Increases	$30,005,499	$26,843,636	$1,101,178	$1,041,075	$1,019,610
Non-Rate Revenue	2,479,539	2,218,255	90,997	86,030	84,257
Total Revenue	**$32,485,038**	**$29,061,255**	**$1,192,175**	**$1,127,105**	**1,103,866**
Requirements					
Cash Operating Expenses	$16,403,199	$14,674,694	$601,985	$569,128	$557,393
Existing Debt Service	5,114,100	4,575,196	187,683	177,440	173,781
New Debt Service	2,802,218	2,506,931	102,839	97,226	95,221
Rate Revenue Available for Capital	8,165,521	7,305,070	299,668	283,312	277,471
Total Requirements	**$32,485,038**	**$29,061,891**	**$1,192,175**	**$1,127,105**	**$1,103,866**
2030					
Revenues					
Rate Revenue after Rate Increases	$41,168,068	$36,829,937	$1,510,836	$1,428,373	$1,398,922
Non-Rate Revenue	2,291,740	2,050,245	84,105	79,515	77,875
Total Revenue	**$43,459,808**	**$38,880,182**	**$1,594,941**	**$1,507,888**	**$1,476,797**
Requirements					
Cash Operating Expenses	$19,681,630	$17,607,656	$722,300	$682,877	$668,797
Existing Debt Service	4,946,317	4,425,094	181,526	171,618	168,080
New Debt Service	15,786,416	14,122,905	579,349	547,728	536,434
Rate Revenue Available for Capital	3,045,444	2,274,527	111,765	105,665	103,486
Total Requirements	**$43,459,808**	**$38,880,182**	**$1,594,941**	**$1,507,888**	**$1,476,797**

The sewer rate increases needed to support the above revenue requirements are the same for all four basins: 6.31% in 2025 and 6% per year through the remaining forecast period. Similarly, the projected debt service coverage is the same for all basins, as are the assumed policies for cash reserves. While the CIP is differentiated by basin, the debt obligations that are needed to fund the capital projects are all incurred at the countywide level, and all financial obligations apply to the County sewer utility as a whole, not to individual basins.

APPENDIX A

NPDES PERMIT

Issuance Date:	September 30, 2015
Effective Date:	December 1, 2015
Expiration Date:	November 30, 2020

National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0032077

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.

Kingston Wastewater Treatment Plant
Kitsap County Department of Public Works

614 Division Street MS - 27
Port Orchard, WA 98366

is authorized to discharge in accordance with the Special and General Conditions that follow.

Plant Location: 23055 South Kingston Road NE Kingston, WA 98346	Receiving Water: Appletree Cove, Puget Sound
Treatment Type: Oxidation Ditch (Activated Sludge System)	

Kevin C. Fitzpatrick
Water Quality Section Manager
Northwest Regional Office
Washington State Department of Ecology

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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	January 15, 2016
S3.A	Discharge Monitoring Report (DMR)	Quarterly	April 15, 2016
S3.A	Discharge Monitoring Report (DMR)	Yearly	January 15, 2017
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	January 31, 2017
S5.F	Bypass Notification	As necessary	
S5.G	Operations and Maintenance Manual Update or Review Confirmation Letter	1/permit cycle	June 30, 2016
S6.E	Annual List of Industrial User Survey	1/permit cycle	May 31, 2020
S8.A	Sediment Baseline Sampling and Analysis Plan	1/permit cycle	May 31, 2018
S8.B	Sediment Data Report	1/permit cycle	March 31, 2020
S9	Outfall Evaluation	1/permit cycle	May 31, 2020
S10	Application for Permit Renewal	1/permit cycle	May 31, 2020
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 Appletree Cove at the permitted location subject to compliance with the following limits:

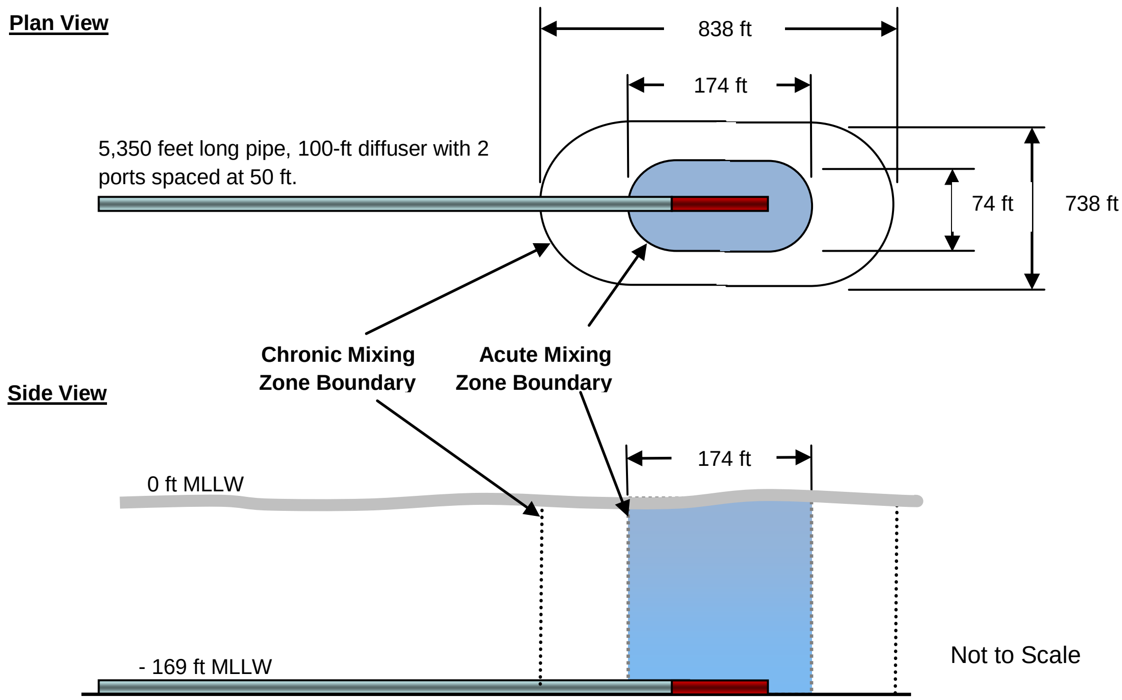
Effluent Limits: Outfall 001 Latitude: 47.788889 Longitude: 122.486389		
Parameter	**Average Monthly [a]**	**Average Weekly [b]**
Carbonaceous Biochemical Oxygen Demand (5-day) ($CBOD_5$)	25 milligrams/liter (mg/L) 61 pounds/day (lbs/day) 85% removal of influent $CBOD_5$	40 mg/L 98 lbs/day
Total Suspended Solids (TSS)	30 mg/L 73 lbs/day 85% removal of influent TSS	45 mg/L 110 lbs/day
Parameter	**Minimum**	**Maximum**
pH [c]	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria [d]	200/100 milliliter (mL)	400/100 mL

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 d 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	Indicates the range of permitted values. Do not average pH values.
d	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:



Chronic mixing zone

The allowable chronic mixing zone is 838 feet (255 meters) by 738 feet (225 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 174 feet (53 meters) by 74 ft (22.5 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	290
Chronic Aquatic Life Criteria	1391
Human Health Criteria - Carcinogen	1391
Human Health Criteria - Non-carcinogen	1391

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.			
$CBOD_5$	mg/L	2/week	24-hr composite [b]
$CBOD_5$	lbs/day	2/week	Calculated [c]
TSS	mg/L	2/week	24-hr composite
TSS	lbs/day	2/week	Calculated
BOD_5	mg/L	2/month	24-hr composite
BOD_5	lbs/day	2/month	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 $CBOD_5$ analysis before or after the disinfection process. If taken after, the Permittee must dechlorinated and reseed the sample whenever chlorine is used for disinfection.			
Flow	MGD	Continuous [a]	Metered/recorded
$CBOD_5$	mg/L	2/week	24-hr composite
$CBOD_5$	lbs/day	2/week	Calculated
$CBOD_5$	% removal [d]	1/month	Calculated
TSS	mg/L	2/week	24-hr composite
TSS	lbs/day	2/week	Calculated
TSS	% removal	1/month	Calculated
Fecal Coliform [e]	# /100 mL	2/week	Grab [f]
pH [g]	Standard Units	Daily	Grab
(3) Effluent characterization – final wastewater effluent			
Total Ammonia	mg/L as N	Quarterly [h]	24-hr composite
Nitrate + Nitrite Nitrogen	mg/L as N	Quarterly	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
(4) Permit renewal application requirements – final wastewater effluent			
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
Temperature	Degrees centigrade (°C)	1/month (Summer months only) [i]	Measurement

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
Footnotes for monitoring table			
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 $CBOD_5$ 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	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 1/1/2016 and submit results by 4/15/2016.		
i	Summer months are July, August, and September. Temperature grab sampling must occur when the effluent is at or near its daily maximum temperature, which usually occurs in the late afternoon.		

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. Establish a calibration frequency for each device or instrument in the O&M manual that conforms to the frequency recommended by the manufacturer.
6. Calibrate flow-monitoring devices at a minimum frequency of at least one calibration per year.
7. 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. Submit monitoring results for parameters shown in S2.A (1), (2), and (3) each month.
2. 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.
3. 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.
4. 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.
5. Not report zero for bacteria monitoring. Report as required by the laboratory method.
6. Calculate and report an arithmetic average value for each day for bacteria if multiple samples were taken in one day.
7. 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.
8. 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.
9. 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 agency-required detection value and the agency-required quantitation value.

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.

10. Report single-sample grouped parameters (for example: priority pollutants, PAHs, pulp and paper chlorophenolics, TTOs) on the WQWebDMR form and include: sample date, concentration detected, detection limit (DL) (as necessary), and laboratory quantitation level (QL) (as necessary). The Permittee must also submit an electronic PDF copy of the laboratory report using WQWebDMR.

    If the Permittee has obtained a waiver from electronic reporting or if submitting prior to the compliance date, the Permittee must submit a paper copy of the laboratory report providing the following information: date sampled, sample location, date of analysis, parameter name, CAS number, analytical method/number, detection limit (DL), laboratory quantitation level (QL), reporting units, and concentration detected.

    The contract laboratory reports must also include information on the chain of custody, QA/QC results, and documentation of accreditation for the parameter.

11. Ensure that DMRs are electronically submitted no later than the dates specified below, unless otherwise specified in this permit.

    If the Permittee has obtained a waiver, it must ensure that paper forms are postmarked or received by Ecology no later than the dates specified below, unless otherwise specified in this permit.

12. Submit DMRs for parameters with the monitoring frequencies specified in S2 (monthly, quarterly, or annual) at the reporting schedule identified below. The Permittee must:

    a. Submit **monthly** DMRs by the 15th day of the following month. The first submittal is January 15, 2016.

    b. Submit **quarterly DMRs** (for nutrient sampling required in S2A(3)) by the 15th 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 April 15, 2016 for the quarter beginning on January 01, 2015.

    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, 2017.

d. Submit permit renewal application monitoring data required in Special Condition S2.A(4)) annually in WQWebDMR by January 15th of the year following the monitoring period.

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 County 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 County Health District	360-337-5235 (call 24/7, press 0 for operator)

b. Twenty-four-hour reporting

The Permittee must report the following occurrences of noncompliance by telephone, to Ecology at the telephone number 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)	0.292 MGD
BOD_5 Influent Loading for Maximum Month	585 lb/day
TSS Influent Loading for Maximum Month	585 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 January 31, 2017.

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 II 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 I plant must be in charge during all regularly scheduled shifts.

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

This permit prohibits a bypass, which is the intentional diversion of waste streams from any portion of a treatment facility. Ecology may take enforcement action against a Permittee for a bypass unless one of the following circumstances (1, 2, or 3) applies.

1. Bypass for essential maintenance without the potential to cause violation of permit limits or conditions.

   This permit authorizes a bypass if it allows for essential maintenance and does not have the potential to cause violations of limits or other conditions of this permit, or adversely impact public health as determined by Ecology prior to the bypass. The Permittee must submit prior notice, if possible, at least ten (10) days before the date of the bypass.

2. Bypass which is unavoidable, unanticipated, and results in noncompliance of this permit.

   This permit authorizes such a bypass only if:

   a. 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.

   b. No feasible alternatives to the bypass exist, such as:

      - The use of auxiliary treatment facilities.
      - Retention of untreated wastes.
      - 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.
      - Transport of untreated wastes to another treatment facility.

   c. Ecology is properly notified of the bypass as required in Special Condition S3.F of this permit.

3. If bypass is anticipated and has the potential to result in noncompliance of this permit.

    a. The Permittee must notify Ecology at least thirty (30) days before the planned date of bypass. The notice must contain:

        - A description of the bypass and its cause.
        - An analysis of all known alternatives which would eliminate, reduce, or mitigate the need for bypassing.
        - A cost-effectiveness analysis of alternatives including comparative resource damage assessment.
        - 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 reoccurrence 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 or facilities plan 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 consider the following prior to issuing an administrative order for this type of bypass:

        - If the bypass is necessary to perform construction or maintenance-related activities essential to meet the requirements of this permit.
        - If feasible alternatives to bypass exist, such as the use of auxiliary treatment facilities, retention of untreated wastes, stopping production, maintenance during normal periods of equipment down time, or transport of untreated wastes to another treatment facility.
        - If the Permittee planned and scheduled the bypass to minimize adverse effects on the public and the environment.

After consideration of the above and the adverse effects of the proposed bypass and any other relevant factors, Ecology will approve or deny the request. Ecology will give the public an opportunity to comment on bypass incidents of significant duration, to the extent feasible. Ecology will approve a request to bypass by issuing an administrative order under RCW 90.48.120.

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 June 30, 2016.
2. When treatment processes or equipment have significant changes or upgrades the Permittee must update the O&M Manual to meet the requirements of 173-240-080 WAC and submit it to Ecology for approval. The Permittee must submit a paper copy and an electronic copy (preferably as a PDF).
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 May 31, 2020. 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. Sediment monitoring

S8.A. Sediment sampling and analysis plan

The Permittee must submit to Ecology for review and approval a Sediment Sampling and Analysis Plan for sediment monitoring no later than May 31, 2018. The Permittee must submit two paper copies and an electronic copy (PDF format). The purpose of the plan is twofold: a) to characterize sediment quality in the vicinity of the Permittee’s previous Kingston outfall for closure purposes, and b) to ensure that sediment quality in the vicinity of the existing outfall meets the Sediment Management Standards (SMS). The Permittee must follow the guidance provided in the Sediment Source Control Standards User Manual, Appendix B: Sediment Sampling and Analysis Plan (SAPA) (Ecology, 2008). The most current information to SAPA is provided in the draft Sediment Cleanup User's Manual (SCUM II) (https://fortress.wa.gov/ecy/publications/SummaryPages/1209057.html).

S8.B. Sediment data report

Following Ecology approval of the Sediment Sampling and Analysis Plan for the old and existing outfall locations, the Permittee must collect and analyze sediments between August 15th to September 30th of 2019. The Permittee must submit to Ecology a Sediment Data Report containing the results of the sediment sampling and analysis no later than March 31, 2020. The Sediment Data Report must conform to the approved Sediment Sampling and Analysis Plan. The Permittee must submit two paper copies and an electronic copy (PDF format).

In addition to a Sediment Data Report, the sediment chemical and/or biological data must be submitted to Ecology's EIM database (http://www.ecy.wa.gov/eim/). Ecology's MyEIM tools must be used to confirm the accuracy of the submitted data (http://www.ecy.wa.gov/eim/MyEIM.htm).

S9. Outfall evaluation

The Permittee must inspect the submerged portion of the outfall line and diffuser to document its integrity and continued function. If conditions allow for a photographic verification, the Permittee must include such verification in the report. The Permittee must submit the inspection report to Ecology through the Water Quality Permitting Portal – Permit Submittals application by May 31, 2020. The Permittee must submit hard copies of any video files to Ecology as required by Permit Condition S3.B. The Portal does not support submittal of video files.

The inspection must at minimum:

- Assess the physical condition of the outfall pipe, diffuser, and associated couplings.
- Determine the extent of sediment accumulation in the vicinity of the diffuser.
- Ensure diffuser ports are free of obstructions and are allowing uniform flow.
- Confirm physical location (latitude/longitude) and depth (at MLLW) of the diffuser section of the outfall.

S10. Application for permit renewal or modification for facility changes

The Permittee must submit an application for renewal of this permit by May 31, 2020. The Permittee must submit a paper copy and an electronic copy (preferably as a PDF).

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, reports, or information 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
Salinity		SM2520-B		3 practical salinity units or scale (PSU or PSS)

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**
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	1.0	2.0
2,4 dinitrophenol	59	51-28-5	625	1.0	2.0
2-Nitrophenol	57	88-75-5	625	0.5	1.0
4-Nitrophenol	58	100-02-7	625	0.5	1.0
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
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	12	24
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

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)					
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	0.5	1.0
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	0.3	0.6
Bis(*2-ethylhexyl*)phthalate	66	117-81-7	625	0.1	0.5
4-Bromophenyl phenyl ether	41	101-55-3	625	0.2	0.4
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	0.5	1.0
Diethyl phthalate	70	84-66-2	625	1.9	7.6
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	0.2	0.4
2,6-dinitrotoluene	36	606-20-2	609/625	0.2	0.4
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	0.5	1.0
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	0.3	0.6
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	0.5	1.0
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
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	0.25	0.5
PCB-1254	107	11097-69-1	608	0.25	0.5
PCB-1221	108	11104-28-2	608	0.25	0.5
PCB-1232	109	11141-16-5	608	0.25	0.5
PCB-1248	110	12672-29-6	608	0.25	0.5
PCB-1260	111	11096-82-5	608	0.13	0.5
PCB-1016 [9]	112	12674-11-2	608	0.13	0.5
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

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**
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 WA-003207-7

KINGSTON WASTEWATER TREATMENT PLANT

November 9, 2010

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 Kitsap County's Kingston 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 Kingston WWTP's NPDES permit number WA-003207-7 were available for public review and comment from October 1, 2010, until October 31, 2010. For more details on preparing and filing comments about these documents, please see *Appendix A—Public Involvement Information.*

Kitsap County staff reviewed the draft permit and fact sheet for factual accuracy. Ecology corrected any errors or omissions regarding the facility's location, history, discharges, or receiving water.

After the public comment period closes, Ecology will summarize substantive comments and provide responses to them. Ecology will include the summary and responses to comments in this fact sheet as *Appendix F—Response to Comments,* and publish it when issuing the final NPDES permit. Ecology will not revise the rest of the fact sheet, but the full document will become part of the legal history contained in the facility's permit file.

Mike Dawda prepared the permit and this fact sheet.

SUMMARY

Kitsap County (County) operates an oxidation ditch (extended aeration) type activated sludge wastewater treatment plant (WWTP) that discharges to Appletree Cove, Puget Sound. Ecology issued the existing permit for this facility on May 2, 2005.

The proposed permit contains the same effluent limits for Carbonaceous Biochemical Oxygen Demand ($CBOD_5$), Total Suspended Solids, Fecal Coliform Bacteria, and pH as the existing permit.

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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 municipal 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) and for ground waters (chapter 173-200 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 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. Ecology will summarize the responses to comments and any changes to the permit in *Appendix E.*

II. BACKGROUND INFORMATION

Table 1. General Facility Information

Applicant	Kitsap County Public Works
Facility Name and Address	Kingston Wastewater Treatment Plant (WWTP) 23055 South Kingston Road NE Kingston, WA 98346
Type of Treatment	Extended Aeration – Secondary Treatment System
Discharge Location	Appletree Cove, Puget Sound Latitude: 47.788889 Longitude: 122.486389

A. <u>Facility Description</u>

History

Kitsap County (the County) owned and operated an activated sludge wastewater treatment plant constructed in 1974, in downtown Kingston. The County built a new extended aeration WWTP at this new site on South Kingston Road, in 2005. The County constructed a pump station at the old WWTP site and a force main to transfer incoming wastewater from the old plant to the new plant. In addition, the County constructed a new discharge outfall into the deep waters of Appletree Cove, Puget Sound. The County began operating the new plant in May 2005.

Description of the Wastewater Collection System

The wastewater collection system consists of 6-inch through 12-inch diameter sewers. Approximately 95 percent of the existing collection system was constructed in 1974. The County constructed the original collection system primarily of asbestos-cement pipe, and short lengths of 10-inch and 12-inch diameter cast iron pipe. The remaining 5 percent of the collection system, built between 1978 and 1984, was constructed using 6-inch and 8-inch diameter PVC pipe. There are six lift stations in the collection system, including the new pump station constructed at the old WWTP site.

Treatment Processes

The treatment process at the plant includes preliminary treatment through a rotary screen and an aerated grit chamber, influent flow measurement with a Parshall flume, biological treatment in two oxidation ditches followed by solids settling in two secondary clarifiers, disinfection with an ultraviolet (UV) light disinfection system, and effluent flow measurement with a Parshall flume. Solids removed from the secondary clarifiers are thickened by a gravity belt thickener, and then transported to the County’s Central Kitsap WWTP for further treatment and utilization.

Diagram showing the treatment plant layout is included in Appendix C.

Discharge Outfall

The County discharges the secondary treated and disinfected effluent from the Kingston WWTP to Appletree Cove, Puget Sound, via an 18-inch diameter concrete-coated steel pipe that is lined with polyurethane. The outfall pipe extends 5350 feet into Appletree Cove to a depth of 169 feet below mean lower low water (MLLW). A diffuser at the end of the outfall pipe consists of two 3-inch diameter ports at 50-foot spacing.

Diagram showing the outfall location is included in Appendix C.

Solid Wastes

The treatment facilities remove solids during the treatment of the wastewater at the headworks (grit and screenings), in addition to incidental solids (rags, scum, and other debris) removed as part of the routine maintenance of the equipment. Grit, rags, scum, and screenings are drained and disposed of as solid waste at the local landfill. Solids removed from the secondary clarifiers are thickened by a gravity belt thickener, and then transported to the County's Central Kitsap WWTP for further treatment and utilization.

B. Permit Status

Ecology issued the existing permit for this facility on May 2, 2005, with the expiration date of May 2, 2010. The County submitted an application for permit renewal on October 28, 2009. Ecology accepted it as complete on November 2, 2009. Ecology extended the existing permit on April 30, 2010. The County is operating the Kingston WWTP under the terms and conditions of this extended permit.

C. Summary of Compliance With the Existing Permit

Ecology staff last conducted a non-sampling compliance inspection of the plant on June 4, 2009. The plant effluent looked very clear at the time of this inspection.

The County has complied with the effluent limits and permit conditions throughout the duration of the existing permit. Ecology assessed compliance based on its review of the facility's discharge monitoring reports (DMRs) and on inspections conducted by Ecology.

The County received Ecology's OUTSTANDING TREATMENT PLANT AWARDS for outstanding performance at Kingston WWTP during 2006, 2007, 2008, and 2009.

D. Wastewater Characterization

The concentration of pollutants in the discharge was reported in the NPDES application and in discharge monitoring reports. The WWTP staff analyzes effluent for metals once a month. The tabulated data below represents the quality of the effluent discharged from the plant. Metals data in the table are from 2009 only.

Table 2. Effluent Characterization

Parameter	Average Concentration	Maximum Concentration	Number of Samples
$CBOD_5$ (mg/L)	3.6	17.7	314
TSS (mg/L)	7.3	32.5	316
Fecal Coliform Bacteria (CFU/100 mL)	2 (GM)*	46,000*	315
Ammonia (NH3-N) (mg/L)	0.6	7.6	72
Dissolved Oxygen (mg/L)	5.8	10.6	1096
Total Nitrogen (TKN) (mg/L)	2.3	13.0	36
Nitrate + Nitrite (as N) (mg/L)	11.1	25.7	26
Oil and Grease (mg/L)	3.6	3.6	3
Phosphorus (Total) (mg/L)	3.8	6.6	36
Parameter	**Average Concentration (2009)**	**Maximum Concentration (2009)**	**Number of Samples (2009)**
Antimony (ug/L)	< 22.20	< 19.20	12
Arsenic (ug/L)	< 12.70	< 12.70	12
Berillium (ug/L)	< 0.22	< 0.22	12
Cadmium (ug/L)	< 2.20	< 2.20	12
Chromium (ug/L)	< 2.03	< 2.03	12
Copper (ug/L)	< 13.30	< 13.30	12
Lead (ug/L)	< 6.61	< 6.61	12
Mercury (ug/L)	< 0.30	< 0.50	12
Molybdenum (ug/L)	< 5.64	< 5.64	12
Nickel (ug/L)	< 5.00	< 5.00	12
Selenium (ug/L)	< 17.40	< 14.70	12
Silver (ug/L)	< 2.36	< 2.36	12
Thallium (ug/L)	< 11.00	< 11.00	12
Zinc (ug/L)	57.20	75.10	12
Parameter	**Average Value**	**Maximum Value**	**Number of samples**
Temperature (^oC – Winter)	12^oC	17^oC	544
Temperature (^oC – Summer)	18^oC	23^oC	552

***Note:** The geometric mean (GM) of 315 samples used for this calculation is 2 CFU/100 mL. The County measured a high fecal coliform (FC) count of 46,000 CFU/100 mL on Thursday, July 24, 2008. This was the result of loss of disinfection (for about 45 minutes) at the plant. Earlier during this week, on Monday (7/21/08) and Tuesday (7/22/08), and the following Monday (7/28/2008), the FC count measured was <1 CFU/100 mL (non-detect). The next two highest values measured were 173 CFU/100 mL and 140 CFU/100 mL. Most of the rest of 315 samples show FC count of <2 CFU/100 mL. The effluent FC concentration at this plant is generally <1 CFU/100 mL (non-detect).

E. Description of the Receiving Water

Kingston WWTP discharges to Appletree Cove, Puget Sound. No ambient background data is available in Puget Sound at this discharge location.

F. SEPA Compliance

Regulation exempts 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 state rules and regulations. 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.

Nor does Ecology usually develop limits for pollutants that were not reported in the permit application but that may be present in the discharge. The permit does not authorize discharge of the non-reported pollutants. If significant changes occur in any constituent of the effluent discharge, the permittee is required to notify Ecology (40 CFR 122.42(a)). The Permittee may be in violation of the permit until Ecology modifies the permit to reflect additional discharge of pollutants.

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 were obtained from *Kingston Wastewater Facilities Plan,* CH2M Hill, December 1999.

Table 3. Design Criteria for Kingston WWTP

Parameter	Design Criteria
Average flow for the maximum month	0.292 MGD
BOD_5 influent loading for the maximum month	585 lbs/day
TSS influent loading for the maximum month	585 lbs/day

B. Technology-Based Effluent Limits

Federal and state regulations define technology-based effluent limits for municipal 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 municipal wastewater.

Chapter 173-221 WAC lists the following technology-based limits for pH, fecal coliform, BOD_5, and TSS:

Table 4. Technology-based Limits

Parameter	Limit
pH	The pH must measure within the range of 6.0 to 9.0 standard units.
Fecal Coliform Bacteria	Monthly Geometric Mean = 200 organisms/100 mL Weekly Geometric Mean = 400 organisms/100 mL
$CBOD_5$ (concentration)	Average Monthly Limit is the most stringent of the following: - 25 mg/L - may not exceed fifteen percent (15%) of the average influent concentration Average Weekly Limit = 40 mg/L
TSS (concentration)	Average Monthly Limit is the most stringent of the following: - 30 mg/L - may not exceed fifteen percent (15%) of the average influent concentration Average Weekly Limit = 45 mg/L

Note: The Permittee has requested continuation of the $CBOD_5$ limits instead of the standard BOD_5 limits. This request is granted as allowed by the state and federal regulations. The average monthly and weekly limits for $CBOD_5$ are 5 mg/l lower than the standard BOD_5 limits.

The following technology-based mass limits are based on WAC 173-220-130(3)(b) and 173-221-030(11)(b).

Monthly average effluent mass limits for $CBOD_5$ = 0.292 MGD (maximum monthly design flow) x 25 mg/L (concentration limit) x 8.34 (conversion factor) = 61 lbs/day.

Weekly average effluent mass limits for $CBOD_5$ = 0.292 MGD (maximum monthly design flow) x 40 mg/L (concentration limit) x 8.34 (conversion factor) = 98 lbs/day.

Monthly average effluent mass limits for TSS = 0.292 MGD (maximum monthly design flow) x 30 mg/L (concentration limit) x 8.34 (conversion factor) = 73 lbs/day.

Weekly average effluent mass limits for TSS = 0.292 MGD (maximum monthly design flow) x 45 mg/L (concentration limit) x 8.34 (conversion factor) = 110 lbs/day.

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 disease, 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

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.

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 existing and designated uses of the receiving water will be protected under the conditions of the proposed permit.

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 does not 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. 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 10 means the effluent is 10% and the receiving water is 90% 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.

Each aquatic life **acute** criterion is 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. Each aquatic life **chronic** criterion is 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.

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 Kingston 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 waterbody'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'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: http://www.ecy.wa.gov/biblio/92109.html.

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 being discharged.

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.**

The effluent data (see Table 2 of this fact sheet) show that ammonia is present in very low concentrations considering high dilution factors achieved in the receiving water. In addition, only zinc was found above the method detection limit, but below the water quality criteria. Based on this, Ecology determined that there is no reasonable potential for the effluent to violate water quality criteria outside the boundary of the mixing zone.

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 rises through the water column as it mixes; 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.

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. <u>Designated Uses and Surface Water Quality Criteria</u>

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). Criteria applicable to this facility’s discharge are summarized below in Table 5.

- **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 receiving water, Puget Sound, in the vicinity of this facility's discharge is designated as Extraordinary Quality. Aquatic Life Uses for this receiving water are identified below.

Table 5. 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 uses** are primary contact recreation and secondary contact recreation.

The recreational uses for this receiving water are identified below in Table 6.

Table 6. 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. 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 biological oxygen demand (BOD) 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 diffuser for the Kingston WWTP has two 3-inch diameter ports at 50-foot spacing.

Chronic Mixing Zone

WAC 173-201A-400(7)(b)(i) 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 as measured during mean lower low water (MLLW). Given a MLLW water depth of 169 feet for the Permittee's outfall, the horizontal distance therefore is 369 feet. The mixing zone is a circle with radius of 369 feet measured from the center of each discharge port. The mixing zone extends from the seabed to the top of the water surface.

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 maximum or chronic zone as measured independently from the discharge ports. The acute mixing zone is a circle with radius of 37 feet measured from the center of each discharge port. The mixing zone extends from the seabed to the top of the water surface.

The dilution factors of effluent to receiving water that occur within these zones have been determined at the critical condition by using near-field and far-field dilution modeling. The modeling provides dilution predictions under critical (worst case) receiving water conditions and for the range of receiving water conditions expected at the discharge site. The dilution modeling and results are discussed in the *"Kingston Replacement Outfall Engineering Report,"* CH2M Hill, January 2000. The design criteria specified in the proposed permit for the new facility are for the year 2012 conditions - diffuser with two 3-inch diameter ports at 50-foot spacing, and a maximum month flow of 0.292 MGD. Model-predicted dilutions for the 2012 discharge conditions, which are used in this permit, are shown in the following table:

Table 7. Dilution Factors (DF)

Criteria	Acute	Chronic
Aquatic Life	290	1391
Human Health, Non-carcinogen		1391

It should be noted that dilution modeling was based on the assumption of the outfall depth of 153 feet below MLLW. However, the actual outfall depth is 169 feet below MLLW. Therefore, Ecology expects that the actual dilutions are higher than those stated in the above table.

Ecology determined the impacts of dissolved oxygen deficiency, temperature, pH, fecal coliform, ammonia, and metals 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.

$CBOD_5$—This discharge with technology-based limitations results in a small amount of CBOD loading relative to the large amount of dilution (1,390:1) occurring in the receiving water at critical conditions. Technology-based limits will ensure that dissolved oxygen criteria are met in the receiving water.

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 marine 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.

- 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 2-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.

Temperature Analysis for this Discharge—Ecology does not have background temperature data for the receiving water in the vicinity of the outfall. Ecology measures water quality parameters, including temperature, at several monitoring stations in Puget Sound. For background, temperature measurements at three locations in Puget Sound were used for this analysis. Daily maximum temperatures measured at these stations are:

(1) 14.71°C in July 2004 at Station PSB 003 (Puget Sound Main Basin–West Point),

(2) 14.77°C in August 1995 at Station PMA 001 (Port Madison), and

(3) 16°C in September 2005 at Station POD 006 (Port Orchard/Liberty Bay).

The data indicate that these areas of Puget Sound naturally have higher temperatures than the criteria, in the summer months.

The WWTP staff at Kingston monitor effluent temperature almost daily. The operators took a total of 552 effluent temperature measurements during the summer months in the past five years. The maximum effluent temperature measured during the summer was 23°C.

Using the dilution factor of 1391and maximum daily temperature of 16°C for the receiving water and 23°C for the effluent, the predicted maximum daily temperature inside the dilution zone is ((1390x16)+(1x23))/1391 = 16.005°C. Thus, under the worst case scenario, the effluent discharge from this facility results in warming of the ambient temperature by 0.005°C, which is less than the allowable warming temperature of 0.3°C.

Since there is no potential for the effluent to violate the water quality standards for temperature in the receiving water, no limits are placed in the permit for effluent temperature. Based on the available data, no potential exist for the effluent to violate the water quality standards for temperature in the receiving water. Therefore, the permit does not require effluent temperature monitoring.

The daily maximum effluent temperature (23°C) prior to discharge is less than 33°C. Therefore, there is no instantaneous lethality for passing fish.

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 1391.

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.

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 toxic pollutants present in the discharge include ammonia and zinc. Ecology conducted a reasonable potential analysis (See Appendix E) for these parameters to determine whether it would require effluent limits in this permit. Ecology determined that these toxic chemicals (ammonia and zinc) present in Kingston WWTP effluent have no reasonable potential to exceed the water quality criteria at the critical condition using procedures given in EPA, 1991.

F. Whole Effluent Toxicity

The water quality standards for surface waters forbid discharge of effluent that causes 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.

Using the screening criteria in Chapter 173-205-040 WAC (see Appendix D), Ecology determined that toxic effects caused by unidentified pollutants in the effluent are unlikely. Therefore, this permit does not require WET testing. Ecology may require WET testing in the future if it receives information indicating that toxicity may be present in this effluent.

G. Human Health

Washington's water quality standards include 91 numeric human health-based criteria that Ecology must consider when writing NPDES permits. These criteria were established in 1992 by the U.S. EPA in its National Toxics Rule (40 CFR 131.36). The National Toxics Rule allows states to use mixing zones to evaluate whether discharges comply with human health criteria.

Ecology determined that the applicant's discharge is unlikely to contain chemicals regulated to protect human health based on the existing effluent data (see Table 2 of this fact sheet) or knowledge of discharges to the Permittee's sewer system. Ecology will reevaluate this discharge for impacts to human health at the next permit reissuance.

H. 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 effluent characteristics, Ecology determined that this discharge has no reasonable potential to violate the sediment management standards.

I. Ground Water Quality Limits

The ground water quality standards (Chapter 173-200 WAC) protect beneficial uses of ground water. Permits issued by Ecology must not allow violations of those standards (WAC 173-200-100).

Kingston WWTP does not discharge wastewater to the ground. No permit limits are required to protect ground water.

J. Comparison of Proposed Effluent Limits With the Existing Effluent Limits

Since there has been no change in the WWTP process and design criteria, the proposed effluent limits are identical to the existing limits as shown in the table below:

Table 8. Comparison of Existing and Proposed Effluent Limits

Parameter	Basis of Limit	Existing Effluent Limits		Proposed Effluent Limits	
		Average Monthly	Average Weekly	Average Monthly	Average Weekly
Carbonaceous Biochemical Oxygen Demand (5-day) (mg/L)	Technology	25	40	25	40
Total Suspended Solids (mg/L)	Technology	30	45	30	45
Fecal Coliform Bacteria (#/100 mL)	Technology	200	400	200	400
pH (Standard Units)	Technology	6.0 to 9.0		6.0 to 9.0	

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.

The monitoring schedule is detailed in the proposed permit under Condition S2. 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 92-09) for activated sludge plants with less than 2 million gallons per day (MGD) average design flow and for plants with oxidation ditches.

Monitoring of stabilized sludge (biosolids) 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.

A. 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). The laboratory analyses for parameters required in this permit are conducted at the Permittee's Central Kitsap (CK) WWTP. The laboratory at the CK WWTP is accredited for all of the parameters to be monitored at the Kingston WWTP.

OTHER PERMIT CONDITIONS

A. <u>Reporting and Record Keeping</u>

Ecology based permit condition S3 on our authority to specify any appropriate reporting and record keeping requirements to prevent and control waste discharges (WAC 173-220-210).

B. <u>Prevention of Facility Overloading</u>

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 Kitsap County to take the actions detailed in proposed permit requirement S4 to plan expansions or modifications before existing capacity is reached and to report and correct conditions that could result in new or increased discharges of pollutants.

C. <u>Operation and Maintenance (O&M)</u>

The proposed permit contains Condition S5 as authorized under RCW 90.48.110, WAC 173-220-150, WAC 173-230, and WAC 173-240-080. Ecology included it to ensure proper operation and regular maintenance of equipment, and to ensure that the Permittee takes adequate safeguards so that it uses constructed facilities to their optimum potential in terms of pollutant capture and treatment.

D. <u>Pretreatment</u>

Primary sources of wastewater tributary to the facility are domestic sewage from residential and light commercial activities in the sewer service area. Since the pretreatment program has not been delegated to the Permittee, the pretreatment Condition S8 in the permit is a standard condition derived from the Federal Regulation 40 CFR 403.5.

E. <u>General Conditions</u>

Ecology bases the standardized General Conditions on state and federal law and regulations. They are included in all individual municipal NPDES permits issued by Ecology.

PERMIT ISSUANCE PROCEDURES

A. <u>Permit Modifications</u>

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 ground waters, 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 five years.

REFERENCES FOR TEXT AND APPENDICES

Environmental Protection Agency (EPA)

1991. *Technical Support Document for Water Quality-based Toxics Control*. EPA/505/2-90-001.

Washington State Department of Ecology

2006. *Permit Writer's Manual.* Publication Number 92-109 (http://www.ecy.wa.gov/biblio/92109.html)

Laws and Regulations (http://www.ecy.wa.gov/laws-rules/index.html)

Kitsap County Department of Public works

December 1999. Final Kingston Wastewater Facilities Plan, CH2M Hill

January 2000. Kingston Replacement Outfall Engineering Report, CH2M Hill

February 2000. Project Manual for Construction of Kingston Wastewater Treatment Plant and Pump Station Number 71, CH2M Hill

APPENDIX A—PUBLIC INVOLVEMENT INFORMATION

Ecology proposes to reissue the 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 Application on November 14 and 21, 2009, in the *Kitsap Sun* to inform the public about the submitted application and to invite comment on the reissuance of this permit.

Ecology placed a Public Notice of Draft on October 1, 2010, 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 http://www.ecy.wa.gov/biblio/0307023.html.

You may obtain further information from Ecology by telephone 425-649-7201 or by writing to the address listed below.

Ms. Tricia Miller
Water Quality Program
Department of Ecology
3190 160th Avenue SE
Bellevue, WA 98008-5452

The primary author of this permit and fact sheet is Mike Dawda.

APPENDIX B—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 period of time, 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).

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 Discharge Limit—The average of the measured values obtained over a calendar month's time.

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.

BOD_5—Determining the 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 BOD_5 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 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.

Chlorine—Chlorine is 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—A mixture of grab samples collected at the same sampling point at different times, formed either by continuous sampling or by mixing discrete samples. May be "time-composite" (collected at constant time intervals) or "flow-proportional" (collected either as a constant sample volume at time intervals proportional to stream flow, or collected by increasing the volume of each aliquot as the flow increased while maintaining a constant time interval between the aliquots).

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.

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%.

Engineering Report—A document which 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.

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 storm water and, also, leachate from solid waste facilities.

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)—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.

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 area of the authorized mixing zone is specified in a facility's permit and follows 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.

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.

Quantitation Level (QL)—The smallest detectable concentration of analyte greater than the Method Detection Limit (MDL) where the accuracy (precision &bias) achieves the objectives of the intended purpose.

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).

Technology-based Effluent Limit—A permit limit that is based on the ability of a treatment method to reduce the pollutant.

Total Suspended Solids (TSS)—Total suspended solids is the particulate material in an effluent. Large quantities of TSS discharged to receiving waters 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.

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.

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.

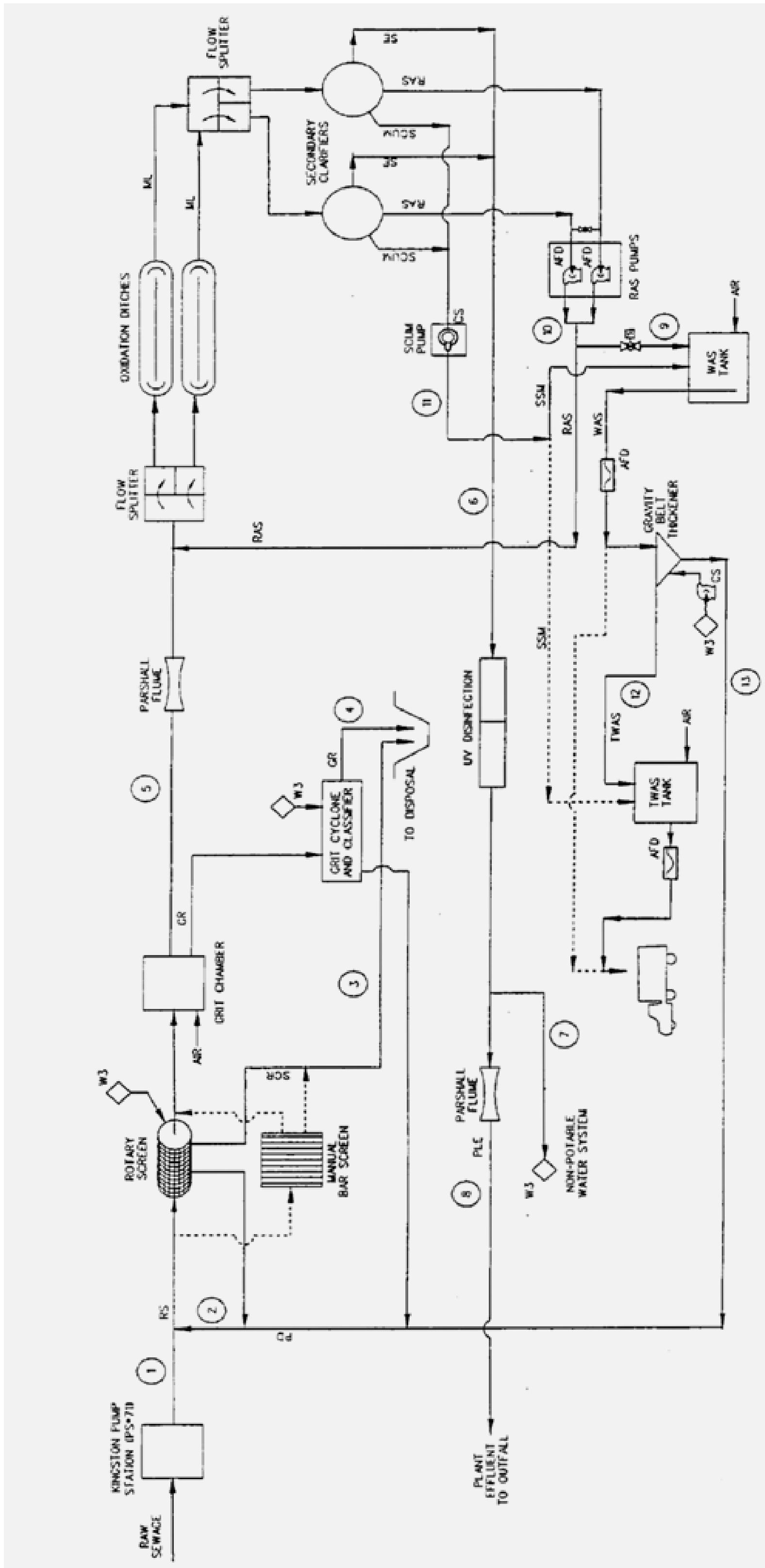
Stormwater—That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a storm water drainage system into a defined surface water body, or a constructed infiltration facility.

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 on the concentration of an effluent parameter that is intended to prevent the concentration of that parameter from exceeding its water quality criterion after it is discharged into receiving waters.

APPENDIX C—TREATMENT PLANT LAYOUT AND OUTFALL LOCATION

TREATMENT PLANT LAYOUT



OUTFALL LOCATION

APPENDIX D—EVALUATION OF WET TESTING REQUIREMENTS

DISCHARGE RANKING SYSTEM FOR WET TESTS

A. Toxicity Likelihood:

1. 5 points Uses, stores, produces as a product or waste, or transfers hazardous substances listed in 40 CFR 302.4 with a statutory code of 1 or 2 with adequate Best Management Practices (adequate secondary containment, good housekeeping, good employee training, thorough self-inspection, sufficient emergency planning, and spill control equipment, etc.) **0 point**

2. 20 points Uses, stores, produces as a product or waste, or transfers hazardous substances listed in 40 CFR 302.4 with a statutory code of 1 or 2 with inadequate Best Management Practices (no or undersized secondary containment, poor housekeeping, little employee training, poor self inspection, little emergency planning, insufficient spill control equipment, history of spills which have reached receiving water, etc.) **0 point**

3. 15 points Discharges in the effluent any toxic pollutant listed in Appendix D of 40 CFR Part 122 for which there are no water quality criteria for aquatic life protection listed in 40 CFR 131.36 (b)(1) or WAC 173-201A-040(3) **0 point**

4. 15 points Discharger belongs in an industry category identified in 40 CFR Part 122, Appendix A **0 point**

5. 15 points Discharger is a municipal facility which receives a discharge from any industry category identified in Appendix C of 40 CFR Part 403, unless the municipality has an adequate pretreatment program which establishes and enforces local limits **0 point**

6. 10 points Any facility with toxicity detected during past acute toxicity testing based on less than 80% survival in 100% effluent **0 point**

7. 15 points Any facility with known or suspected receiving water impacts **0 point**

Sum of Scores in Part A: 0 point

B. Potential for Impact:

1. Average Annual Discharge Flow Volume:

a. 5 points	Flow < 0.5 mgd		**5 points**
b. 10 points	Flow 0.5 mgd to 12.5 mgd		
c. 15 points	Flow 12.5 mgd to 25 mgd		
d. 20 points	Flow 25 mgd to 37.5 mgd		
e. 25 points	Flow 37.5 mgd to 50 mgd		
f. 30 points	Flow > 50 mgd		

2. Chronic Critical Effluent Concentration at Edge of Mixing Zone:

a. 1 point	CCEC < 0.1% effluent	= (1/1390)*100 = 0.07%	**1 point**
b. 5 points	CCEC = 0.1% effluent to 2% effluent		
c. 10 points	CCEC = 2% effluent to 4% effluent		
d. 15 points	CCEC = 4% effluent to 6% effluent		
e. 20 points	CCEC = 6% effluent to 8% effluent		
f. 25 points	CCEC = 8% effluent to 10% effluent		
g. 30 points	CCEC > 10% effluent		

Sum of Scores in Part B: 6 points

C. Multiply the sum of scores from Part A by the sum of scores in Part B to rank the discharge:

Score in Part C: 0 point

D. Discharge Ranks*:

Rank 1 - greater than 2500 points

Rank 2 - 1500 points to 2500 points

Rank 3 - 750 points to 1500 points

Rank 4 - 100 points to 750 points

Rank 5 - less than 100 points

* Borderline values go to any adjacent group at the discretion of the permit manager.

TESTING FREQUENCY

DISCHARGE RANK	EFFLUENT CHARACTERIZATION	
	Acute Toxicity	Chronic Toxicity
RANK 1	6/year, 1 fish 1 invert.	6/year, 1 fish 1 invert. 1 algal*
RANK 2	6/year, 1 fish 1 invert.	4/year, 1 fish 1 invert. 1 algal*
RANK 3	4/year, 1 fish 1 invert.	4/year, 1 fish 1 invert.
RANK 4	4/year, 1 fish 1 invert.	2/year, 1 fish 1 invert.
RANK 5	2/year, 1 fish 1 invert.	2/year, 1 fish 1 invert.

* Optional at permit manager's discretion

APPENDIX E—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 on Ecology's homepage at http://www.ecy.wa.gov/programs/eap/pwspread/pwspread.html.

Calculations to Determine Surface Water Quality Standards for Ammonia

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.	
Based on Lotus File NH3SALT.WK1 Revised 19-Oct-93	
INPUT	
1. Temperature (deg C):	16.0
2. pH:	8.1
3. Salinity (g/Kg):	28.96
OUTPUT	
1. Pressure (atm; EPA criteria assumes 1 atm):	1.0
2. Molal Ionic Strength (not valid if >0.85):	0.594
3. pKa8 at 25 deg C (Whitfield model "B"):	9.314
4. Percent of Total Ammonia Present as Unionized:	3.027%
5. Unionized ammonia criteria (mg un-ionized NH3 per liter) from EPA 440/5-88-004	
Acute:	0.233
Chronic:	0.035
6. Total Ammonia Criteria (mg/L as NH3)	
Acute:	7.70
Chronic:	1.16
7. Total Ammonia Criteria (mg/L as NH3-N)	
Acute:	6.33
Chronic:	0.95

Reasonable Potential Calculation for Water Quality Criteria

				State Water Quality Standard		Max concentration at edge of...			CALCULATIONS									
	Metal Criteria Translator as decimal	Metal Criteria Translator as decimal	Ambient Concentration (metals as dissolved)	Acute	Chronic	Acute Mixing Zone	Chronic Mixing Zone	LIMIT REQ'D?	Effluent percentile value		Max effluent conc. measured (metals as total recoverable)	Coeff Variation		# of samples	Multiplier	Acute Dil'n Factor	Chronic Dil'n Factor	
Parameter	Acute	Chronic	ug/L	ug/L	ug/L	ug/L	ug/L			*Pn*	ug/L	*CV*	*s*	*n*				COMMENTS
Ammonia - N (NH3-N)				6330.00	950.00	24.83	5.18	**NO**	1.00	0.959	7600.0	0.60	0.55	72	0.95	290	1391	Out of 72 samples, highest effluent ammonia concentartion was 7.6 mg/L
Zinc	0.946	0.946		90.00	81.00	0.24	0.05	**NO**	1.00	0.779	75.1	0.60	0.55	12	1.00	290	1391	Out of 12 samples, highest effluent zinc concentartion was 75.1 ug/L

APPENDIX F—RESPONSE TO COMMENTS

Ecology did not receive any public comments on the draft permit.

APPENDIX B

INDUSTRIAL USER SURVEY

KINGSTON WASTEWATER TREATMENT PLANT

INDUSTRIAL USER SURVEY

FOR THE

DEPARTMENT OF ECOLOGY

Prepared by:

Kitsap County Public Works – Sewer Utility
12351 Brownsville Hwy NE
Poulsbo, WA 98370

May 2020

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SECTION 1

KINGSTON INDUSTRIAL USER SURVEY

Kitsap County Code

Chapter 13.12

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13.12.010 Definitions.

Unless the context indicates otherwise, the terms used in this chapter shall be as set forth in this section:

(1) "ASTM" means the American Society for Testing Materials.

(2) "Board" means the Kitsap County board of county commissioners.

(3) "Biosolids" means primarily organic solid product produced by wastewater treatment processes that can be beneficially recycled.

(4) "B.O.D." is the abbreviation for biochemical oxygen demand, the quantity of oxygen utilized in the biochemical oxidation of organic matter in five days at twenty degrees Celsius under standard laboratory procedure expressed in milligrams per liter.

(5) "Building" means any structure the use of which requires location or attachment to something on the ground and which is used for human occupancy, employment or recreation.

(6) "Building drain" means the lowest part of a building's drainage system where it connects to the building sewer.

(7) "Building sewer" means the piping of a drainage system which extends from the building drain to the side sewer.

(8) "Building sewer contractor" means a person who constructs, installs, repairs, excavates or connects building sewers, and who is licensed as such by Kitsap County.

(9) "County" means all portions of Kitsap County exclusive of areas within the boundaries of municipalities which are empowered to provide sewerage service but including those areas of municipalities which are served by sewerage systems which are owned, operated or maintained by Kitsap County.

(10) "Director" means the director of Kitsap County department of public works or a duly authorized representative.

(11) "Equivalent residential unit" means a sewage service unit which is substantially equivalent to a single-family residence in sewage output and function.

(12) "Garbage" means putrescrible material resulting from the preparation and consumption of food except body waste, swill and animal carcasses.

(13) "Parts per million" is equivalent to milligrams per liter.

(14) "Person" means any individual, firm, company, corporation, partnership, association, society or group.

(15) "pH" means the negative logarithm of the concentration of hydrogen ions (H+) in a solution measured in standard units; pH is the intensity factor of acidity.

(16) "Properly shredded garbage" means garbage which has been shredded so that all particles may be carried freely under the sewage flow conditions normally prevailing and which has no particle greater than one-quarter inch in any dimension.

(17) "Public sewer" means a sewer owned by a governmental body or public utility and/or which is operated and maintained by the county.

(18) "Sanitary sewer" means a sewer that carries sewage.

(19) "Sewage" means the liquid and liquid-carried wastes from residences, commercial buildings, industrial plants and institutions together with minor quantities of ground, storm and surface waters that are not intentionally admitted.

(20) "Sewage treatment facilities" means structures, equipment and processes used to collect, carry and treat sewage.

(21) "Side sewer" means piping from a public sewer to the property line of the parcel served and to which a building sewer is connected.

(22) "Suspended solids" means particles that float on or are suspended in sewage and which may be substantially removed by filtering; measured in milligrams per liter.

(Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 1, 1974)

13.12.015 Relationship to comprehensive plan and Growth Management Act.

Provisions set forth in this chapter are to be consistent with and implement the Kitsap County Comprehensive Plan in accordance with Chapter 36.70A RCW.

(Ord. 494 (2012) § 4, 2012: Ord. 493 (2012) § 4, 2012)

13.12.020 Connection with public sewer required.

A proposal to develop, redevelop, or substantially remodel a structure that increases the volume or strength of sewage above the permitted design capacity of the on-site sewage system located within an Urban Growth Area (UGA) which is or will be situated within two hundred feet of an existing public sewer main that has adequate capacity to serve shall connect. A structure served by a septic system located within a UGA which has been determined by the Health District to be failing and in need of repair and is located within two hundred feet of a public sewer main that has adequate capacity to serve shall be required to connect. The two-hundred-foot distance shall be measured along the usual or most feasible route to access. Connection may be authorized outside of a UGA if consistent with RCW 36.70A.110(4).

Such connection shall be made entirely at the expense of the owner. Prior to such connection, the owner shall connect every toilet, sink, stationary washstand, washing machine, dishwasher, shower, bathtub or other device producing sewage located on the premises so that the sewage thereby produced will be transported to the building drain. In the case of buildings under construction, any use or occupancy of such buildings is unlawful until such connection has been made.

(Ord. 494 (2012) § 5, 2012: Ord. 493 (2012) § 4, 2012; Ord. 55-B (1978) § 1, 1978; Ord. 55 (1974) § 2, 1974)

13.12.025 Waivers.

(1) With the exception of the requirement in Section 13.12.020 regarding the connection of existing septic systems to public sewer, the director may waive the requirements in this chapter upon making findings that the following criteria are met:

(a) The waiver is based on unusual and site-specific conditions that are not created by the property owner; and

(b) The requirements of this chapter impose a severe and unexpected economic hardship on the applicant. Sewer connection fees and rates shall not be considered in the determination of a severe and unexpected economic hardship; and

(c) The grant of a waiver will not increase the risk to the public health and welfare, nor be injurious to other properties in the vicinity, to properties downstream or to the quality of the waters of the state; and

(d) The grant of a waiver will in no way prevent or deter the extension of public sewers at any future date; and

(e) The grant of a waiver will meet the objectives of safety, function, appearance, environmental protection and maintainability based on sound engineering judgment.

In granting a waiver, the director has the authority to impose conditions, including but not limited to requiring a no-protest agreement for future connection to public sewer.

(2) With respect to the requirement in Section 13.12.020 regarding the connection of existing septic systems to public sewers, the board of county commissioners may consider, upon appeal by the owner of the property subject to the requirement, a waiver of the requirement, if the board finds that the conditions set forth in RCW 36.01.330, as it now exists or is hereafter amended, are met.

(Ord. 534 (2016) § 7(4) (App. D), 2016: Ord. 494 (2012) § 6, 2012: Ord. 493 (2012) § 4, 2012; Res. 132-1984, 1984)

13.12.030 Connection or repair by director.

(a) Any repairs to a building sewer deemed necessary by the director shall be made by a licensed sewer contractor or the owner of the real property on which the building sewer is situated within thirty days after the director mails notice by certified mail to the owner specifying the repairs required; provided, the director may provide less than thirty days if he believes an emergency exists.

(b) In the event that a connection is not made within the time and manner specified in Section 13.12.020 or in the event that repairs are not made as specified in subsection (a) of this section, the director may forthwith cause the same to be made. The director shall thereupon charge the owner for such expenditures and shall thereafter certify such expenditures, if not paid, to the Kitsap County treasurer. Such expenditures shall constitute a lien upon the premises and bear interest at eight percent per year.

(Ord. 55-A (1975) § 1 (part), 1975; Ord. 55 (1974) § 3, 1974)

13.12.040 Permit required prior to connection.

(a) It is unlawful for any person other than a licensed building sewer contractor or the owner of the real property on which the building sewer is situated to construct, uncover, repair, replace, alter, disturb any building sewer or to make any connection with or opening into any public sewer or side sewer. It is unlawful for any person to construct a building sewer without first having obtained a building sewer permit from the director as provided in this section. It is unlawful for any person to make any connection with or opening into any public sewer or side sewer without first having caused an inspection to be made and approval received as provided in Section 13.12.130.

(b) The application for a building sewer permit shall be made to the director and shall contain the following:

(1) Contractor's name and mailing address;

(2) Owner's name and mailing address;

(3) Street address and legal description of the property;

(4) Contractor's registration number;

(5) Use or proposed use of the building;

(6) Number of residential, commercial or industrial units;

(7) A diagram showing the real property involved, the location or proposed location of the building, and the location of the building drain, building sewer and, if known, the nearest sewer stub;

(8) Type and size of materials used or to be used;

(9) Other information considered necessary by the director.

(c) The director shall review each application and shall issue a building sewer permit if the applicant and application meet the requirements of this chapter and if all fees have been properly paid.

(d) A building sewer permit shall become null and void if the construction of the building sewer authorized thereby is not commenced within sixty days from the issuance of such permit or if the work authorized thereby is suspended or abandoned for a period of one hundred twenty days.

(e) Upon application for a building sewer permit, the applicant shall pay a fee to the director in the amount of fifty dollars for each building to be connected to a public sewer and an additional twenty dollars for each additional connection where the building is to have more than one connection to the public sewer.

(f) A building sewer permit shall be displayed in a conspicuous place at or near the work allowed thereby during the performance of the work and until the completion thereof and inspection and approval by the director.

(Ord. 55-C (1978) § 1, 1978; Ord. 55-A (1975) § 1 (part), 1975; Ord. 55 (1974) § 4, 1974)

13.12.050 Building sewer contractor's license.

(a) It is unlawful to engage in the activities of a building sewer contractor in the county without a current building sewer contractor's license.

(b) An applicant for a building sewer contractor's license must possess a current certificate of registration issued by the Washington State Department of Labor and Industries pursuant to RCW Chapter 18.27.

(c) An application for a building sewer contractor's license shall be made to the director on forms provided by the director. The application must be accompanied by a fee of twenty-five dollars to defray in part the costs of examining the applicant. This fee is not refundable.

(d) The director shall examine each applicant both orally and in writing to determine if the applicant possesses adequate knowledge of this chapter and adequate knowledge and skill to properly construct, install, repair, excavate and connect building sewers, to the end that the public health, safety, morals and welfare will not suffer from improperly constructed, installed, repaired, excavated or connected building sewers.

(e) Upon successful completion of the examination, the director shall issue the applicant a building sewer contractor's license. The fee for such license shall be fifty dollars for each fiscal year which shall expire on June thirtieth. A license may be renewed without examination provided renewal is made by the first day of the succeeding fiscal year.

(f) The director or any person may file a verified petition with the board requesting that a building sewer contractor's license be granted or revoked. A copy of such petition shall be served by the director or other person upon the person who seeks a building sewer contractor's license or upon the person whose license is sought to be revoked. The board shall thereafter set a time for a public hearing giving due notice of such to the interested parties. The board may grant a building sewer contractor's license if the petitioner demonstrates that the person seeking the license meets the requirements of this section. The board may revoke a building sewer contractor's license if the petitioner demonstrates that the licensed building sewer contractor has performed in an incompetent or negligent manner or that he has misrepresented facts in an application for a building sewer contractor's license or permit as required by Section 13.12.040.

(Ord. 55 (1974) § 5, 1974)

13.12.060 Location of building sewer connection.

The connection of a building sewer to a public sewer shall be made at the point and in the manner specified by the director.

(Ord. 55 (1974) § 6, 1974)

13.12.070 Protection of excavations.

It is unlawful for any person to fail to protect any excavation in a public right-of-way or in lands adjacent thereto. Such protection may include fencing, covering or lighting. The protection of the public from the danger of such excavation shall be the duty of the person making or causing the excavation. The person making or causing the excavation shall be responsible for insuring adherence to all applicable safety and health standards required by the Occupational Safety and Health Act (OSHA) and the Washington Industrial Safety and Health Act (WISHA).

(Ord. 55-I (1996) § 1 (part), 1996: Ord. 55-A (1975) § 1 (part), 1975; Ord. 55 (1974) § 7, 1974)

13.12.080 Building sewer for each building.

A building sewer shall serve only one building unless, prior to construction of the building sewer, written approval is obtained from the director allowing a building sewer to serve more than one building.

(Ord. 55 (1974) § 8, 1974)

13.12.090 Sewer service – Where not required.

(a) Where the owner of a building is not required to connect to a public sewer pursuant to Section 13.12.020, the lawful mandate of a utility local improvement district, the lawful mandate of the Kitsap County planning commission, or any other lawful order or mandate, the owner may elect to connect to a public sewer upon agreement with board. Such agreement shall be known as a "sewer assessment agreement."

(b) The board shall not enter into a sewer assessment agreement unless the sewer treatment facilities can adequately provide the additional sewer service.

(c) A sewer assessment agreement shall provide:

(1) That the owner have full authority to bind the property on which the building is located with the terms and covenants contained in the contract;

(2) That the owner shall abide by the laws and regulations of the county appertaining to sewers and that the owner shall duly and regularly pay for sewer service as shall from time to time be fixed by the board;

(3) That the property on which the building is situated shall be subject to liens, penalties and interest for nonpayment of sewer service charges;

(4) That the building on which the property is situated shall be provided with sewer service;

(5) Other terms agreeable to the owner and the board.

(d) Subsequent to the execution of a sewer assessment agreement, it shall be filed with the Kitsap County auditor.

(Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 9, 1974)

13.12.110 Building sewer specifications.

(a) A building sewer shall be constructed of one or more of the following materials:

(1) Ductile iron pipe (ANSI specification A 21.51 or AWWA specification C151);

(2) Polyvinyl chloride gravity sewer pipe and fittings (ASTM specification D-3033 (Type PSP), D-3034 (Type PSM);

(3) Other material authorized by the director.

(b) It is unlawful to lay or cause to be laid a building sewer or nonmetallic material in a trench which carries water intended for consumption within the building unless the bottom of the water pipe is at all points at least twelve inches above the top of the building sewer and the water pipe rests on a solid shelf at one side of the common trench.

(c) It is unlawful to lay or cause to be laid a building sewer composed of a material other than ductile iron pipe in filled or unstable ground, provided, the director may approve the use of some other material if laid on a granular or concrete bed as approved by the director.

(d) Building sewers shall have clean-outs of the same diameter as the pipe they serve (except that manholes may be utilized as clean-outs), located as follows:

(1) Where the building sewer connects to the building drain;

(2) At all bends of forty-five degrees or greater;

(3) At intervals of no greater than one hundred feet;

(4) An upright tee where the building sewer connects to the side sewer; the upright portion of the tee must be plugged in a manner approved by the director.

(e) The inside diameter of a building sewer must, at a minimum, be as follows for the following applications:

(1) Equivalent residential unit, four inches;

(2) Two or more equivalent residential units up to ten such units, six inches;

(3) Other applications, as approved by the director.

(f) No building sewer shall be laid under or within two feet of any building unless it is composed of ductile iron pipe.

(g) The minimum cover for a building sewer is eighteen inches unless it is composed of cast iron soil pipe.

(h) Whenever topographically possible, building sewers shall have a grade of not less than two percent nor more than one hundred percent. Where the grade is less than two percent, a check valve shall be installed, at the discretion of the director, to prevent backflooding into the building. Where the grade is greater than one hundred percent, the director may require manholes or other devices at the lower end of the building sewer in order to reduce the velocity of the sewage.

(i) Whenever possible, a building sewer shall be installed at a uniform grade and without curves. Where curves are necessary (excluding manufacturer's allowable joint deflection), curved pipe or fittings shall be used.

(j) Joints and connections shall be gastight and watertight. Pipe joints shall have flexible sealing gaskets conforming to ASTM Specification D-1869.

(k) Building sewers composed of the material permitted by subdivision (6) of subsection (a) of this section shall have flexible couplings at no greater than sixty-foot intervals.

(1) Cement mortar joints are prohibited except for repairs or connections to existing building sewers utilizing such joints.

(m) Ball and spigot pipes shall be laid with spigot end toward the side sewer.

(Ord. 55-I (1996) § 1 (part), 1996; Ord. 55 (1974) § 11, 1974)

13.12.120 Building sewer excavation and trenches.

(a) Building sewers shall be laid in open trenches unless otherwise approved by the director.

(b) Pipe must be carefully bedded by forming the trench bottom to meet the contour of the bottom one-quarter of the pipe or by overexcavating and bedding with tamped and compacted granular material.

(c) Rocks larger than one inch in diameter shall not be left in the trench bottom nor shall they be placed closer than six inches from the pipe when backfilling.

(d) Trench must be free of water when pipe is laid.

(e) Backfill shall be placed by hand and be tamped and compacted by hand to six inches above the top of the pipe.

(Ord. 55 (1974) § 12, 1974)

13.12.130 Inspection of building sewers.

No building sewer shall be connected to a public sewer nor shall any trench in which a building sewer lies be filled unless and until the building sewer passes an inspection by the director, except as provided by subsection (4) of this section. The contractor or owner shall give the director forty-eight hours' notice prior to the time when the inspection is desired. At such inspection, the director shall determine that the building sewer meets the requirements of Sections 13.12.080, 13.12.110 and 13.12.120. In addition thereto, the director shall ascertain that the building sewer passes one of the following tests. Such tests are to be conducted by and at the expense of the contractor or owner. The type of test utilized is within the discretion of the director. Such tests are to be conducted as follows:

(1) Water Exfiltration Test. Prior to test, the contractor or owner may fill the building sewer with clear water to permit normal absorption into pipe walls; however, if the building sewer is so filled, the test must be completed within twenty-four hours after filling. The contractor or owner shall fill the building sewer with clear water. Exfiltration shall be no more than five-tenths gallon per hour per inch of inside pipe diameter per one hundred feet of pipe with a minimum test pressure of six feet of water column above the crown at the upper end of the pipe or above the active groundwater, whichever is higher.

(2) Air Exfiltration Test. The contractor or owner shall pressurize the building sewer with air to three pounds per square inch. Exfiltration shall be measured by the use of a rotometer. Exfiltration shall not exceed 0.003 cubic feet of air per minute per square foot of internal pipe surface or, alternatively, two cubic feet of air per minute when subjected to a constant pressure of three pounds per square inch. The rate of loss is to be determined when the system reaches equilibrium. For each foot of water table elevation above the invert of the pipe, the allowable loss shall be reduced six percent.

(3) Water Infiltration Test. When the natural groundwater table is above the crown of the higher end of the building sewer, infiltration shall not exceed four-tenths gallon per hour per inch of internal pipe diameter per one hundred feet of pipe.

(4) Internal Television Inspection. This inspection technique shall be utilized if and only if the trench in which the building sewer lies has been backfilled. The director shall then visually inspect the interior of the building sewer via television to determine if the building sewer is of the proper materials and constructed as herein provided. In addition to the television inspection the director may require an additional test as set forth in subsections (1), (2) or (3) of this section.

(Ord. 55-I (1996) § 1 (part), 1996; Ord. 55-A (1975) § 1 (part), 1975: Ord. 55 (1974) § 13, 1974)

13.12.140 Standards.

When not inconsistent or in conflict with the provisions of this chapter, the director shall utilize the standards specified in the Kitsap County public works, Standards for Sanitary Sewer Extensions, as now or hereafter amended, for all sanitary sewer design, materials, construction and inspection practices.

(Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 14, 1974)

13.12.150 Disconnection proscribed.

It is unlawful to disconnect a building from a building sewer or to disconnect a building sewer from a public sewer without first having obtained a capping permit from the director. In the event that disconnection is allowed, the building sewer or public sewer shall be sealed and capped by the person causing the disconnection at the points and in the manner designated by the director.

(Ord. 55 (1974) § 15, 1974)

13.12.160 Prohibited discharges.

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.

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.

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.

(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.

(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.

(Ord. 55-I (1996) § 1 (part), 1996)

SECTION 2

KINGSTON INDUSTRIAL USER SURVEY

Information used for Master List

Sources of Information:

As recommended by the "Guidance Manual for Performing an Industrial User Survey", Kitsap County complied a Master List of potential industrial users using billing records and water use. The manual recommended surveying businesses using over 25,000 gallons per day or business contributing a process waste stream of 5% or more of the average dry weather hydraulic or organic capacity of the Kingston Wastewater Treatment Plant. These criteria eliminated every business from our survey pool. Kitsap County decided to set the standard at 10,000 gallons per day or just below 5% capacity, which qualified 4 businesses for the Industrial User Survey.

Along with using water consumption rates, the business accounts were evaluated for potential industrial discharges based on their production. After this assessment, there were no new businesses added to the list of Industrial Users. At the time of this submittal, Kitsap County was still awaiting a Customer Survey from Northwest Laborers.

SECTION 3

KINGSTON INDUSTRIAL USER SURVEY

Copy of Customer Letter and Questionnaire

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 10,000 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 Kingston Wastewater Treatment Plant. 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 Friday, May 22, 2020.

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

KITSAP COUNTY DEPARTMENT OF PUBLIC WORKS

614 DIVISION STREET (MS-26), PORT ORCHARD, WA 98366-4699 | KITSAP1: 360.337.5777 | KITSAPGOV.COM

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 Kingston Wastewater Treatment Plant's National Pollutant Discharge Elimination System (NPDES) Permit through the WA State Department of Ecology. The Permit number is WA-0032077.

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.

SECTION 4

KINGSTON INDUSTRIAL USER SURVEY

List of Surveyed Industries

NAME	Street	City	Gallons per month
North Kitsap School District	18360 NE Caldart Avenue	Poulsbo	210,000 **
Northwest Laborers	27055 Ohio Ave	Kingston	74,110
Peninsula Health Services	25989 Barber Cut Off Rd NE	Kingston	95,931
Port of Kingston	25864 Washington Blvd NE	Kingston	85,646

** North Kitsap School District gallons per month mostly irrigation.

SECTION 5

KINGSTON INDUSTRIAL USER SURVEY

List of Eliminated Industries

Business Name	Telephone number	Address
All about Sewing	360-731-9973	11264 WA-104, #201
Apple Tree Cove Animal Hospital	360-297-2898	11254 NE 2nd St
Arco	360-297-1717	10951 WA-104
Bayside Community Church	360-297-2000	25992 Barber Cut Off Rd NE
Bim Prince Ameriprise Financial Services	360-297-4848	10950 NE State Hwy 104
Bliss Day Spa	360-881-0737	10978 NE State Hwy 104
Borrowed Kitchen Bakery	360-860-2255	10811 NE State Hwy 2014 #101
Clearview Blainds and Shades	360-774-2658	11133 NE Maine St A
Coffee Oasis Kingston Café	360-881-0314	11212 NW State Hwy 104
Country Pet Shoppe	360-297-4165	11132 NE 2nd St
Downpour Brewing	360-881-0452	10991 NE State Hwy 104
d'Vine Wine Bar	360-297-3010	11227 NE State Hwy 104
Eastern Fish	360-297-5551	26076 Iowa Ave NE
Expeditino Press	360-434-2093	10975 WA-104
Filling Station	360-297-7732	11200 WA-104
Firehouse Theater	360-297-4849	11171 NE State Hwy 104
Food Market at Kignston	360-297-3350	10978 WA-104
Galare Thai	360-297-4022	26050 Illinois Avenue NE
Henery Hardware	360-297-3366	10960 WA-104
Hot Dogs at the Cove	??	11252 WA-104
J'aime les crepes Creperie	360-297-5886	11264 WA-104
Joy Luck Restaurant	360-297-3342	10978 NE State Hwy 104
Jumpin Java	??	10943 NE State Hwy 104
Kafe Neo	360-881-0197	11171 NE State Hwy 104
Kingston Dental	360-297-2298	25985 Barber Cutoff Rd NE
Kingston Ale House	360-881-0412	11225 NE Stae Hwy 104
Kingston Auto Shop	360-297-2803	26262 Lindvog Rd NE

Kingston Bookery	360-297-7380	10978 WA-104 Ste 121
Kingston Cove Yacht Club	360-297-3371	25815 Washington Blvd NE
Kingston Nails and Spa	360-297-5099	25829 Ohio Ave NE
Kingston's Central Valley Child Care	360-297-8020	11026 NE Oregon St
Kingston Chamber of Commerce	360-215-7022	25923 Washington Blvd / PO Box 78
Kingston Christian Church	360-297-2551	11255 NE 2nd St
Kingston Co-Op Preschool	360-297-3220	11128 NE Maine St
Kingston High School	360-396-3300	26201 Siyaya Ave NE
Kingston Mini Storage	360-297-3019	11126 NE State Hwy 104
Kitsap Regional Library	360-297-3330	26159 Dulay Rd NE
McDonalds	360-297-4350	10977 State Hwy 104
Mora Iced Creamery	360-215-7022	11250 NE State Hwy 104
Mossback	360-297-2373	26185 Ohio Ave NE
Oregon Street Salon	360-297-1899	11053 Oregon St
Reliable Storage	360-930-6687	10600 WA-104 NE
Richard Gordon Elementary	360-396-3800	26331 Barber Cut Off Rd NE
Roots and Razors	360-638-6105	10801 WA-104
Roy's Marine Services	360-297-7117	26282 Lindvog Rd NE #130
Stanley Steemer	360-626-9012	26262 Lindvog Rd NE Ste 130 & 140
Subway	360-297-4498	10978 WA-104
Sweet Life Cakery	360-881-0215	11201 NW State Hwy 104
Sweet Tansosha Yoga	360-638-6171	26569 Lindvog Rd NE Suite 102
The Cup and Muffin	360-297-3364	10969 NE State Hwy 104
The Grub Hut	360-881-0147	11130 NE State Hwy 104
Thistle Floral and Home	360-638-2849	25960 Central Ave NE
Unity Church	360-297-5100	26011 Ohio Ave NE
USPS	800-275-8777	10990 NE State Hwy 104
Westside Pizza	360-297-6800	25960 Ohio Avenue NE Ste 102
WSDOT Ferries		

Industries listed above were eliminated after determining their discharge to the Kingston WWTP was considered domestic in quantity and characteristics.

SECTION 6

KINGSTON INDUSTRIAL USER SURVEY

Copies of Signed Surveys

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: North Kitsap School District #400
2. Mailing Address: Transportation Svcs. NKSD #400
26000 Siyaya AVE NE Kingston WA 98346
3. Facility Address: 26000 Siyaya AVE NK
KINGSTON, WA 98346
4. Telephone Number: 360-396-3099
5. Name and Title of Contact Person: John SIDES Interim Dir Trans.
6. Please provide a brief narrative of manufacturing, production, or services provided at your facility: Routine maintenance and upkeep of Public School Bus fleet -
7. You use approximately <5000 gallons of water per day.
8. How much of your daily water use goes into the wastewater sewer system? 80%
9. Do you discharge any wastewater other than domestic waste (restrooms, showers, etc)
(X) Yes ( ) No
10. If Yes, what kind of non-domestic waste do you discharge?
Small vehicle washbay - 1 Bay used to wash school busses and fleet vehicles
11. Will water be used for product manufacturing, washdown, or floor cleaning in production areas? ( ) Yes (X) No
12. Do you have floor drains in your process / production area? ( ) Yes (X) No
13. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes (X) No

14. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? (X) Yes ( ) No

15. If Yes, which do you have?

    ( ) Grease Trap ( ) Oil / Water Separator (X) Both

16. How often do you have it cleaned? Annual / Contracted SVC

17. Do you store toxic, hazardous, or dangerous materials at your facility? (X) Yes ( ) No

18. If Yes, what materials? Fuels / Lubricants / Batteries / Automotive Chemical

19. Do you qualify as a Hazardous Waste Small Quantity Generator? (X) Yes ( ) No

20. Are you aware of Kitsap County's Small Generator (SQG) Program? (X) Yes ( ) No

21. Do you have a plan do prevent accidental spills? (X) 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 Kingston Wastewater Treatment Plant's National Pollutant Discharge Elimination System (NPDES) Permit through the WA State Department of Ecology. The Permit number is WA-0032077.

Please return this survey to:

12351 Brownsville Hwy NE
Poulsbo, WA 98370

Print Name and Title
Albert Hoch Asst. Director Maintenance NKSD

Signature [signature] Date 22 May 2020

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.

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: PENINSULA COMMUNITY HEALTH
2. Mailing Address: P.O. BOX 960 BREMERTON WA 98337
3. Facility Address: 25989 BARBER CUT-OFF ROAD NE KINGSTON WA 98346
4. Telephone Number: 360 616 3140
5. Name and Title of Contact Person: CHUCK RUSSELL FACILITIES MANAGER
6. Please provide a brief narrative of manufacturing, production, or services provided at your facility: OUT PATIENT MEDICLE CLINIC
7. You use approximately 30 gallons of water per day.
8. How much of your daily water use goes into the wastewater sewer system? All
9. Do you discharge any wastewater other than domestic waste (restrooms, showers, etc)
( ) Yes (X) No
10. If Yes, what kind of non-domestic waste do you discharge?
N/A
11. Will water be used for product manufacturing, washdown, or floor cleaning in production areas? (X) Yes ( ) No
12. Do you have floor drains in your process / production area? ( ) Yes (X) No
13. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes (X) No

14. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? ( ) Yes ( ) No UNKNOWN

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 (X) No

18. If Yes, what materials? N/A

19. Do you qualify as a Hazardous Waste Small Quantity Generator? (X) Yes ( ) No
FLORESCENT LIGHT TUBES

20. Are you aware of Kitsap County's Small Generator (SQG) Program? (X) Yes ( ) No

21. Do you have a plan do prevent accidental spills? ( ) Yes (X) 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 Kingston Wastewater Treatment Plant's National Pollutant Discharge Elimination System (NPDES) Permit through the WA State Department of Ecology. The Permit number is WA-0032077.

Please return this survey to:

12351 Brownsville Hwy NE
Poulsbo, WA 98370

Print Name and Title

CHUCK RUSSELL FACILITIES MANAGER

Signature [signature] Date 5/14/20

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.

KITSAP COUNTY DEPARTMENT OF PUBLIC WORKS
614 DIVISION STREET (MS-26), PORT ORCHARD, WA 98366-4699 | KITSAP1: 360.337.5777 | KITSAPGOV.COM

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: PORT of KINGSTON
2. Mailing Address: PO BOX 559
   KINGSTON, WA 98346
3. Facility Address: 25864 WASHINGTON BLVD
4. Telephone Number: 360 900 8235 cell
5. Name and Title of Contact Person: TOREY GRANDT
6. Please provide a brief narrative of manufacturing, production, or services provided at your facility: PORT DISTRICT, MARINA, PARK.
7. You use approximately 400 gallons of water per day.
8. How much of your daily water use goes into the wastewater sewer system? 250
9. Do you discharge any wastewater other than domestic waste (restrooms, showers, etc)
   (X) Yes ( ) No
10. If Yes, what kind of non-domestic waste do you discharge?
    MARINE PUMP-OUT System, DISCHARGE vessel BLACKWATER
11. Will water be used for product manufacturing, washdown, or floor cleaning in production areas? ( ) Yes (X) No
12. Do you have floor drains in your process / production area? (X) Yes ( ) No — RESTROOM FLOOR DRAINS
13. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes (X) No

14. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? ( ) Yes (X) No

15. If Yes, which do you have? N/A

    ( ) Grease Trap ( ) Oil / Water Separator ( ) Both

16. How often do you have it cleaned? N/A

17. Do you store toxic, hazardous, or dangerous materials at your facility? (X) Yes ( ) No

18. If Yes, what materials? EPOXY PAINT, Fuel = GASOLINE, DIESEL, ANTIFREEZE,

19. Do you qualify as a Hazardous Waste Small Quantity Generator? (X) Yes ( ) No

20. Are you aware of Kitsap County's Small Generator (SQG) Program? (X) Yes ( ) No

21. Do you have a plan do prevent accidental spills? (X) 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 Kingston Wastewater Treatment Plant's National Pollutant Discharge Elimination System (NPDES) Permit through the WA State Department of Ecology. The Permit number is WA-0032077.

Please return this survey to:

12351 Brownsville Hwy NE
Poulsbo, WA 98370

Print Name and Title

TOREY GRANDT / PORT MAINTENACE LEAD

Signature [signature] Date 21 MAY 20

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.

consor

APPENDIX C
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

murraysmith

Pump Station:		41							
Basin:		Kingston							
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	Unidirectional vehicle access down single-lane driveway
Parking	Limited parking; Capacity for approx. 2 pickup trucks
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type			Fence Height			
Notes	*Small wooden pickett fence located at the end of access driveway, runs along northern border of pump station site					

Wet Well			Age	46 years		
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	3		Criticality (1-5)		5	
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	46 years		
Condition (1-5)	3		Criticality (1-5)		5	
Dry Well Material	Steel		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)	3		Criticality (1-5)		2	
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:	41								
Basin:	Kingston								
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		*Located in dry well	Age	46		
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)		3	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)		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; 4B3 & 5K6228XHM2			Quantity	2	46 years	
Design Point	240	gpm	92	tdh	Capacity Checked	Yes	No
Condition (1-5)	3			Criticality (1-5)		5	
Notes							

Miscellaneous					
Washdown Water	Yes	No	Backflow Assembly	Yes	No
Bypass Piping Condition (1-5)		N/A	Bypass Piping Criticality (1-5)		
Bypass Piping Condition (1-5)		N/A	Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- Gets power from LS-71
- Odor complaints from low tide
- Dry can, Smith and Loveless
- Telemetry is around 75% reliable
- Old but works, not a lot of issues
- Continuous ventilation

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	41
Basin:	Kingston
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	3.2	5.0	11.9
Civil	4.0	2.0	8.0
Structural	3.0	5.0	15.0
Pumping Systems	2.7	5.0	13.3
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	3.5	1.0	3.5
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:	42								
Basin:	Kingston								
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	Easy access from middle school parking lot
Parking	Space for approx. 3 pickup trucks and 1 commercial vehicle; School parking lot availabilty is high given current conditions
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		
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:	42
Basin:	Kingston
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		
Vault Condition (1-5)	3		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions	81"x105"	
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)		
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				Quantity	2	Age	
Design Point		gpm		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			

- Corrosion on discharge piping, County not concerned
- No issues
- Has overflow tank

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	42
Basin:	Kingston
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	10.1
Civil	2.0	2.0	4.0
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	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:	43							
Basin:	Kingston							
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	Accessible from entrance to Richardson Elementary School
Parking	Limited parking; Space for approx. 3 pickup trucks along shoulders/sides of road leading to Richardson Elementary School
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	30 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	2	
Wet Well Material	Concrete		Dimensions	5 ft. 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	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:	43							
Basin:	Kingston							
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	30 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)	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)		
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	Flygt; C3102090			Quantity	2	Age	30 years
Design Point	400	gpm	32	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 works
- Serves school only
- Pig launch
- Pig tail
- Might have overflow, possibly overflow tank

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	43
Basin:	Kingston
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	3.3	2.0	11.3
Civil	4.0	2.0	8.0
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	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	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

Pump Station:	52							
Basin:	Kingston							
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	Easy access from Siyaya Ave NE
Parking	Room for approx. 4 pickup trucks and 1 commercial vehicle provided by bus barn parking lot
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	22 years	
Pump Station Configuration		Submersible	Dry Pit	Suction Lift	
Condition (1-5)	3		Criticality (1-5)	1	
Wet Well Material	Concrete		Dimensions	4' inside diameter	
Coating Material	Unknown		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:	52							
Basin:	Kingston							
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	22 years	
Vault Condition (1-5)	4		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)	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)	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	ABS; Piranha V2			Quantity	2	Age	22 years
Design Point	31	gpm	48 tdh	Capacity Checked	Yes	No	
Condition (1-5)	3			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			

- If pump is running during outage, when power returns it trips breaker
- 2 Grinder pumps
- Pig tail

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	52
Basin:	Kingston
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	2.8	2.0	9.8
Civil	2.0	2.0	4.0
Structural	3.5	5.0	17.5
Pumping Systems	3.0	3.0	9.0
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	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:		71							
Basin:		Kingston							
Assessment By:		Peter Cunningham, Andrew Henson,Tom Hubert							
Access provided by:		Jim Foley, Cliff							
Date of Visit:		9/14/2020							
Condition	1	good	5	bad	Criticality	1	not critical	5	critical

General Site Conditions/Access	
Access	2-way access; Vehicles can pull through and around the station with no backing required.
Parking	Abundant parking; Approx. 25 available parking spots surrounding station.
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type	Chainlink fence w/ bar		Fence Height	Approx. 6-7 ft.		
Notes						

Wet Well			Age			
Pump Station Configuration		Submersible	Dry Pit		Suction Lift	
Condition (1-5)	2		Criticality (1-5)		5	
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	(Pump Room)		Age			
Condition (1-5)	1		Criticality (1-5)		5	
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)	1		Criticality (1-5)	2	
Continuous Supply	Yes	No	Supply Fan	Yes	No
Exhaust Fan	Yes	No	Heat	Yes	No
Notes	Air intake and duct heater located on 1st floor.				

Control Building					
Building		Shed	Roof	Age	
Condition (1-5)	2		Criticality (1-5)	3	
Description					
Material	CMU construction		Dimensions		
Intrusion Alarm	Yes; Controlled via switch (alarm ON/OFF) on station control panel				
Notes					

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	71
Basin:	Kingston
Assessment By:	Peter Cunningham, Andrew Henson,Tom Hubert
Access provided by:	Jim Foley, Cliff
Date of Visit:	9/14/2020

Condition	1	good	5	bad	Criticality	1	not critical	5	critical

HVAC (Control Building)			Age	
Condition (1-5)	1		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)	N/A		Vault Criticality (1-5)		
Material	N/A		Dimensions		
Coating Material	Latex-based paint		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)	3	
Isolation Valve Type	Gate	Plug			
Piping Condition (1-5)	1		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)	N/A		Presssure Gauge Criticality (1-5)	N/A	
Flow Meter Condition (1-5)	2		Flow Meter Criticality (1-5)	2	
Notes					

Pumps							
Make/Model	Cornell; 4x4x14T-VF18DB			Quantity	2	Age	16 years old
Design Point	450	gpm	205	tdh	Capacity Checked	Yes	No
Condition (1-5)	3			Criticality (1-5)	5		
Notes							

Miscellaneous						
Washdown Water	Yes	No	Backflow Assembly	Yes	No	*W2 air gap tank located in generator room
Bypass Piping Condition (1-5)	2		Bypass Piping Criticality (1-5)			
Bypass Piping Condition (1-5)	2		Bypass Piping Criticality (1-5)			
SCADA	Yes	No				

- Rags on floats at inlet
- Pumps get ragged
- Grease mat increased since lockdown
- FM capacity is limited, second pump only adds 20-40 gpm
- Approximately 15 years old
- Feeds LS-41 power
- G&O did study regarding adding VFDs or jockey pumps, but it didn't pencil out to make the upgrades
- Charcoal filter, change every 6 months
- Bioxide is on site
- Wet well in decent shape, no coating

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	71
Basin:	Kingston
Assessment By:	Peter Cunningham, Andrew Henson,Tom Hubert
Access provided by:	Jim Foley, Cliff
Date of Visit:	9/14/2020

Category	Condition	CoF	Condition*CoF
Overall	1.7	5.0	5.8
Civil	1.0	2.0	2.0
Structural	1.7	5.0	8.3
Pumping Systems	2.3	3.0	7.0
Motors (greater than 25 hp only)	2.0	3.0	6.0
Piping Systems	1.5	5.0	7.5
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:	72							
Basin:	Kingston							
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 road off of Kingston High School's loop road; Steep driveway may make commercial vehicle access difficult
Parking	Space for approx. 2 work trucks and 1 commercial vehicle; limited turnaround space for larger trucks (3-5 point turn necessary)
Notes	

Site Security and Safety						
Facility Fenced	Yes	No	Privacy Fence	Yes	No	
Fence Material/type			Fence Height			
Notes	*Chain is strung across gravel driveway entrance					

Wet Well			Age			
Pump Station Configuration		Submersible	Dry Pit	Suction Lift		
Condition (1-5)	3.5		Criticality (1-5)	2		
Wet Well Material	Conc		Dimensions	6 foot 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:	72						
Basin:	Kingston						
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 Buildir	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		
Vault Condition (1-5)	3		Vault Criticality (1-5)	1	
Material	Concrete		Dimensions	80"x152"	
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)		3	Presssure Gauge Criticality (1-5)		1
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)	N/A	
Notes	*Pumps did not run during site visit; should verify pressure gauges are working properly when pumps are running				

Pumps							
Make/Mo	ABS; Piranha 09			Quantity	2	Age	
Design Point		gpm		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)		2	Bypass Piping Criticality (1-5)		1
Bypass Piping Condition (1-5)			Bypass Piping Criticality (1-5)		
SCADA	Yes	No			

- No big issues
- Explosion proof float boxes
- Corrosion on piping
- Pig launch
- Small diameter bypass
- Lid is hitting cables when closed

Kitsap County Facilities Plan
Pump Station Condition Assessment

murraysmith

Pump Station:	72
Basin:	Kingston
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	3.5	2.0	12.6
Civil	3.0	2.0	6.0
Structural	3.5	5.0	17.5
Pumping Systems	3.5	3.0	10.5
Motors (greater than 25 hp only)	3.5	3.0	10.5
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:	73								
Basin:	Kingston								
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	NE Schoolhouse Rd provides easy access; wide driveway into pump station and cul-de-sac make maneuvering commercial vehicles easy
Parking	Parking available for 1 tanker truck in pump station driveway and approx. 2 pickup trucks in cul-de-sac
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		
Pump Station Configuration	Submersible		Dry Pit	Suction Lift	
Condition (1-5)	1		Criticality (1-5)	3	
Wet Well Material	Concrete		Dimensions		
Coating Material	Raven lining system		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:	73								
Basin:	Kingston								
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 Buildir	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		
Vault Condition (1-5)	1		Vault Criticality (1-5)	2	
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)		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)		5*	Presssure Gauge Criticality (1-5)		2
Flow Meter Condition (1-5)		N/A	Flow Meter Criticality (1-5)	N/A	
Notes	*Pressure gauge was observed to reach full scale pressure (60 psig) upon pump discharging, may need recalibration/replacement				

Pumps							
Make/Model	Flygt; NP3153.095-760			Quantity		Age	1 year
Design Point	83.8	gpm	172	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				

- New (2 years old, online for 1 year)
- No issues
- Floats, multitrode
- OneLift
- Constant speed
- Raven 405
- Need sign with station number and phone number
- Passive carbon filter doesn't do much

Kitsap County Facilities Plan
Pump Station Condition Assessment

Pump Station:	73
Basin:	Kingston
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	1.8	2.0	5.5
Civil	2.0	2.0	4.0
Structural	1.0	5.0	5.0
Pumping Systems	1.0	3.0	3.0
Motors (greater than 25 hp only)	1.0	3.0	3.0
Piping Systems	1.0	5.0	5.0
Valve Systems or Assemblies	3.0	2.0	6.0
Support Systems	3.5	1.0	3.5
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			

APPENDIX D
KITSAP COUNTY PIPELINE OCI

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 E

WWTP CONDITION ASSESSMENT

Kingston Wastewater Treatment Plant

Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

Description: The preliminary treatment processes at Kingston WWTP include a rotary bar screen with a bypass channel with a manual screen, a grit tank, grit cyclone and classifier. The preliminary treatment equipment is located in the Headworks building, which was constructed in 2005.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Mechanical Fine Screen	M-201	1	2	2	2019	Headworks upper level	Rotating drum screen	Huber	Rotamat (6 mm)	2	2.574 MGD
Pressate Pump	P-213	1	2	2	2019	Headworks upper level	Centrifugal Explosion Proof	Gorman-Rupp	81 1/2D3-X1 3P	1	75 gpm
Booster Pump	P-214	1	2	2	2019	Headworks upper level	Multi-stage Vertical Centrifugal	Grundfos	CR	3	
Booster W3 strainer	N/A	1	1	2	2019	Headworks upper level	Manual disc filter	Netafim	40 mesh 400 micron		40-120 gpm
Manual Screen	M-202	N/A	1	2	2005	Headworks upper level	Bar Screen Rack 1 inch				2.1 MGD
Grit Chamber	M-210	2	2	2	2005	Headworks upper level	Vortex	Smith & Loveless	2.5	0.75	2.26 MGD
Grit Cyclone	M-205	3	2	2	2005	Headworks upper level	Vortex	WEMCO	12 inch	1/2	220 gpm
Grit Classifier	M-205	3	2	2	2005	Headworks upper level	Inclined Screw-type dewatering classifier	WEMCO	12 inch Hydrogritter	1/2	15 gpm
Grit Pump	P-212	2	2	2	2005	Headworks lower level	Recessed impeller centrifugal	WEMCO	C 3x3 Torque Flow Pump	5	220 gpm
Screenings and Grit Hopper		2	2	1	2005	Headworks lower level					~ 2 CY
Influent Sampler	M-220	2	4	2	2005	Headworks upper level	Outdoor auto sampler	Southwell Controls	BVS-CM1RC9-CDFX		

INSTRUMENTATION

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Influent Level Ultrasonic	LE 200	1	3	1	2019	Headworks upper level	Ultrasonic	Milltronics	Hydroranger		
Influent Float LSH	LSH 206	1	3	1	2019	Headworks upper level	Level Float				
Parshall Flume Flow Transducer	FE/FIT 219	2	2	1	2005	Headworks upper level		Milltronics	OCM III		

STRUCTURAL/FACILITIES

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Influent Parshall Flume	M-221	Not obs	2		2005	Headworks upper level					12-inch, 10.4 MGD
Headworks Building	N/A	2	4		2005	Headworks					

Kingston Wastewater Treatment Plant

Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

PIPING

Influent Piping	N/A	2	5	1	2005						
Mixed Liquor Piping	N/A	2	3	1	2005						

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Photos:

M-201 Mechanical

P-213 Pressate Pump

P-214 Booster Pump

M-210 Grit Chamber

M-205 Grit Cyclone and Classifier

Corrosion on M-205 Grit Cyclone and Classifier

P-212 Grit Pump

Kingston Wastewater Treatment Plant

Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

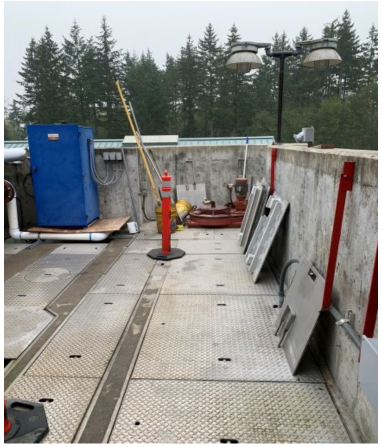
Photos:

M-220 Influent Sampler

Grit and Screenings Dumpster

Headworks Building

Grit Channel



Notes:

Corrosion on Grit Classifier

Poor access to pressate and booster pumps

Corrosion on grit classifier body

Kingston Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Oxidation Ditches, Blower Building and Secondary Clarifiers

Unit Process: Secondary Treatment

Description: Kingston WWTP has two parallel oxidation ditches that are operated one at a time and rotated once per year. Oxidation ditch No. 2 was retrofitted with new equipment in 2020, and Oxidation ditch No. 1 has the same retrofit planned. Blowers for the oxidation ditches are in the blower building north of the oxidation ditches. Two Secondary clarifiers are located north of the oxidation ditches and east of the blower building.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Submersible Mixer	MXR-301	N/A	N/A	N/A	N/A	Oxidation ditch no. 1	Banana blade slow speed submersible				
Submersible Mixer	MXR-302	N/A	N/A	N/A	N/A	Oxidation ditch no. 1	Banana blade slow speed submersible				
Submersible Mixer	MXR-303	1	3	1	2020	Oxidation ditch no. 2	Banana blade slow speed submersible			6.2	
Submersible Mixer	MXR-304	1	3	1	2020	Oxidation ditch no. 2	Banana blade slow speed submersible			6.2	
Air diffusers (installation is ongoing)		1	3	1	2020	Oxidation ditch no. 1	9" fine bubble disc	Sanitaire	SS-II		
Air diffusers		1	3	1	2020	Oxidation ditch no. 2	9" fine bubble disc	Sanitaire	SS-II		
Aeration Blower No. 1	B-301	1	3	1	2020	Blower area	Variable speed PD	Aerzen USA	GM 10 S SO-19-00281	15	264 scfm @ 5.5 psig
Aeration Blower No. 2	B-302	1	3	1	2020	Blower area	Variable speed PD	Aerzen USA	GM 10 S SO-19-00281	15	264 scfm @ 5.5 psig
Aeration Blower No. 3	B-303	1	3	1	2020	Blower area	Variable speed PD	Aerzen USA	GM 10 S SO-19-00281	15	264 scfm @ 5.5 psig
Secondary Clarifier 1 Drive	M-401	3	3	1	2005	Secondary clarifiers	Center column	Dodge Quantis	HB382CN56C		
Secondary Clarifier 2 Drive	M-402	3	3	1	2005	Secondary clarifiers	Center column	Dodge Quantis	HB382CN56C		

INSRUMENTATION

4" Air Flow Meter	AE/AIT 302	1	3	1	2020	Oxidation ditches					
DO Probe	DOP-302	1	4	1	2020	Oxidation ditches					
ORP Probe	ORP-302	1	4	1	2020	Oxidation ditches					

*Condition (1 = very good, 5 = very poor). Criticality (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Oxidation Ditches, Blower Building and Secondary Clarifiers

Unit Process: Secondary Treatment

STRUCTURAL/FACILITIES

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Oxidation Ditch No. 1	N/A	1	4	N/A	2005	Oxidation ditches					
Oxidation Ditch No. 2	N/A	1	4	N/A	2005	Oxidation ditches					
Oxidation Ditch No. 1 Effluent Weir	N/A	1	N/A	N/A	2005	Oxidation ditches		AUMA	GF80.3R90		
Oxidation Ditch No. 2 Effluent Weir	N/A	1	4	N/A	2005	Oxidation ditches		AUMA	GF80.3R90		
Flow Splitter to Oxidation Ditches	N/A	1	4	N/A	2005	Oxidation ditches					
Flow Splitter to Secondary Clarifiers	N/A	1	4	N/A	2005	Secondary clarifiers					
Secondary Clarifier 1	N/A	1	3	N/A	2005	Secondary clarifiers					
Secondary Clarifier 2	N/A	1	3	N/A	2005	Secondary clarifiers					

PIPING

Secondary Effluent Piping	N/A	2	3	1	2005						
RAS Piping	N/A	2	3	1	2005						
Aeration air piping	N/A	1	5	N/A	2020	Blower and Oxidation Ditch	SST piping				

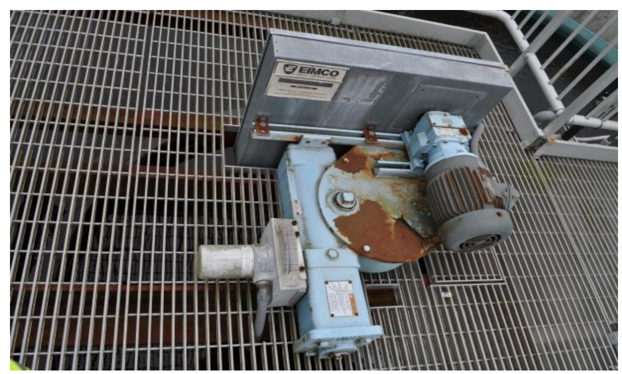
*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Photos:

Oxidation Ditches

B-303 Aeration Blower

Secondary Clarifier Drive



Kingston Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Oxidation Ditches, Blower Building and Secondary Clarifiers

Unit Process: Secondary Treatment

Photos:

Flow Splitter to secondary clarifiers

Secondary Clarifiers

Clarifier effluent box valve stem

Notes:

There are two submersible mixers for the oxidation ditches. The oxidation ditches are operated one at a time and rotate once per year. Submersible mixers will be moved between the oxidation ditches. When they are location in OD No. 1 they will be MXR-301 and MXR-302. When they are location in OD No. 2 they will be MXR-303 and MXR-304.

Corrosion on secondary clarifier drives

Corrosion on secondary clarifier effluent box valve stems and assemblies

Kingston Wastewater Treatment Plant

Facility Name: UV Disinfection and Reclaimed Water

Location: UV Area

Unit Process: UV Disinfection

Description: Kingston WWTP treats secondary effluent using UV disinfection prior to the outfall, and meters effluent flow with a Parshall flume and ultrasonic level.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
UV Bank 1	N/A	4	3	3	2005	UV Area		Trojan	3000B		1.4 MGD
UV Bank 2	N/A	4	3	3	2005	UV Area		Trojan	3000B		1.4 MGD
Effluent Sampler	M-510	3	4	2	2005	UV Area	Outdoor auto sampler	Southwell Controls	BVS-CM1RC9-CDF		

INSTRUMENTATION

Parshall Flume Effluent Flow Transducer	FE/FIT 505	2	4	2	2005	Effluent Parshall Flume	Ultrasonic	Milltronics	OCM 111		
UV Channel Floats	LSL/H 504	2	3	2	2005	UV Area	Level floats				

STRUCTURAL/FACILITIES

Parshall Flume	M-505	2	2		2005	UV Area					6 inch, 2.5 MGD

PIPING

Effluent Piping	N/A	2	5	4	2005						

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

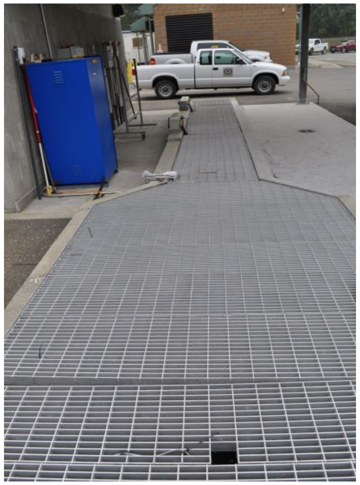
Facility Name: UV Disinfection and Reclaimed Water

Location: UV Area

Unit Process: UV Disinfection

Photos:

UV Bank and Effluent



M-510 Effluent Sampler

M-505 Parshall Flume

Effluent Flowmeter

Notes:

Kingston Wastewater Treatment Plant

Facility Name: Process Building

Location: Process Building

Unit Process: Sludge Processing

Description: Two RAS pumps pump sludge from secondary clarifiers back to the oxidation ditches. WAS is metered off the RAS discharge line, and sent to the WAS Tank. Two sludge pumps can be used pump WAS to the GBT, or pump the TWAS to the sludge truck loadout.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Gravity Belt Thickener	M-615	2	4	2	2005	Process Building	Gravity belt thickener	Ashbrook	Aquabelt		200 gpm
Polymer System	M-800	2	2	2	2005	Process Building	Liquid polymer mix/activation	Polyblend	SP60101954		
Polymer metering pump	M-801	2	2	2	2005	Process Building	Metering				
Sludge Tank Blower	B-601	2	3	2	2005	Process Building	Positive Displacement	Gardner Denver	Sutorbilt GACMDPA	15	200 scfm @ 7.0 psig
Sludge Tank Blower	B-602	2	3	2	2005	Process Building	Positive Displacement	Gardner Denver	Sutorbilt GACMDPA	15	200 scfm @ 7.0 psig
Sludge Tank Blower	B-603	2	3	2	2005	Process Building	Positive Displacement	Gardner Denver	Sutorbilt GACMDPA	15	200 scfm @ 7.0 psig
Sludge Pump	P-611	2	3	2	2005	Process Building	Progressing cavity	Mono Pump	Monoflo C177500-01	15	200 gpm @ 50 psig
Sludge Pump	P-612	2	3	2	2005	Process Building	Progressing cavity	Mono Pump	Monoflo C177500-01	15	200 gpm @ 50 psig
Scum Pump	P-405	2	4	2	2005	Secondary clarifiers	Submersible			1	100 gpm
RAS Pump	P-411	2	3	1	2005	Process Building	End suction	Flygt	NSX	5	275 gpm
RAS Pump	P-412	2	3	1	2005	Process Building	End suction	Flygt	NSX	5	275 gpm
Compressed Air System	M-230	2	2	2	2005	Process building	Reciprocating	Devair	TAPV-5052-45XL	5	

*Condition (1 = very good, 5 = very poor). Criticality (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: Process Building

Location: Process Building

Unit Process: Sludge Processing

INTRUMENTATION

Equipment Name	Equipment Tag	Condition (1-5)	Criticality (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Sludge to GBT Magmeter	FE/FIT 606	Not obs	2	1	2005	Process Building	Magnetic flowmeter	Siemens	MAG5000		
Scum Tank float	LSL/LSH 405	2	2	2	2005	Process Building	Level floats				
RAS Magmeter	FE/FIT 415	1	2	2	2005	Process Building	Magnetic flowmeter	Siemens	MAG5000		
RAS Magmeter	FE/FIT 416	1	2	2	2005	Process Building	Magnetic flowmeter	Siemens	MAG5000		
WAS Magmeter	FE/FIT 417	1	2	2	2005	Process Building	Magnetic flowmeter	Siemens	MAG5000		
Control Valve to WAS Tanks 3 inch	FV 410	2	2	2	2005	Process Building					
WAS Tank Level Transmitter	LE/LIT 631	2	3	2	2005	Process Building	Ultrasonic	Milltronics	Hydroranger 200		
WAS Tank Level Transmitter	LE/LIT 632	2	3	2	2005	Process Building	Ultrasonic	Milltronics	Hydroranger 200		
TWAS Level Transmitter	LE/LIT 605	2	4	2	2005	Process Building	Ultrasonic	Milltronics	Hydroranger 201		
WAS Tanks LEL monitor	AE 633	4	2	3	2005	Process Building	Combustible gas detector	MSA	Ultima X		not working per operator
WAS Tanks LEL monitor	AE 634	4	2	3	2005	Process Building	Combustible gas detector	MSA	Ultima X		not working per operator
TWAS Tank LEL monitor	AE 604	4	2	3	2005	Process Building	Combustible gas detector	MSA			not working per operator

STRUCTURAL/ FACILITIES

Process Building		2	4		2005						
Scum Wetwell		2	3		2005						
TWAS Tank	T-605	2	3		2005	Process Building					16,000 gallons
WAS Tank	T-631	2	3		2005	Process Building					25,000 gallons
WAS Tank	T-632	2	3		2005	Process Building					25,000 gallons
Truck Loading		2	5		2005	Outside of Headworks					

PIPING

Sludge Piping	N/A	2	5	N/A	2005	Process Building	Ductile iron				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: Process Building

Location: Process Building

Unit Process: Sludge Processing

Photos:

P-411/ P-412 RAS Pumps

P-405 Scum Pump

B-601-3 Sludge Tank Blowers

P-611-2 Sludge Pumps

M-615 Gravity Belt Thickener

M-800 Polymer System

Kingston Wastewater Treatment Plant

Facility Name: Process Building

Location: Process Building

Unit Process: Sludge Processing

Photos:

P-811 Polymer Metering Pump

M-230 Air Compressor

FE/FIT 415-6 RAS Magmeters

WAS Metering and Control

Scum Pump Wetwell

Process Building

Kingston Wastewater Treatment Plant

Facility Name: Process Building

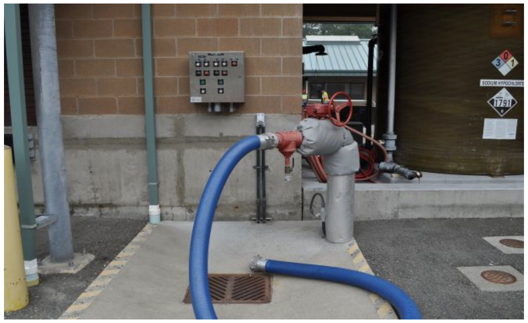
Location: Process Building

Unit Process: Sludge Processing

Photos:

T-631-2 WAS Tanks

Truck Loading



Notes:

WAS tanks are filled and emptied simultaneously

Kingston Wastewater Treatment Plant

Facility Name: Process Building

Location: Process building

Unit Process: Sodium Hypochlorite

Description: Kingston WWTP has a 2,000-gallon FRP sodium hypochlorite tank that is not in use. The tank was originally designed to feed sodium hypochlorite to headworks, the secondary clarifiers and the W-3 system. It is not able to be fully pumped out or drained and is not functional. The associated pumps and instrumentation are also not in use.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
NaOCl Feed Pump	P-811	N/A	1	N/A	2005	Process Building		Milton Roy	RA-12		
NaOCl Feed Pump	P-812	N/A	1	N/A	2005	Process Building		Milton Roy	RA-12		

INSTRUMENTATION

Hypo Tank Ultrasonic	LE/LIT 810	N/A	1	N/A	2005	Hypo tank		Milltronics	MIN-RANGER+		

STRUCTURAL/FACILITIES

Sodium Hydrochlorite Tank	T-810	5	1	4	2005	Outdoors - Outside Headworks		Harrington	2,000 gallons FRP		

PIPING

Hypochlorite System Piping	N/A	2	1	1	2005						

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Photos:

T-810 Sodium Hydrochlorite Tank

Notes:

2,000 gal bulk hypo storage tank outside headworks and hypo pumps next to GBT in Process Building - not in use

Kingston Wastewater Treatment Plant

Facility Name: Biofilter

Location: Biofilter/Headworks

Unit Process: Odor Control

Description: Kingston WWTP has an odor control system that was constructed in 2005. It consists of a biofilter with an associated fan, humidifier, heater and sump. The system is pulling foul air from the headworks building, WAS and TWAS tanks, and GBT room, but the biofilter is collapsed and no longer operational.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Odor Control Fan	B-705	3	1	2	2005	Outside headworks		Hartzell	A41P0-182FA-66FGFQM3		
Odor Control Duct Heater	H-706	2	1	2	2005	Outside headworks		Chromalox			
Odor Control Humidifier	HF-706	2	1	2	2005	Outside headworks					
Biofilter Sump Pump No. 1	P-711	Not obs	1	4	2005	Biofilter			HPGLX		
Biofilter Sump Pump No. 2	P-712	Not obs	1	4	2005	Biofilter			HPGLX		

INSTRUMENTATION

		N/A									

STRUCTURAL/FACILITIES

Biofilter		N/A	1	4	2005	Biofilter		Special-Made	F R P		
Biofilter Sump		4	1	4		Biofilter					

PIPING

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: Biofilter

Location: Biofilter/Headworks

Unit Process: Odor Control

Photos:

Biofilter

B-705 Odor Control Fan

Notes:

Biofilter no longer operational; media needs to be replaced.

Kingston Wastewater Treatment Plant

Facility Name: W2 and W3 systems and Sump

Location: Process Building

Unit Process: Plant water

Description: Kingston WWTP has a process building sump to handle plant and process drainage. W2 and W3 systems support plant operations and process water needs.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Process Building Sump Pump	P-921	Not obs	3	3	2005	Process Building LL	Submersible	Hydromatic	S4PX	5	180 gpm @ 43 psig
Process Building Sump Pump	P-922	Not obs	3	3	2005	Process Building LL	Submersible	Hydromatic	S4PX	5	180 gpm @ 43 psig
W3 Pump	P-901	2	3	2	2005	Process Building LL	Horizontal centrifugal	Goulds	3196	20	150 gpm @ 100 psig
W3 Pump	P-902	2	3	2	2005	Process Building LL	Horizontal centrifugal	Goulds	3196	20	150 gpm @ 100 psig
Flush Pump	P-907	2	3	2	2005	Process Building LL	Horizontal centrifugal	Goulds	3196	5	
Automatic Strainer	M-905	2	1	2	2005	Process Building LL		Evoqua	VAF V325J		200 gpm
W2 Pump No. 1	P-931	2	3	1	2005	Process Building GL	Vertical Centrifugal inline	Grundfos	A96425945P1043 1US760	15	125 gpm @ 100 psig
W2 Pump No. 2	P-932	2	3	1	2005	Process Building GL	Vertical Centrifugal inline	Grundfos	A96425945P1043 1US761	15	125 gpm @ 100 psig

INSTRUMENTATION

W3 Flow Totalizer	FE 906	Not obs	1		2005	Process Building LL		Mccrometer	RE 100-012		

STRUCTURAL/FACLILITIES

Hydropneumatic Tank	T-935	2	2	1	2005	Process Building LL		Wessels	6759		
Process building sump	N/A	Not obs	4	3	2005	Process Building LL					

PIPING

W2 Piping	N/A	2	3	1	2005						
W3 Piping	N/A	2	3	1	2005						

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: W2 and W3 systems and Sump

Location: Process Building

Unit Process: Plant water

Photos:

P-901-2 W3 Pump

P-902 W32 Pump gasket leak

M-905 Automatic Strainer

W2 Water System

P-931-2 W2 Pumps

Notes:

P-902 appears to have a leaking casing gasket that should be repaired

Kingston Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Other Facilities

Description: The Operations Building houses the backup generator room, electrical room, garage/shop, bathroom and locker room, plant control room and lab area. The backup diesel generator fuel tank is outside of the operations building.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Puget Sound Energey Utility Transformer and Meter (Service)		2	5	1	2005	Outside, North of Main Control Building	underground primary power source, padmount transformer				
Diesel Tank		2	5	2	2005	Outside operations building					2000 gallons
Generator		2	3	1	2005	Operations building		Cummins	DFCC-5667361		350 kW
Service Entrance Equipment		2	3	1	Estimate 2004	Operations Building		Cutler Hammer	MDL3800F		
Automatic/Manual Transfer Switch		2	4	1	Estimate 2004	Operations Building		Asco	7000 Series H07ATSA30800N5XC		
Switchboard/Panelboard	DPP-01	2	4	1	5/1/2004	Operations Building		Cutler Hammer	PRL3A		
Switchboard/Panelboard	DPP-02	2	4	1	5/1/2004	Process Building		Cutler Hammer	PRL3A		
Switchboard/Panelboard	DPP-UV	2	4	1	5/1/2004	Operations Building		Cutler Hammer	PRL1A		
Switchboard/Panelboard	DPL-01	2	4	1	5/1/2004	Operations Building		Cutler Hammer	PRL1A		
Switchboard/Panelboard	DPL-02	2	4	1	5/1/2004	Process Building		Cutler Hammer	PRL1A		
Transformer	XFMR-01	2	4	1	5/1/2004	Operations Building		Cutler Hammer	V48M28T45K		45 KVA
Transformer	XFMR-02	2	4	1	4/1/2004	Process Building		Cutler Hammer	V48M28T30K		30 KVA
Transformer	XFMR-03	2	4	1	5/1/2004	Operations Building		Cutler Hammer	H48M28T15A		15 KVA
MCC	MCC-01	2	4	1	6/1/2004	Process Building		Cutler Hammer	Freedom Series 2100		
MCC	MCC-01A	1	4	1	6/1/2020	Process Building		Cutler Hammer	Freedom Series 2100		
Control Panel	CP-200 Plant Main PLC Pnl	2	4	1	Estimate 2020	Operations Building		Quality Controls Corp.	PLC Brand/Model: Allen-Bradley CompactLogix L33ER		

Kingston Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Other Facilities

Control Panel	CP-300 Plant Remote I/O Pnl	2	4	1	Estimate 2000	Process Building		Quality Controls Corp.	PLC Brand/Model: Allen-Bradley CompactLogix 1769 I/O		
Control Panel	FCP-201 Fine Screen Pnl	2	4	1	5/1/2020	Headworks Area		Elemech Control Systems	PLC Brand/Model: Allen-Bradley MicroLogix 1400		
Control Panel	LP-200 Grit Collection Pnl	2	2	1	Estimate 2005	Headworks Area		Quality Controls Corp.			
Control Panel	LP-710 Bio Filter Sump Pnl	3	1	1	Estimate 2005	Bioswale Area		Hydronix			
Control Panel	LP-920 Sump Pump Pnl	2	4	1	Estimate 2005	Process Building (lower level)		Hydronix			
Control Panel	LP-TLP Truck Loading Pnl	2	2	1	Estimate 2005	Process Building		Quality Controls Corp.			
Control Panel	LP-TCP Thickening Panel	2	4	1	Estimate 2005	Process Building		Quality Controls Corp.			
Control Panel	Gravity Belt Panel	2	4	1	Estimate 2005	Process Building		Ashbrook Corp.			
Control Panel	LP-Scum Pump	4	2	1	Estimate 2005	Process Building		Quality Controls Corp.			
Control Panel	UV System Panel	2	4	1	Estimate 2005	Effluent Area		Trojan Technologies Inc.			
Lighting - Exterior		1	1	1		Process Area					
Lighting - Interior		1	1	1		Process/Operations Building					

INSTRUMENTATION

STRUCTURAL/FACILITIES

Operations Building					2005	Operations building					

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Kingston Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Other Facilities

PIPING

Photos:

Operations Building and diesel tank

Lab Area

Generator

Notes:

APPENDIX F

SEWER UTILITY SCADA MASTER PLAN TECHNICAL MEMORANDUM

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.

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Appendices

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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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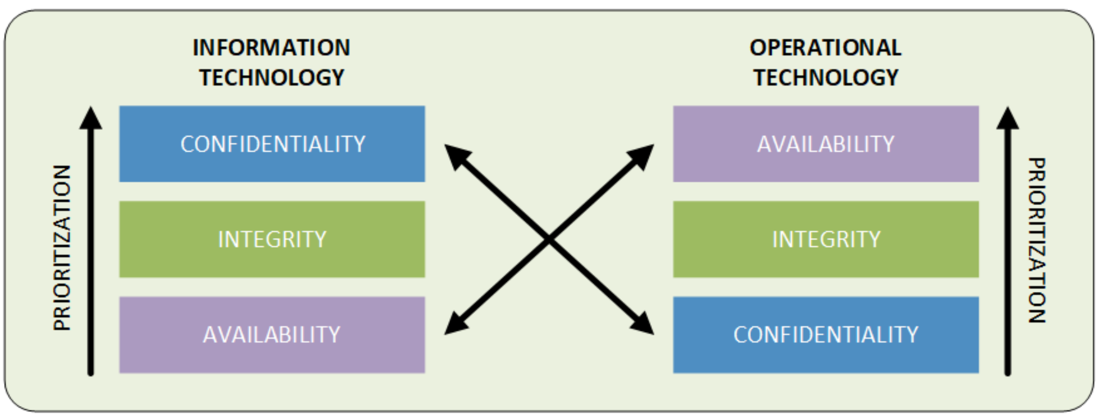
2 Network Architecture

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

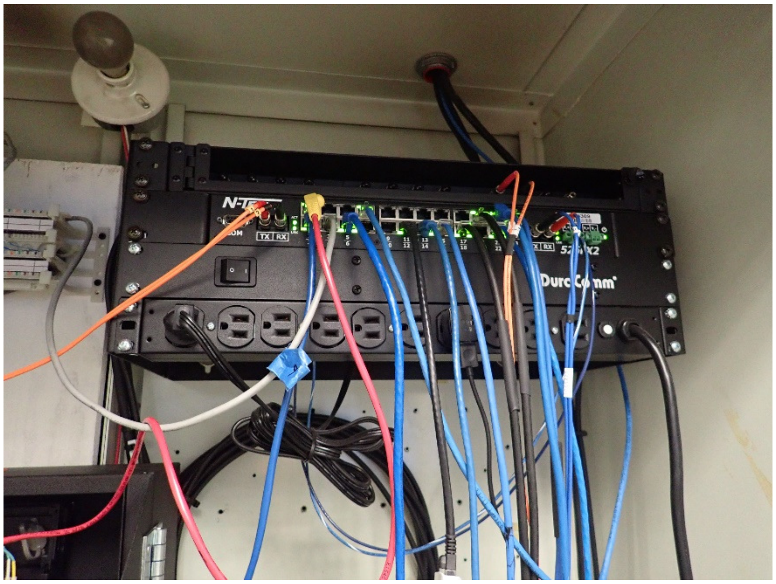
This subsection provides an overview of the network at each of the Sewer Utility WWTPs.

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.

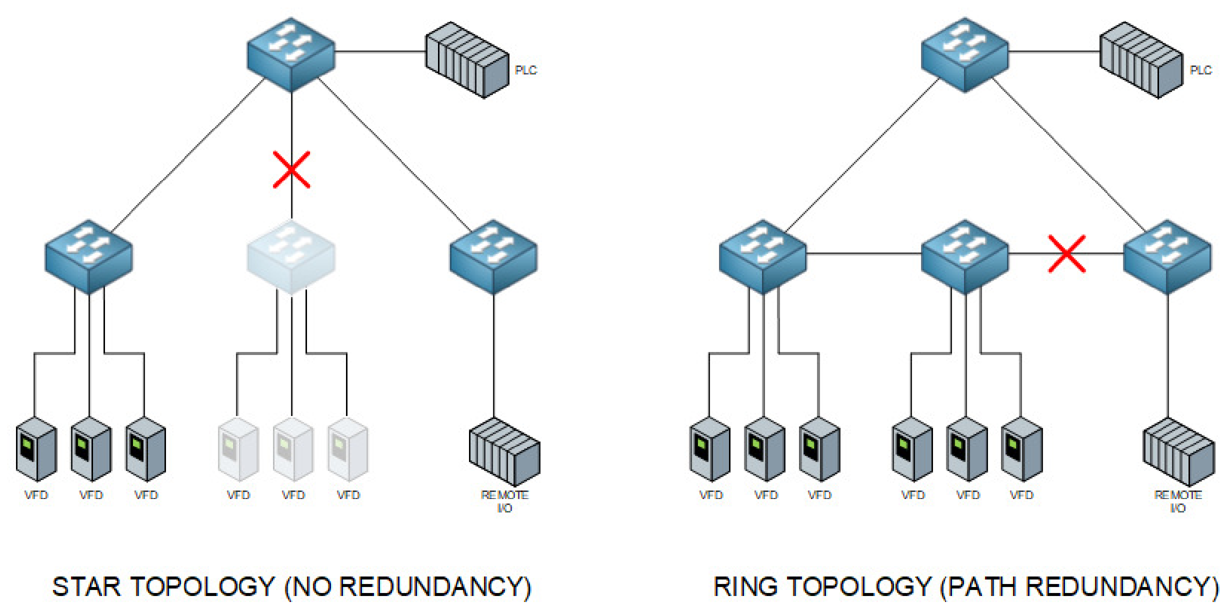
2.2.4 Suquamish Wastewater Treatment Plant

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.

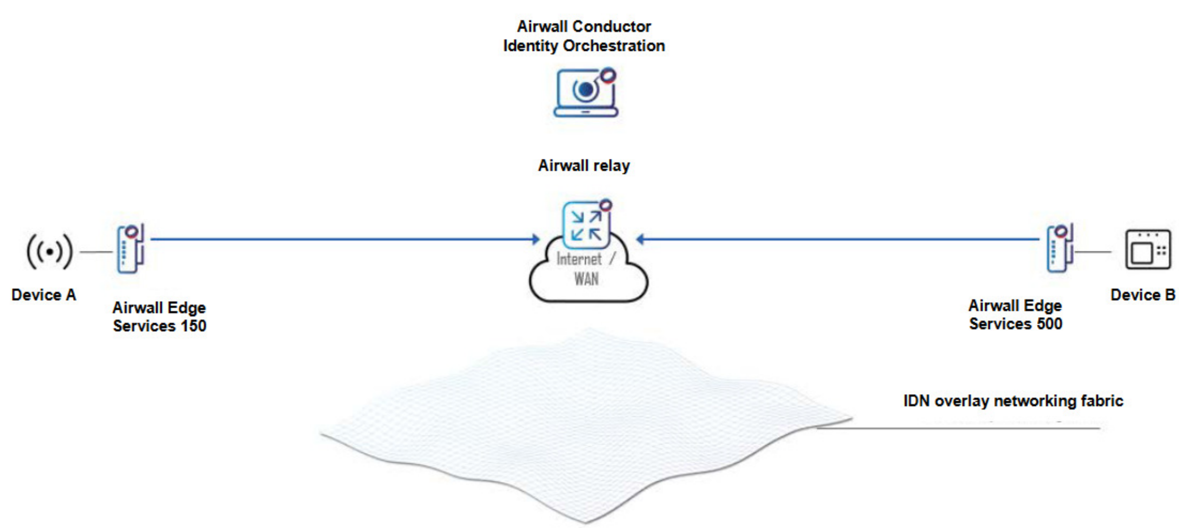
2.3 Wide-area Network Architecture Overview

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.

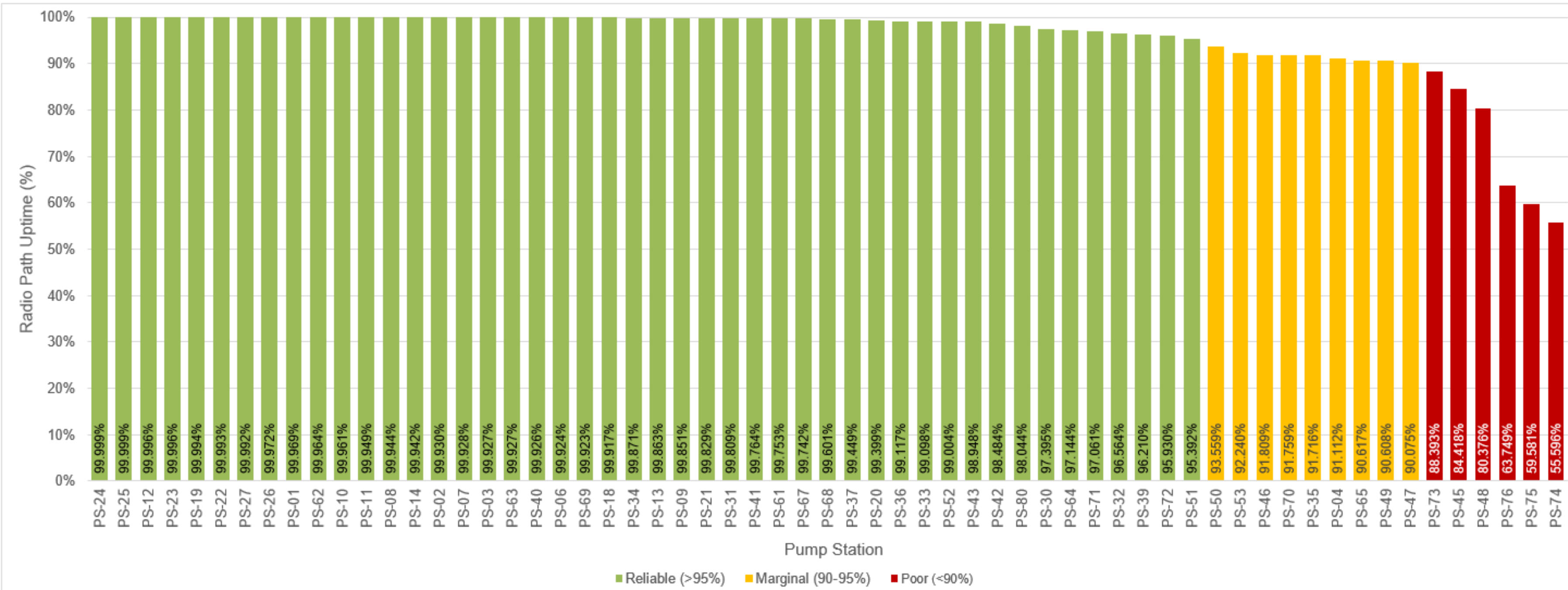
The Sewer Utility has expressed a desire to move toward more real-time monitoring and alarming for the pump stations. Furthermore, the recommendations that are anticipated to come from the ongoing Sewer Utility SCADA Master Plan will likely include increasing the amount of data exchanged between the 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.

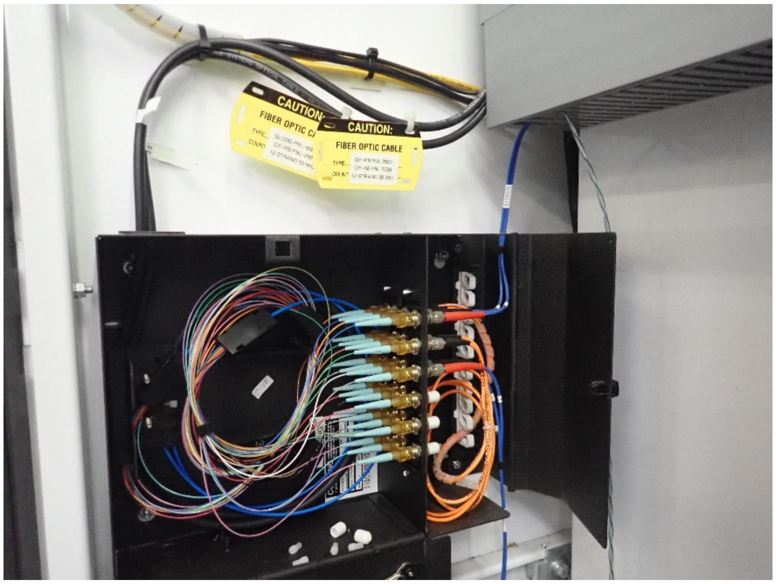
2.4.1 Central Kitsap Treatment Plant

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.

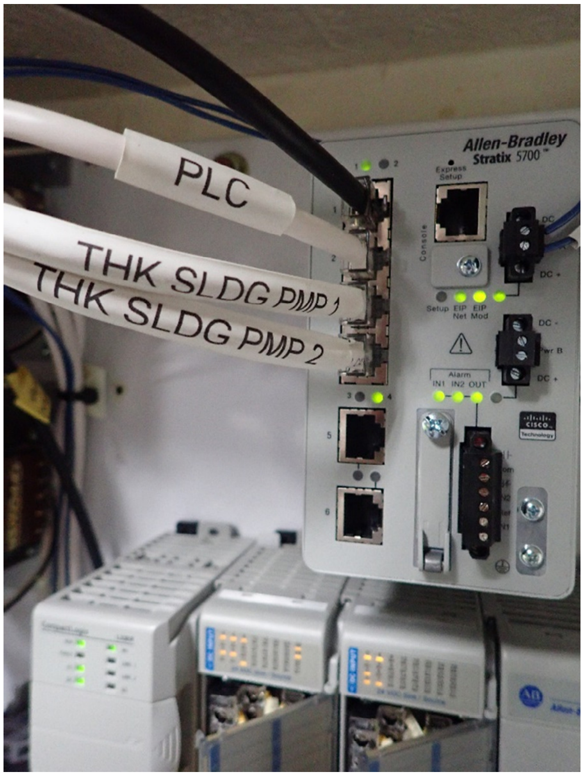
During its site visits, HDR noticed that an OM1 patch cord (the orange patch cord shown in Figure 2-9) was used to connect two OM3 cables at the fiber-optic patch panel within PNL 2920 in the power/blower building. Mixing OM1 and OM3 fiber-optic cables can result in severe losses at the connection points 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

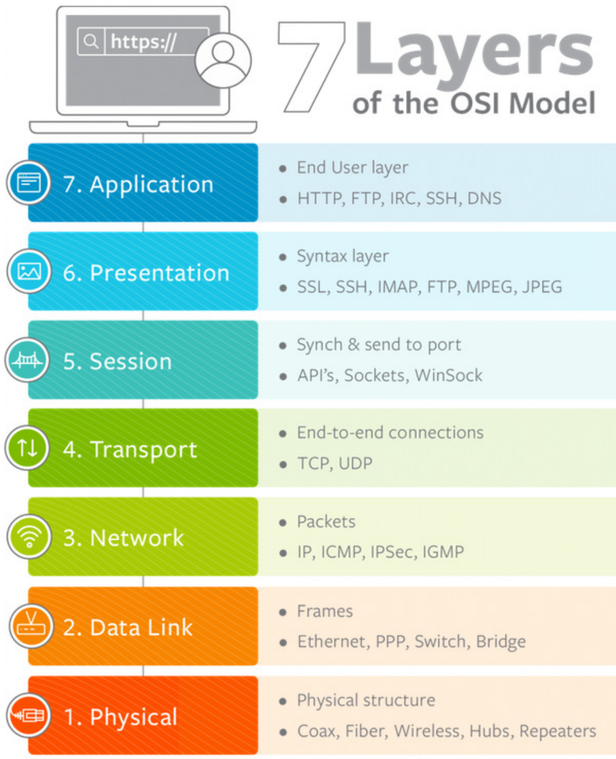
Ethernet cabling at the pump stations is limited and, where found, appears to be exclusively copper, UTP Category cable. HDR observed UTP Category cable connecting the VFDs for PS-67 pumps to the network switch in the station's control panel. HDR did not confirm the insulation rating of these cables. 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

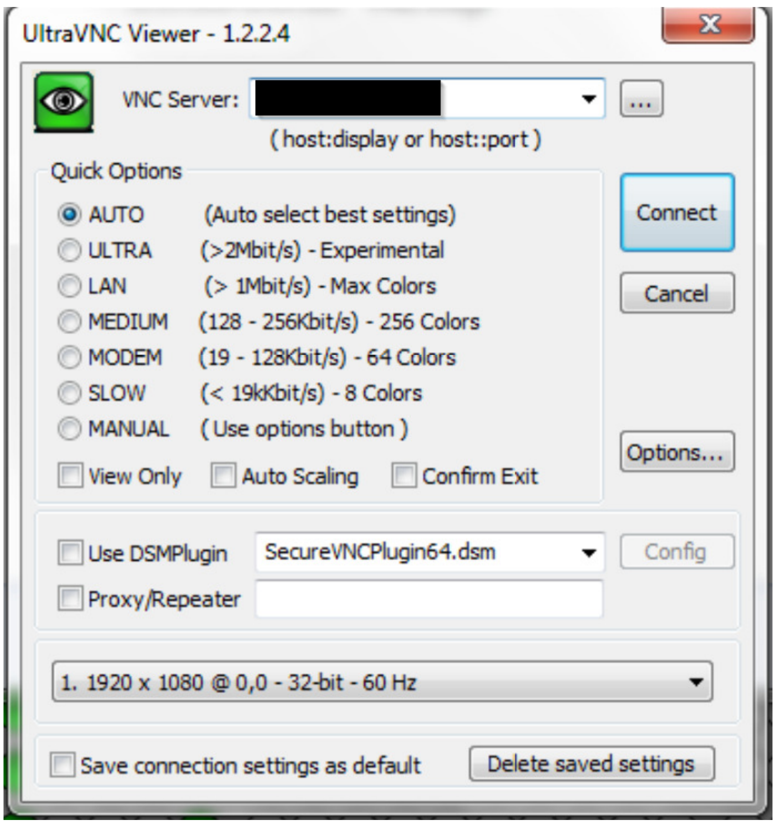
This subsection describes the remote access methods in place for the Sewer Utility's OT networks.

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

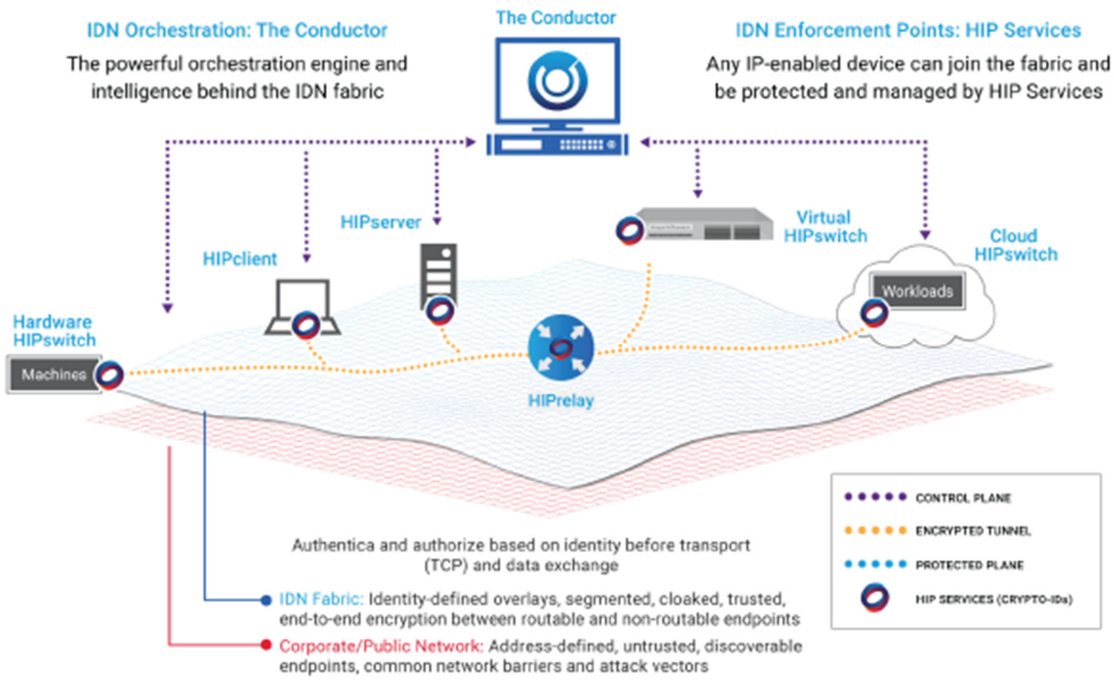
This subsection describes the network security hardware currently enforcing security controls for Sewer Utility OT network ingress and egress traffic.

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

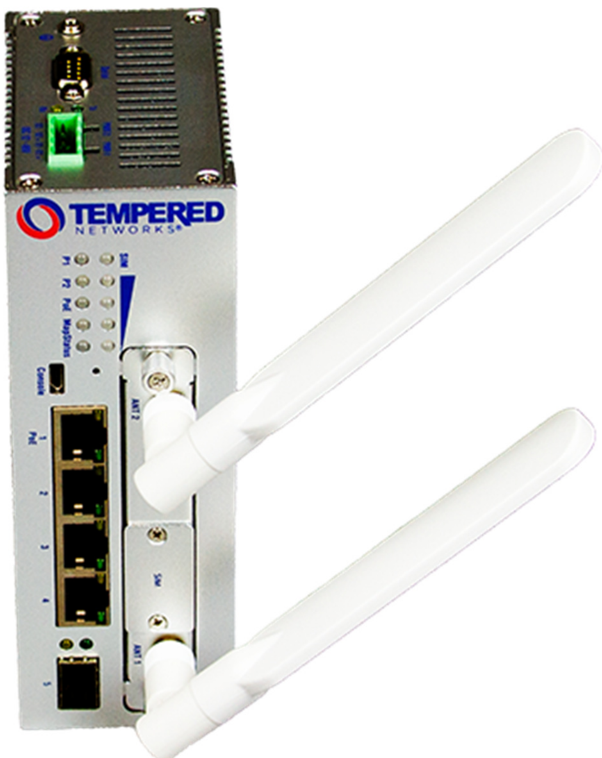
Source: Tempered Networks.

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

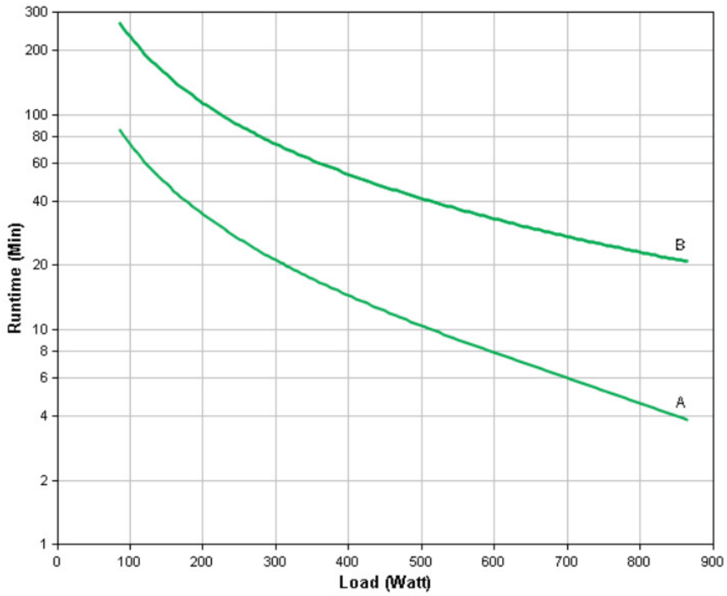
The SCADA PCs, CKTP historian server, and CKTP control room network cabinet have been provided with uninterruptible power supply (UPS) battery backup power to ride through brownouts and keep components powered until the plant or pump station transitions to standby generator power. These UPSs are line-interactive 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.

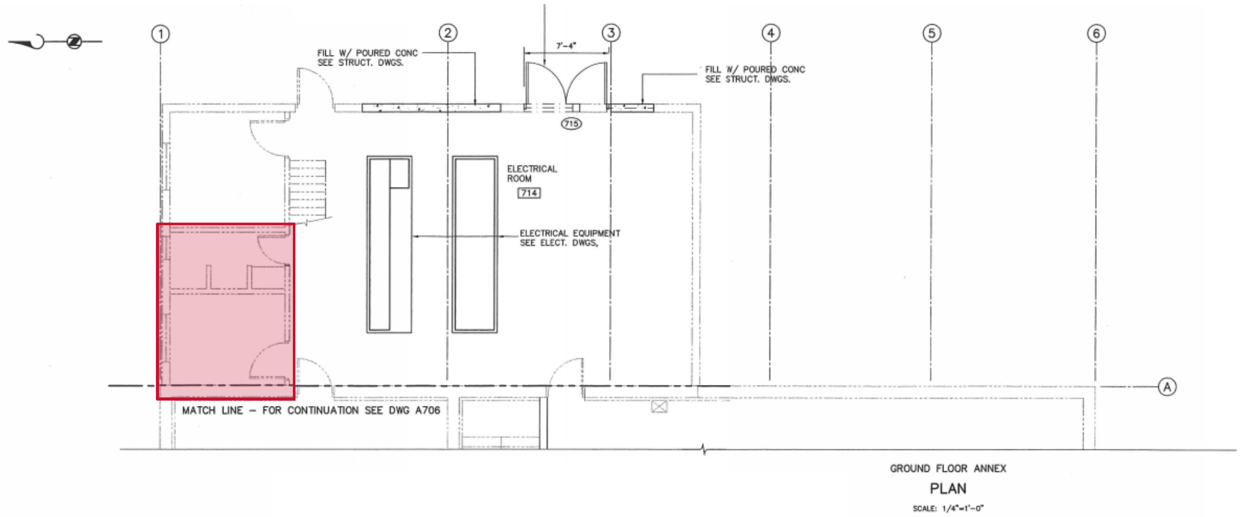
Though the control room has a SCADA PC, the PC is equipped with only two standard-size monitors (see Figure 3-11). This arrangement may be suitable for an individual, but is not an ideal solution for control center scenarios where multiple staff members need to engage with the SCADA screens and discuss 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.

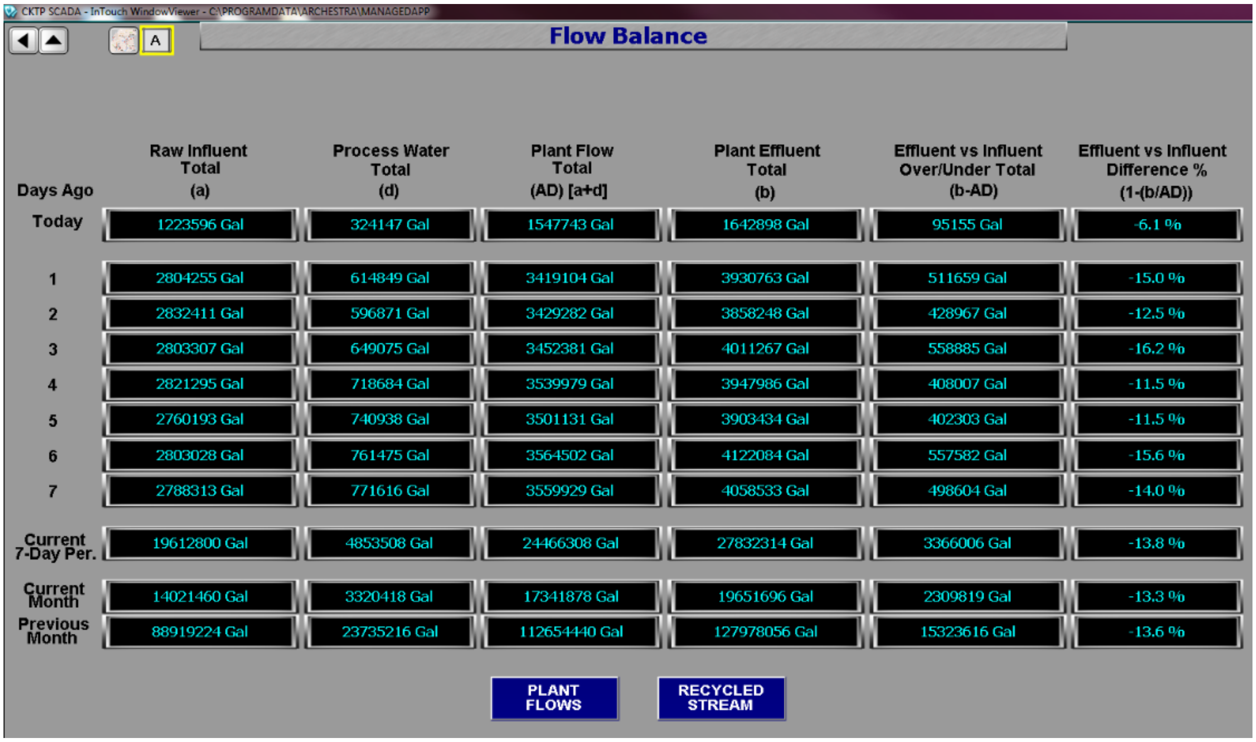
3.5.2 Central Kitsap Treatment Plant

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

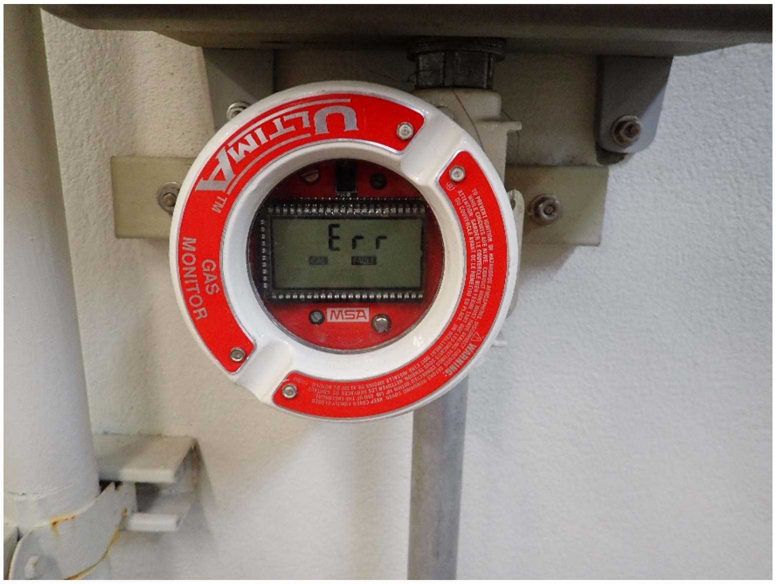
Aeration Basin Dissolved Oxygen Monitoring

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.

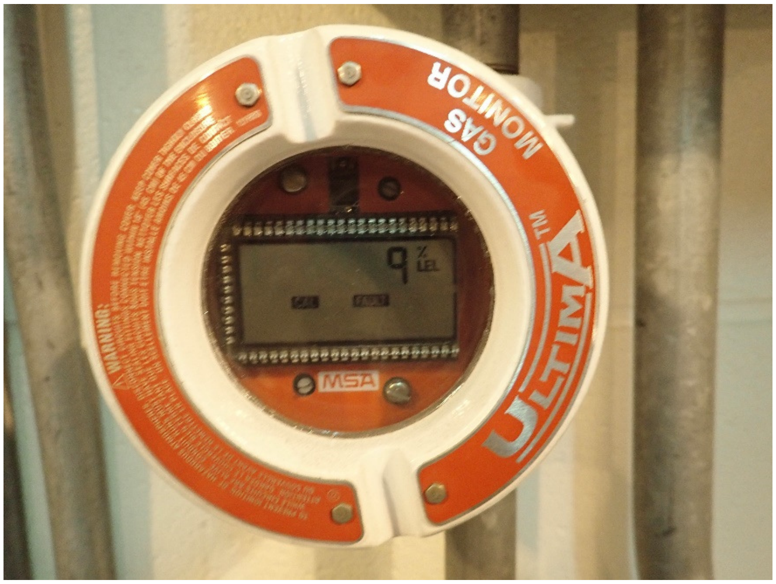
PS-24 Pumps Short Cycling

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

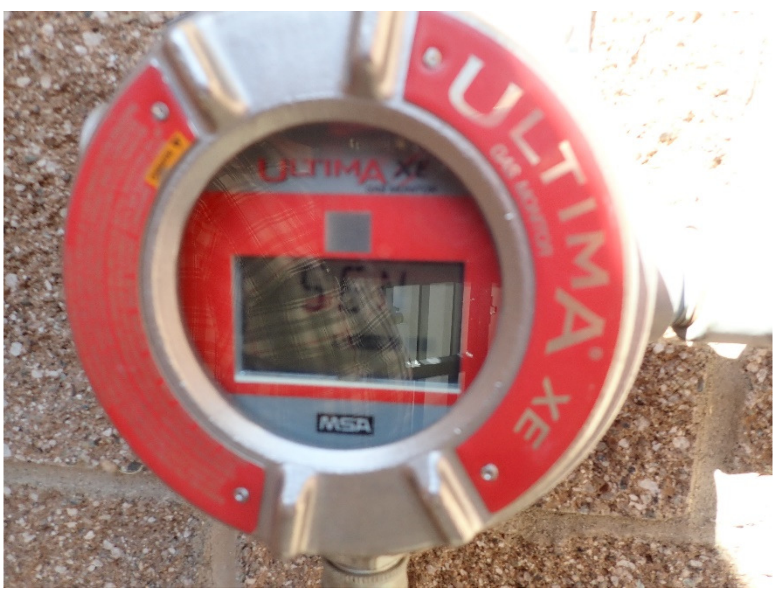
Sewer Utility staff indicated that the ultrasonic probe on the old sodium hypochlorite tank failed after 2 weeks because of exposure to the chemical. The tank has since been converted to a BIOXIDE storage tank, but the level instrument still remains hanging off of an old flange and is no longer connected 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.

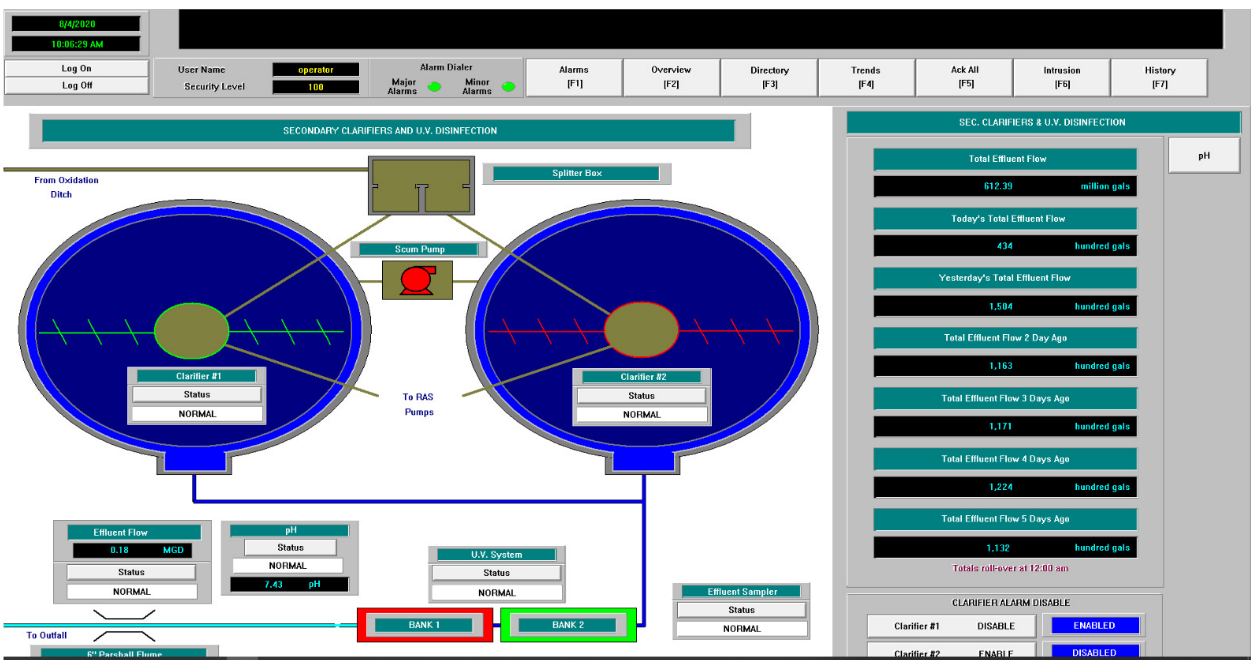
However, the alarm summary banner at SWWTP may be non-functional because it was displaying a single alarm from more than 4 months prior to HDR's site visit and did not include more current alarms found on the alarm summary screen. At CKTP, several plant flow values and select equipment operational statuses 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

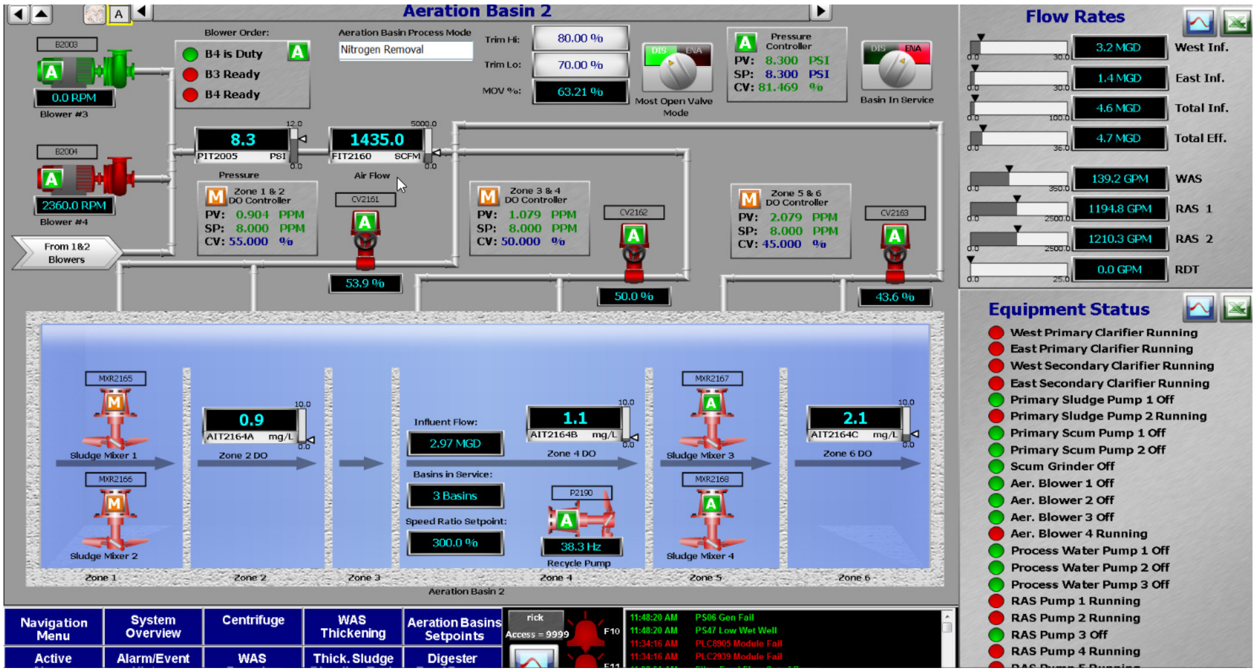
Throughout the HMI screens, color is often the sole means of differentiating important condition, status, or alarm state. For example, the secondary clarifiers and UV disinfection HMI screen at KWWTP shown in Figure 4-1 communicates clarifier, scum pump, and UV bank running status with color only. Because 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

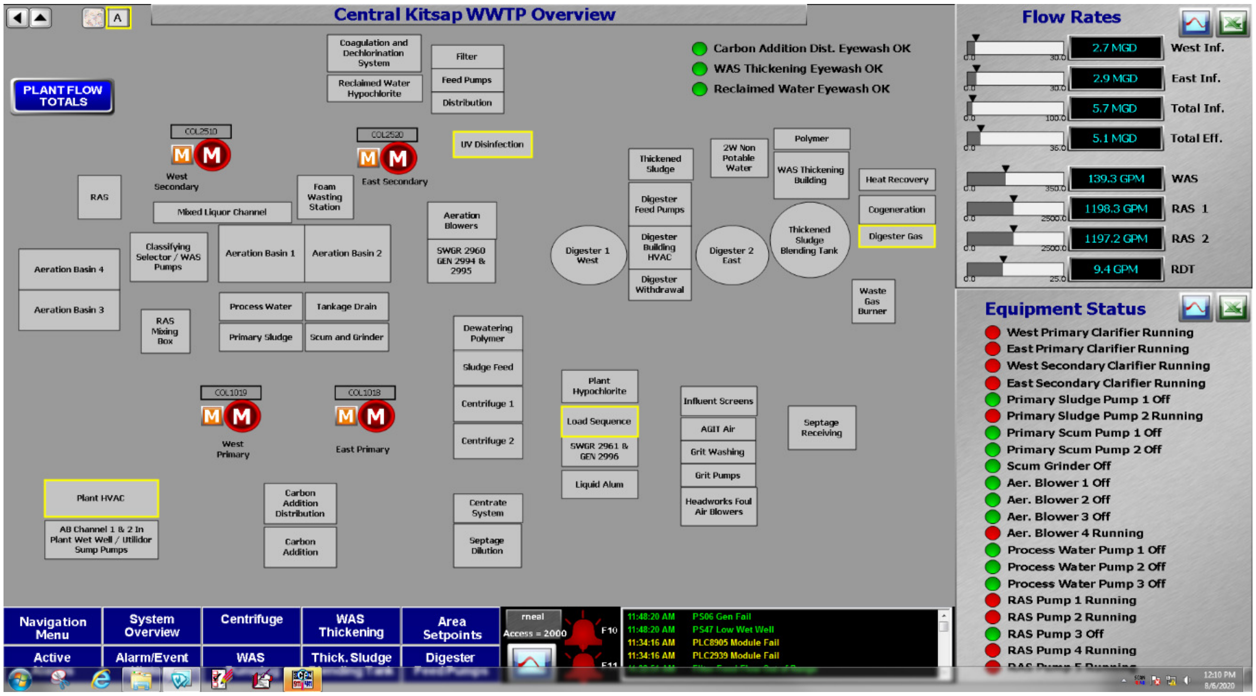


In many cases throughout the Sewer Utility's HMI screens, binary-type statuses like on and off are distinguished with equally vivid colors. Static portions of the CKTP and SWWTP HMI screens, like the piping and equipment graphics, are often displayed with colors that are brighter than the HMI screen 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

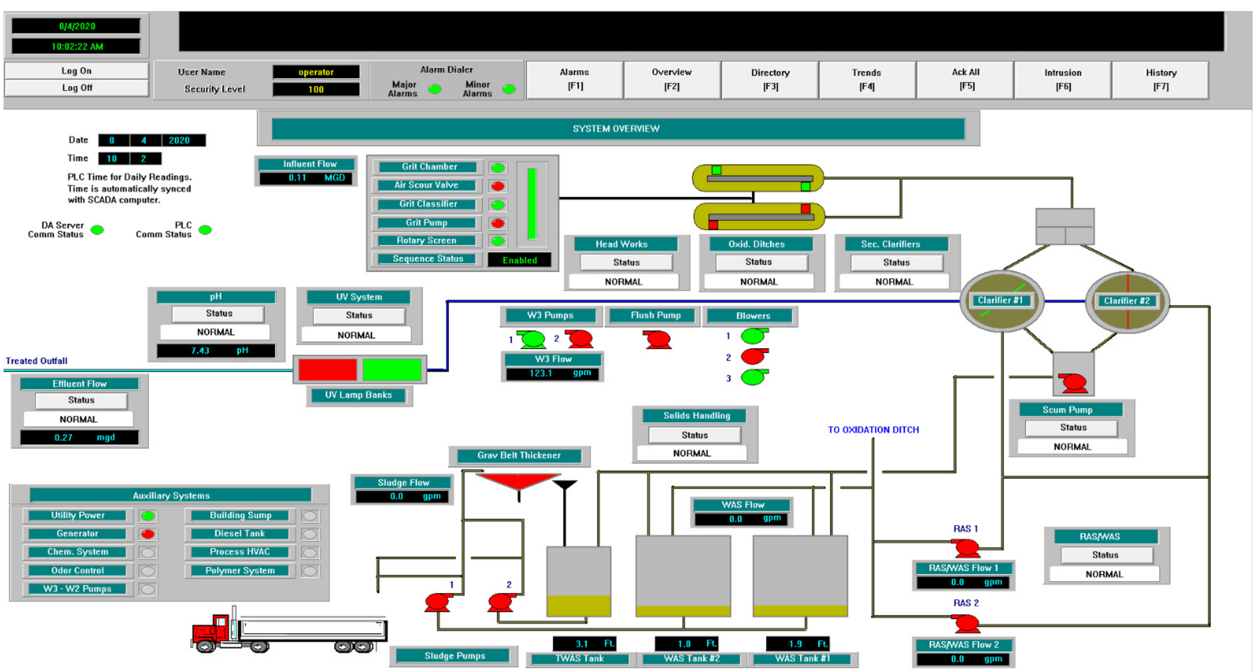
The CKTP overview HMI screen is displayed in Figure 4-3. Aside from displaying primary and secondary clarifier status and some emergency eyewash alarm status indications, the HMI screen functions more as a directory for operators to navigate to specific process screens than an overview of current CKTP 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



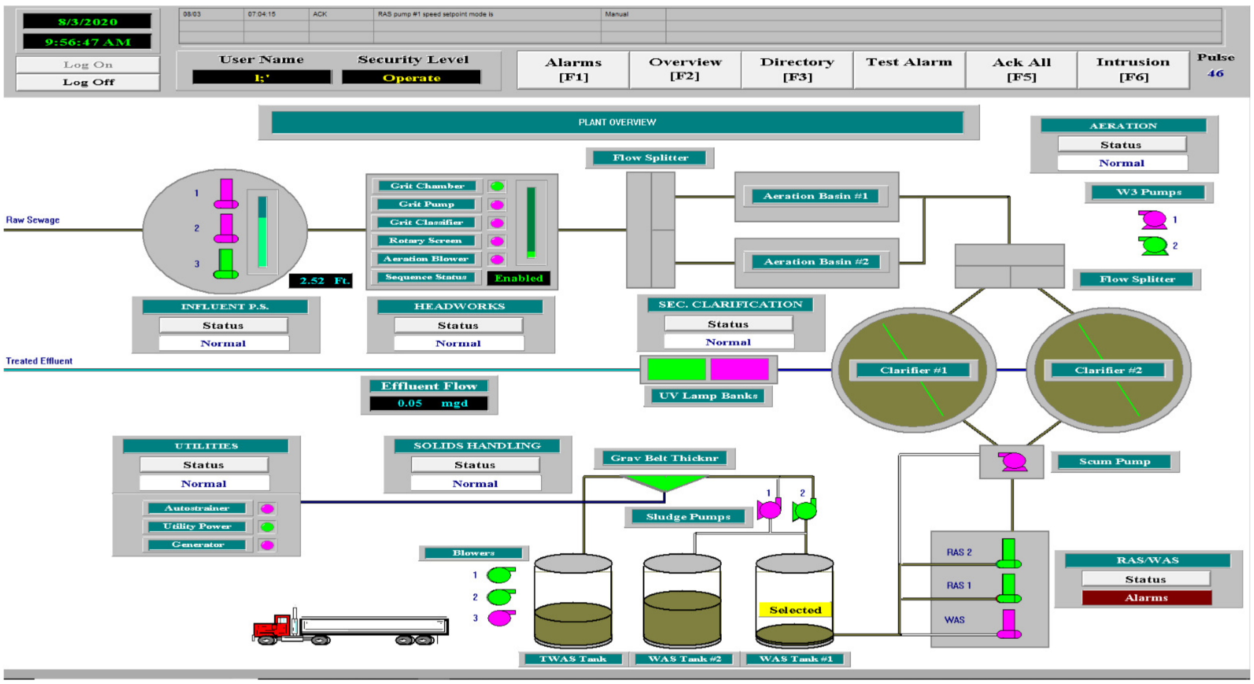
The KWWTP overview HMI screen is displayed in Figure 4-4. This screen provides a general process flow overview for KWWTP with running status for major plant equipment communicated by the plant's red and green color scheme. Several process parameters like level, flow, and pH are displayed on the overview screen along with current utility and generator power statuses.

Figure 4-4. KWWTP overview HMI screen



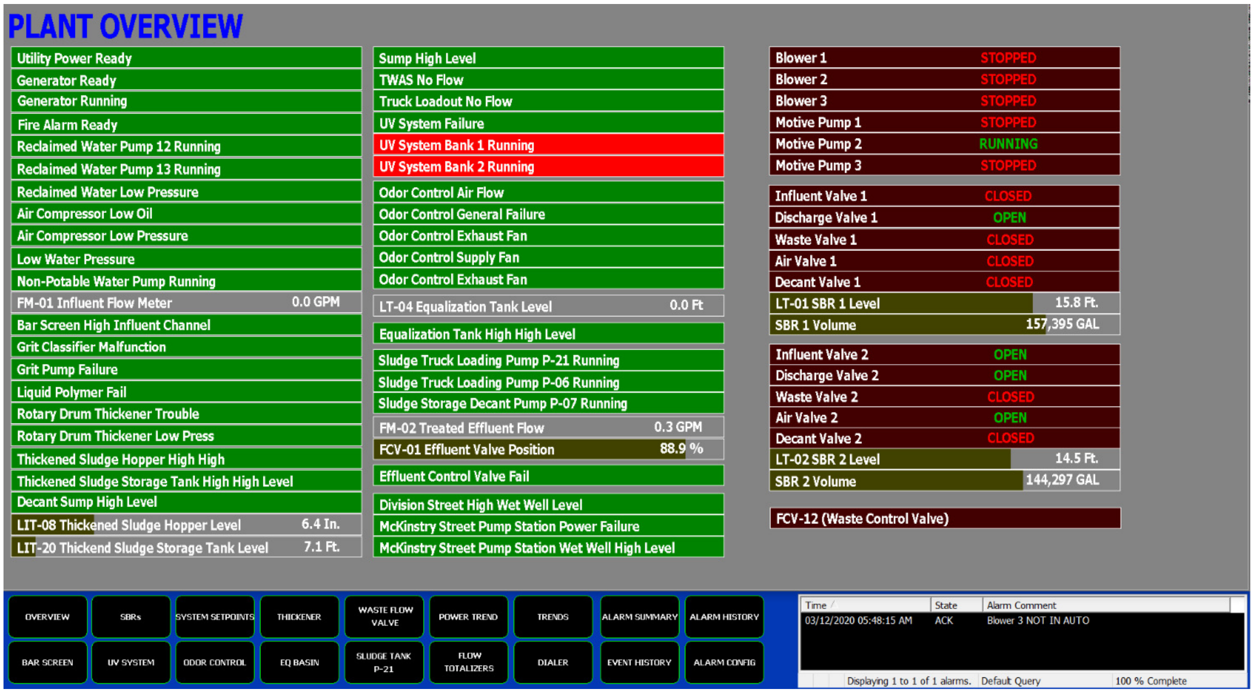
The MWWTP overview HMI screen is displayed in Figure 4-5. This screen provides a general process flow overview for MWWTP with running status for major plant equipment communicated by the plant's magenta and green color scheme. MWWTP influent pump station level and effluent flow values are displayed on 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

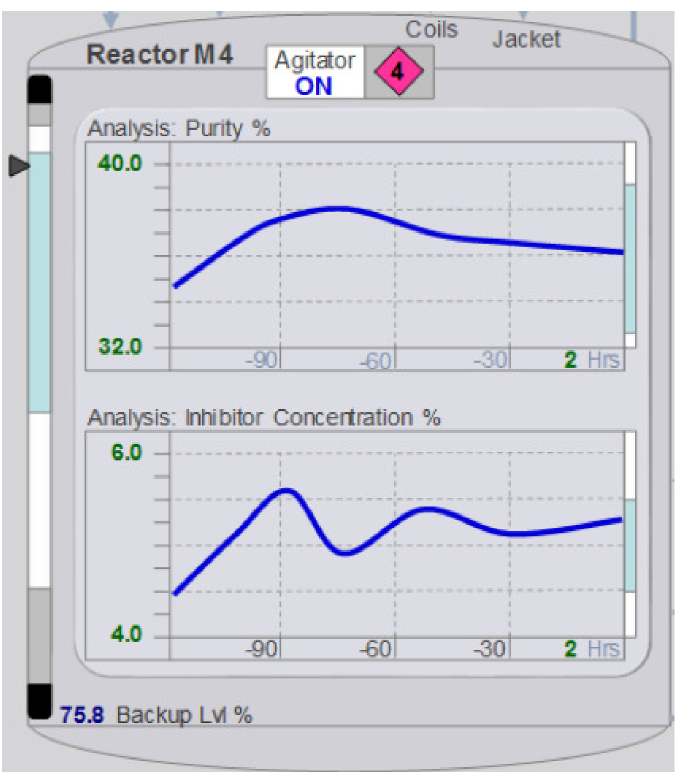
The various Sewer Utility process-specific HMI screens typically show a piping and instrumentation diagram (P&ID)-like, not-to-scale representation of the process with major equipment and vessels interconnected via pipelines with arrows showing flow direction. Process equipment and actuated valves are 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

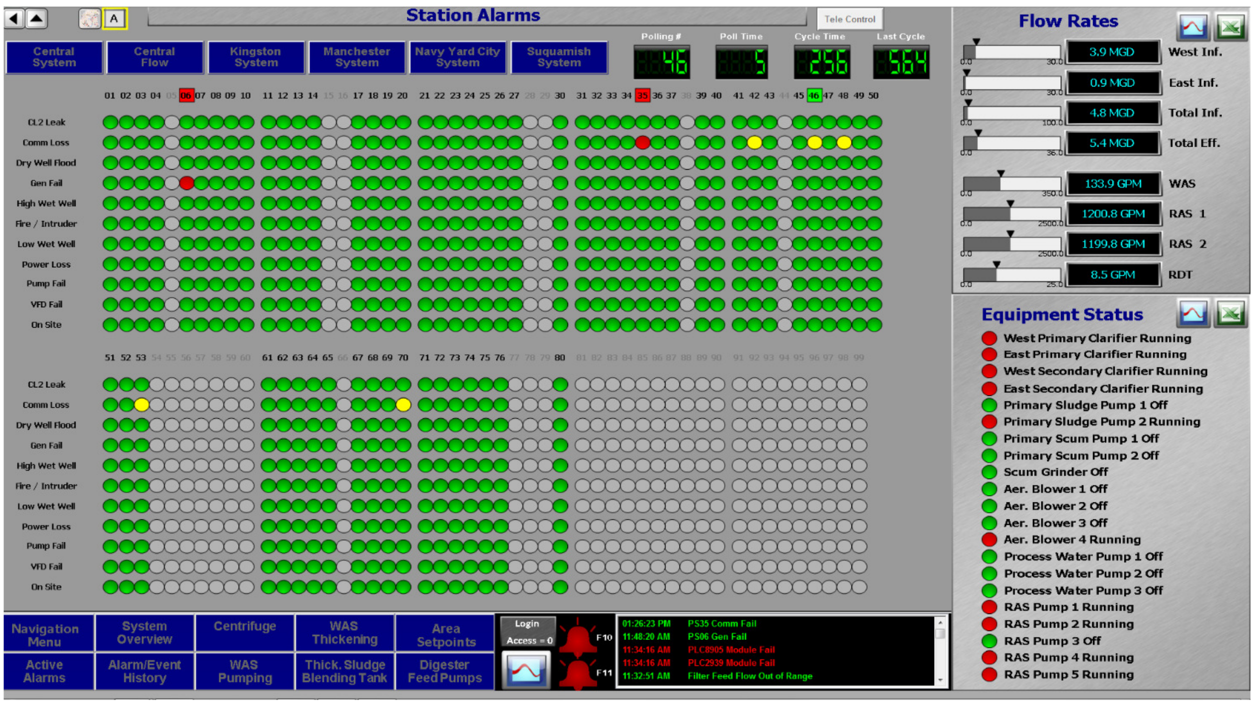


Source: PAS Global LLC.

Pump Station Screens

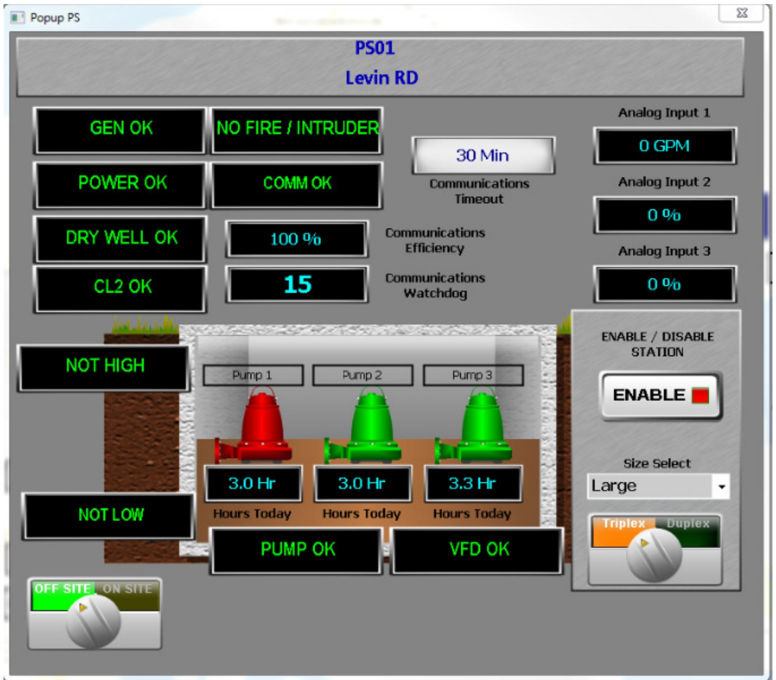
At CKTP, a pump station alarm screen displays the states of all monitored alarms for each pump station along with information pertaining to the current pump station being polled, the polling time, and current and previous polling cycle times (see Figure 4-8). As shown in the figure, the screen provides 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.

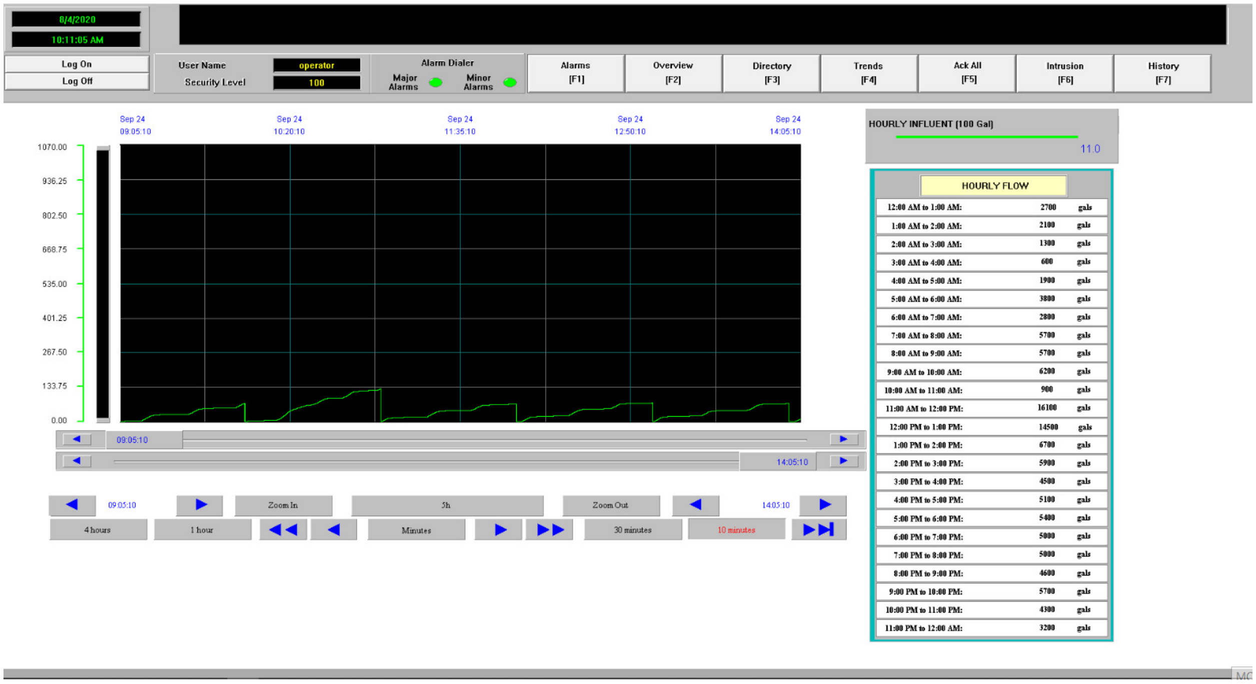
Figure 4-10. CKTP HRR pump 1 equipment pop-up window

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.

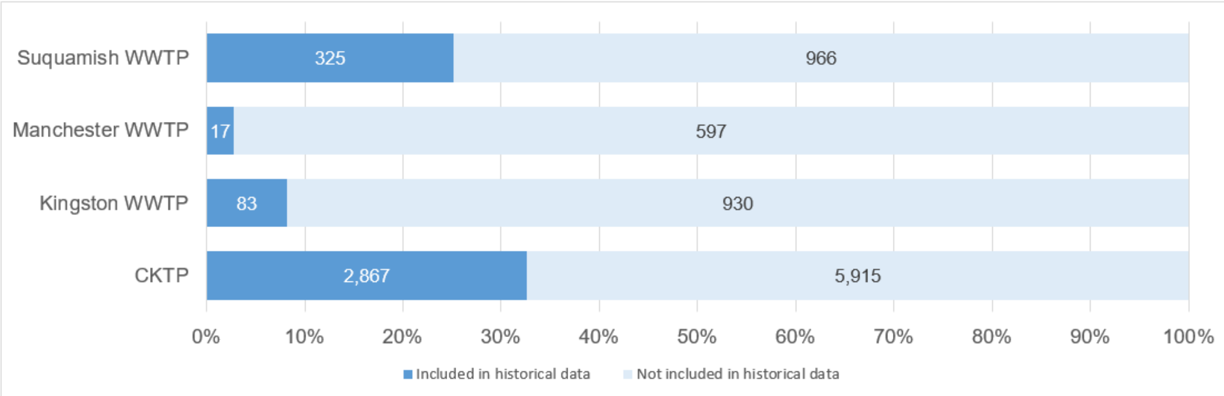
4.3.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

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

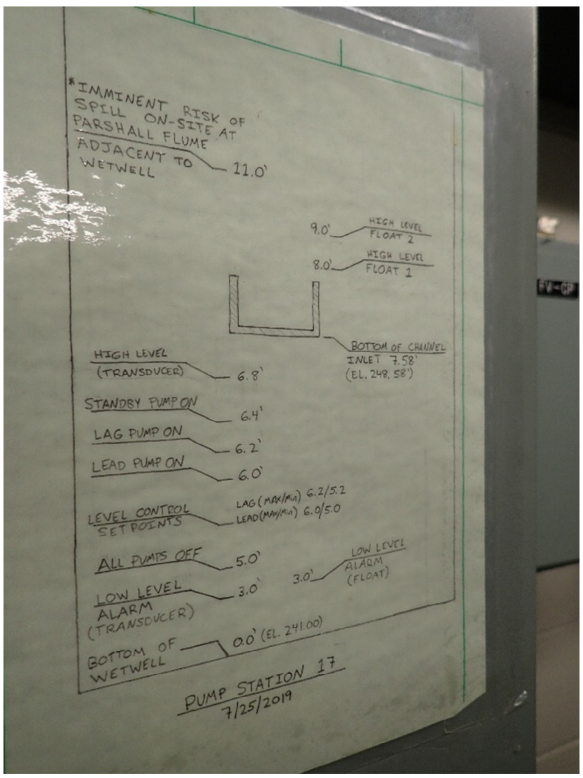
The County's eO&M SharePoint site includes narratives documenting general control descriptions for the major CKTP processes. However, the Sewer Utility has yet to add similar narratives for the processes at the other WWTPs or the wastewater pump stations. HDR understands that the County's eO&M SharePoint 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.

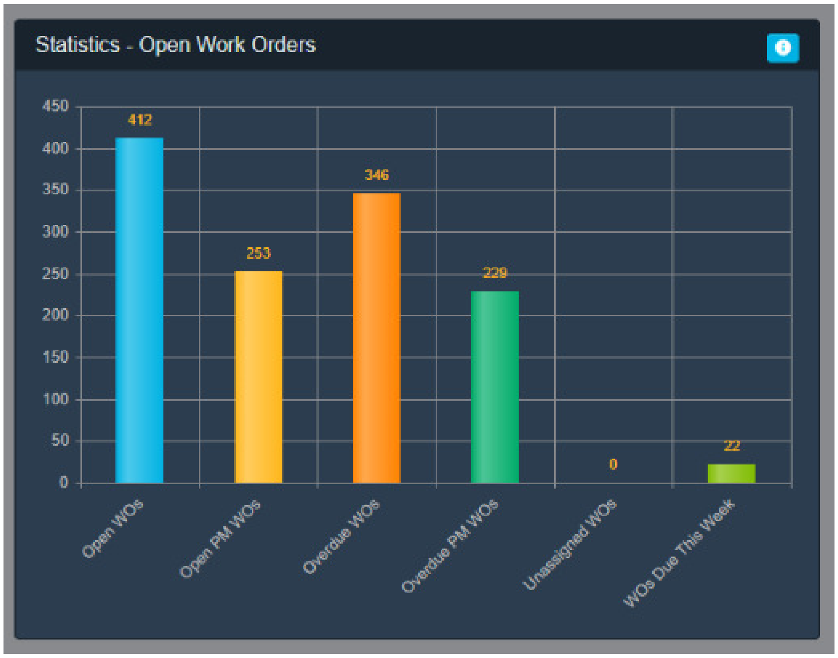
6.1 Computerized Maintenance Management System

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.

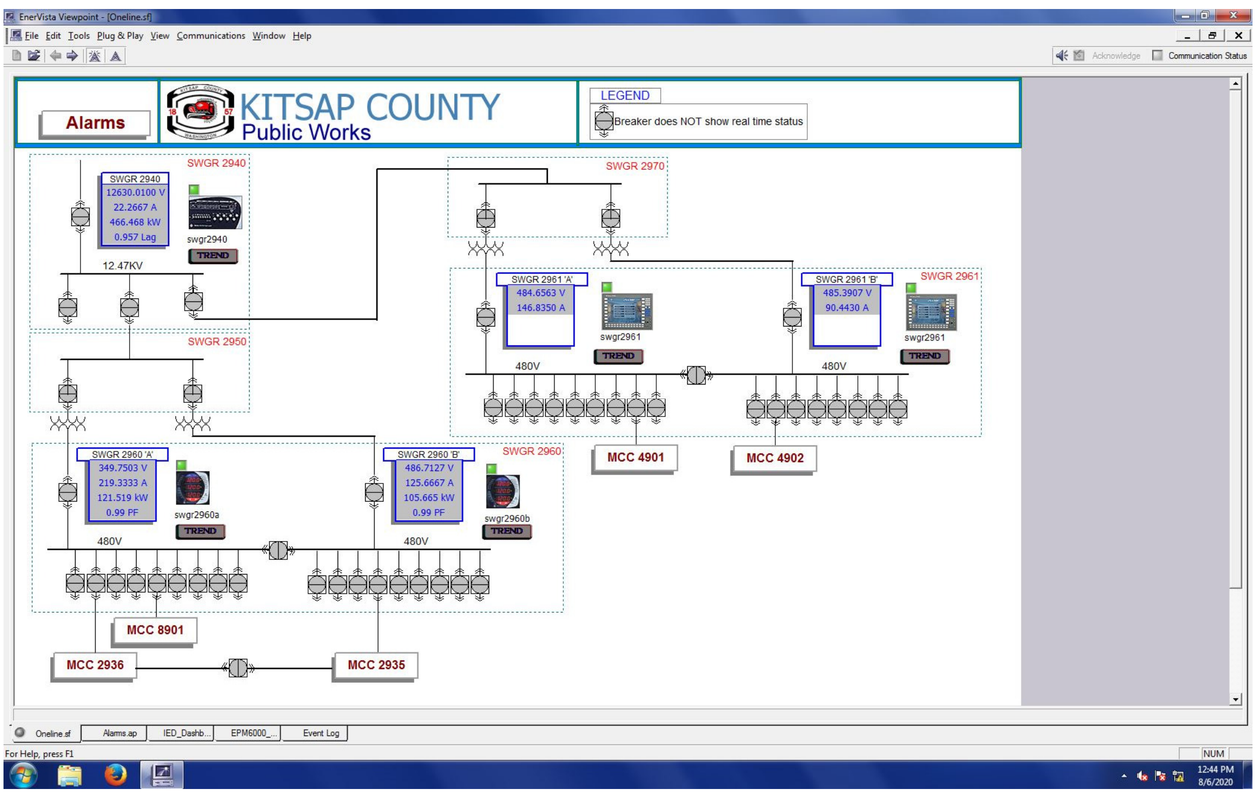
6.2 Energy Management System

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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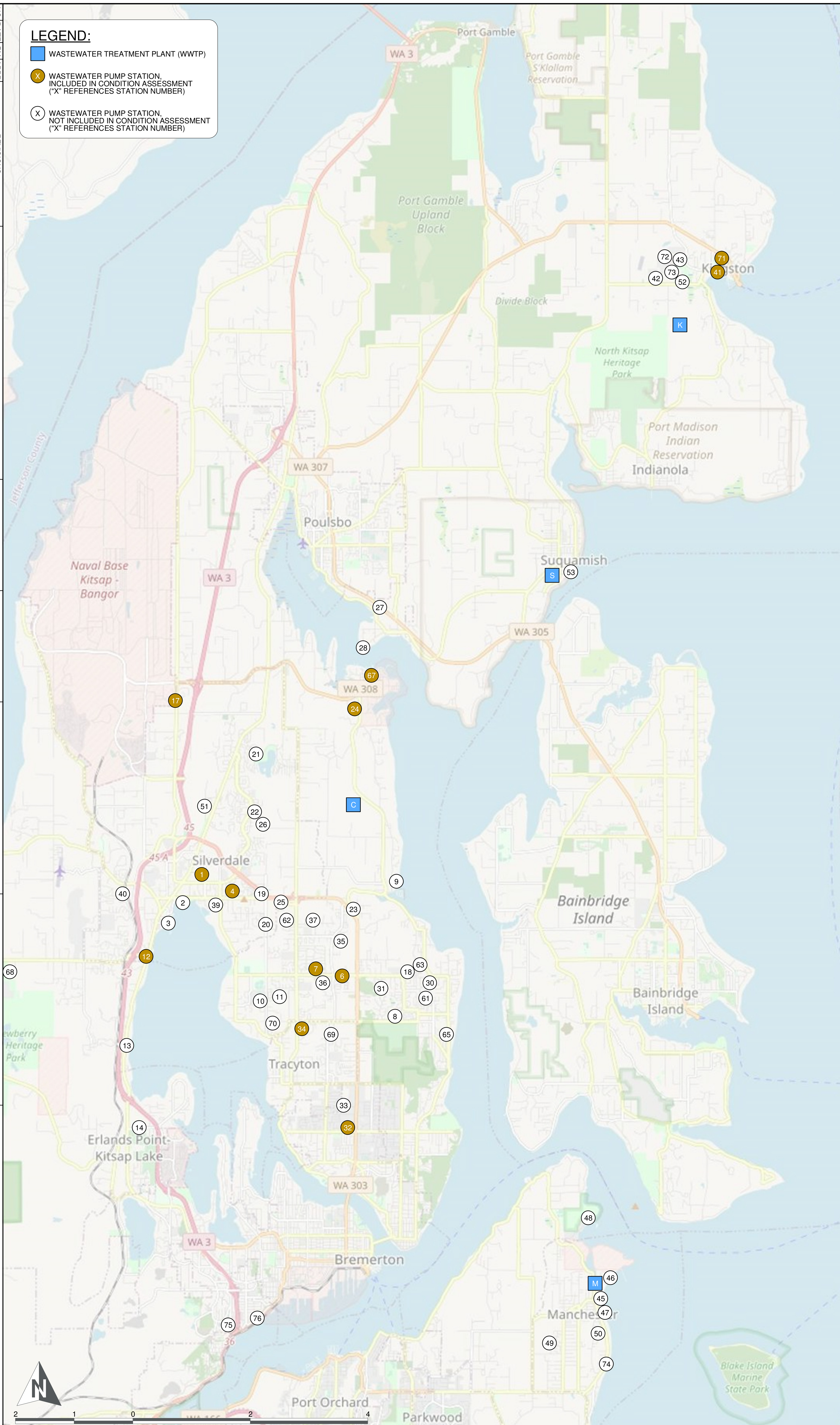
Appendix A

Site Maps



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Phone: (206) 462-7030

HDR Engineering, Inc.
929 108th Avenue NE #1300
Bellevue, WA 98004
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Fax: (425) 453-1707

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CLIENT PROJECT NUMBER	KC-205-20		

KITSAP COUNTY WASHINGTON 1857

Kitsap County Public Works
Sewer Utility Division
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KITSAP COUNTY PUBLIC WORKS SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING
0 1"

GENERAL
SITE MAP

FIGURE A1

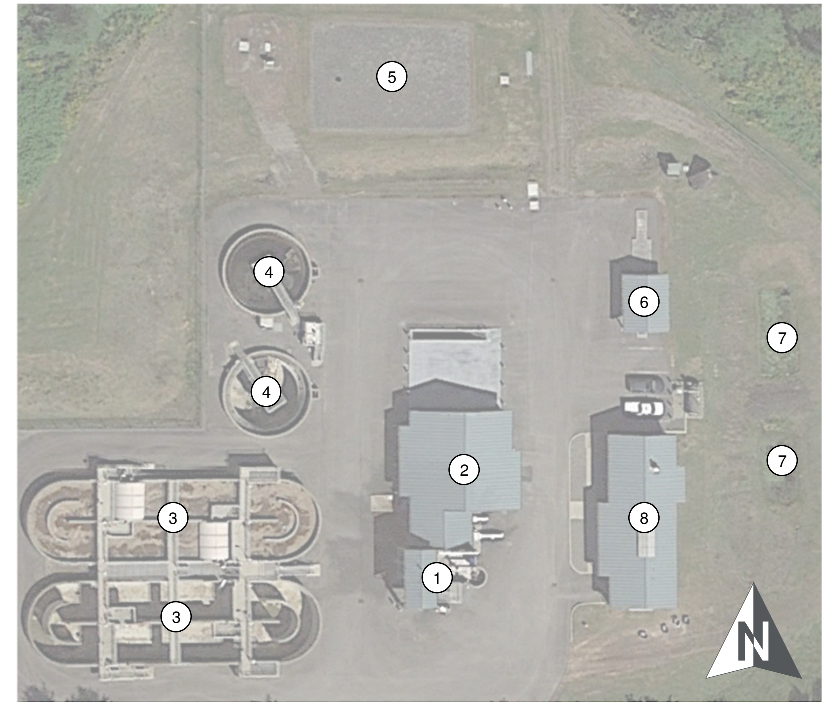
SHT 1 OF 2

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

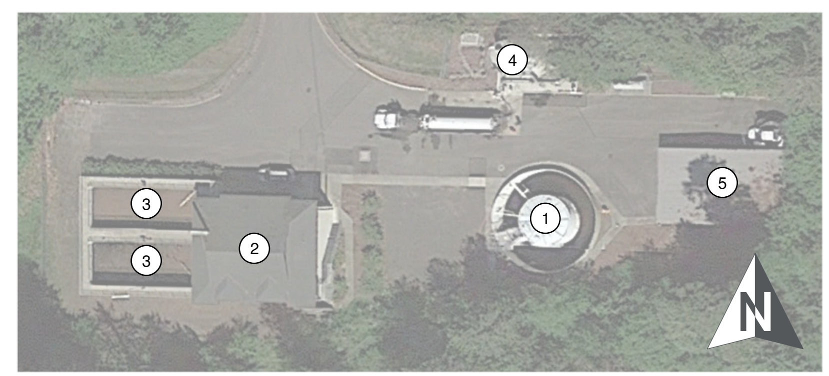


KINGSTON WASTEWATER TREATMENT PLANT

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

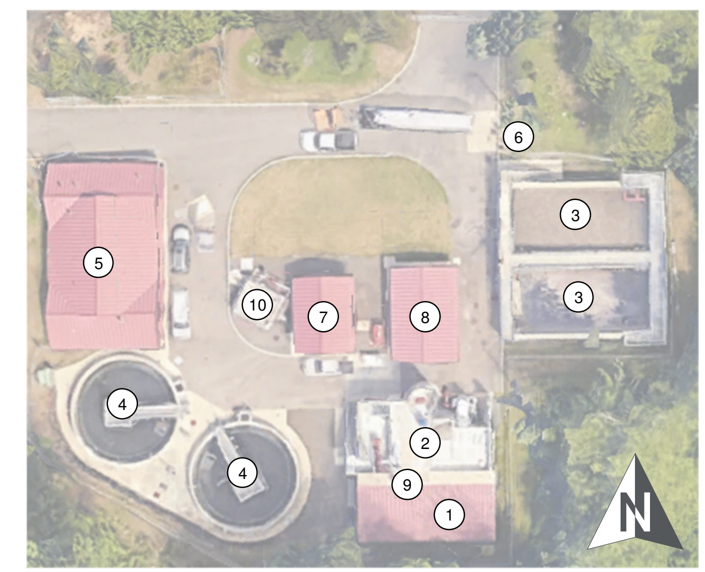


SUQUAMISH WASTEWATER TREATMENT PLANT

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

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

NO	DATE	BY	APPR	REVISIONS
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600 University Street #300
Seattle, WA 98101
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HDR Engineering, Inc.
929 108th Avenue NE #1300
Bellevue, WA 98004
Phone: (425) 453-1523
Fax: (425) 453-1707

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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

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

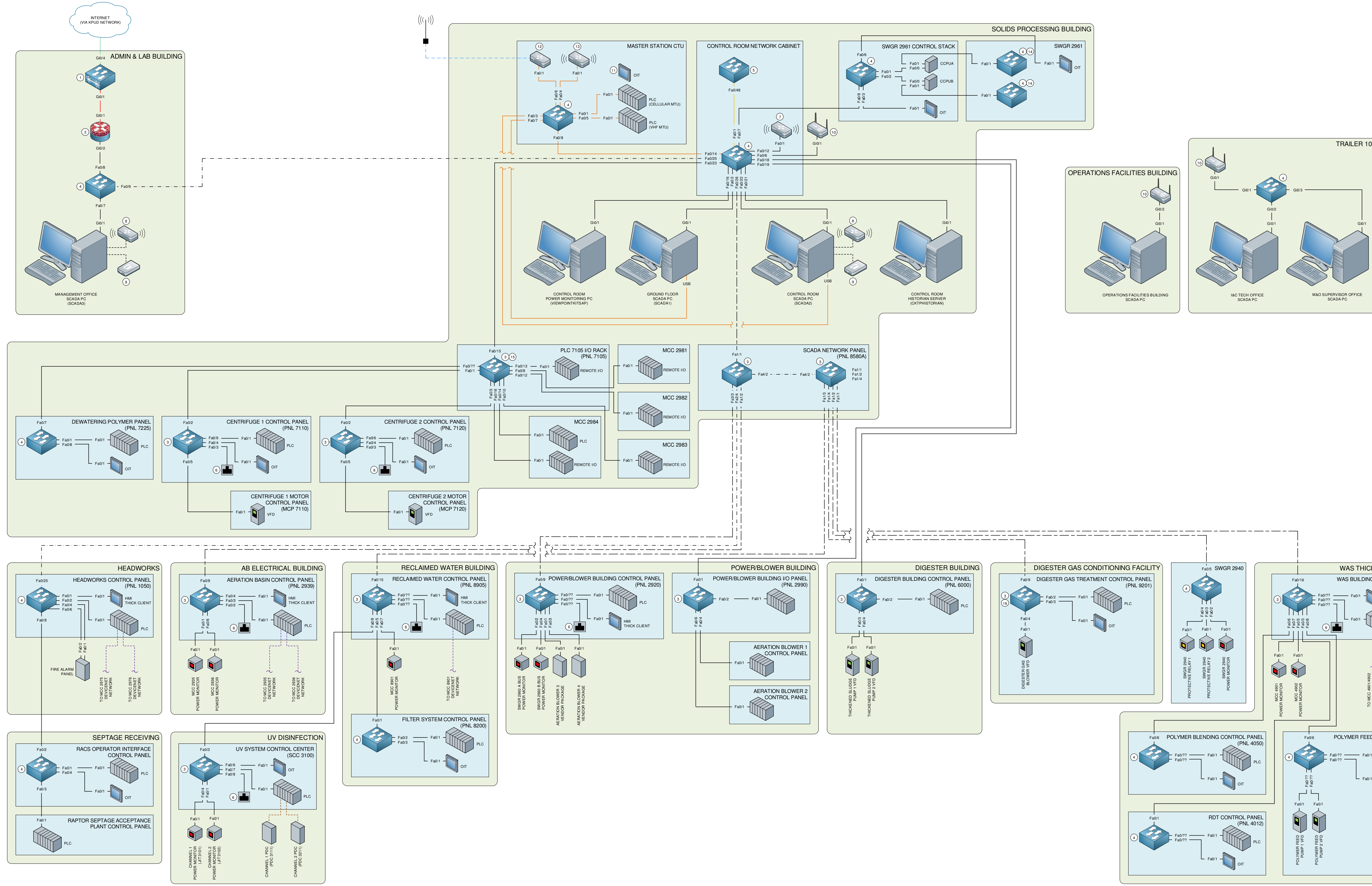
GENERAL
WWTP SITE MAPS

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 #

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Seattle, WA 98101
Phone: (206) 462-7030

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SEWER UTILITY SCADA MASTER PLAN

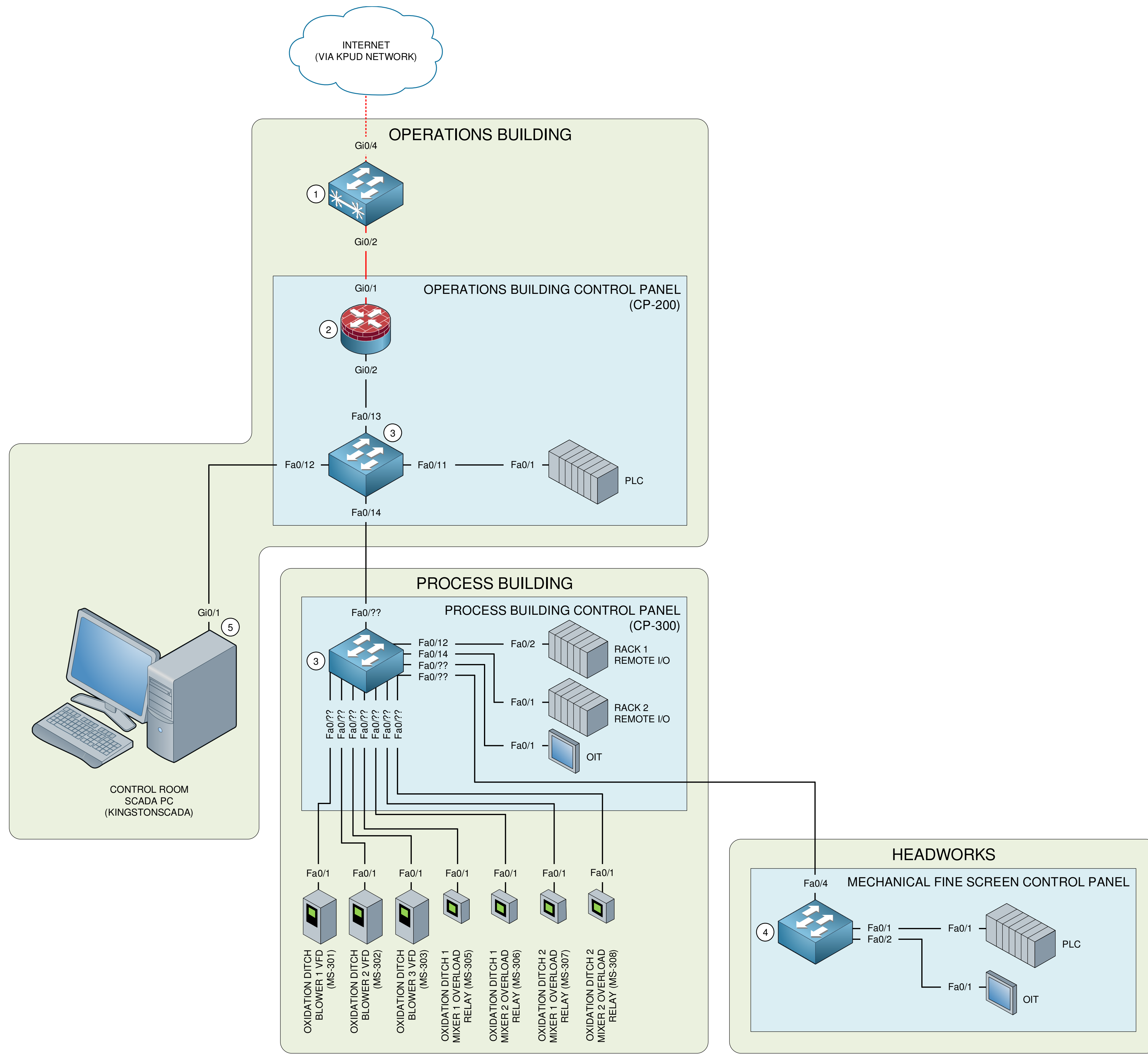
BAR IS 1 INCH ON ORIGINAL 22"x34" DRAWING 0 1"

GENERAL

CENTRAL KITSAP TREATMENT PLANT PHYSICAL NETWORK DIAGRAM

FIGURE B1

SHT 1 OF 4



GENERAL NOTES:

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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 #

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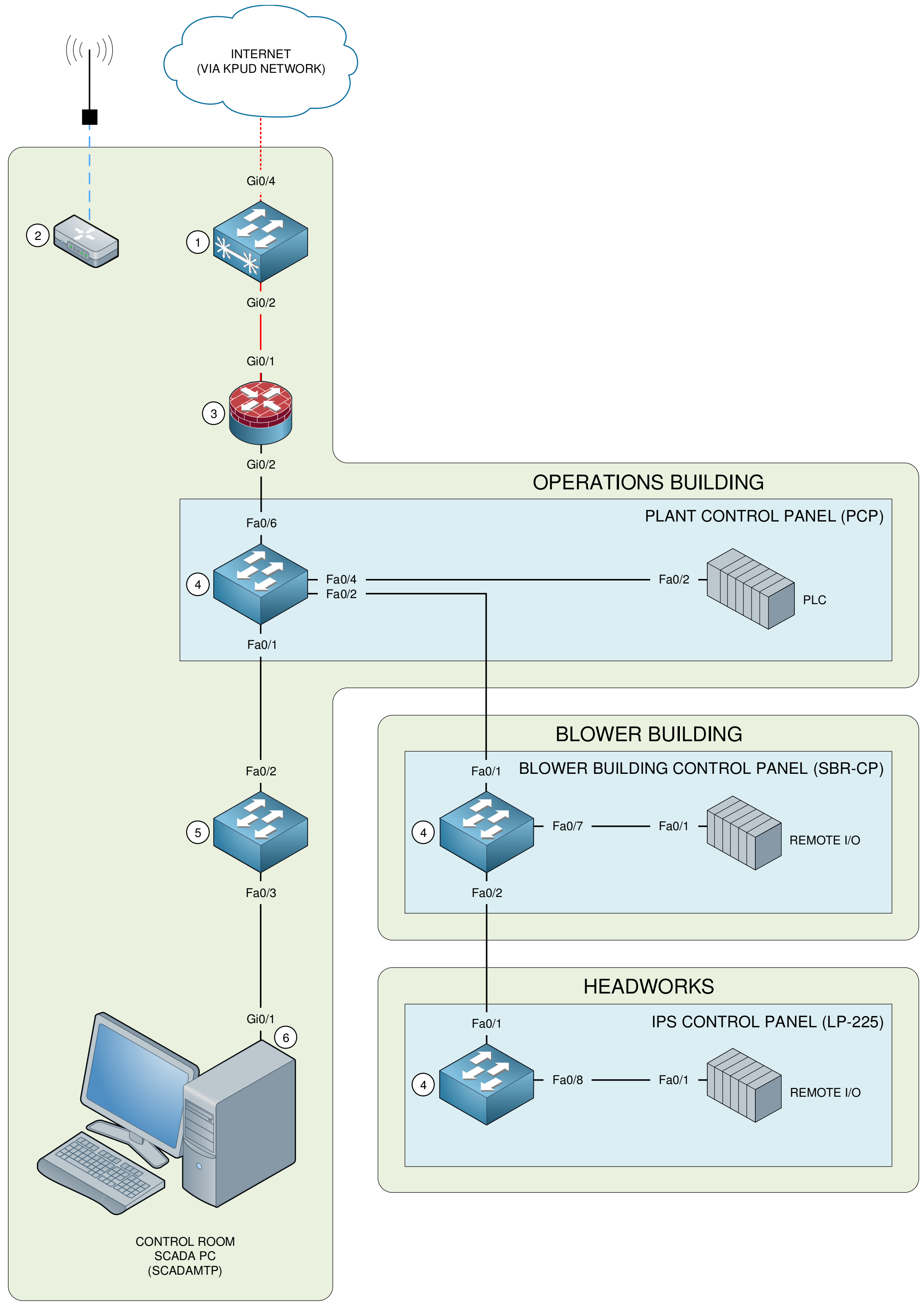
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL

KINGSTON WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B2 SHT 2 OF 4



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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
——— (red)	KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
——— (blue)	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 #

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SEWER UTILITY SCADA MASTER PLAN

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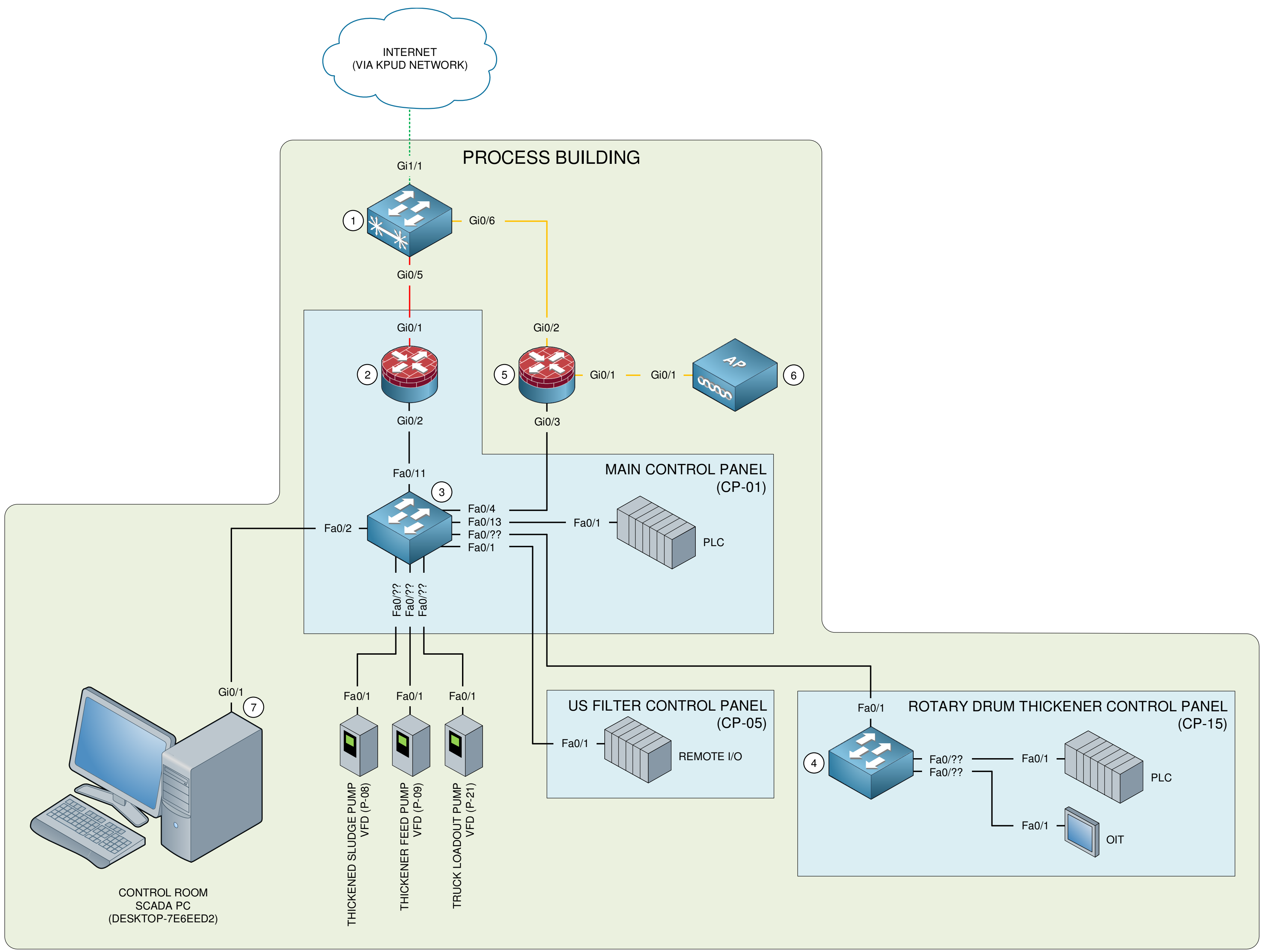
GENERAL

MANCHESTER WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B3

SHT 3 OF 4



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KEY NOTES:

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(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:

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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 #

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HDR PROJECT NUMBER
KC-205-20
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
SUQUAMISH WWTP
PHYSICAL NETWORK DIAGRAM

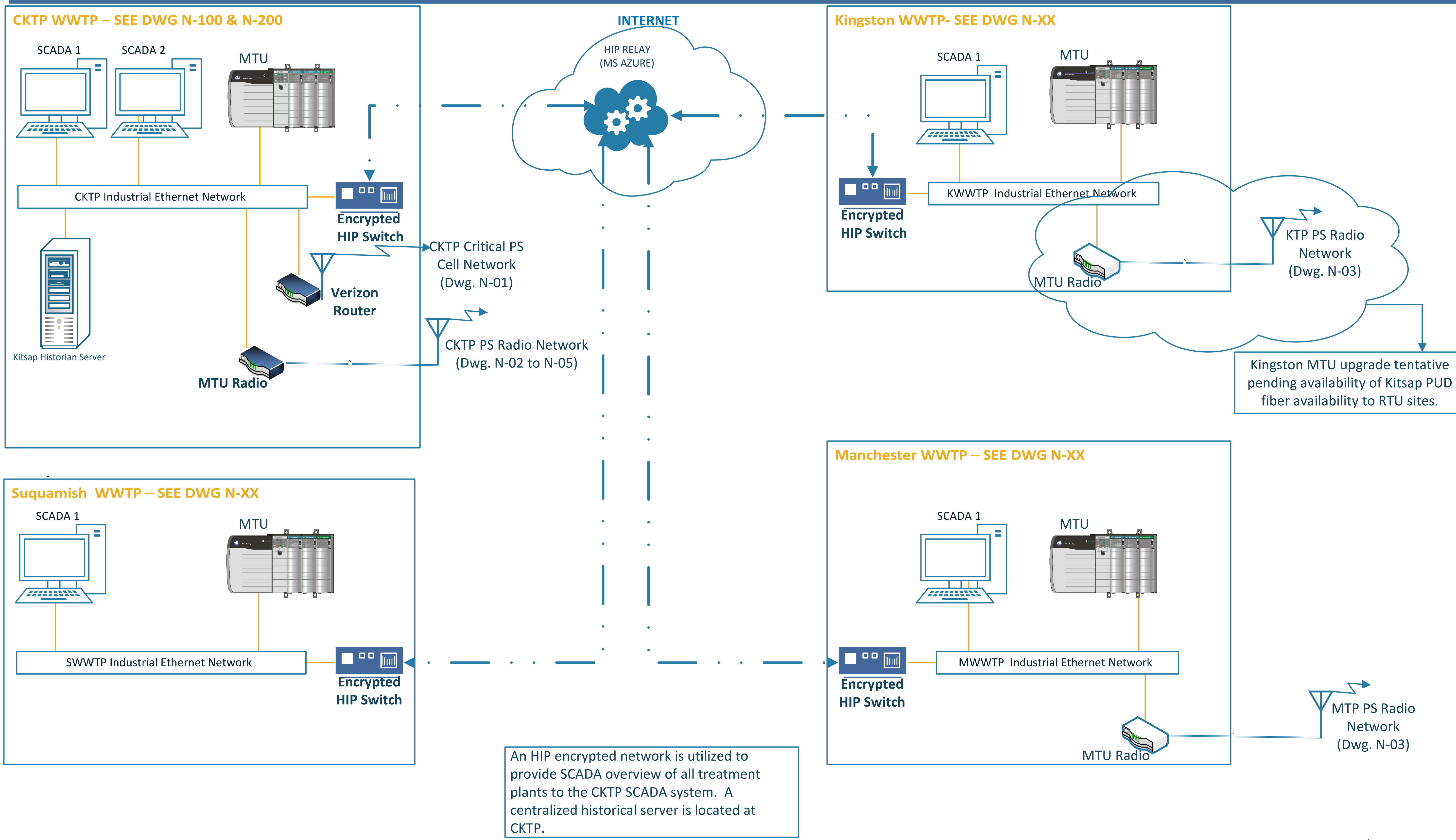
FIGURE B4 SHT 4 OF 4

Appendix C

QCC Network Design Diagrams

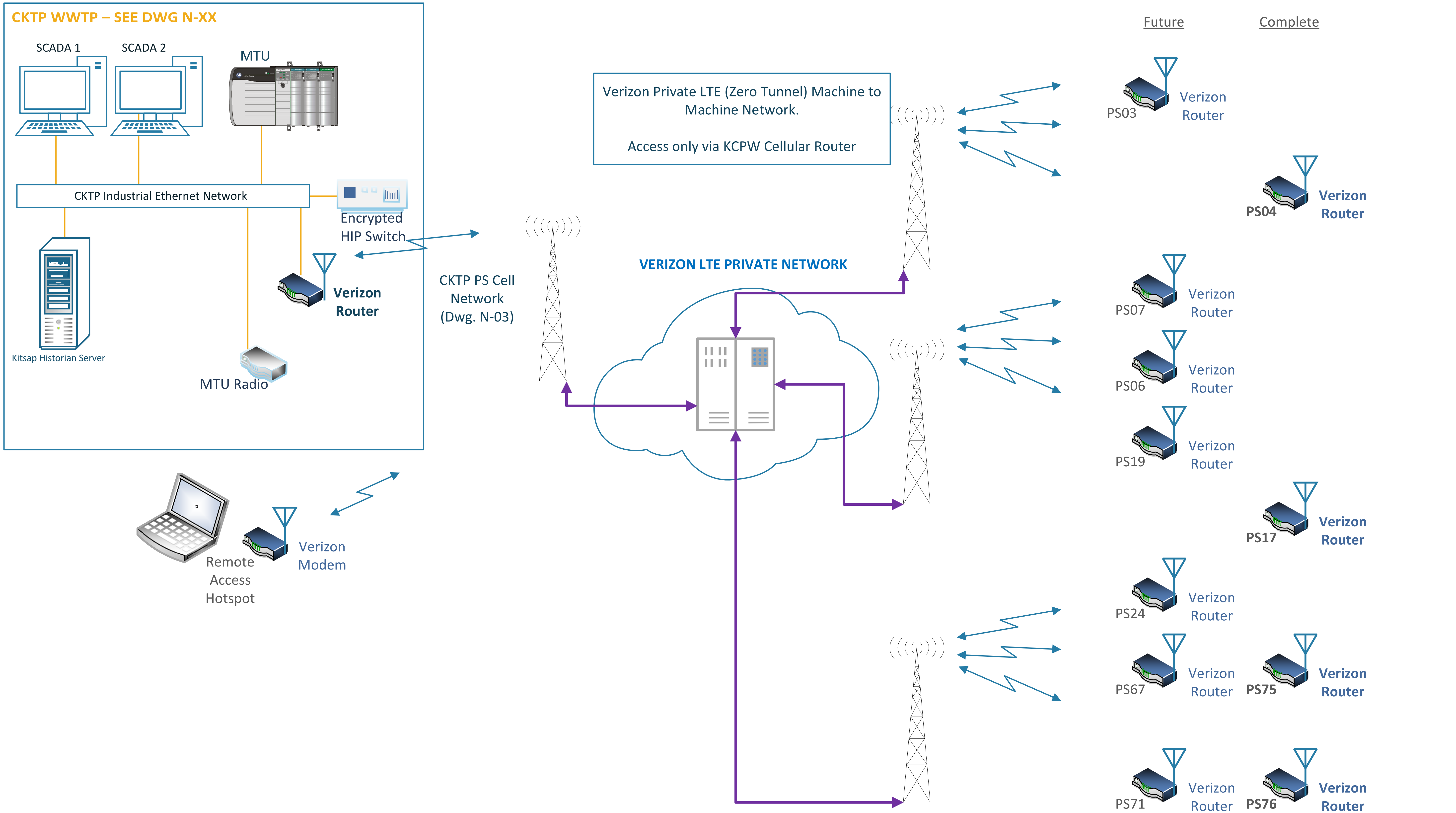
Wastewater Treatment Plants SCADA Network Overview

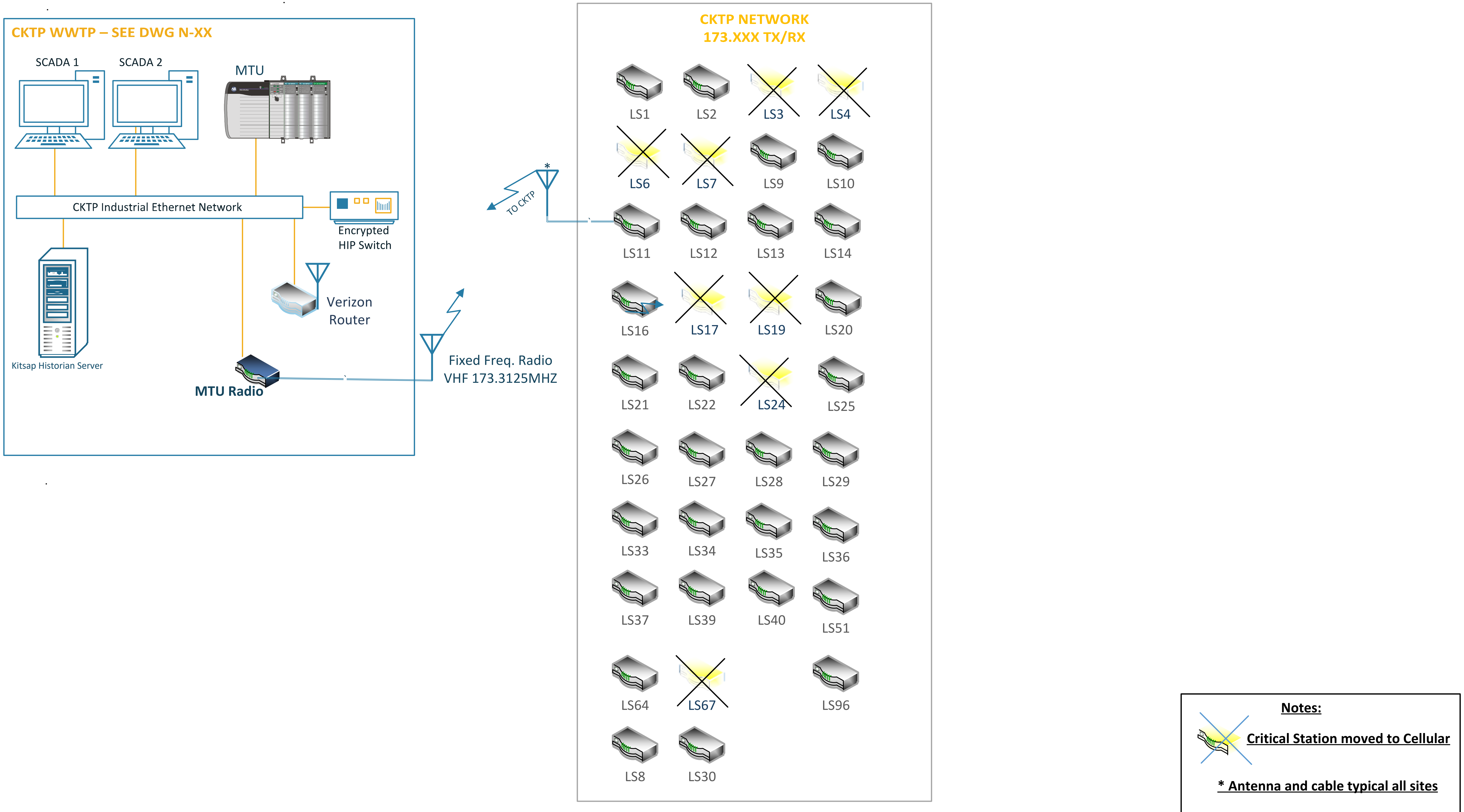
August 20, 2020

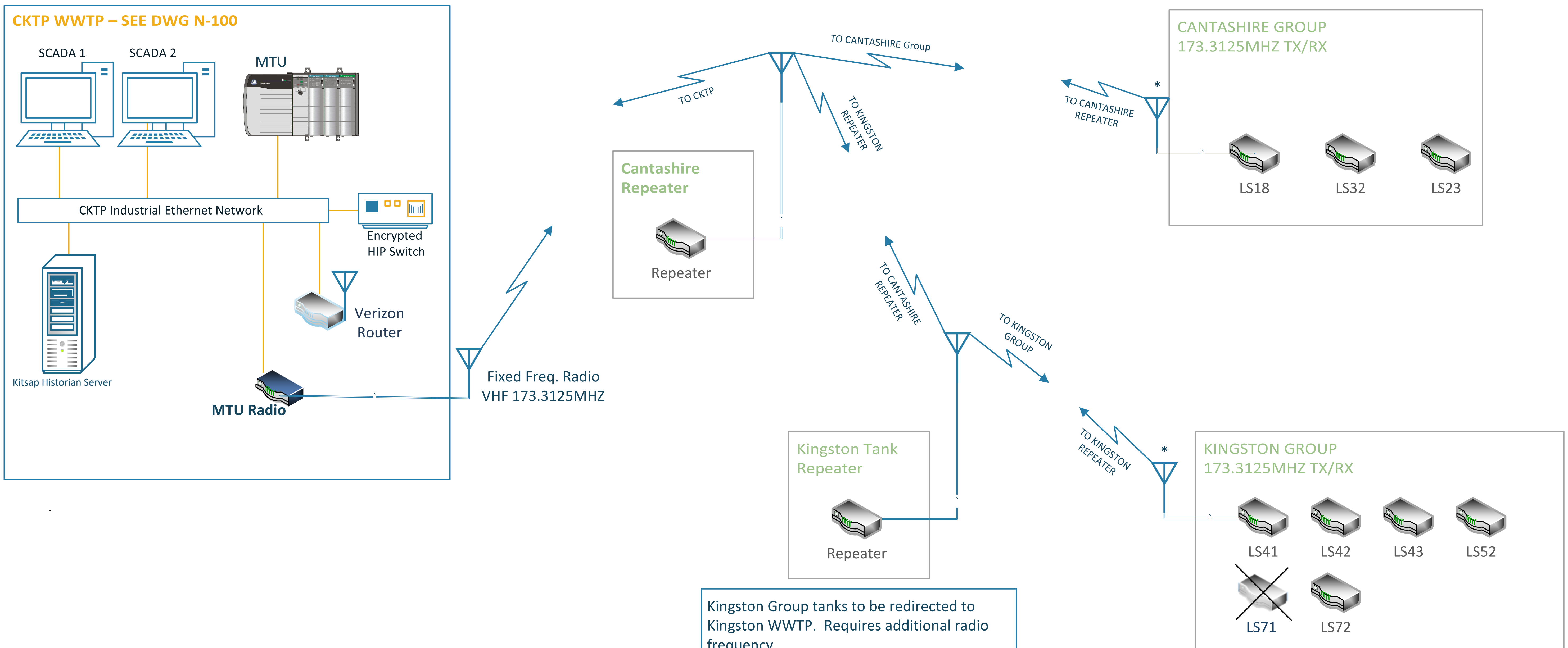


Pump Station Telemetry – Private Cellular (Critical Sites)

August 20, 2020




CKTP WWTP – SEE DWG N-XX
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
*
CKTP NETWORK
173.XXX TX/RX
LS1
LS2
LS3
LS4
LS6
LS7
LS9
LS10
LS11
LS12
LS13
LS14
LS16
LS17
LS19
LS20
LS21
LS22
LS24
LS25
LS26
LS27
LS28
LS29
LS33
LS34
LS35
LS36
LS37
LS39
LS40
LS51
LS64
LS67
LS96
LS8
LS30
Notes:
Critical Station moved to Cellular
* Antenna and cable typical all sites

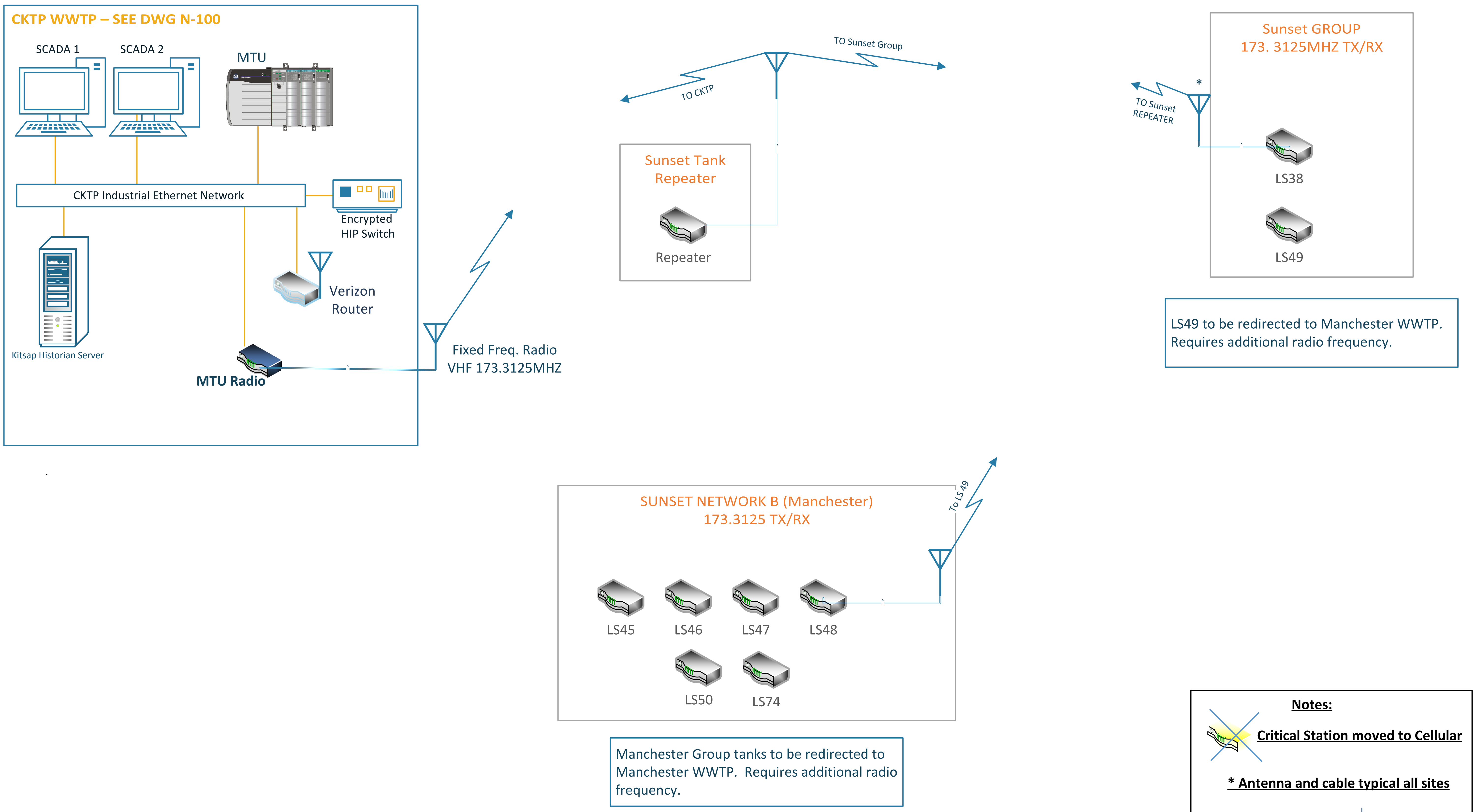


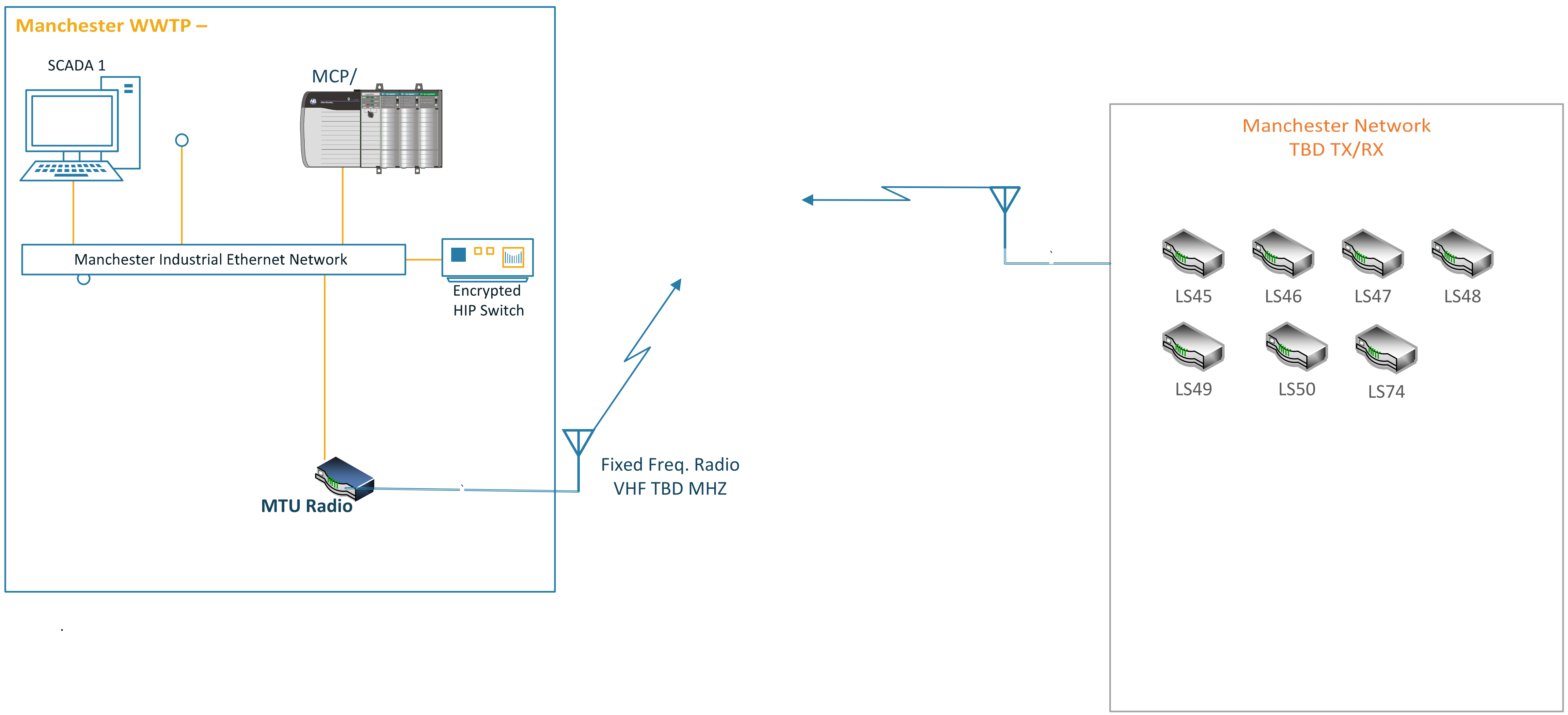
Kingston Group tanks to be redirected to Kingston WWTP. Requires additional radio frequency.

Notes:

Critical Station moved to Cellular

*** Antenna and cable typical all sites**


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 Sunset Group
Sunset Tank
Repeater
Repeater
Sunset GROUP
173. 3125MHZ TX/RX
*
TO Sunset
REPEATER
LS38
LS49
LS49 to be redirected to Manchester WWTP. Requires additional radio frequency.
SUNSET NETWORK B (Manchester)
173.3125 TX/RX
To LS 49
LS45
LS46
LS47
LS48
LS50
LS74
Manchester Group tanks to be redirected to Manchester WWTP. Requires additional radio frequency.
Notes:
Critical Station moved to Cellular
* Antenna and cable typical all sites



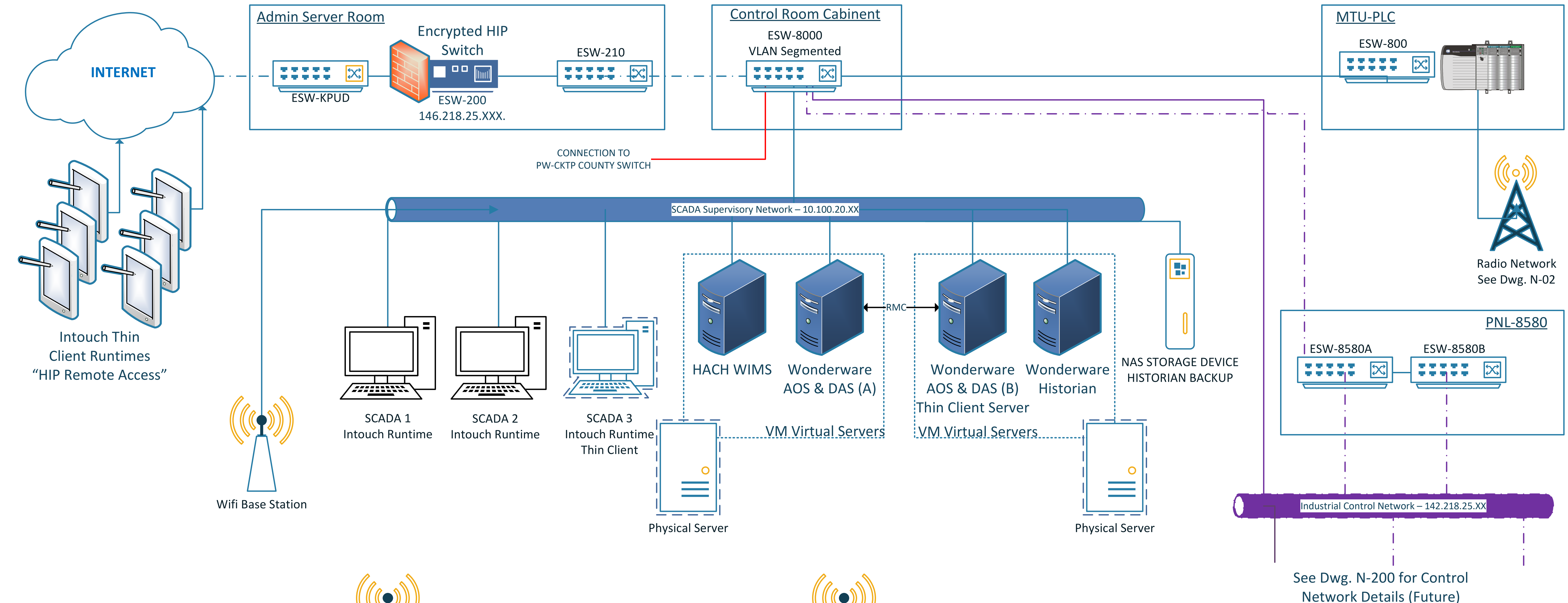
Notes:

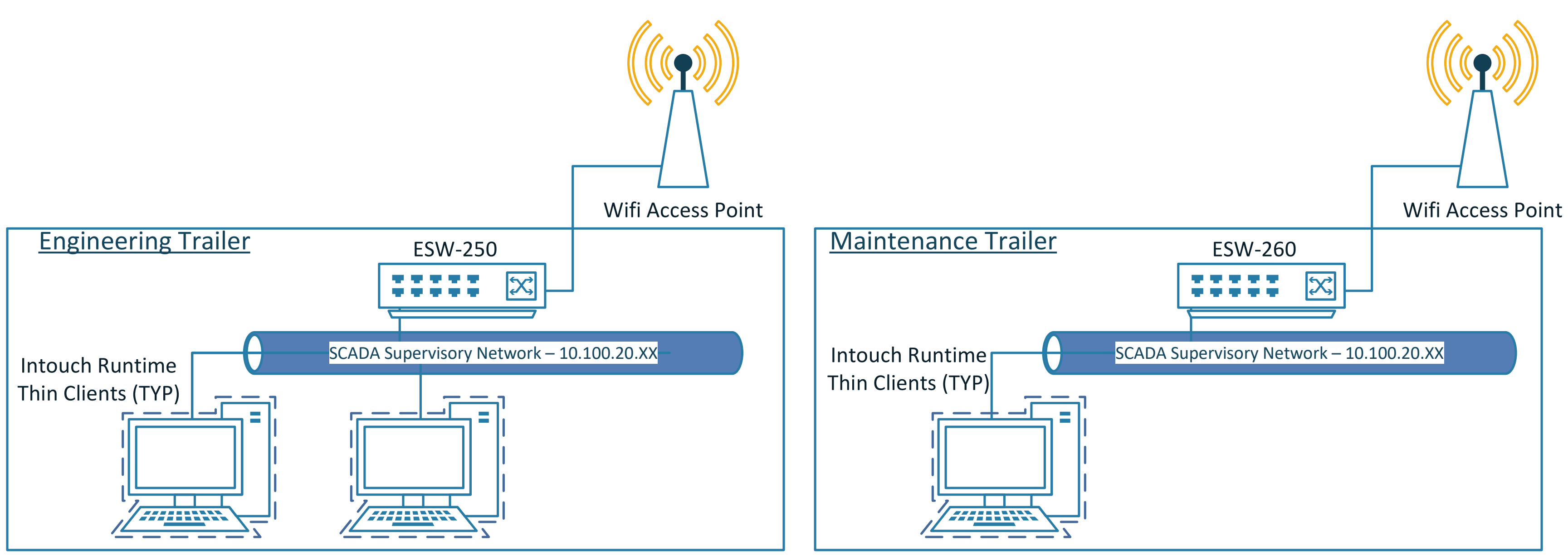
Critical Station moved to Cellular

*** 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:

John M. Thomas, PE
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.

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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

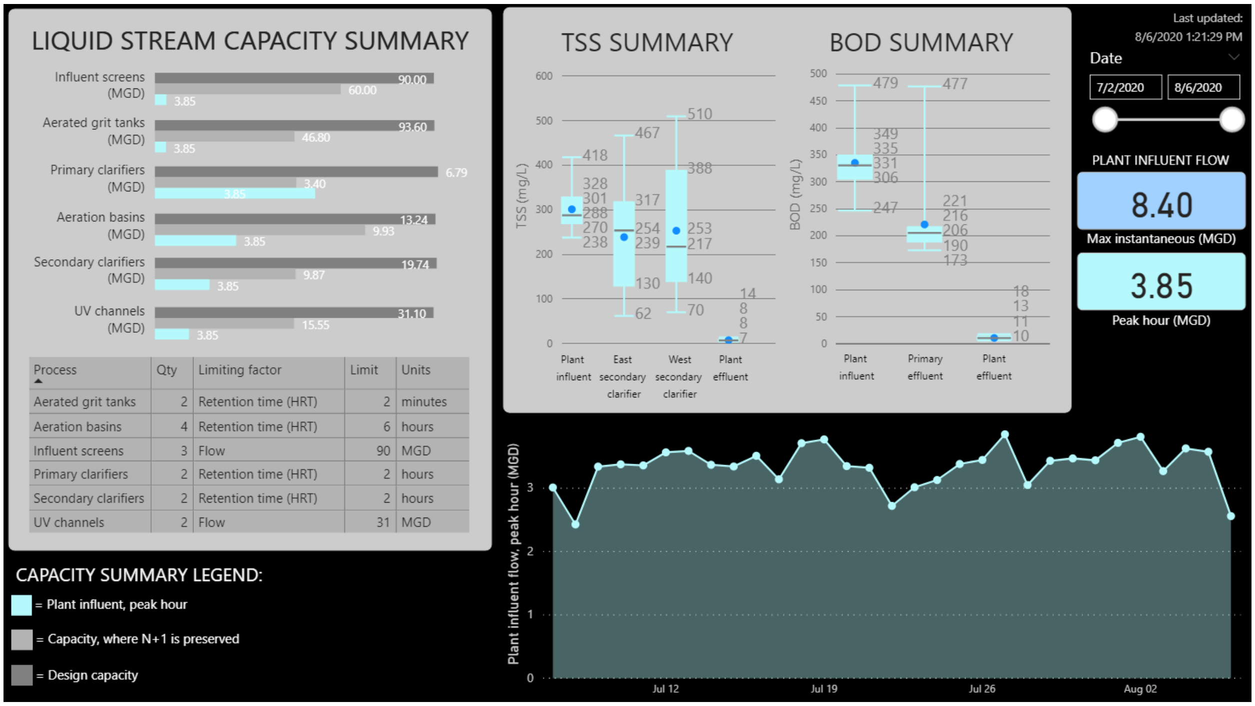
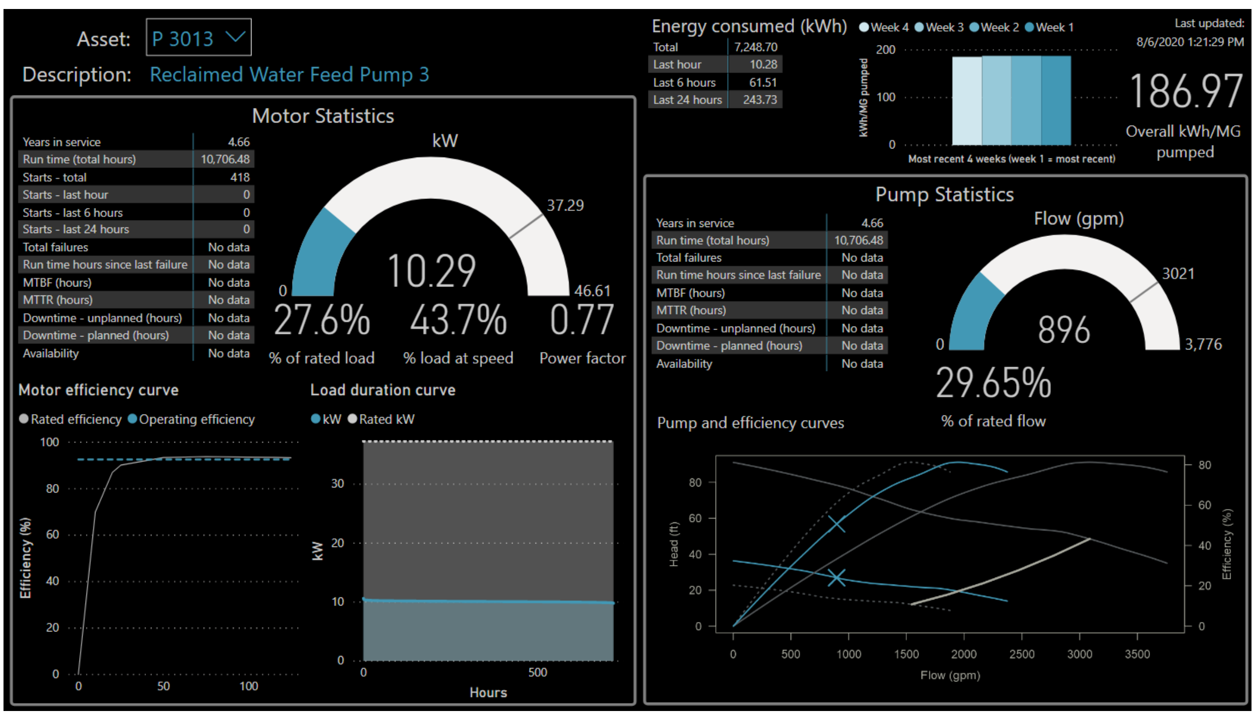


Figure 2-2. Pump asset health and performance dashboard



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.

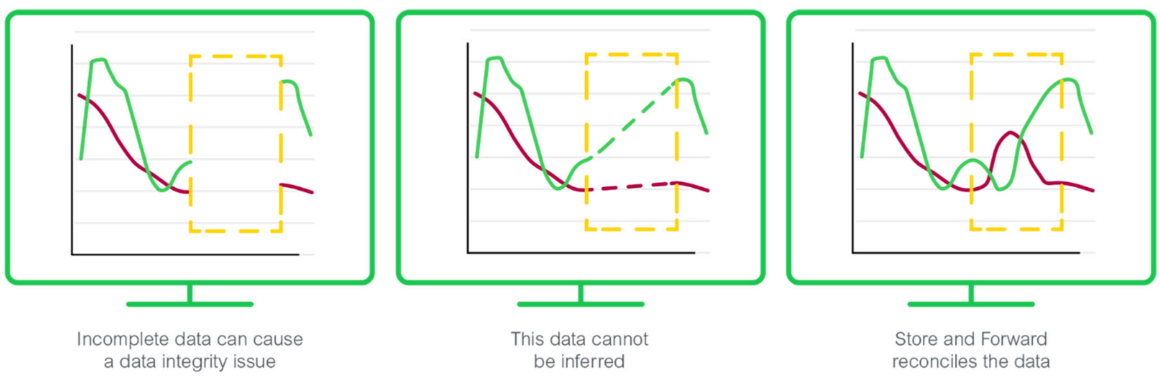
HDR recommends leaving the very high frequency (VHF) licensed radios in place for the more critical stations and implementing routing and communication driver configuration so that the stations revert to the VHF licensed radio WAN when communications over the cellular WAN are lost.

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

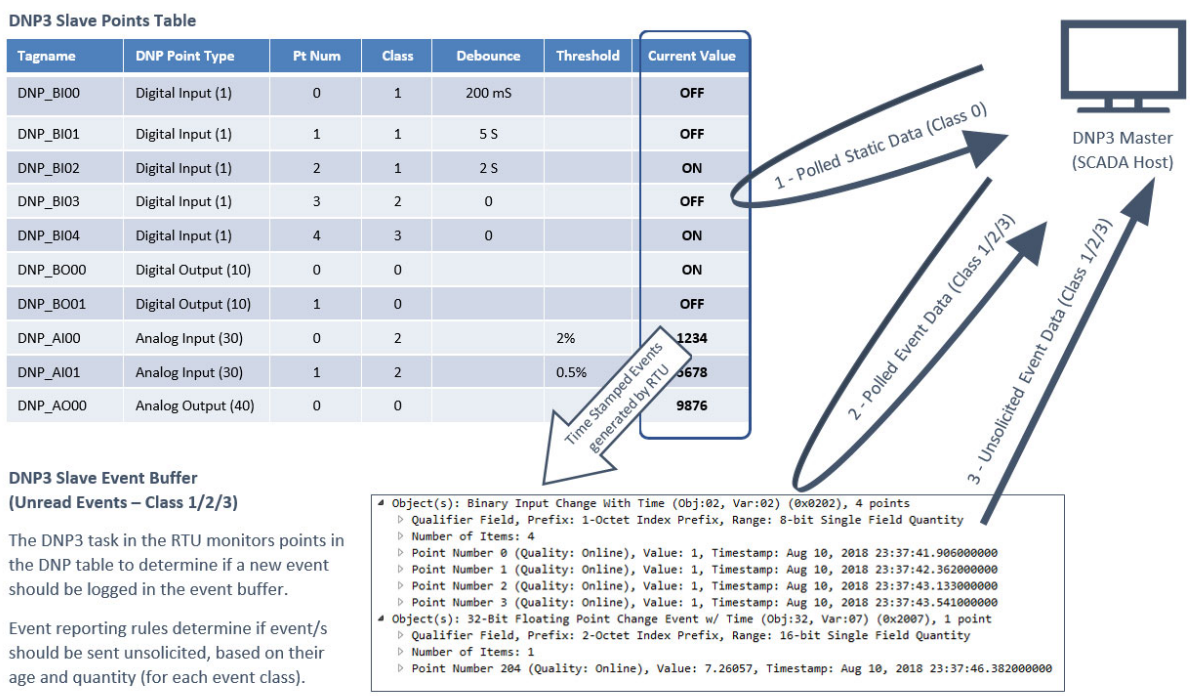


Source: Schneider Electric.

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

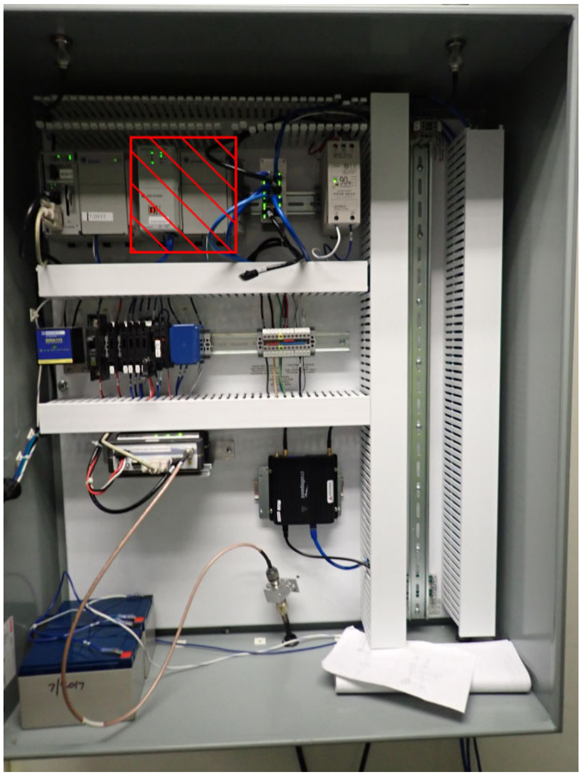


Tagname	DNP Point Type	Pt Num	Class	Debounce	Threshold	Current Value
DNP_BI00	Digital Input (1)	0	1	200 mS		OFF
DNP_BI01	Digital Input (1)	1	1	5 S		OFF
DNP_BI02	Digital Input (1)	2	1	2 S		ON
DNP_BI03	Digital Input (1)	3	2	0		OFF
DNP_BI04	Digital Input (1)	4	3	0		ON
DNP_BO00	Digital Output (10)	0	0			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.

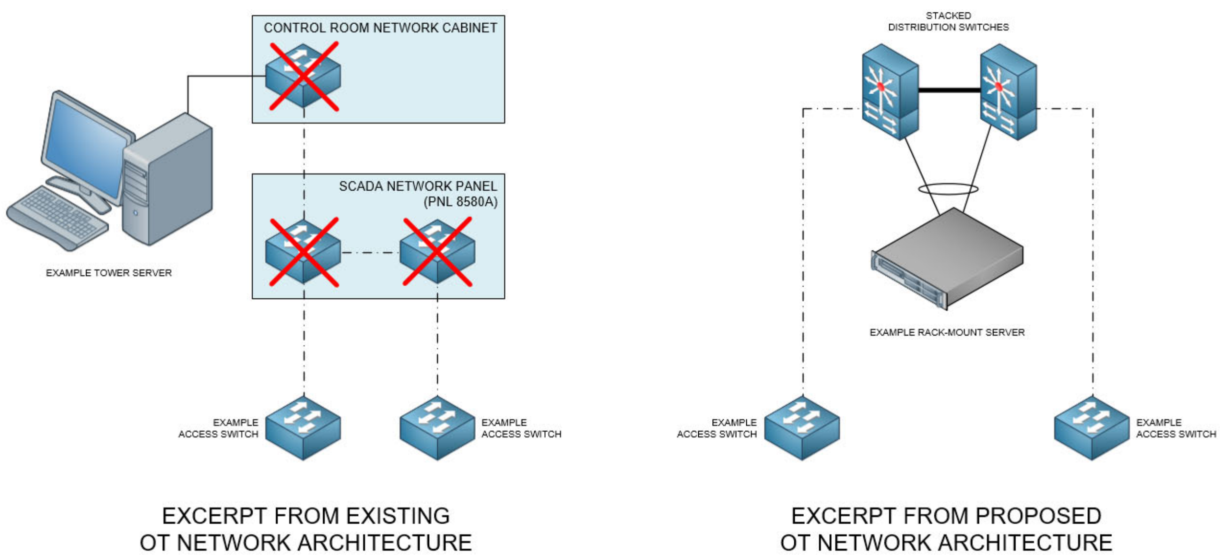
Upgrade to Stacked Layer 3 Distribution Switches at CKTP SPB

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

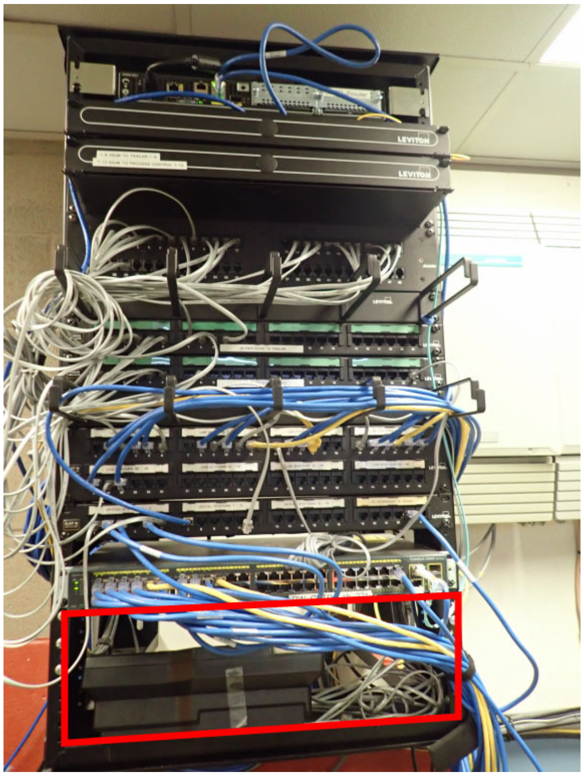
The CKTP administration and laboratory building electrical room contains mechanical and electrical equipment along with network components for both the OT network and business LAN. The costs involved with relocating the mechanical equipment and rerouting the air and water lines to eliminate the impact 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

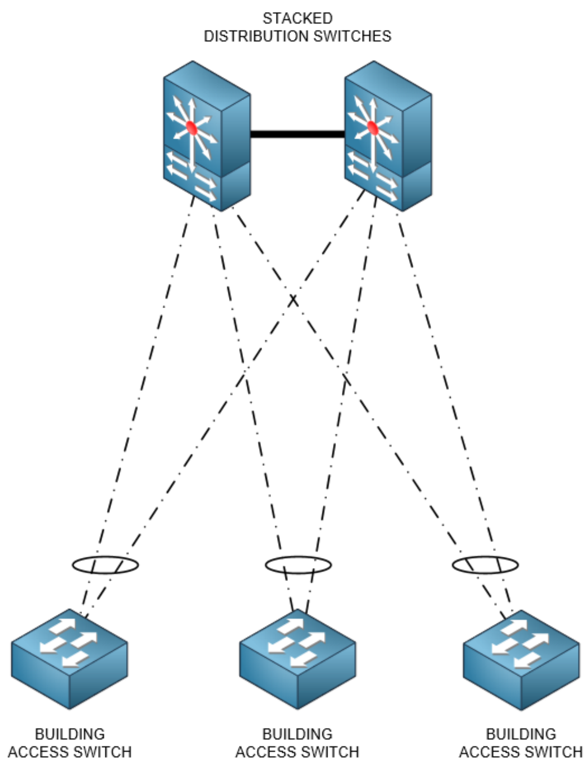


Table 5-1. Network topology advantages and disadvantages

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.

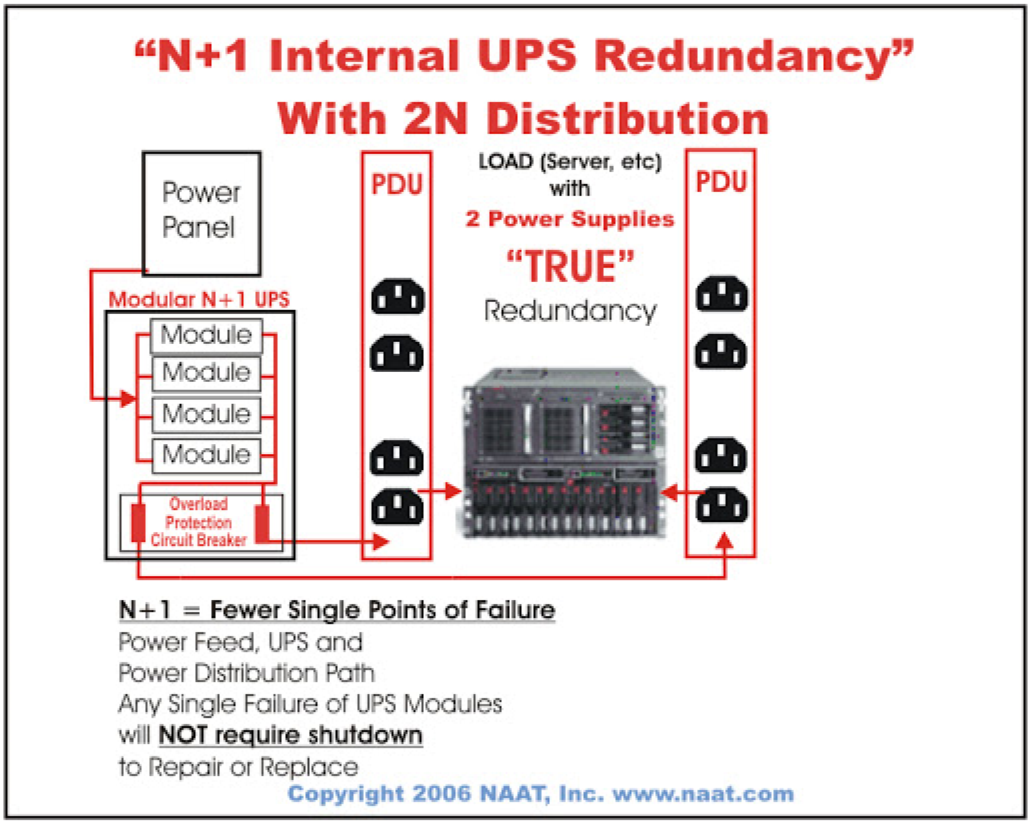
The approach of a standalone online double-conversion UPS is also recommended for the Sewer Utility's PLC and remote input/output (RIO) control panels currently without battery backup power at its WWTPs and remote pump stations, as indicated in TM-1. Per Sewer Utility goals for battery backup times, 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.

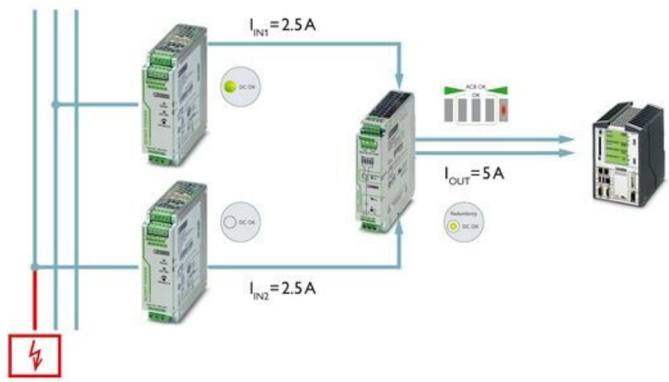
Figure 5-11. Overview of power supply and distribution redundancy for network rack components



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).

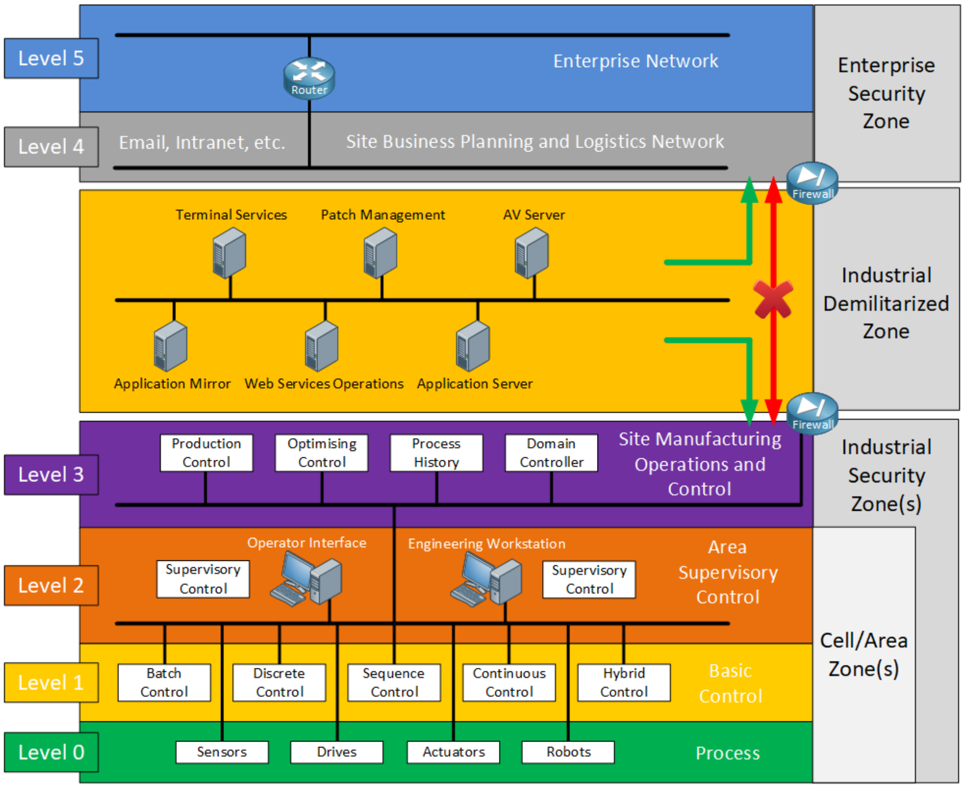
To implement this approach, upgrades to existing control panel 24 VDC power distribution could be made as time and operation and maintenance (O&M) budget allow and/or coordinated with other recommended improvements affecting the control panels. To ensure that future control panels and OT network upgrades 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



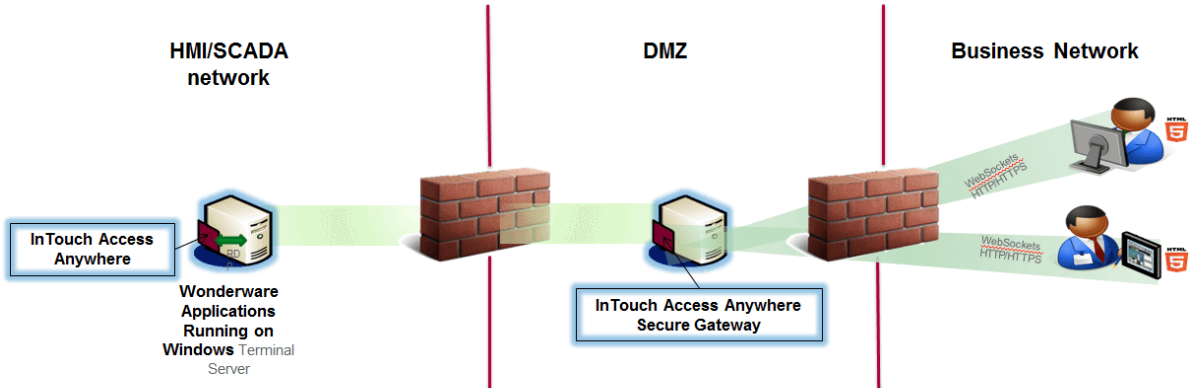
Source: NetworkLessons.com

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

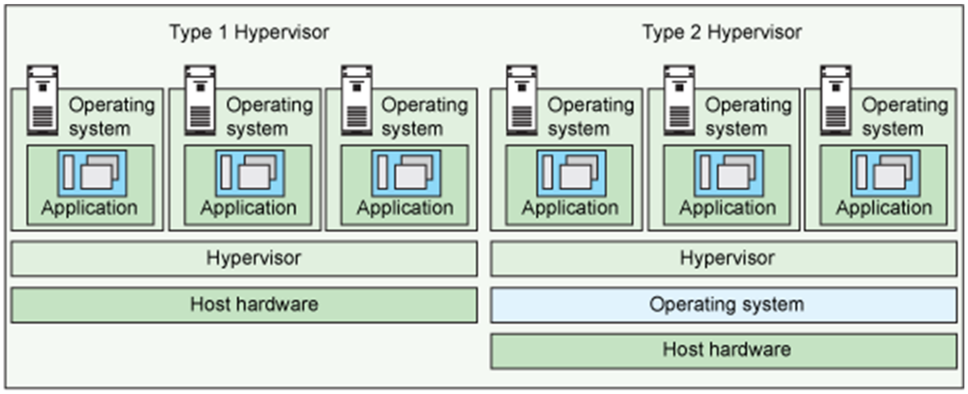
HDR recommends establishing unique user accounts for each individual requiring access to the OT network PCs and servers. Shared user accounts should be eliminated. To simplify management of user accounts, security policies and permissions are best made at the group level rather than for each user account. 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.

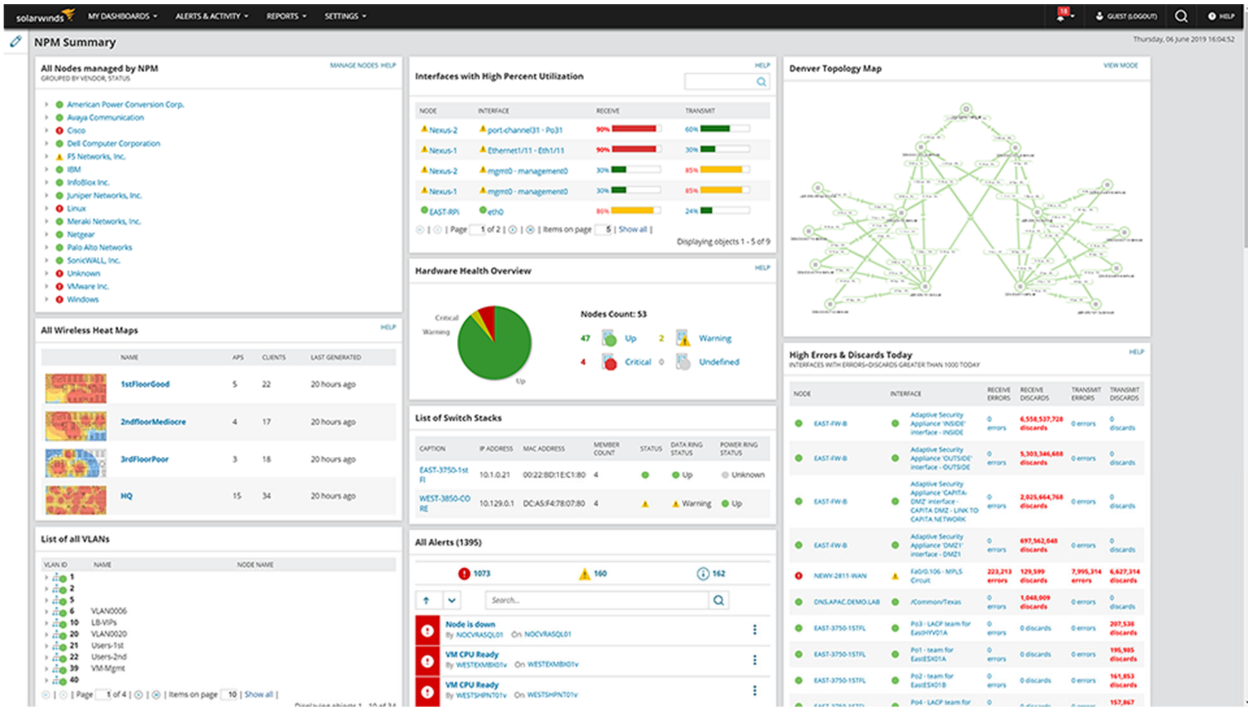
Though it is possible to automate backup processes by developing scripts and scheduling backup tasks at the operating system level, this process is labor-intensive and requires a level of expertise that may take some time for the Sewer Utility to develop with in-house staff. Backups over WANs can also 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.

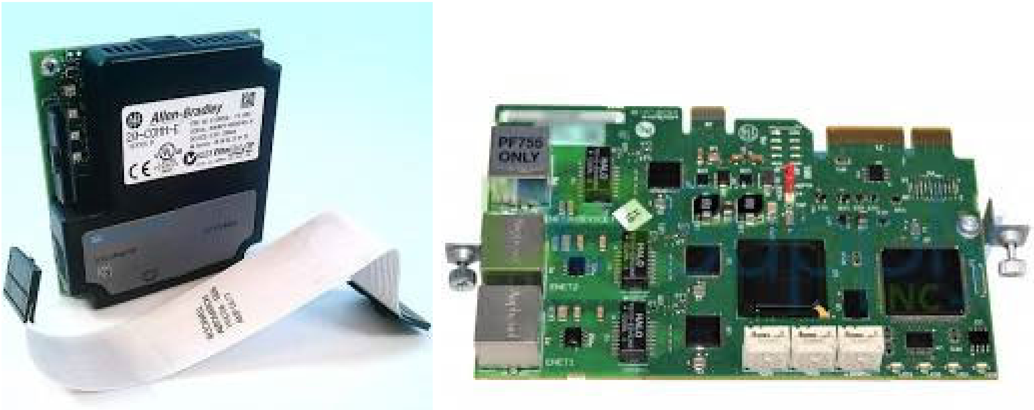
6.2.4 Replace CKTP MCC DeviceNet Networks with Ethernet-capable Motor Controllers

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

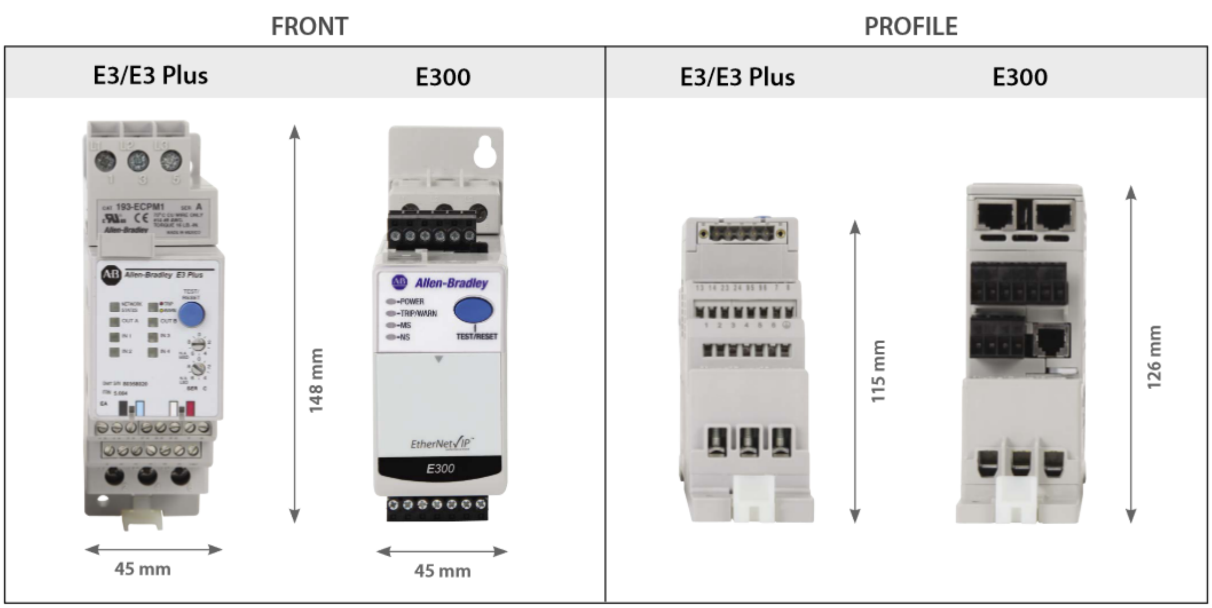


Source: Rockwell Automation.

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.

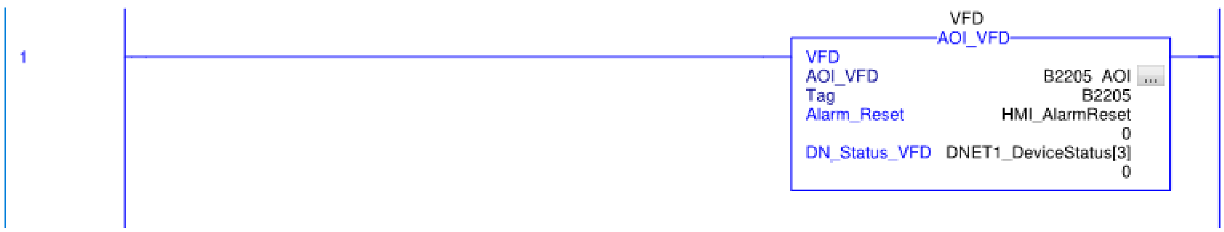
After the Sewer Utility finalizes its PLC firmware standards, HDR recommends that the selected PLC firmware versions be documented in the proposed Sewer Utility ICS standards documentation. The Sewer Utility should then work with a systems integrator to schedule the PLC firmware upgrades to bring the 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.

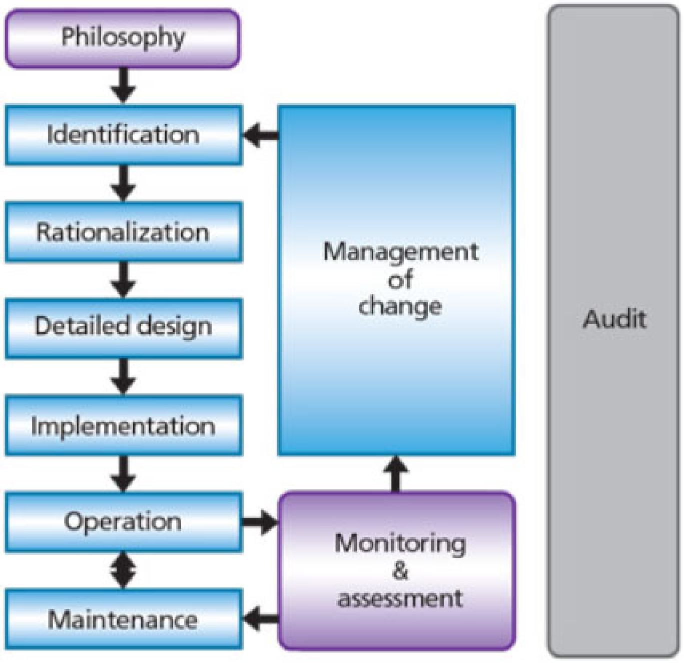
Figure 7-1. Example AOI for VFD equipment called in CKTP PLC 2939 programming



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

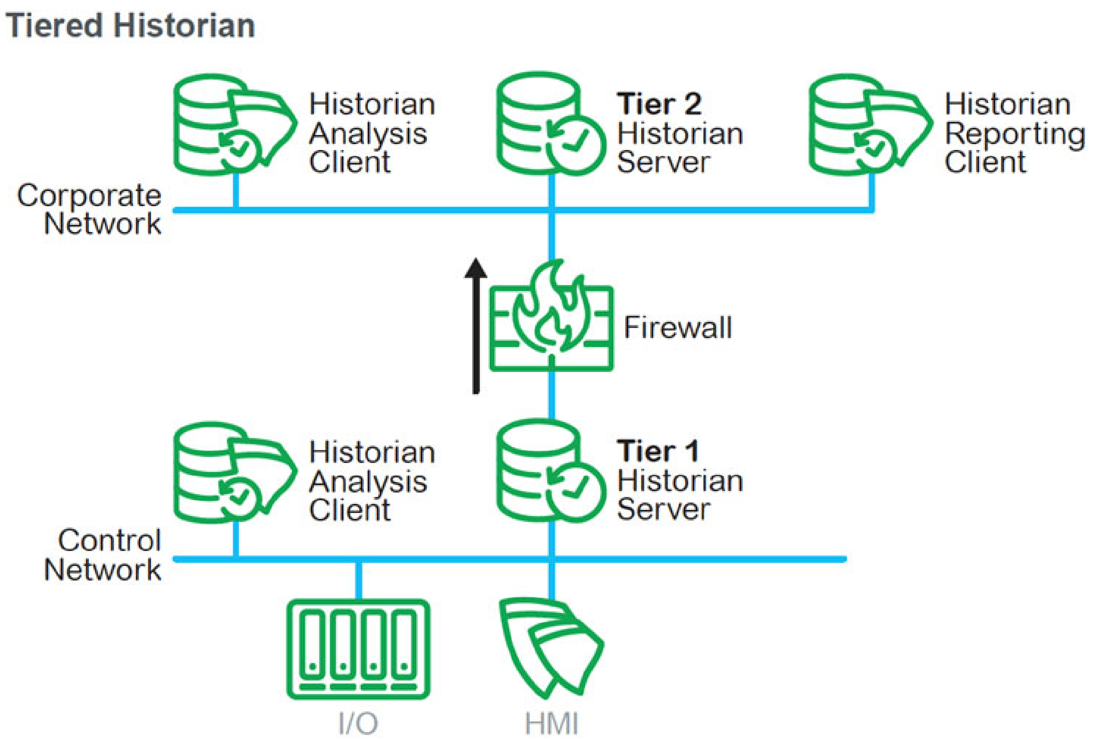
As part of the proposed alarm management program, HDR recommends that data related to ICS alarms be captured in the historian or other database environment and made available to users on the Sewer Utility business LAN. Third-party alarm management software or dashboarding tools like Tableau and Microsoft 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

Prepared by:

Brandon Erndt, PE
HDR Engineering, Inc.
(602) 522-7712

Christopher Maras, PE
HDR Engineering, Inc.
(402) 208-7051

and

Bruce Johnston, PE
HDR Engineering, Inc.
(425) 450-6217

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.

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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

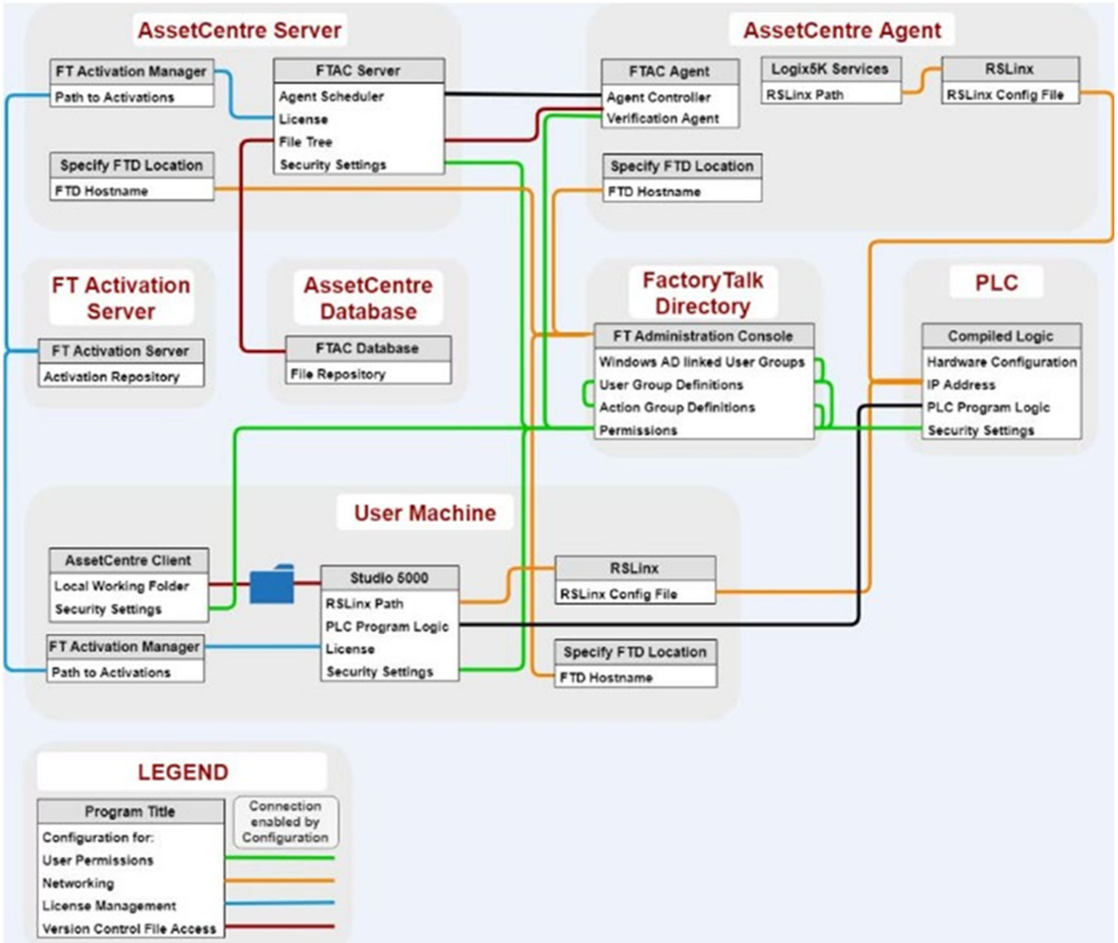
In a disaster response scenario, it is critical to have current configuration files for ICSs components (PLCs, operator panel, network switches, motor drives, etc.). Rockwell Software FactoryTalk (FT) Asset Centre provides a centralized tool for securing, managing, versioning, tracking, and reporting 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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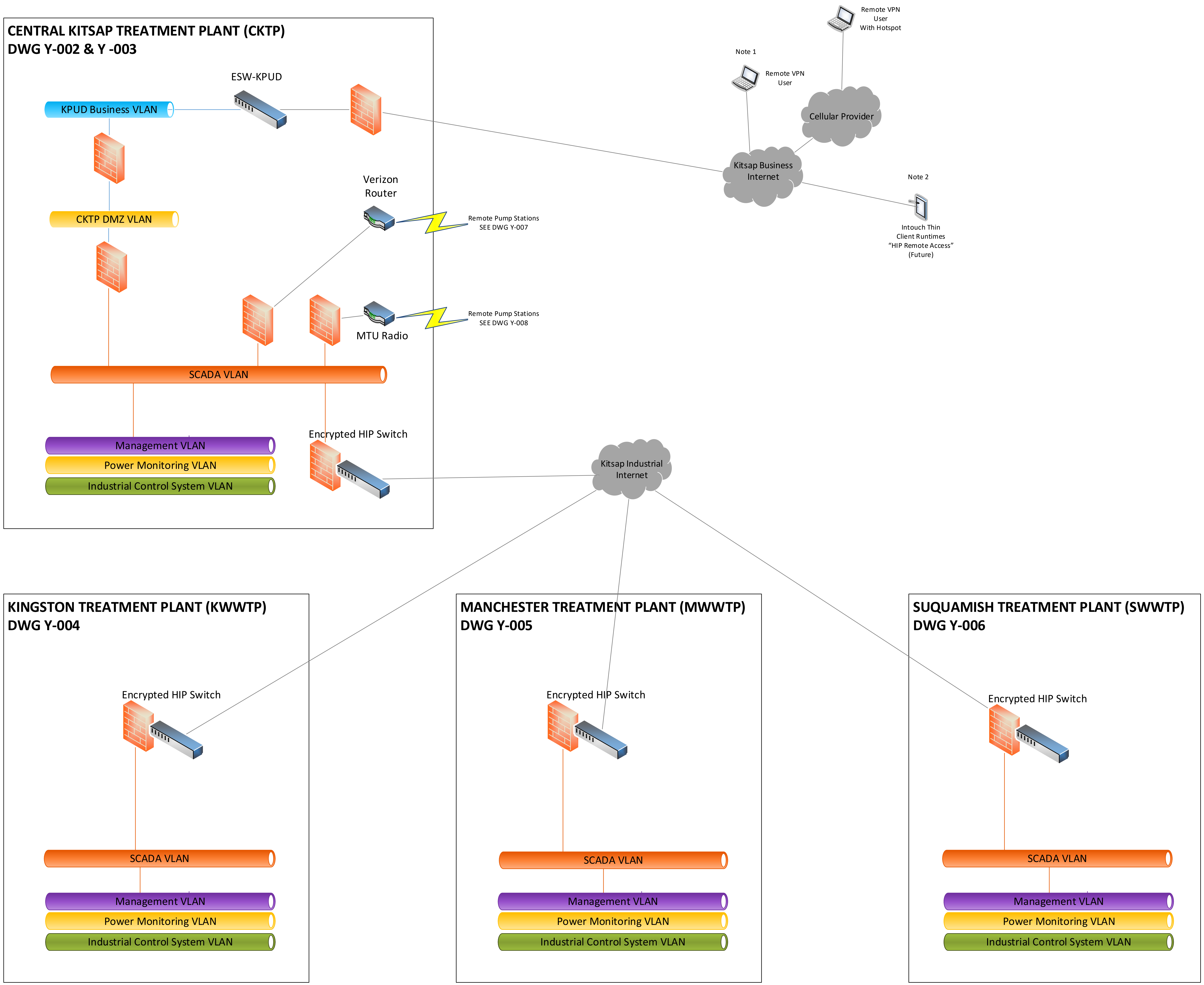
TM-4: System Architecture Conceptual Design

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

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

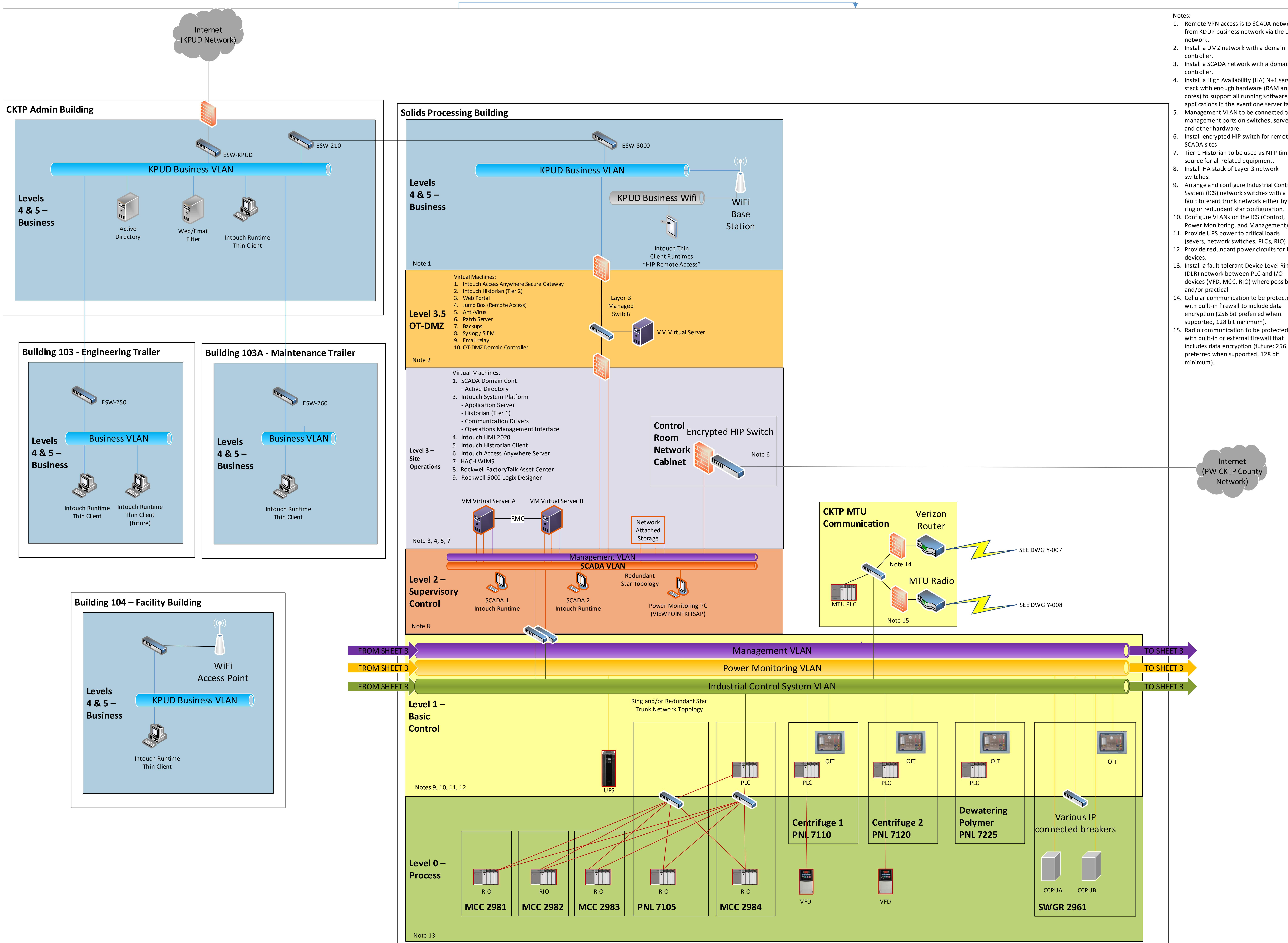
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM
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).

NO	DATE	BY	APPR	REVISIONS

HDR Engineering, Inc.
1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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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

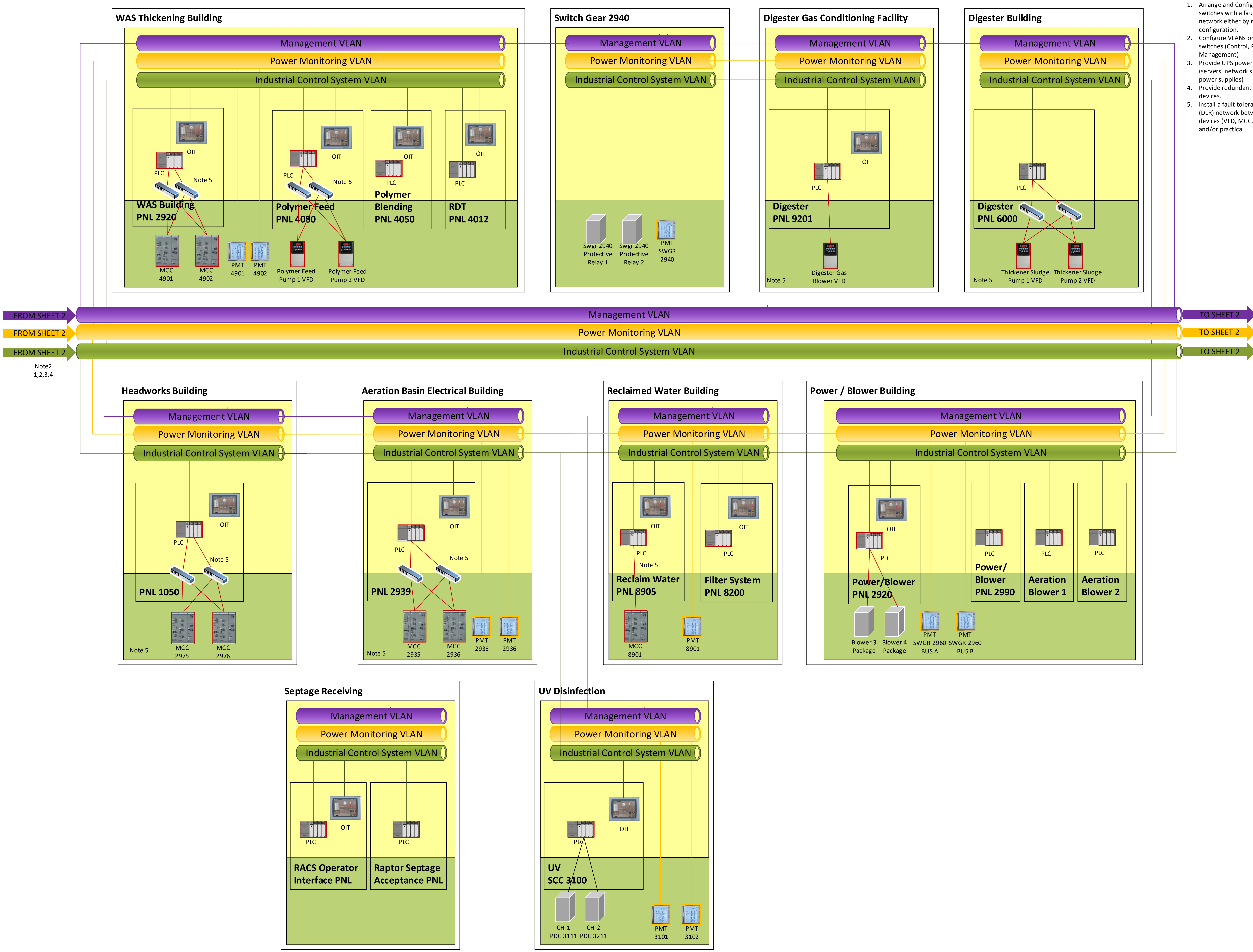
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM
CKTP ADMIN AND SOLID PROCESSING BUILDINGS

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

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1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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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

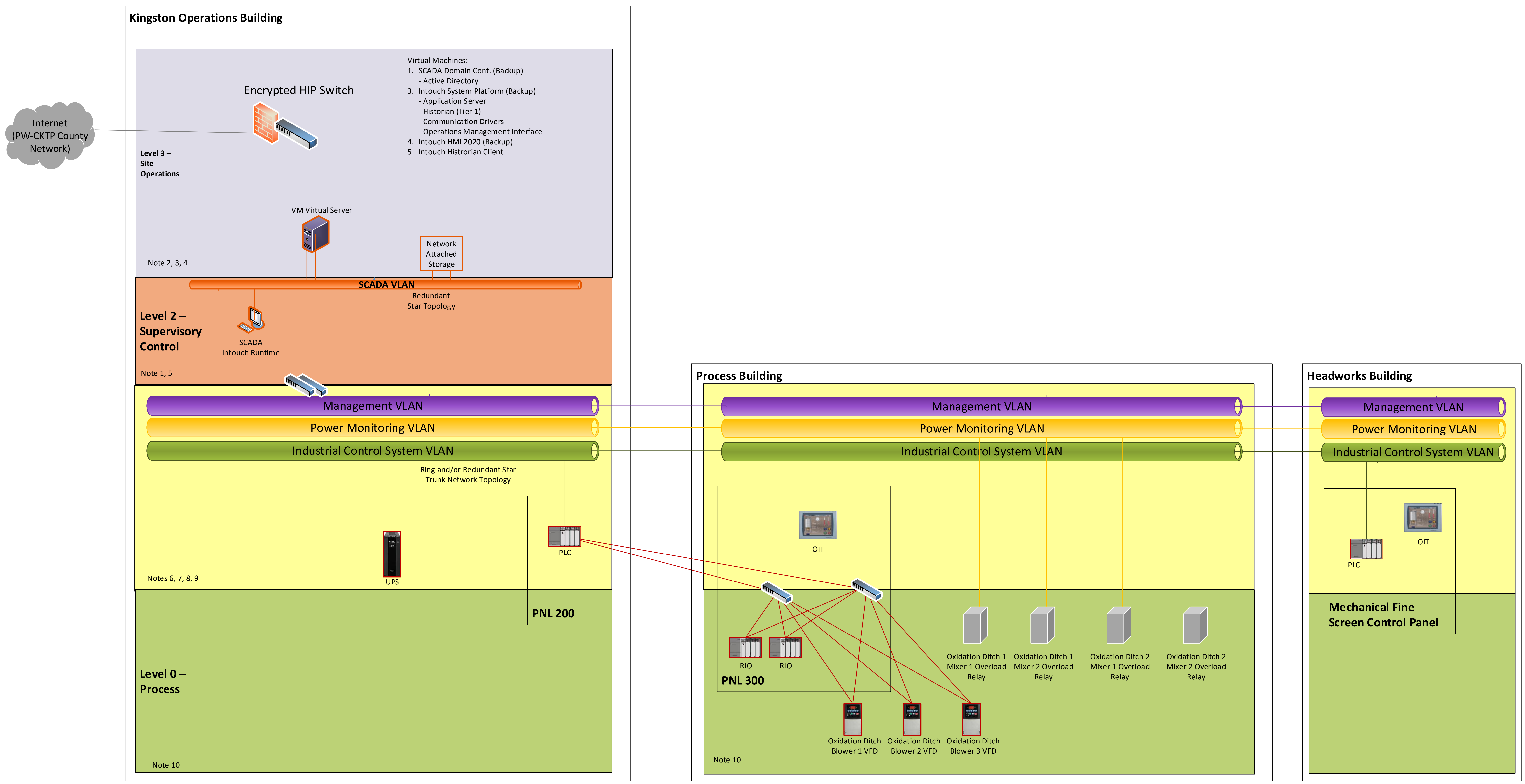
CONCEPT DIAGRAM
CKTP BALANCE OF PLANT

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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1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

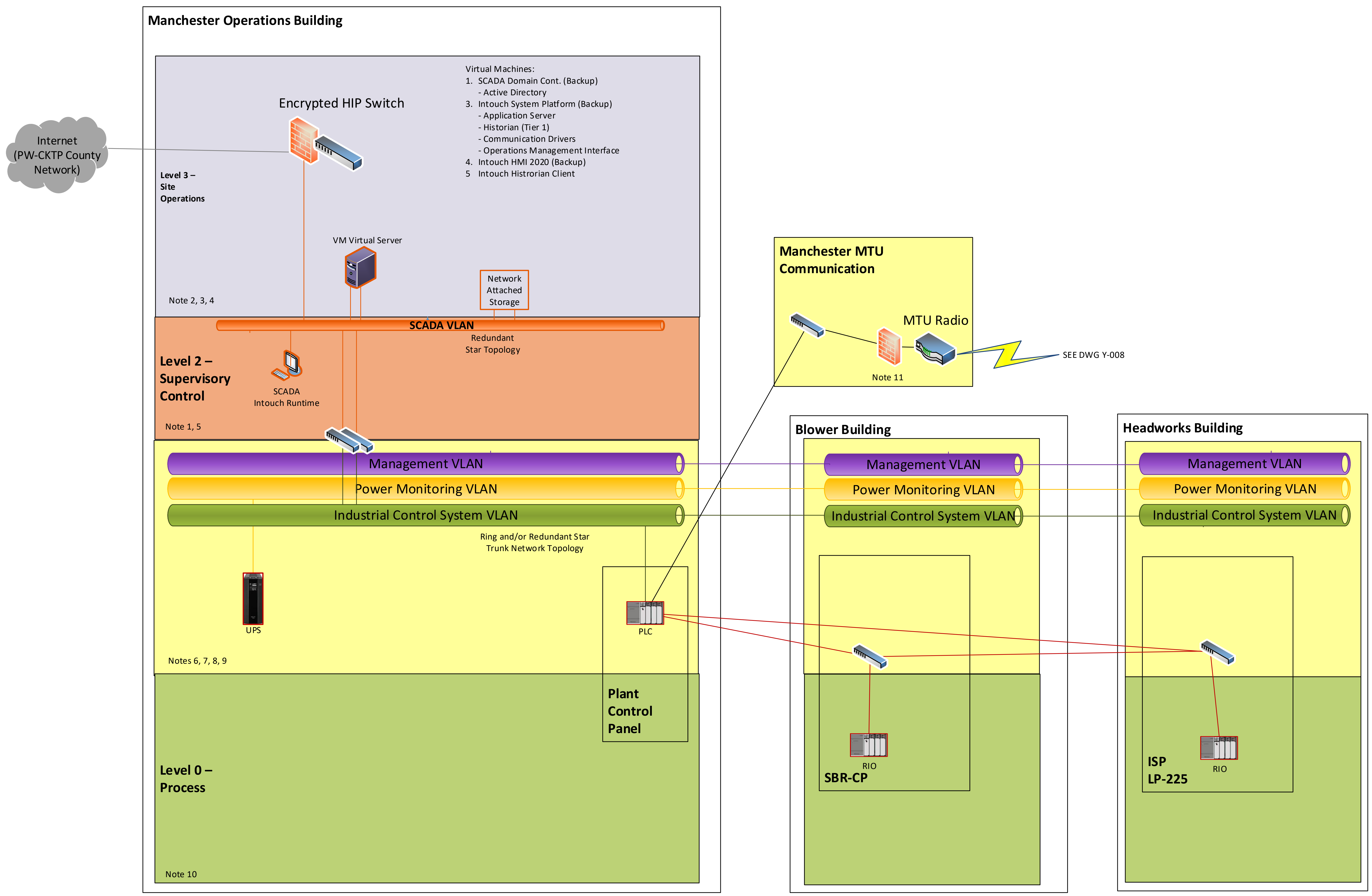
CONCEPT DIAGRAM
KINGSTON WWTP

SCALE: NONE

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.
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
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.
1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

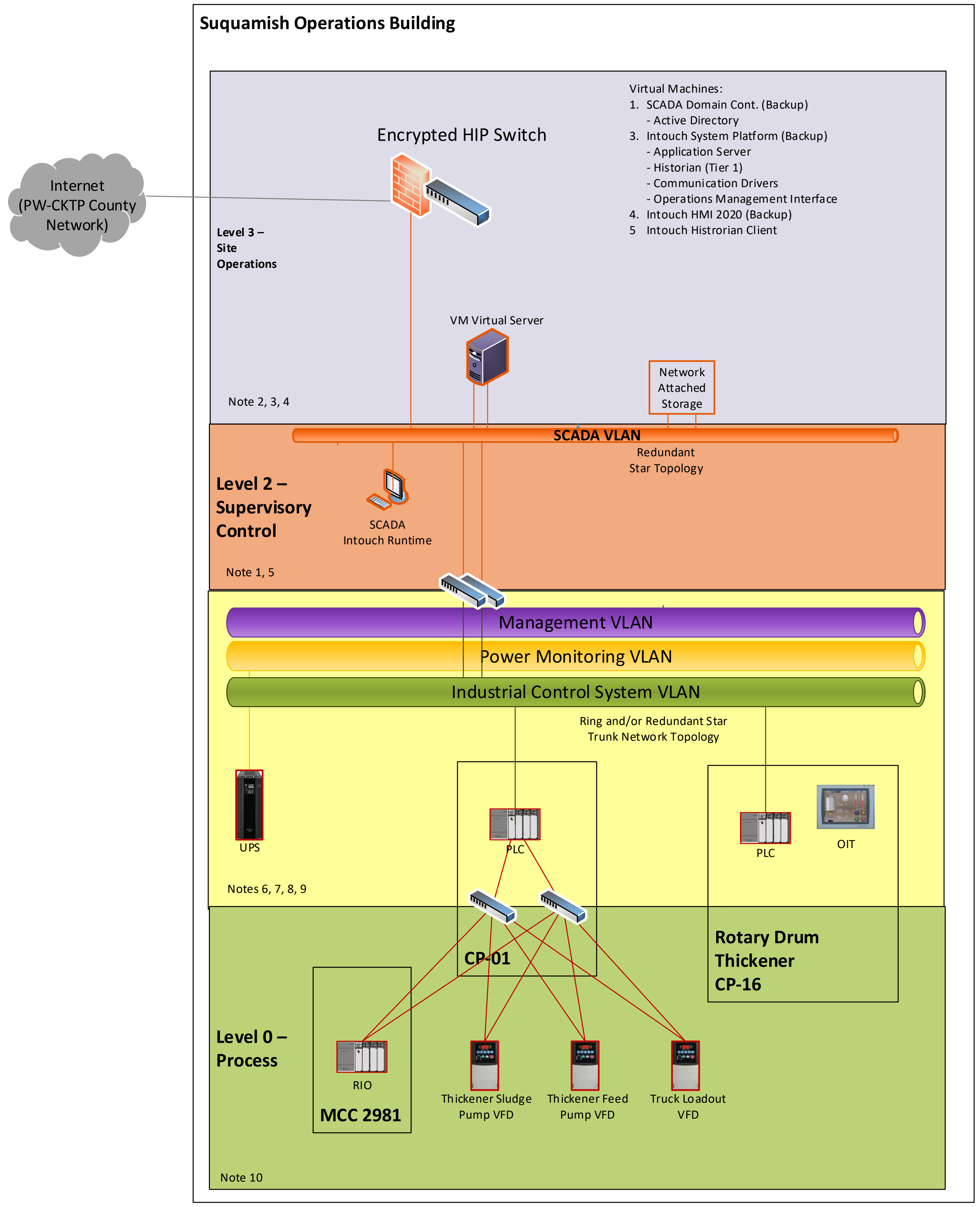
SCALE: NONE

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

HDR Engineering, Inc.
1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

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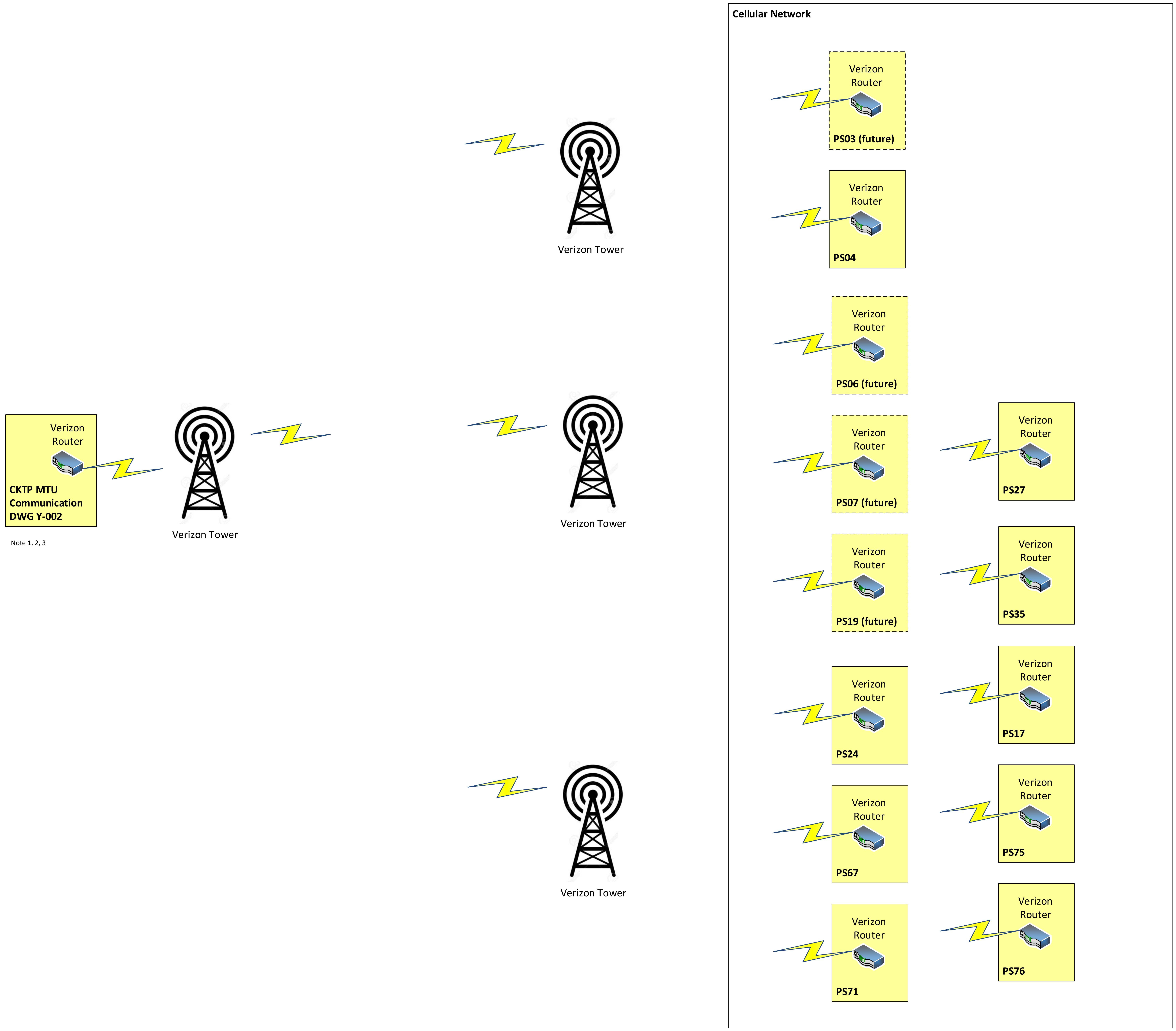
SEWER UTILITY SCADA MASTER PLAN

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).

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HDR Engineering, Inc.
1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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CLIENT PROJECT NUMBER — DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

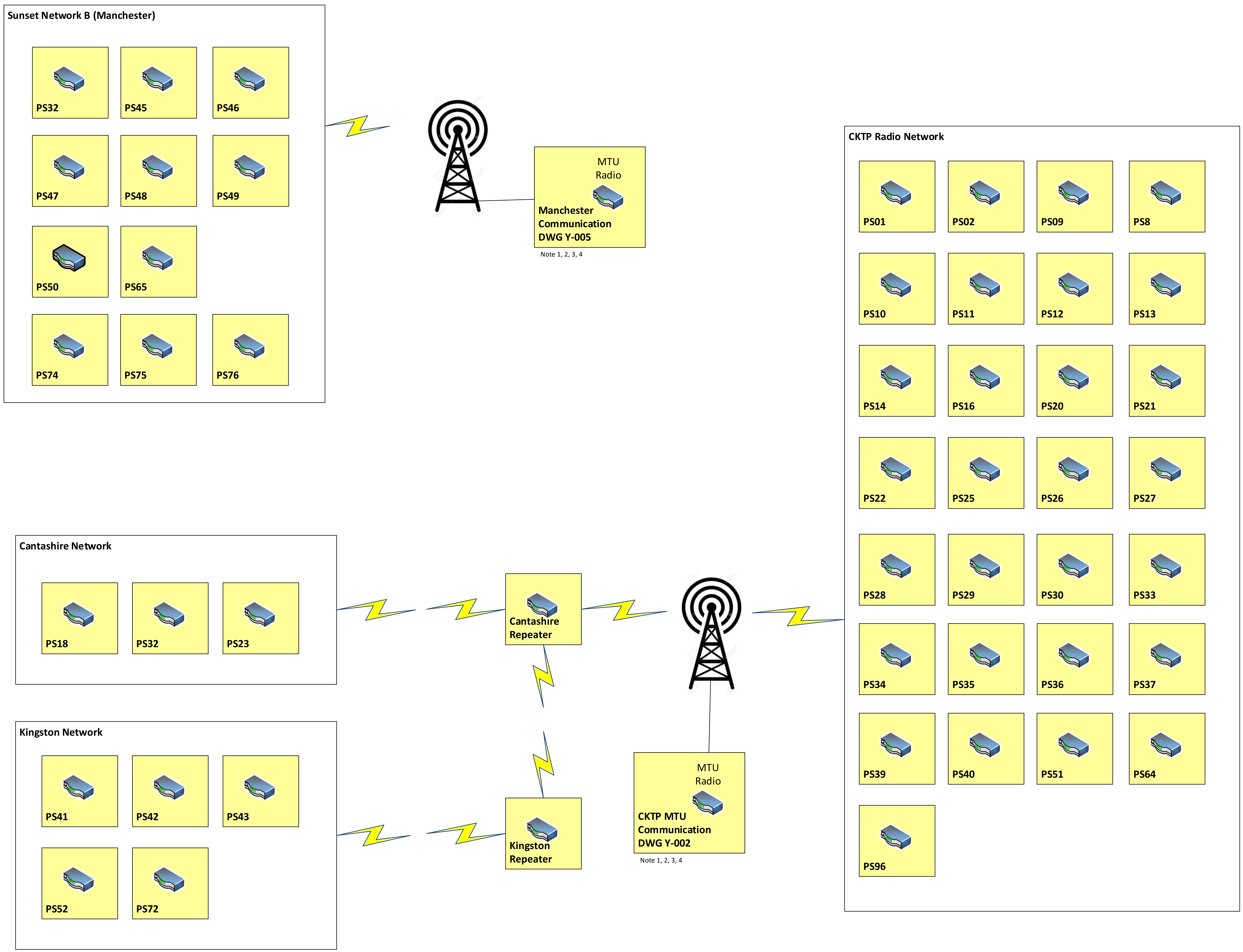
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

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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1917 S. 67th Street
Omaha, NE 68106
402.399.1000

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Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

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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

HDR Engineering, Inc.

(602) 522-7712

Christopher Maras, PE

HDR Engineering, Inc.

(402) 208-7051

and

Bruce Johnston, PE

HDR Engineering, Inc.

(425) 450-6217

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.

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Appendix

Appendix A – Cost Estimate

Appendix B – Schedule

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	

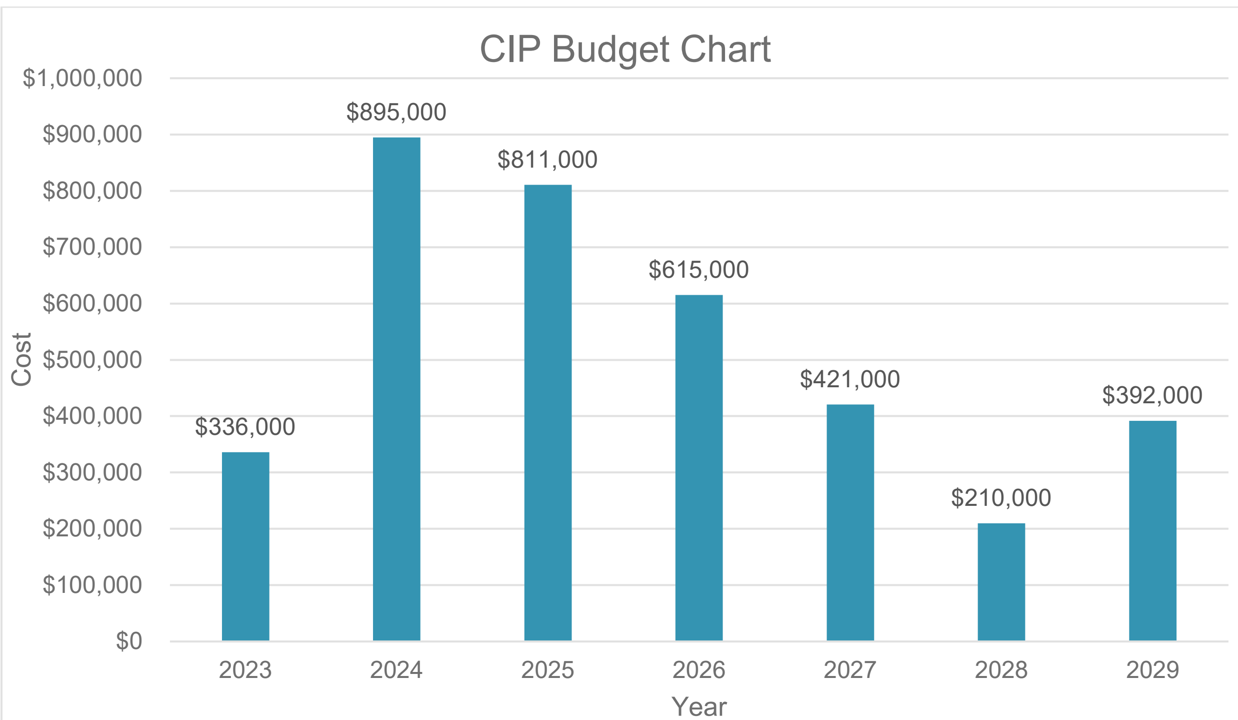

Figure 4-1. CIP Budget Chart

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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

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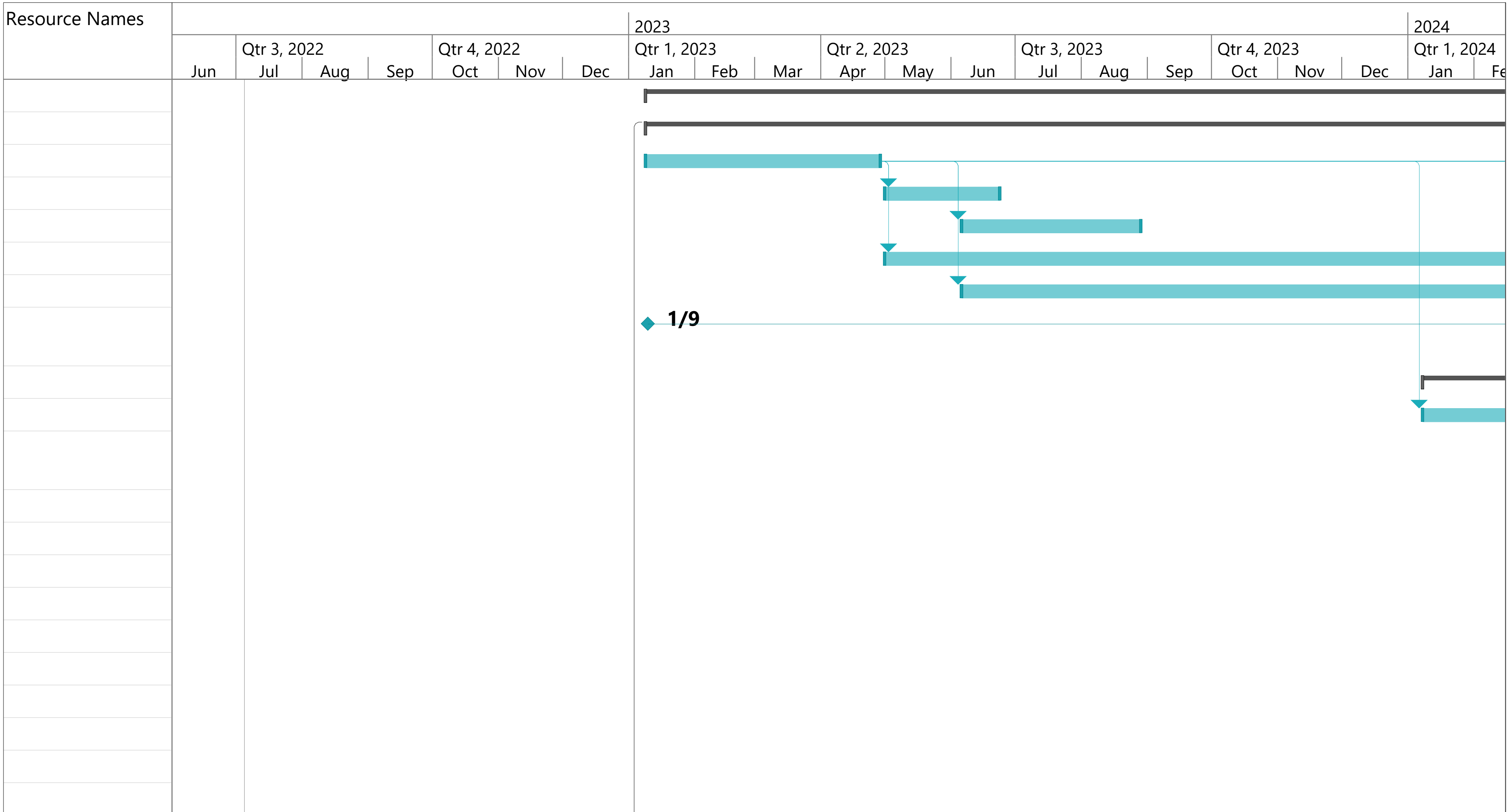
Date: Mon 5/23/22

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			



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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			Qtr 4, 2022			Qtr 1, 2023			Qtr 2, 2023			Qtr 3, 2023			Qtr 4, 2023			Qtr 1, 2024	
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Fe

Project: SCADA Master Plan Pro
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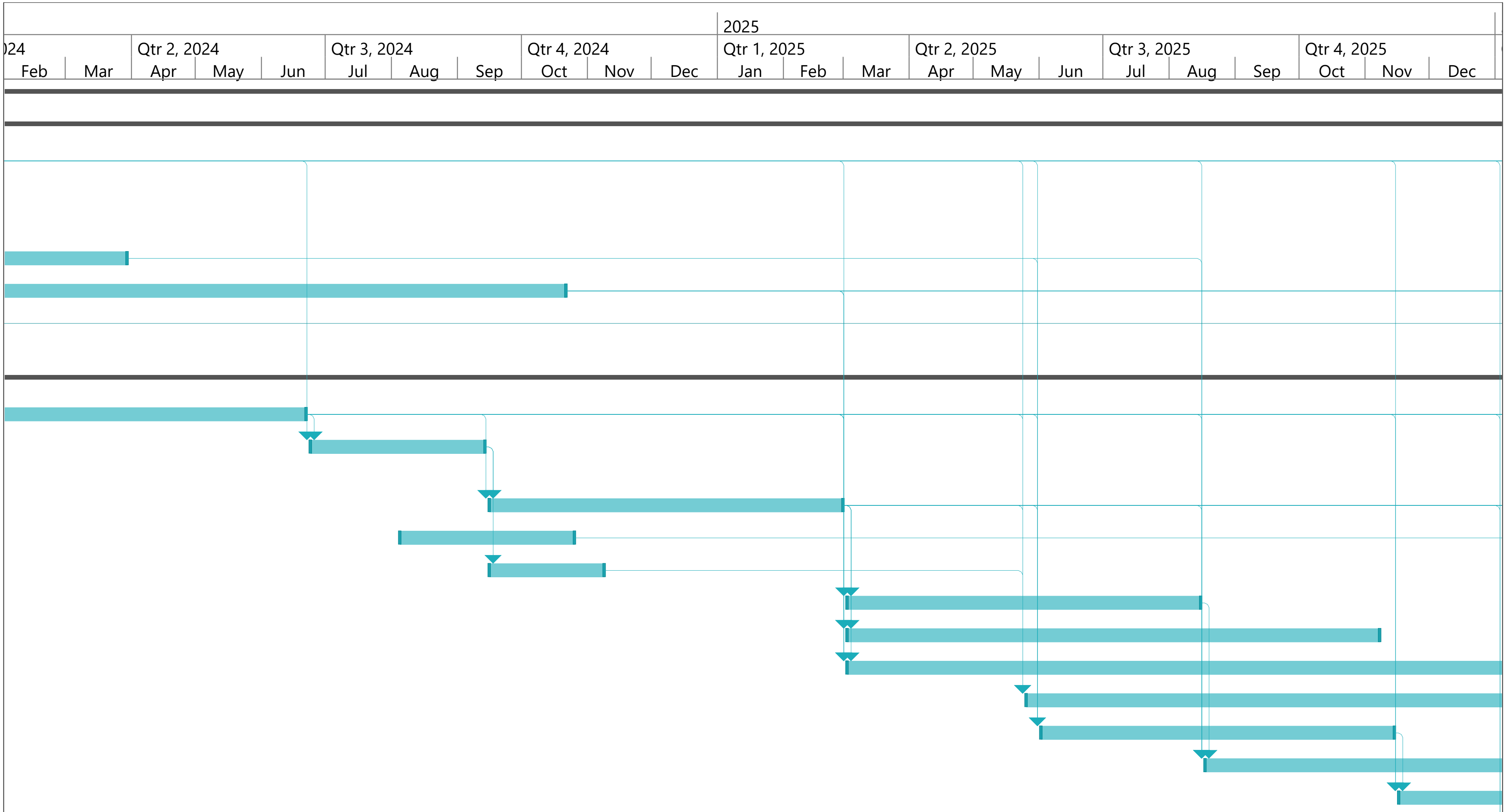

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

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		Qtr 2, 2024			Qtr 3, 2024			Qtr 4, 2024			Qtr 1, 2025			Qtr 2, 2025			Qtr 3, 2025			Qtr 4, 2025		
Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

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Date: Mon 5/23/22

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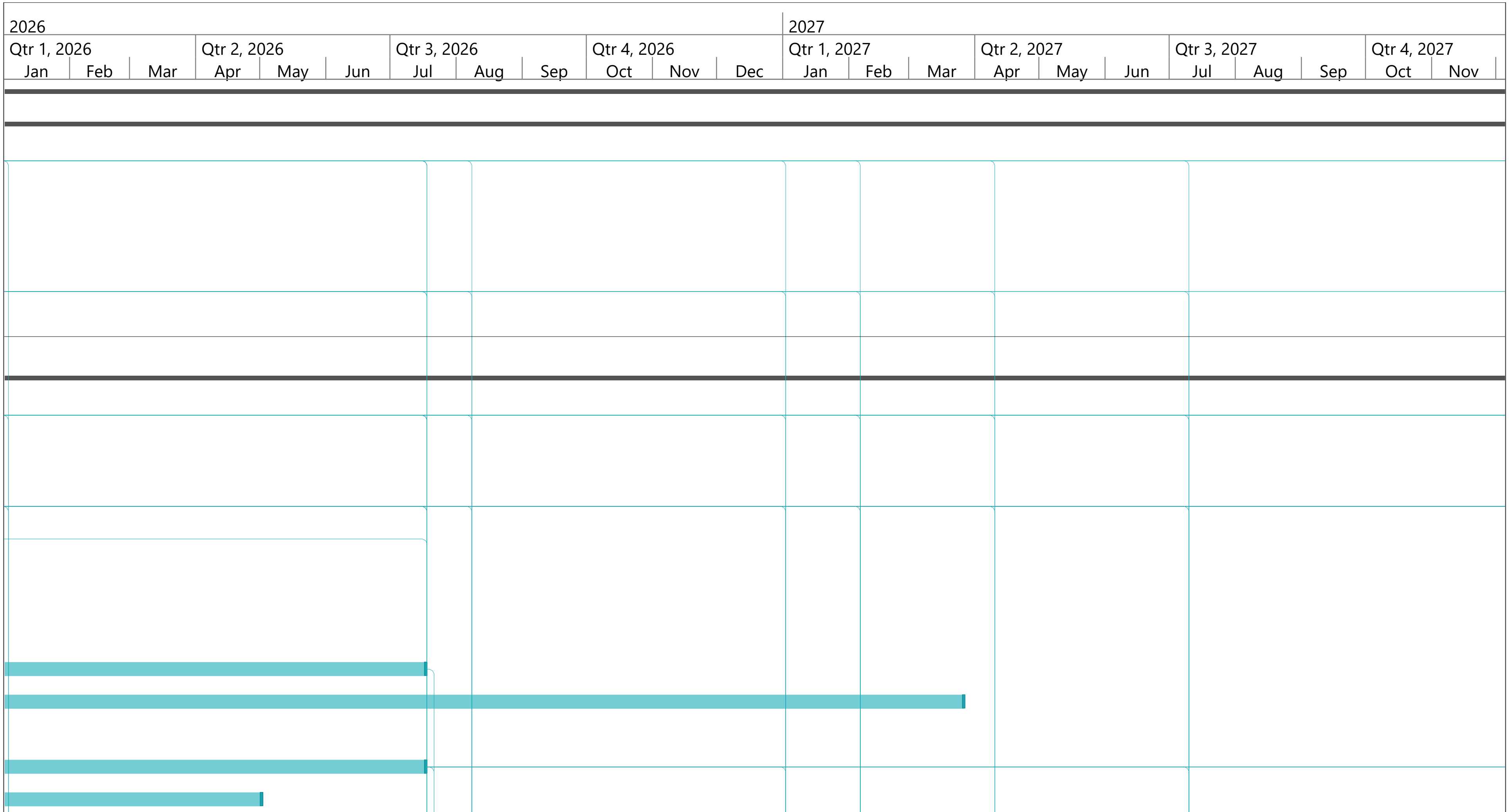

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Date: Mon 5/23/22

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Split	Manual Task	External Milestone
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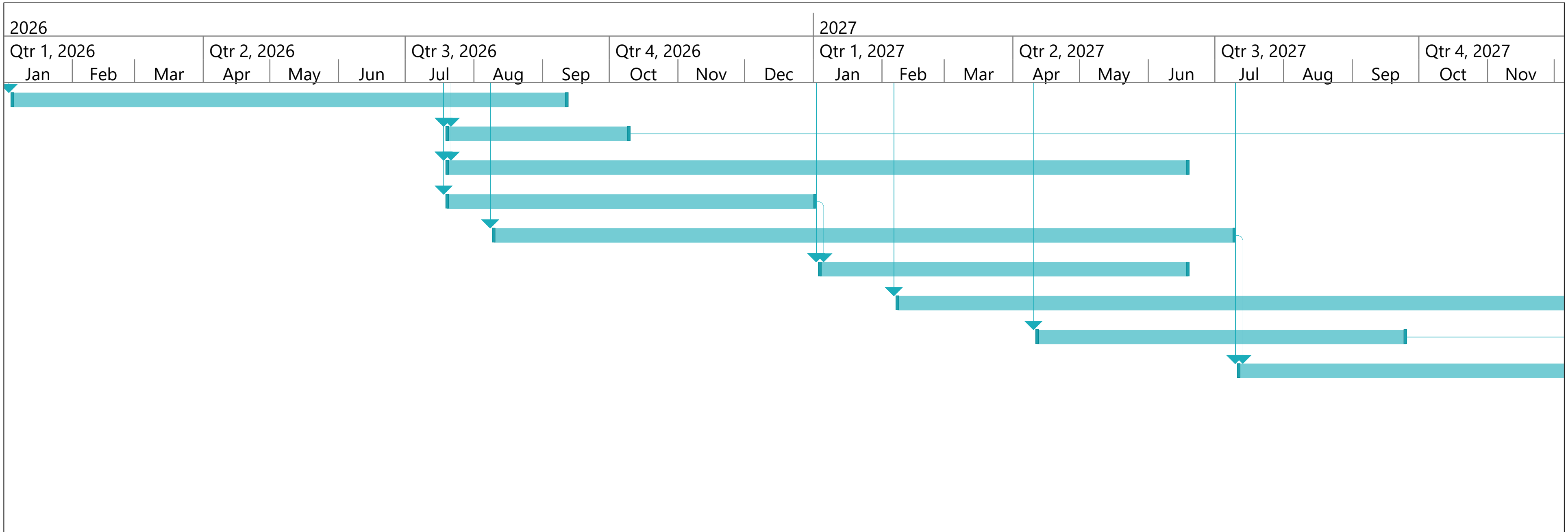

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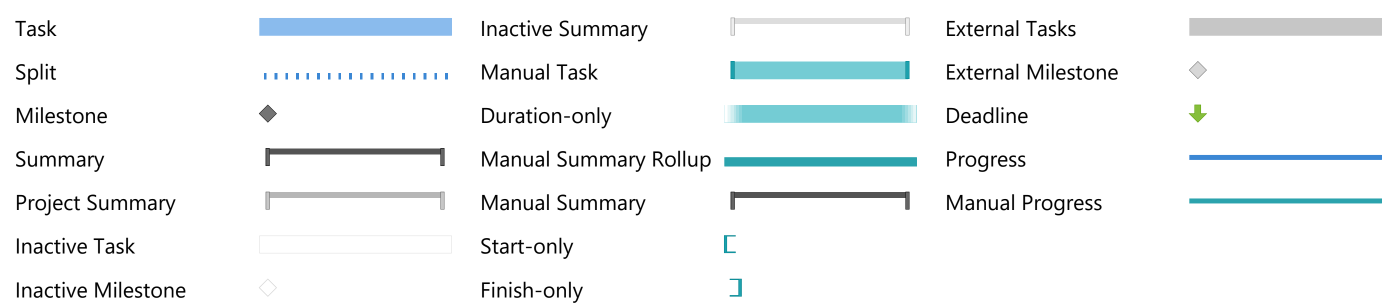

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Date: Mon 5/23/22

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
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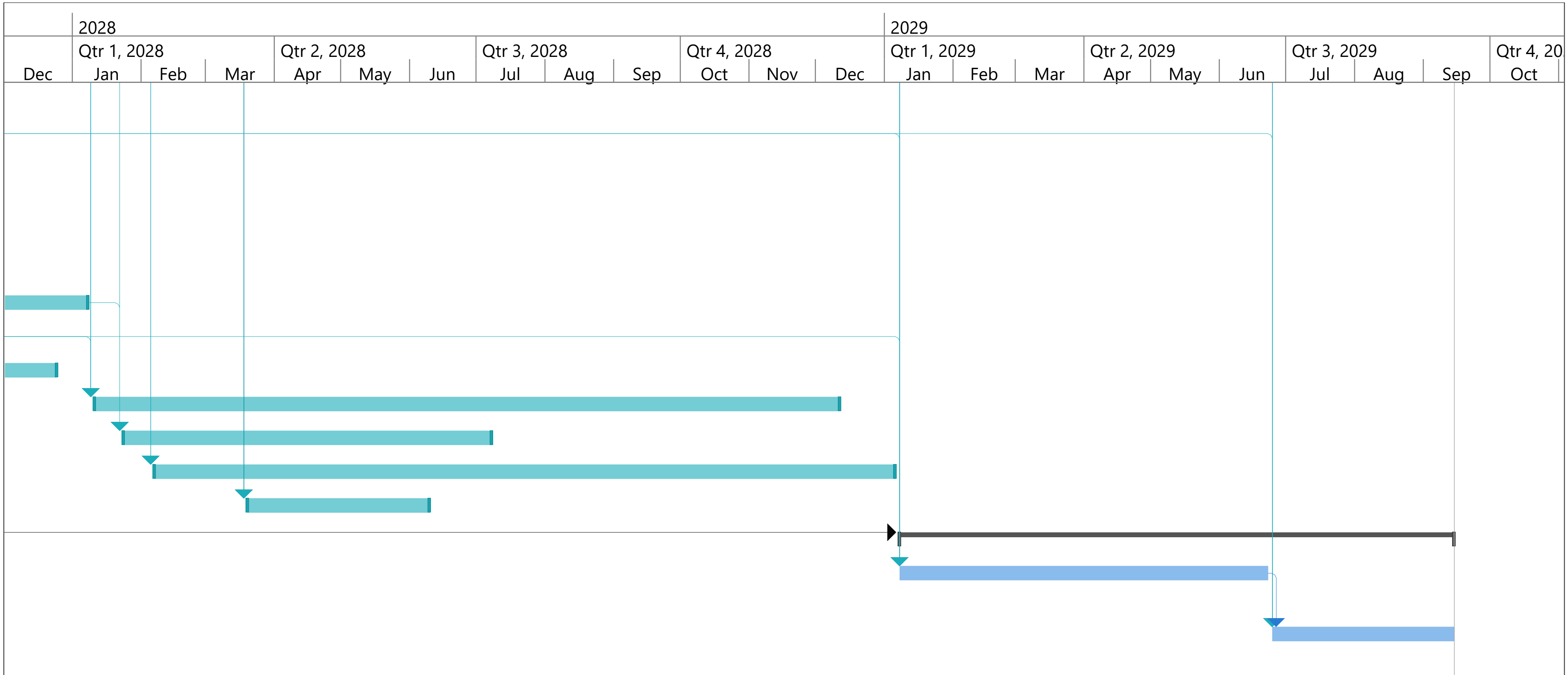

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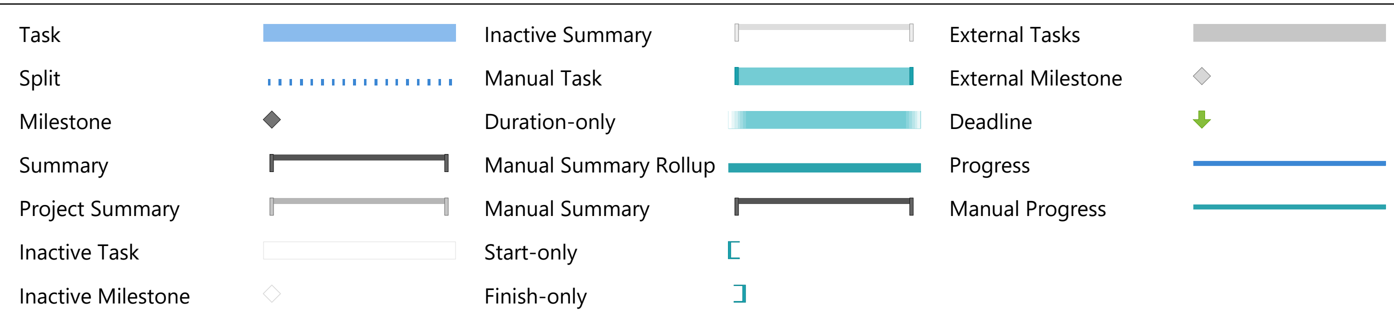

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APPENDIX G

VISUAL HYDRAULICS MODEL

Visual Hydraulics Summary Report - Hydraulic Analysis

Project: **Kingston_Existing.vhf**
Company:
Date:

Current flow conditions

Forward Flow =	1.41 mgd
Return I Flow =	0.18 mgd
Return II Flow =	-----
Return III Flow =	-----

Section Description	Water Surface Elevation
Starting water surface elevation	**131.85**
Eff_Box	**131.85**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 3.33 ft
Channel width/diameter = 3.33 ft
Flow = 0.27 mgd
Downstream channel invert = 131
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 2.83 ft^2
Hydraulic radius = 0.563
Normal depth = infinite
Critical depth = 0.08 ft
Depth downstream = 0.85 ft
Bend loss = 0 ft
Depth upstream = 0.85 ft
Velocity = 0.15 ft/s
Flow profile = Horizontal

Eff_Flume **136.34**

Flume invert = 135.97
Flume throat width = 0.5 ft
Flow through flume = 0.27 mgd
Flume 'm' value = 2
Flume 'e' value = 1.58

Section Description	Water Surface Elevation
Head through flume = 0.37 ft	
UV_Eff_Channel	**136.34**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 7.6 ft	
Channel width/diameter = 8.33 ft	
Flow = 0.27 mgd	
Downstream channel invert = 131	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 44.5 ft^2	
Hydraulic radius = 2.34	
Normal depth = infinite	
Critical depth = 0.04 ft	
Depth downstream = 5.34 ft	
Bend loss = 0 ft	
Depth upstream = 5.34 ft	
Velocity = 0.01 ft/s	
Flow profile = Horizontal	
UV_Eff_Weir	**137.53**
Weir invert (top of weir) = 137.5	
Weir length = 31 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 0.27 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.03 ft	
UV_Channel	**137.53**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 22 ft	
Channel width/diameter = 3 ft	
Flow = 0.27 mgd	
Downstream channel invert = 136.08	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 4.33 ft^2	
Hydraulic radius = 0.736	
Normal depth = infinite	
Critical depth = 0.08 ft	
Depth downstream = 1.44 ft	
Bend loss = 0 ft	
Depth upstream = 1.45 ft	
Velocity = 0.1 ft/s	

Section Description	Water Surface Elevation
Flow profile = Horizontal	
UV_Channel_box	**137.53**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 3.33 ft	
Channel width/diameter = 3 ft	
Flow = 0.27 mgd	
Downstream channel invert = 131.5	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 18.08 ft^2	
Hydraulic radius = 1.201	
Normal depth = infinite	
Critical depth = 0.08 ft	
Depth downstream = 6.03 ft	
Bend loss = 0 ft	
Depth upstream = 6.03 ft	
Velocity = 0.02 ft/s	
Flow profile = Horizontal	
Clarifiers_Common_Eff	**137.54**
Pipe shape = Circular	
Diameter = 14 in	
Length = 120 ft	
Flow = 0.27 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2.4	
Pipe area = 1.07 ft²	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 0.39 ft/s	
Friction loss = 0.01 ft	
Fitting loss = 0.01 ft	
Total loss = 0.01 ft	
Calrifier_Eff	
Clarifier_1_Pipe	**137.54**
Pipe shape = Circular	
Diameter = 14 in	
Length = 25 ft	
Flow = 0.27 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	

Section Description	Water Surface Elevation
Total fitting K value = 0.89 Pipe area = 1.07 ft² Pipe hydraulic radius = 0.292 Age factor = 1 Solids factor = 1 Velocity = 0.39 ft/s Friction loss = 0 ft Fitting loss = 0 ft Total loss = 0 ft	
Clarifier_2_Pipe	**Off-line**
Clarifier 2	**Off-line**
Clarifier 2 weir	**Off-line**
Splitter box to Clarifier 2	**Off-line**
Splitter box weir to clarifier 2	**Off-line**
Clarifier 1 Launder invert = 139 Launder length = 54.98 ft Launder width = 1 ft Launder slope = 0.0136 ft/ft Flow through launder = 0.27 mgd Critical depth = 0.18 ft Downstream depth = 0.18 ft Upstream depth = 0.18 ft	**139.92**
Clarifier 1 weir Invert of V notch = 140.5 Angle of V notch = 90 degrees Number of notches = 220 Total flow over weir = 0.27 mgd Weir submergence = unsubmerged Head over weir = 0.06 ft	**140.56**
Splitter box to Clarifier 1 Pipe shape = Circular Diameter = 14 in Length = 42 ft Flow = 0.27 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 1.95 Pipe area = 1.07 ft² Pipe hydraulic radius = 0.292	**140.56**

Section Description	Water Surface Elevation
Age factor = 1 Solids factor = 1 Velocity = 0.39 ft/s Friction loss = 0 ft Fitting loss = 0 ft Total loss = 0.01 ft	
Splitter box weir to clarifier 1	**141.45**
Weir invert (top of weir) = 141.25 Weir length = 1.5 ft Weir 'C' coefficient = 3 Flow over weir = 0.27 mgd Weir submergence = unsubmerged Head over weir = 0.2 ft	
Flow_Splitter_Box	**141.45**
User defined loss for flow split = 0 ft Total flow through flow split = 0.27 mgd	
Flow_Mix_Chnnl	**141.46**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 2.5 ft Channel width/diameter = 10 ft Flow = 0.37 mgd Downstream channel invert = 125 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 164.55 ft^2 Hydraulic radius = 3.835 Normal depth = infinite Critical depth = 0.05 ft Depth downstream = 16.45 ft Bend loss = 0 ft Depth upstream = 16.46 ft Velocity = 0 ft/s Flow profile = Horizontal	
Ox_Ditch_2_Eff	**141.46**
Pipe shape = Circular Diameter = 14 in Length = 191 ft Flow = 0.135 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 4.5	

Section Description	Water Surface Elevation
Pipe area = 1.07 ft²	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 0.2 ft/s	
Friction loss = 0 ft	
Fitting loss = 0 ft	
Total loss = 0.01 ft	
Ox_Ditch_1_Eff	**141.46**
Pipe shape = Circular	
Diameter = 14 in	
Length = 87 ft	
Flow = 0.135 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2.25	
Pipe area = 1.07 ft²	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 0.2 ft/s	
Friction loss = 0 ft	
Fitting loss = 0 ft	
Total loss = 0 ft	
Ox Ditch 1 Eff Weir	**146.34**
Weir invert (top of weir) = 146.31	
Weir length = 14 ft	
Weir 'C' coefficient = 3.33	
Flow over weir = 0.185 mgd	
Weir submergence = unsubmerged	
Head over weir = 0.03 ft	
Ox Ditch 1	**146.35**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 197 ft	
Channel width/diameter = 16 ft	
Flow = 0.185 mgd	
Downstream channel invert = 136.1	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 163.9 ft^2	
Hydraulic radius = 4.492	
Normal depth = infinite	
Critical depth = 0.02 ft	

Section Description	Water Surface Elevation
Depth downstream = 10.24 ft Bend loss = 0 ft Depth upstream = 10.25 ft Velocity = 0 ft/s Flow profile = Horizontal	
Ox Ditch 1 Weir	**146.92**
Weir invert (top of weir) = 146.8 Number of contracted sides = 2 Weir length = 2.5 ft Flow over weir = 0.185 mgd Submergence = unsubmerged Head over weir = 0.12 ft	
Ox Ditch 2 Eff Weir	**146.34**
Weir invert (top of weir) = 146.31 Weir length = 14 ft Weir 'C' coefficient = 3.33 Flow over weir = 0.185 mgd Weir submergence = unsubmerged Head over weir = 0.03 ft	
Ox Ditch 2	**146.35**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 197 ft Channel width/diameter = 16 ft Flow = 0.185 mgd Downstream channel invert = 136.1 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 163.9 ft^2 Hydraulic radius = 4.492 Normal depth = infinite Critical depth = 0.02 ft Depth downstream = 10.24 ft Bend loss = 0 ft Depth upstream = 10.25 ft Velocity = 0 ft/s Flow profile = Horizontal	
Ox Ditch 2 Weir	**146.92**
Weir invert (top of weir) = 146.8 Number of contracted sides = 2 Weir length = 2.5 ft Flow over weir = 0.185 mgd Submergence = unsubmerged	

Section Description	Water Surface Elevation
Head over weir = 0.12 ft	
Ox_Ditch_Infl_Split	**146.92**
User defined loss for flow split = 0 ft	
Total flow through flow split = 0.37 mgd	
ML_Pipe	**146.94**
Pipe shape = Circular	
Diameter = 14 in	
Length = 55 ft	
Flow = 0.37 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2.25	
Pipe area = 1.07 ft^2	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 0.54 ft/s	
Friction loss = 0.01 ft	
Fitting loss = 0.01 ft	
Total loss = 0.02 ft	
RS_Pipe	**146.94**
Pipe shape = Circular	
Diameter = 14 in	
Length = 25 ft	
Flow = 0.27 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 0.75	
Pipe area = 1.07 ft^2	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 0.39 ft/s	
Friction loss = 0 ft	
Fitting loss = 0 ft	
Total loss = 0 ft	
RS_Channel	**149.87**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 5 ft	
Channel width/diameter = 3.25 ft	
Flow = 0.27 mgd	
Downstream channel invert = 149.75	

Section Description	Water Surface Elevation
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 0.32 ft^2	
Hydraulic radius = 0.093	
Normal depth = infinite	
Critical depth = 0.08 ft	
Depth downstream = 0.08 ft	
Bend loss = 0 ft	
Depth upstream = 0.12 ft	
Velocity = 1.6 ft/s	
Flow profile = Horizontal	
Parshall Flume	**150.23**
Flume invert = 150	
Flume throat width = 1 ft	
Flow through flume = 0.27 mgd	
Flume 'm' value = 4	
Flume 'e' value = 1.522	
Head through flume = 0.23 ft	
Flume_Inf	**150.23**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 4 ft	
Channel width/diameter = 3.25 ft	
Flow = 0.27 mgd	
Downstream channel invert = 26.75	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 401.3 ft^2	
Hydraulic radius = 1.604	
Normal depth = infinite	
Critical depth = 0.08 ft	
Depth downstream = 123.48 ft	
Bend loss = 0 ft	
Depth upstream = 123.48 ft	
Velocity = 0 ft/s	
Flow profile = Horizontal	
Grit Chamber	**150.35**
2nd degree polynomial	
Flow = 0.27 mgd	
Overall head loss = 0.12 ft	
Grit_Inf	**150.36**
Channel shape = Rectangular	
Manning's 'n' = 0.013	

Section Description	Water Surface Elevation

Channel length = 20 ft
Channel width/diameter = 1.25 ft
Flow = 0.27 mgd
Downstream channel invert = 150
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.44 ft^2
Hydraulic radius = 0.226
Normal depth = infinite
Critical depth = 0.15 ft
Depth downstream = 0.35 ft
Bend loss = 0 ft
Depth upstream = 0.36 ft
Velocity = 0.96 ft/s
Flow profile = Horizontal

Screen Eff **150.36**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 5 ft
Channel width/diameter = 2 ft
Flow = 0.27 mgd
Downstream channel invert = 150
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.72 ft^2
Hydraulic radius = 0.265
Normal depth = infinite
Critical depth = 0.11 ft
Depth downstream = 0.36 ft
Bend loss = 0 ft
Depth upstream = 0.36 ft
Velocity = 0.58 ft/s
Flow profile = Horizontal

Screen Combine

Mech_Screen_Eff **150.37**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 6 ft
Channel width/diameter = 2 ft
Flow = 0.27 mgd
Downstream channel invert = 28.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 243.73 ft^2

Section Description	Water Surface Elevation

Hydraulic radius = 0.992
Normal depth = infinite
Critical depth = 0.11 ft
Depth downstream = 121.86 ft
Bend loss = 0 ft
Depth upstream = 121.87 ft
Velocity = 0 ft/s
Flow profile = Horizontal

Manual_Screen_Eff **150.37**

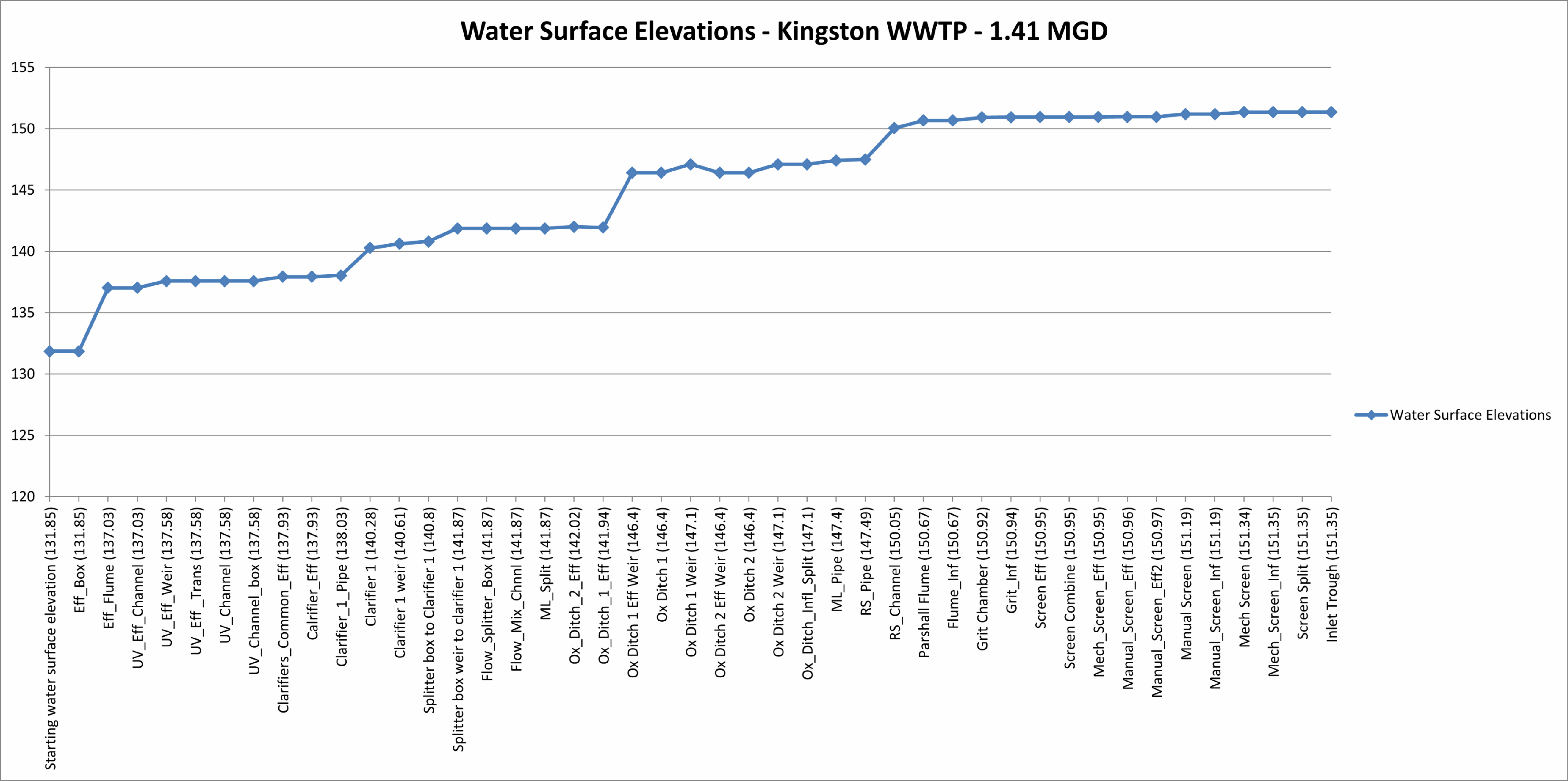
Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 10 ft
Channel width/diameter = 2 ft
Flow = 0.27 mgd
Downstream channel invert = 150
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.73 ft^2
Hydraulic radius = 0.268
Normal depth = infinite
Critical depth = 0.11 ft
Depth downstream = 0.36 ft
Bend loss = 0 ft
Depth upstream = 0.37 ft
Velocity = 0.57 ft/s
Flow profile = Horizontal

Manual_Screen_Eff2 **150.37**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 3 ft
Channel width/diameter = 1.75 ft
Flow = 0.27 mgd
Downstream channel invert = 150
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.65 ft^2
Hydraulic radius = 0.26
Normal depth = infinite
Critical depth = 0.12 ft
Depth downstream = 0.37 ft
Bend loss = 0 ft
Depth upstream = 0.37 ft
Velocity = 0.65 ft/s
Flow profile = Horizontal

Section Description	Water Surface Elevation
Manual Screen	**150.38**
Theory used = Kirschmer	
Rack/screen invert = 150	
Rack/screen width = 1.75 ft	
Flow through rack = 0.27 mgd	
Bar width = 0.38 in	
Bar spacing = 1.38 in	
Bar shape = Rectangular	
Angle of inclination = 60 degrees	
Downstream depth = 0.37 ft	
Approach velocity = 0.63 ft/s	
Rack/screen head loss = 0.01 ft	
Manual_Screen_Inf	**150.38**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 2 ft	
Channel width/diameter = 1.75 ft	
Flow = 0.27 mgd	
Downstream channel invert = 150	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 0.66 ft^2	
Hydraulic radius = 0.264	
Normal depth = infinite	
Critical depth = 0.12 ft	
Depth downstream = 0.38 ft	
Bend loss = 0 ft	
Depth upstream = 0.38 ft	
Velocity = 0.63 ft/s	
Flow profile = Horizontal	
Mech Screen	**150.65**
3rd degree polynomial	
Flow = 0.27 mgd	
Overall head loss = 0.28 ft	
Mech_Screen_Inf	**150.65**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 6 ft	
Channel width/diameter = 1.75 ft	
Flow = 0.27 mgd	
Downstream channel invert = 150	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 1.14 ft^2	

Section Description	Water Surface Elevation
Hydraulic radius = 0.373 Normal depth = infinite Critical depth = 0.12 ft Depth downstream = 0.65 ft Bend loss = 0 ft Depth upstream = 0.65 ft Velocity = 0.37 ft/s Flow profile = Horizontal	
Screen Split	**150.65**
User defined loss for flow split = 0 ft Total flow through flow split = 0.54 mgd	
Inlet Trough	**150.65**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 2.66 ft Channel width/diameter = 5.25 ft Flow = 0.27 mgd Downstream channel invert = 150 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 3.42 ft^2 Hydraulic radius = 0.522 Normal depth = infinite Critical depth = 0.06 ft Depth downstream = 0.65 ft Bend loss = 0 ft Depth upstream = 0.65 ft Velocity = 0.12 ft/s Flow profile = Horizontal	



Water Surface Elevations - Kingston WWTP - 1.41 MGD
155
150
145
140
135
130
125
120
Starting water surface elevation (131.85)
Eff_Box (131.85)
Eff_Flume (137.03)
UV_Eff_Channel (137.03)
UV_Eff_Weir (137.58)
UV_Eff _Trans (137.58)
UV_Channel (137.58)
UV_Channel_box (137.58)
Clarifiers_Common_Eff (137.93)
Calrifier_Eff (137.93)
Clarifier_1_Pipe (138.03)
Clarifier 1 (140.28)
Clarifier 1 weir (140.61)
Splitter box to Clarifier 1 (140.8)
Splitter box weir to clarifier 1 (141.87)
Flow_Splitter_Box (141.87)
Flow_Mix_Chnnl (141.87)
ML_Split (141.87)
Ox_Ditch_2_Eff (142.02)
Ox_Ditch_1_Eff (141.94)
Ox Ditch 1 Eff Weir (146.4)
Ox Ditch 1 (146.4)
Ox Ditch 1 Weir (147.1)
Ox Ditch 2 Eff Weir (146.4)
Ox Ditch 2 (146.4)
Ox Ditch 2 Weir (147.1)
Ox_Ditch_Infl_Split (147.1)
ML_Pipe (147.4)
RS_Pipe (147.49)
RS_Channel (150.05)
Parshall Flume (150.67)
Flume_Inf (150.67)
Grit Chamber (150.92)
Grit_Inf (150.94)
Screen Eff (150.95)
Screen Combine (150.95)
Mech_Screen_Eff (150.95)
Manual_Screen_Eff (150.96)
Manual_Screen_Eff2 (150.97)
Manual Screen (151.19)
Manual_Screen_Inf (151.19)
Mech Screen (151.34)
Mech_Screen_Inf (151.35)
Screen Split (151.35)
Inlet Trough (151.35)
Water Surface Elevations

APPENDIX H
KINGSTON AND SUQUAMISH DESIGN STORM, MODEL LOADINGS, AND FUTURE CONDITION PARAMETERS

consor

Technical Memorandum

Date:	February 4, 2022
Project:	Kingston and Suquamish General Sewer Plan
To:	Barbara Zaroff, PE, PMP
From:	Andrew Henson, PE, PMP; Ryan Jones, PE
Reviewed By:	Adam Schuyler, PE, PMP
Re:	Kingston and Suquamish Design Storm, Model Loadings, and Future Condition Parameters

Introduction

Completion of the General Sewer Plan updates for the Kitsap County (County) Kingston and Suquamish basins relies on hydraulic and hydrologic (H/H) modeling. Model scenarios representing the existing conditions and 20-year planning horizon will be used to identify capacity deficiencies and develop proposed alternatives to address system issues. Each basin is represented by a calibrated model developed in the Danish Hydraulic Institute's (DHI's) MIKE+ software. The calibrated models simulate dry and wet weather system response in the existing collection systems. A design storm will be applied to the calibrated models to identify existing system deficiencies under certain wet weather conditions.

Model scenarios representing the 20-year planning horizon will be created from the calibrated model for each basin. In these new scenarios, future dry weather flow (DWF) will be updated to reflect expected population growth. The design storm will be adjusted for climate change and will be used to determine future deficiencies. Future DWF and a climate change adjusted design storm will be used in developing proposed alternatives to address system deficiencies.

Documented in this Technical Memorandum (TM) are the selection of the design storm, the climate change adjustments, existing model flow loadings, and the future DWF loadings.

Design Storm Generation and Usage

The collection systems for the Kingston and Suquamish basins will be analyzed using a 25-year design storm to be consistent with the analysis used in the on-going Central Kitsap Wastewater Facility Plan and Sewer Plan Update. The project team proposes using a design storm based on a

Soil Conservation Service (SCS) Type 1A 25-year 12-hour storm and a storm volume of 3.637 inches, which is the volume associated with the 25-year return period for this area (State of Washington Water Research Center, 2015).

Hydrologic parameters in the model represent how much rainfall is infiltrated into the soil versus how much is surface runoff. These parameters, in turn, determine how rainfall is routed into the sewer system in the form of inflow and infiltration (I/I). Running the model for a longer period, e.g., an entire wet season, allows for the model to account for antecedent soil moisture conditions. This is important for the model to generate a wet weather response in the separated sewer system due to infiltration. Note that the inflow portion of wet weather flow, i.e., the runoff that enters through manhole lids or connected storm lateral connections, is less sensitive to the model simulation duration but it is still accounted for in the selected hydrologic parameters. The hydrologic parameters are tuned during model calibration so that the simulation results align with available flow monitoring data.

Using a single design storm alone will not properly build antecedent soil conditions. Therefore, the developed design storm was inserted into the recorded rainfall timeseries such that the peak rainfall intensity lined up with the peak rainfall intensity of the 12/21/2020 storm, a large storm from both the observed Kingston and Suquamish rainfall. This storm placement allows for running the model using observed rainfall to develop hydrologic antecedent soil moisture conditions that will be consistent with the calibrated model. Table 1 shows the peak rainfall intensity and total rainfall volume for these timeseries for this storm. The 12-hour duration of the SCS Type 1A design storm was selected to better match the rainfall peak intensities in the observed rainfall data. This design storm will be used to determine existing conditions deficiencies.

Table 1: Rainfall Summary of December 21, 2020 Storm Event and Design Storm

Rainfall Source	Rainfall Peak Intensity (in/hr)	Rainfall Volume (in)
Kingston Rain Gage	0.24	0.41
Suquamish Rain Gage	0.24	0.43
25-year 12-hour Design Storm	0.25	0.73

Design Storm Climate Change Adjustments

The rainfall input described above will be adjusted for climate change by scaling up the overall storm volume and intensity by a percentage shown in bold in Table 2. The adjustment reflects the fact that a 25-year storm in the future is projected to be larger than the current 25-year storm. The University of Washington Climate Impacts group publishes expected increased in rainfall for each decade between 2030 and 2080 (Climate Impacts Group, 2021). Note that the published values include the 24-hour and 6-hour storm durations but did not include a 12-hour storm. As such the 6-hour storm was used to be more conservative. Two different climate change adjustment factors are proposed for use for different purposes. The first, representative of the 2040s to align with the 20-year planning horizon, will be used to determine future system deficiencies. The second, representative of the 2080s, will be used to size alternatives to address identified deficiencies. The 2080s projection aligns more closely with the expected useful life of a pipe.

Table 2: Projected Change from UW Climate Impacts Group.

Decade	Projected Change*
2030s	10%
2040s	**16%**
2050s	22%
2060s	22%
2070s	21%
2080s	**27%**

*Based on location of Kingston basin which is the more conservative projection provided by Climate Impacts Group.

Existing Conditions Model Loadings

ADS Environmental placed flow meters in both the Kingston and Suquamish collection systems from 10/1/2020 through 5/1/2021. The flow monitoring data is the preferred data set to develop the loadings for application in the model as it was collected at a relatively high resolution (nine total meter sites, four in Kingston and five in Suquamish, at 5-minute intervals) and collects flow from the entire service area. As such, the models were calibrated to dry and wet weather events using this data, including developing DWF average values and patterns and determining hydrologic parameters. However, flow data collected at each Wastewater Treatment Plant (WWTP) is used as the basis for the plant loadings at the as described in the Population, Flow, and Loading sections of the General Sewer Plans. Therefore, the flow monitoring data was compared to available data at each of the Wastewater Treatment Plants (WWTP) to ensure consistency between plant and collection system loadings. Average annual flow (AAF) at the WWTPs is compared to the average DWF value determined from the flow metering data Table 3.

Table 3: Flow Data Comparisons

Basin	2020 AAF (mgd)	DWF Average Value from Flow Monitoring Data (mgd)
Kingston	0.11	0.24
Suquamish	0.23	0.26

The data sets compare favorably in the Suquamish basin given the magnitude of the flow and the varying metering approaches (i.e., daily flow recorded at the WWTP versus 5-minute data recorded in the collection system flow monitoring). Therefore, it is recommended to use the flow monitoring data as the basis for the dry weather loading and to determine the hydrologic parameters in the Suquamish basin model.

The comparison in the Kingston basin is less favorable, however, with an over 100 percent difference in the average daily flow in the basin. The project team discussed potential reasons for the discrepancy internally, with Kitsap County staff, and with ADS Environmental, including:

- Potential for ADS flow meters to be installed in different locations than planned resulting in accidentally “double counting” flows, which could result in inflated DWF summations. The project team reviewed ADS flow meter install sheets and discussed this with ADS and determined that the meters were installed as expected.
- Low flow depths in the collection system present metering challenges for collecting accurate data, thereby influencing the flow calculations (flow is computed by multiplying measured depth and velocity readings). ADS reviewed the depth data upon request and found no apparent issue with the data collection or flow computations.
- Potential for the metering at the Kingston WWTP to be erroneous. County staff expressed confidence in this metering, noting that it has been calibrated.
- Potential that the collection system connectivity is different than represented in the geographic information system (GIS) data, which could result in flow paths being different than expected. County staff provided as-built data near the ADS flow meter install location and no differences from GIS data were discovered.
- Potential for an unknown break in a pipeline between an ADS flow meter install locations and the Kingston WWTP resulting in a loss of flow. County staff discussed that system issues would have likely been evident in pump run times or surface conditions in the vicinity given the magnitude of loss needed to explain the difference between WWTP plant data and ADS flow meter data.

Ultimately, no obvious error in either collection methodologies were determined through these discussions. To provide another data point, County operations and maintenance (O&M) staff performed pump draw down tests at Lift Station (LS) 71 and LS 41 and provided monitoring data from a meter on the force main at LS 71. The project team evaluated this data to determine if it supported the magnitude of flows at the Kingston WWTP or the ADS collection flow monitoring data. LS 41 feeds directly into LS 71, and there were three individual flow meters placed upstream of LS 41. LS 71 feeds directly into the Kingston WWTP, and there was one individual flow meter upstream of this station to record data from the system that does not flow through LS 41.

Table 4 and Table 5 show the comparisons of the ADS flow meter data with County data at LS 41 and LS 71, respectively. Multiple County data sources – data from the Kingston WWTP, LS 71, and LS 41 – agree while the ADS data is an outlier. It is recommended to use the average value from the County data sources for DWF loading in the Kingston model. Using the County data for DWF loading places the collection system flows more in alignment with the flows used to evaluate the Kingston WWTP for dry weather.

Table 4: Average DWF Comparison at LS 41

Location	Average DWF (mgd)
Sum of ADS Meters Upstream of LS 41	0.15
LS 41 Runtime Data (Average monthly value for December 2020 per available data)	0.05

Table 5: Average DWF Comparison at LS71 and Kingston WWTP

Location	Average DWF (mgd)
Sum of ADS Meters Upstream of LS 71	0.24
LS 71 Runtime Data (Average monthly value for October 2020 based per available data)	0.09
LS 71 Force Main Mag Meter	0.08
Kingston WWTP	0.11

The comparison of wet weather events from the various data sources in the Kingston basin is more difficult. The LS 71 runtime and Kingston WWTP data are provided in daily totals so peak flow magnitudes related to a storm event are unlikely to be reflected in the data. The ADS flow monitoring data is collected in 5-minute intervals so peak flows are more apparent in this data. The peak hour flow (PHF) peaking factor at the WWTP was estimated as 5.16, which was documented in the Kingston draft plan Section 3 (Population, Flow, and Load Projections). A similar PHF peaking factor is achieved in the model by using a DWF loading reduced to better match the Kingston WWTP AAF DWF value in conjunction with the wet weather hydrologic parameters determined by using the ADS data for wet weather calibration. *For this reason, it is recommended that the Kingston model hydrologic parameters be based on the calibration to the ADS flow monitoring data while the model DWF component be based on the Kingston WWTP AAF DWF value.*

Future Conditions DWF Loadings

Future DWF loadings are projected to increase based on population growth in both Kingston and Suquamish for the 20-year planning horizons which align with the available population growth estimates for these areas. Future conditions DWF will be computed by increasing the existing conditions DWF based on projections of AAF at the Kingston and Suquamish WWTPs in 2042. As the 2080 climate change planning condition will be used for pipe sizing, using the same AAF as in the 2042 planning horizon was deemed appropriate for this analysis. Current and projected AAF are summarized below in Table 6.

At the time of compiling this TM, the Arborwood development is being planned for the southern portion of the Kingston basin that will have 358 equivalent residential units (ERU). Flows from this area will be pumped directly to the Kingston WWTP and therefore will not impact the modeled Kingston collection system. As a result, the projected flow associated with this development is subtracted from the WWTP AAF to determine the appropriate model loadings.

Table 6: Future DWF Projected Increase in Collection System

WWTP	2020 AAF (mgd)	2042 AAF (mgd)	2042 AAF without Arborwood (mgd)	Projected Increase*
Kingston	0.11	0.27	0.23	109%
Suquamish	0.23	0.26	N/A	12%

*Projected increase based on 2042 AAF without Arborwood.

consor

APPENDIX I

RECYCLED WATER FACILITY PLAN

FINAL

Kingston Recycled Water Facility Plan

Prepared for

Kitsap County Public Works

Sewer Utility Division

Port Orchard, Washington

March 12, 2020

FINAL

Kingston Recycled Water Facility Plan

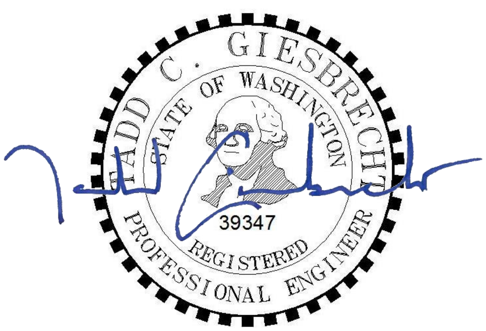
Prepared for

Kitsap County Public Works, Port Orchard, Washington

March 12, 2020

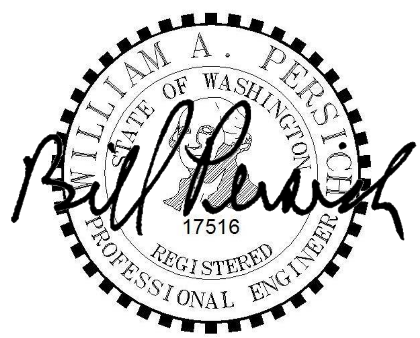
Prepared By: Matthew DeBoer

March 12, 2020



Reviewed By: Tadd Giesbrecht

March 12, 2020



Reviewed By: Bill Persich

March 12, 2020

Brown AND Caldwell

701 Pike Street, Suite 1200
Seattle, Washington 98101
T: 206.624-0100

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List of Abbreviations

°F	degree(s) Fahrenheit
AACE	Association for the Advancement of Cost Engineering International
AAF	annual average flow
ac	acre(s)
ADWF	average dry weather flow
Albuquerque	Albuquerque Bernalillo County Water Utility Authority
amsl	above mean sea level
AWWA	American Water Works Association
BAT	backflow assembly tester
BMP	best management practice
BCE	business case evaluation
BOD_5	5-day biochemical oxygen demand
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CDBG	Community Development Block Grant
CERB	Community Economic Revitalization Board
CFDA	Catalog of Federal Domestic Assistance
CFR	Code of Federal Regulations
cfs	cubic foot/feet per second
CFU	colony-forming unit(s)
CKTP	Central Kitsap Treatment Plant
Cl_2	chlorine
cm_2	square centimeter(s)
CO_2	carbon dioxide
Commerce	Washington State Department of Commence
County	Kitsap County
CWA	Clean Water Act
d	day(s)
DAHP	Department of Archaeology and Historic Preservation
DBP	disinfection by-product
DCD	Kitsap County Department of Community Development
DNR	Washington State Department of Natural Resources
DNS	Determination of Non-Significance
DO	dissolved oxygen
DWSRF	Drinking Water State Revolving Fund
Ecology	Washington State Department of Ecology
EDA	Economic Development Administration
EDC	endocrine-disrupting compound
EPA	U.S. Environmental Protection Agency
EQ	equalization
ESSB	Engrossed Substitute Senate Bill
Facilities Plan Update	Kingston Wastewater Facilities Plan Update Addendum
Feasibility Study	USBR Title XVI Feasibility Study
FEMA	Federal Emergency Management Agency
FPPA	Farmland Protection Policy Act
ft	foot/feet
ft^2	square foot/feet
FTE	full-time equivalent
gal	gallon(s)
GBT	gravity belt thickener
gpcd	gallon(s) per capita per day
gpm	gallon(s) per minute
Health	Washington State Department of Health
hp	horsepower
hr	hour(s)
HVAC	heating, ventilation, and air conditioning
I&I	inflow and infiltration
in.	inch(es)
IRP	integrated resource planning
KPUD	Kitsap Public Utility District
kW	kilowatt(s`)
lb	pound(s)
LF	linear foot/feet
LOTT	Cities of Lacey, Olympia, and Tumwater and Thurston County
m	meter(s)
MCL	maximum contaminant level
MG	million gallons
mgd	million gallons per day
MHI	median household income
mJ	millijoule(s)

mL	milliliter(s)
MLLW	mean lower low water
MMF	maximum month flow
MPN	most probable number
N/A	not applicable
NEPA	National Environmental Policy Act
NKHP	North Kitsap Heritage Park
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRCS	Natural Resources Conservation Service
NSAID	nonsteroidal anti-inflammatory drug
NTU	nephelometric turbidity unit(s)
NWRI	National Water Research Institute
O&M	operations and maintenance
OM&R	operation, maintenance, and replacement
Orange Book	Criteria for Sewage Works Design
PDF	peak day flow
PIC	Pollution Identification and Correction
Plan	Kingston Recycled Water Facility Plan
ppcd	pound(s) per capita per day
PPCP	pharmaceuticals and personal care product
Project	Kingston Recycled Water Project
PSCAA	Puget Sound Clean Air Agency
PSP	Puget Sound Partnership
PSRF	Puget Sound Restoration Fund
Purple Book	Reclaimed Water Facilities Manual
PVC	polyvinyl chloride
PWAA	Public Works Assistance Account
PWB	Public Works Board
PWTF	Public Works Trust Fund
RAS	return activated sludge
RCW	Revised Code of Washington
RUS	Rural Utilities Service
SAT	soil aquifer treatment
scfm	standard cubic foot/feet per minute
SEPA	State Environmental Policy Act
SFHA	Special Flood Hazard Area
SMA	Shoreline Management Act
SRF	State Revolving Fund
SRT	solids retention time
SWD	side water depth
TMDL	total maximum daily load
TN	total nitrogen
Tribe	Suquamish Tribe
TSS	total suspended solids
TWAS	thickened waste activated sludge
UE	unemployment
UGA	urban growth area
USBR	United States Bureau of Reclamation
USC	United States Code
USDA	United States Department of Agriculture
USG	UnStructured Grid
USGS	United States Geological Survey
UV	ultraviolet
UVI	ultraviolet intensity
WAC	Washington Administrative Code
WAS	waste activated sludge
WDFW	Washington State Department of Fish and Wildlife
WHGC	White Horse Golf Course
WIFIA	Water Infrastructure Finance and Innovation Act
wk	week(s)
WWTP	wastewater treatment plant
yr	year(s)

Executive Summary

Sustainable and resilient water supplies require “closing the water loop,” essentially minimizing discharges from the overall water system and capturing that water for replenishment and recycling. This replenishment and recycling is essential in Kitsap County, especially because 80 percent of the local water supply comes from the Kitsap Peninsula aquifer.

Kingston area stakeholders are focused on achieving long-term, sustainable solutions to protecting area water resources, in terms of both water quality and quantity. Initiatives underway like the Puget Sound Partnership’s (PSP’s) Action Agenda and Washington State Department of Ecology’s (Ecology’s) Blue Ribbon Panel and Puget Sound Nutrient Reduction Project are taking steps to address the greatest threats to Puget Sound and to protect the long-term health and supply of area waters and habitat.

In the past, Kitsap County has discharged billions of gallons of treated effluent to Puget Sound. New approaches and principles defined in Kitsap County’s (County’s) Water as a Resource Policy promote significant reduction of discharges to Puget Sound and replenishment of the existing water supplies, both directly and indirectly.

Through discussions and outreach with the Suquamish Tribe (Tribe) and other area stakeholders, it has been determined that all stakeholders favor the concept of producing recycled water, using it beneficially, and reducing wastewater treatment plant (WWTP) discharges to Puget Sound. The Kingston area offers a unique and ideal situation to implement a recycled water program with the WWTP situated near a golf course for irrigation and prime hydrogeological conditions for infiltration.

The County is proposing to produce Class A recycled water at the existing Kingston WWTP, which would be used for summer irrigation at the White Horse Golf Course (WHGC) and winter indirect groundwater recharge to the area north of WHGC. The objective of the County and this Kingston Recycled Water Project (Project) is to “**treat water as a resource rather than a waste stream**” to address water quality and quantity concerns specific to Kingston, and other related water resource issues throughout the county. The proposed Project represents a unique opportunity to achieve new, far-reaching benefits for multiple stakeholders. Wastewater would be further treated, recycled, and managed as a valuable resource rather than treated and disposed of as a waste product. This water management approach represents a fundamental shift in how wastewater is managed on the Kitsap Peninsula, deriving multiple benefits while eliminating a continuous direct discharge to Puget Sound.

Current Water Issues

The Kitsap Peninsula has both water quantity and water quality concerns that need to be addressed.

Water Quantity

The Kitsap Peninsula is essentially an “island,” surrounded by salt water with little freshwater sources other than direct rainfall to recharge local aquifers and surface water impoundments. More than 80 percent of the potable water being used in Kitsap County comes from groundwater—a percentage that will increase in the future as new surface water sources are limited. Recharge of this aquifer is limited to moderate rainfall, as intense storms result in water leaving the system as runoff to Puget Sound.

With increased aquifer mining, there is a concern of saltwater intrusion from "reverse flow" of salt water entering the aquifer system. Anticipated climate change impacts, such as longer and hotter summers (requiring additional irrigation demand) and more intense rainfall events during the winter (potential recharge lost from the system as runoff), put increasing stress on Kitsap County's water supply system.

Stream flow is also a concern and a limiting factor for salmon habitat. Stream flows in Grovers Creek have been monitored by the Washington State Department of Natural Resources (DNR) (1991–96) and the Tribe (2004–05). Summer low flows in Grovers Creek are approximately 1.5 cubic feet per second (cfs) and do not currently meet minimum flows (2.0 cfs) established in Washington Administrative Code (WAC) Chapter 173-515.

Water Quality

The Kingston WWTP discharges an average of 42 million gallons (MG) per year of treated wastewater through the Appletree Cove Outfall. Since construction of the existing facility in 2005, the Kingston WWTP has been in full compliance with the requirements of its National Pollutant Discharge Elimination System (NPDES) permit. However, portions of Appletree Cove are closed to shellfish harvesting because of the presence of the Kingston Marina and Ferry Terminal. The outfall terminus is located such that treated effluent discharged to Appletree Cove does not impact commercial shellfish harvesting per Washington State Department of Health (Health) shellfish management criteria.

The mainstem of Grovers Creek consists of approximately 5.1 miles of stream channel, plus numerous small tributaries, flowing to the south and discharging to Miller Bay. Grovers Creek is classified as a Class AA stream under WAC 173-201A, with designated uses including salmon and trout spawning, core and non-core rearing, and migration; wildlife habitat; primary contact recreation, boating, and aesthetic values; domestic, industrial, and agricultural water supply and stock watering; and commerce and navigation. The Tribe operates a fall Chinook and chum hatchery near the mouth of Grovers Creek, which ultimately flows into Miller Bay. Grovers Creek is listed as impaired for fecal coliform and dissolved oxygen (DO) immediately upstream of the mouth at Miller Bay, and for fecal coliform at two additional upstream reaches. In addition, Miller Bay is currently closed for shellfish harvesting because of pollution.

Beneficial Reuse Options

In 2003, the County began assessing opportunities to use recycled water that could be produced at the Kingston WWTP to address long-term County water quantity and water quality goals. In 2015, the County initiated a Kingston WWTP Recycled Water project to build on previous planning efforts and select a preferred recycled water option.

The following beneficial uses of the Project were identified based on these assessments and current understanding of area stakeholder interests:

- **Irrigation:** Water recycled at the Kingston WWTP would offset groundwater withdrawal by meeting summer irrigation needs at WHGC (approximately 29 MG/year) and other potential sites within North Kitsap Heritage Park (NKHP) ball fields.
- **Infiltration:** Investigations in the area north of WHGC indicate favorable subsurface conditions for indirect groundwater infiltration (winter only or year round). Infiltration in this area is anticipated to result in subsurface migration of Class A recycled water to Grovers Creek, potentially providing a significant benefit in the summer when stream flows are below minimum instream flow requirements. Infiltration through the soil column would also have the positive impacts of

providing additional treatment and thermal cooling of the water resulting in lower stream temperatures.

- **Wetlands:** Providing that water temperature and quality regulations would be achieved, directing Class A recycled water through the wetlands located to the northwest of the Kingston WWTP would provide benefits such as improved water quality (through wetland treatment), hydrologic storage, thermal cooling, and seasonal wetland hydration. The temperature of Class A recycled water may need to be lowered between June and September from 70 degrees Fahrenheit (°F) to 61°F–64°F to meet state and federal criteria for delivery to salmon-bearing streams (Golder 2010). The recycled water would ultimately be conveyed to Grovers Creek and help address low summer stream flow issues.

Table ES-1 summarizes the beneficial-use alternatives that were assessed to improve area water quality and water quantity concerns.

Table ES-1. Alternatives Screening Criteria

Discharge Alternatives			Relative Benefits		
Alternative	Summer	Winter	Puget Sound (Quality)	Vashon (Deep) Advanced Aquifer (Quantity)	Shallow Aquifer and Streams (Quantity and Quality)
1. Puget Sound wastewater discharge ("no action")	Puget Sound	Puget Sound	+	N/A	N/A
2. Winter discharge, summer irrigation	Irrigation	Puget Sound	++	++	N/A
3. Winter infiltration, summer irrigation	Irrigation	Infiltration	+++	++	+
4. Irrigation and storage	Irrigation	Storage	+++	+++	N/A
5. Infiltration	Infiltration	Infiltration	+++	+	++
6. Wetlands	Wetlands	Wetlands	+++	N/A	+++

The number of "+" notations represents the relative benefits for each option.

Based on discussions with major stakeholders (County and Tribe), a strong preference was expressed for alternatives that included elements of irrigation and infiltration to benefit not only Puget Sound water quality, but also the aquifer and area streams. The alternatives evaluation process also supported the selection of Alternative 3 as the preferred alternative.

Stakeholder Coordination and Public Involvement

In 2015, when the County reinitiated the Project to build on previous planning efforts and select a preferred recycled water option, a stakeholder outreach program was developed to identify shared interests and goals. The following stakeholders were engaged throughout Project development:

- Kitsap County Public Works
- Kitsap Board of Commissioners
- Kitsap County Parks
- Suquamish Tribe
- Kitsap Public Utility District
- Puget Sound Partnership
- White Horse Golf Club

- Port of Kingston
- Washington State Department of Health
- Washington State Department of Ecology
- Washington State Department of Fish and Wildlife

Public outreach was performed in June 2018 that included presentation of the proposed Project and an overview of two local case studies. The public was provided the opportunity to visit with Project representatives and participate in a question and answer session to provide feedback on the proposed Project. In general, support was expressed for the concept of developing a recycled water program and realizing the potential benefits specifically around the preferred alternative (Alternative 3).

The County, Tribe, and other stakeholders are excited to embark on this unique opportunity. Through previous stakeholder outreach efforts, unanimous and enthusiastic support has been expressed for advancing the Project and realizing the multiple benefits that are anticipated from this Project. This Project is a microcosm of the broader goal where Tribal and State government partnerships are coming together to support these agencies' and organizations' initiatives. These actions are also in alignment with the broader goals of Ecology, Governor Jay Inslee's Shellfish Initiative, West Central Local Integrating Organization, and the Puget Sound Partnership's Strategic Initiatives to prevent pollution, protect and restore habitat, and recover shellfish beds.

Recycled Water Benefits

The proposed Project is an important element of a more holistic water resources management approach in the region. The specific environmental benefits supported by the Project are described below.

Conserve limited groundwater resources

Currently, irrigation water for WHGC is purchased from the Kitsap Public Utility District (KPUD) and is sourced from groundwater wells in the area that pump from a sea-level aquifer. Quantity of usable groundwater is limited and, eventually, as the local demand for groundwater supplies increases, this water source could decline because it is not being adequately replenished. Additionally, with increased withdrawals from the sea-level aquifer, there is a concern of saltwater intrusion and the associated impacts to groundwater quality over time.

Delivery of recycled water to WHGC would preserve 29 MG per year of potable water from KPUD's groundwater supply system and eliminate the stress to the supply system imposed by dramatic swings in potable water system demands during the irrigation season. Recycled water use will also decrease the risk of saltwater intrusion within the regional sea-level aquifer and extend the useful life of existing potable water infrastructure.

Divert nutrients away from the marine environments and to where they are needed

The proposed Project would virtually eliminate the direct discharge of nutrients to Puget Sound. At this time, the existing Kingston WWTP outfall would be used only intermittently to "exercise" the outfall and keep it operational for emergency situations until such time that a year-round land application or storage site is identified. As a result, the potential negative impacts of excess nutrients on marine life would be avoided and instead, nutrients would be beneficially used as a fertilizer for irrigation purposes. More than 2,300 golf courses in the United States use recycled water for irrigation to take advantage of these types of benefits. Recycled water accounts for 25 percent of total golf course irrigation use in the United States

Restore and replenish streams and fish habitats

Through the infiltration component of the Project, aquatic habitat in Grovers Creek would be improved. Grovers Creek supports Chinook, chum, and coho salmon and steelhead and cutthroat trout. The Tribe has a fall Chinook and chum hatchery near the mouth of the creek, which ultimately flows into Miller Bay. The Project would improve habitat in Grovers Creek and Miller Bay by recharging the aquifer that feeds the creek, increasing the flow of cool, clean water.

Like many streams in the Puget Sound lowlands, Grovers Creek suffers from insufficient baseflow during the dry season. Flow often falls below 2 cubic feet per second (cfs), which is the minimum instream flow for Grovers Creek established in state regulations. The proposed Project would infiltrate about 107 MG per year of highly treated recycled water into the shallow aquifer that provides baseflow to Grovers Creek and its tributaries. Assuming an average infiltration volume of 0.3 million gallons per day, the Project could increase baseflow in Grovers Creek by roughly 0.5 cfs.

Enhance marine life ecosystems

By eliminating direct discharge to Puget Sound, and associated nutrient loading, the Project would provide a wide range of environmental benefits:

Improved Fish Habitat

The Project would help avoid overpopulation of phytoplankton (floating, microscopic plants) and zooplankton (small animals that eat phytoplankton). When the phytoplankton and zooplankton die, they settle to the bottom, where they are decomposed by bacteria that consume DO from the water column. This process can create areas where DO concentrations are too low to support fish and other marine life.

The Project would also help protect eelgrass, kelp, and other plant species important to Puget Sound salmon, crab, and other marine life. The 2016 *Washington State Water Quality Assessment* listed Appletree Cove as impaired by excessive growth of ulvoid algae and reduced eelgrass beds associated with human causes. The Project would reduce the nitrogen loads that can cause plankton to become so dense that it blocks sunlight and limits the growth of eelgrass and kelp.

Improved Shellfish Habitat and Decreased Shellfish Toxicity

- Ocean acidification harms shellfish and other marine organisms that need calcium carbonate to form their skeletons and shells. Climate change is causing increased ocean acidification as roughly 25 percent of carbon dioxide (CO_2) in the atmosphere is being adsorbed into oceans. A 2-year ocean acidification monitoring program completed by the Puget Sound Restoration Fund (PSRF) in 2010 indicates that ocean acidification is contributing to changing seawater chemistry in Puget Sound. The study also found that mechanisms driving more acidic conditions including human-driven activities, such as nutrient loading, were amplifying the effects of changing water quality conditions in Puget Sound.
- Excess nitrogen can trigger blooms of algal species that release toxic substances, such as paralytic shellfish poisoning and domoic acid. These substances can cause illness or death in people or animals eating shellfish from the affected waters. They can also be harmful to animals that are directly exposed to the toxins in the water column. The Project would help reduce the potential for shellfish toxicity associated with excessive nitrogen loading.

Engage the community about our critical water resources

Community education, particularly at the grade school level, is critical to demonstrating the values of the region and highlighting how agencies are acting as stewards of the environment. This Project would allow the County and stakeholders to showcase the importance of preserving the area's water supply and water quality for future generations. Without a venue or showcase project for this type of communication, the message is less tangible and meaningful to residents and children, who will be charged with being stewards of our future water resources and this special ecosystem. This Project would provide a range of opportunities to inform the public about how the Project benefits the environment, public health, and local economy.

Create a community asset

Using water for its "highest and best use" and planning for future resilience keeps long-term costs down for water resources management and controls utility rates. Businesses (and ratepayers) are interested in controlled utility rates, so by planning ahead and investing in resilient supplies, the County will not be forced into emergency investments (and corresponding drastic utility rate spikes) in the future. Making these investments now in a thoughtful and strategic manner will result in the maximum environmental and financial benefit to the area for long-term value.

Implementation

The estimated Project cost for the preferred alternative (Alternative 3) to provide opportunities for summer irrigation and winter infiltration is $13,700,000. A Financial Capability Assessment was conducted to determine the likelihood that the County would be able to provide its share of the non-federal portion of the Project costs. Based on this assessment, it was determined that the projected debt service coverage ratio would be in the acceptable range based on a number of assumptions for funding sources.

The next step of the Project will be to develop a user agreement with the major stakeholder (e.g., the Tribe) to confirm the level of financial commitment to the Project. Additionally, all applicable sources of grant funding from state, federal, and sovereign nation sources will be explored. As agreements are developed and Project funding is secured, the design phase of the Project would be initiated as required by WAC 173-240-070. Throughout the next steps, the County intends to continue with the stakeholder outreach program to provide status updates and maintain Project support.

Section 1

Introduction

Section 1 provides Kingston Recycled Water Project (Project) background information and defines the purpose and scope of this *Kingston Recycled Water Facility Plan* (Plan). Furthermore, this section identifies the role of Kitsap County (County) as the Project sponsor, facilitating stakeholder involvement, with authority and responsibility for future recycled water facilities.

1.1 Project Background

In 2003, the County began assessing opportunities to use recycled water that could be produced at the Kingston Wastewater Treatment Plant (WWTP) to address long-term County water quantity and water quality goals. Production of recycled water at the Kingston WWTP is one of the specific actions identified in the County's Water as a Resource Policy, adopted in 2009, which aims to conserve groundwater resources, restore the natural hydrologic flow in local streams and creeks, and reduce water pollution.

The County engaged Golder Associates to evaluate numerous recycled water applications and consider financial, regulatory, stakeholder, and technical factors specific to the Kingston WWTP. Golder Associates' *Kingston Reclaimed Water Environmental Feasibility Study* (Golder 2010) outlined a recommended approach: produce Class A recycled water and apply to wetlands to augment flows in Grovers Creek.

In 2015, the County initiated the Project to build on previous planning efforts and select a preferred recycled water option. Potential beneficial uses were refined based on continuing assessment and through discussions with area stakeholders to identify shared interests and goals. Implemented alone or in combination, beneficial-use opportunities included irrigation of the White Horse Golf Course (WHGC), wetlands/stream flow augmentation, and groundwater infiltration. The *Kingston Recycled Water Project: A Preliminary Investigation of Recycled Water Opportunities in the Kingston Area* (BC 2016) report summarizes the County's efforts and findings to date and includes a "baseline" option. This baseline option was developed to demonstrate to the stakeholders what a representative Kingston recycled water project would look like and what it would cost. Appendix A provides select sections of the 2016 report, including identification and evaluation of alternatives, a summary of stakeholder goals, and conceptual analysis of Project components.

The baseline option (see Figure 1-1) was selected as the representative project because it provides several water quality and quantity benefits, flexible end-use locations, and met the goals of the major stakeholder (e.g., County and Tribe). Components of the baseline option included:

- Treatment upgrades at Kingston WWTP to produce Class A recycled water
- Pumping, conveyance, and equalization (EQ) infrastructure to deliver Class A recycled water to the area north of WHGC
- Infiltration gallery to allow winter indirect groundwater recharge to the area north of WHGC

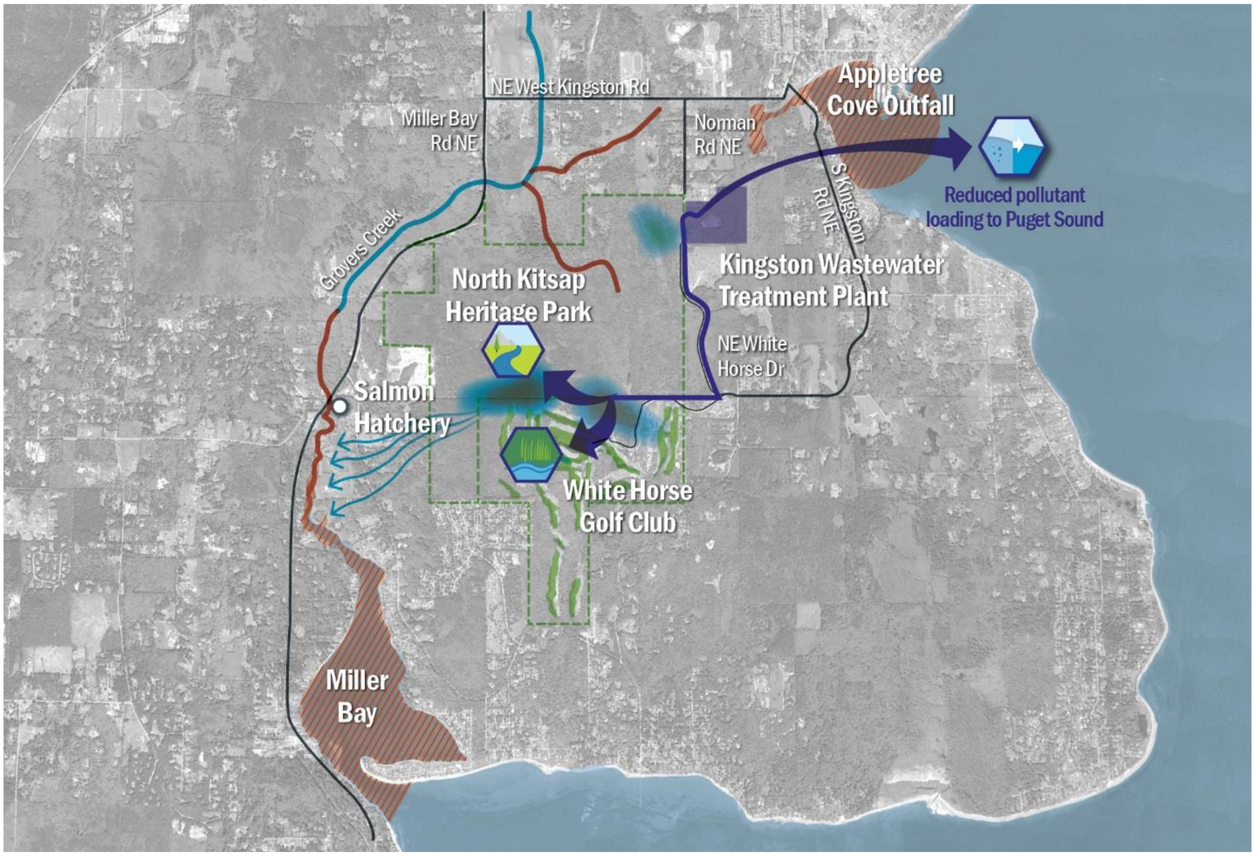


Figure 1-1. Baseline option summary

1.2 Purpose and Scope

The purpose of this Plan is to build on the BC 2016 report and further assess recycled water conveyance and use/disposal alternatives, focusing on irrigation, infiltration, and continued discharge to Puget Sound. The alternatives are evaluated against each other and the "no action" alternative using factors such as overall environmental benefit and cost. The preferred alternative is refined herein to a conceptual level for regulatory approval prior to design and implementation of the preferred alternative by the County.

This Plan has been prepared consistent with Washington Administrative Code (WAC) Sections 173-240-060 and 173-219-180, and the guidance documentation of the Washington State Department of Ecology (Ecology) and Department of Health (Health). Ecology provides guidance for Facility Plan development in Section G1-4.1 of the *Criteria for Sewage Works Design* (Orange Book) (Ecology 2008). Similarly, Feasibility Analysis guidance is documented in Section 5.2.4 of the *Reclaimed Water Facilities Manual* (Purple Book) (Ecology and Health 2019). Furthermore, because the development of this Plan is partially funded by the United States Bureau of Reclamation (USBR) through its Title XVI Program, the Plan includes specific components that address USBR requirements. Appendix B includes a cross-walk document that identifies Plan components and how they address USBR Title XVI requirements.

The Plan organization was developed to efficiently address Ecology, Health, and USBR requirements, and is structured as follows:

- **Section 1** provides Project background, identifies the planning area, and defines the purpose and scope of the Plan.

- **Section 2** provides information to support recycled water planning, including a service area summary and a description of the environmental setting in the vicinity of the proposed Project.
- **Section 3** evaluates existing wastewater characteristics and presents wastewater flow and load projections based on population forecasts for the planning period
- **Section 4** presents a recycled water market analysis that describes the Project need, identifies the existing potable water resources, and evaluates potential recycled water uses and barriers to recycled water use
- **Section 5** summarizes existing Kingston wastewater facilities.
- **Section 6** presents recycled water alternatives, evaluation criteria, and the results of alternatives analyses. A recommended alternative is identified for further conceptual design.
- **Section 7** summarizes the environmental benefits of the proposed Project and how those benefits are consistent with goals established by regional stakeholders.
- **Section 8** presents the conceptual design for the preferred alternative, staffing requirements for the proposed facilities, and estimated Project costs.
- **Section 9** presents a financial analysis of the proposed Project, including a funding plan.
- **Section 10** identifies the potential environmental impacts of the proposed Project as documented in a State Environmental Policy Act (SEPA) checklist.
- **Section 11** summarizes permitting requirements related to the proposed Project, evaluates potential effects to water rights, and presents initial documentation related to interlocal agreements required for the beneficial use of recycled water generated by the County.
- **Section 12** identifies the subsequent research needs and “next steps” to be performed after completion of the present planning analyses.
- **Section 13** states the Project limitations as established in the contract between Kitsap County and Brown and Caldwell.
- **Section 14** provides a summary of reference documentation cited throughout this Plan.

1.3 Project Planning Area

The Project planning area, as shown in Figure 1-1 above, includes the Kingston WWTP site, North Kitsap Heritage Park (NKHP), WHGC, and adjacent areas. Recycled water irrigation would occur at WHGC while infiltration would occur within the boundaries of NKHP. This Plan also includes analysis of potential Project benefits to Appletree Cove and Puget Sound from reduced (or eliminated) discharge of treated effluent from the current WWTP outfall, and benefits to Grovers Creek from increased stream flows.

1.4 Authority and Management

The County owns, operates, and maintains the existing Kingston WWTP, associated collection system, and outfall discharge to Appletree Cove as described in Section 5. Treatment and discharge at the Kingston WWTP are regulated under Ecology National Pollutant Discharge Elimination System (NPDES) Permit WA0032077. The ownership, operation and maintenance responsibility of the recycled water system elements will be determined once project funding has been established. Future permitting requirements and interlocal agreements between the County and Tribe are addressed in Section 11.

The County representative for the Project is:

Barbara Zaroff
Capital Projects Engineer
Kitsap County Sewer Utility
360.337.5777
bzaroff@co.kitsap.wa.us

The Tribe representatives for the Project are:

Alison O'Sullivan
Suquamish Tribe
Senior Biologist, Fisheries Department
360.394.8447
aosullivan@suquamish.nsn.us

Mark Fisher
Suquamish Tribe
Tribal Engineer
360.394.7128
mfisher@suquamish.nsn.us

1.5 Stakeholder Coordination and Public Involvement

In summer 2016, the County convened a group of stakeholders to provide an update on the Project and engage stakeholders in a dialogue about their objectives and concerns related to the Project. Stakeholders from the following entities were represented at the workshop:

- Kitsap County Public Works
- Kitsap Board of Commissioners
- Kitsap County Parks
- Suquamish Tribe
- Olympic Property Group
- Silverdale Water District
- Kitsap Public Utility District (KPUD)
- White Horse Golf Club
- Port of Kingston
- Climate Reality Leadership
- Washington State Department of Health
- Washington State Department of Ecology
- Washington State Department of Fish and Wildlife (WDFW)

The Project team gave an overview of area water issues, a description of the Project, and an outline of identified shared stakeholder goals. Following this presentation, the team's public outreach specialist facilitated a discussion with the group to confirm shared priorities and goals, identify any concerns or missing information, refine participation scope and roles, and explore preliminary funding strategies. Significant support for the Project was demonstrated by the stakeholders, with no direct opposition raised. There was general agreement that the Project planning efforts should move ahead to better understand the overall Project infrastructure details, costs, benefits, and funding opportunities.

Following the initial planning effort for the present analyses, a second stakeholder and public outreach meeting was held on June 26, 2018. The meeting provided an overview of the Project and two area case studies by King County and the Cities of Lacey, Olympia, and Tumwater and Thurston County (LOTT) Clean Water Alliance. The public was provided the opportunity to listen to presentations on each of these recycled water programs and visit with Project representatives in an open-house format before and after the presentations. King County focused on golf course use of its recycled water while LOTT focused on infiltration of recycled water.

Each presentation was followed by a “question and answer” session where attendees were encouraged to ask questions and provide feedback on the proposed Project. In general, support was expressed for the concept of developing a recycled water program and realizing the potential benefits and not just “wasting” the water by discharging it to Puget Sound. Stakeholder concerns centered around the following three main themes:

- **Fate and transport of recycled water and potential chemicals of concern:** What are the risks of chemicals of concern and what does the science say?
- **Impacts to the environment:** Has background/baseline sampling been conducted to determine the impact that recycled water could have on the ecosystem?
- **End-use options:** Where else could the recycled water be used (e.g., future ball fields)?

Public outreach meeting materials, including attendee list, meeting notes, and presentation slides, are provided in Appendix C.

Section 2

Service Area Characteristics

This section provides information to support recycled water facilities planning, including a description of the service area zoning and population, as well as the environmental setting in the vicinity of the Project planning area. The existing Kingston WWTP and proposed treatment, conveyance, and beneficial-use improvements are located outside of the existing sewer service area. The planning area for recycled water improvements is located to the south and west of the Kingston service area/urban growth area as shown in Figure 2-1.

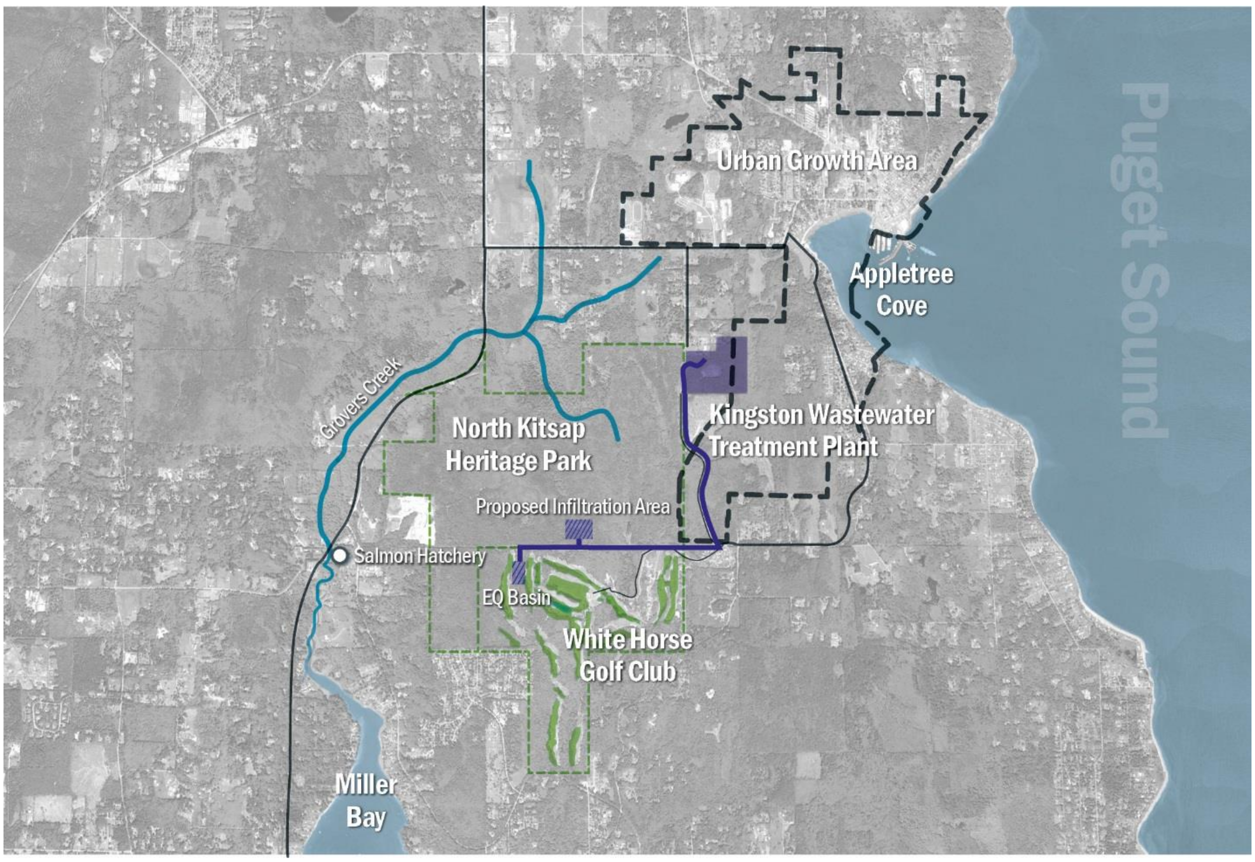


Figure 2-1. Project planning area

Information on service area boundaries and population projections used in developing this Plan was based on the *Kingston Wastewater Facilities Plan Update Addendum* (BHC 2013), updated to account for 2016 population data available at www.census.gov, and to project out to a 20-year horizon (for a design year of 2040). Population forecasts, and the associated flows and loads, are discussed in Section 3.3.

2.1 Service Area Land Use, Zoning, and Demographics

This section describes land use, zoning, and demographics characteristics of the service area, both existing and future.

2.1.1 Existing Service Area

Kingston is Kitsap County's northernmost urban growth area (UGA). The Kingston UGA was originally established in May 1998. Kitsap County most recently updated the Kingston Sub-Area Plan and the Kingston UGA as part of its *2012 Comprehensive Plan* (Kitsap County 2012).

The current Kingston UGA, as shown in Figure 2-1 above, is approximately 1,400 acres in area. Wastewater facilities planning for Kingston is based on providing service to the entire UGA. Figure 2-2 shows zoning designations for the UGA. Development within the service area is primarily residential, with higher densities located north of NE West Kingston Road, which roughly divides the service area into north and south sections. Existing commercial development is located adjacent to State Route 104, in the north section of the service area.

2.1.2 Future Service Area

Analysis in this Plan assumes continued development within the UGA only, consistent with the zoning designations identified in Figure 2-2. The current sewer collection system serves most of the northern portion of the UGA. It is conservatively assumed that the entire service area population will be sewered within the 20-year planning period. Figure 2-3 shows the current and projected future collection system infrastructure as discussed in the 2013 Facilities Plan Update.

Population growth forecasts are discussed in Section 3, as they relate to projected wastewater flows and loads. It is assumed that the nonresidential population (employment-based) will remain commensurate with the existing population-to-employment ratio.

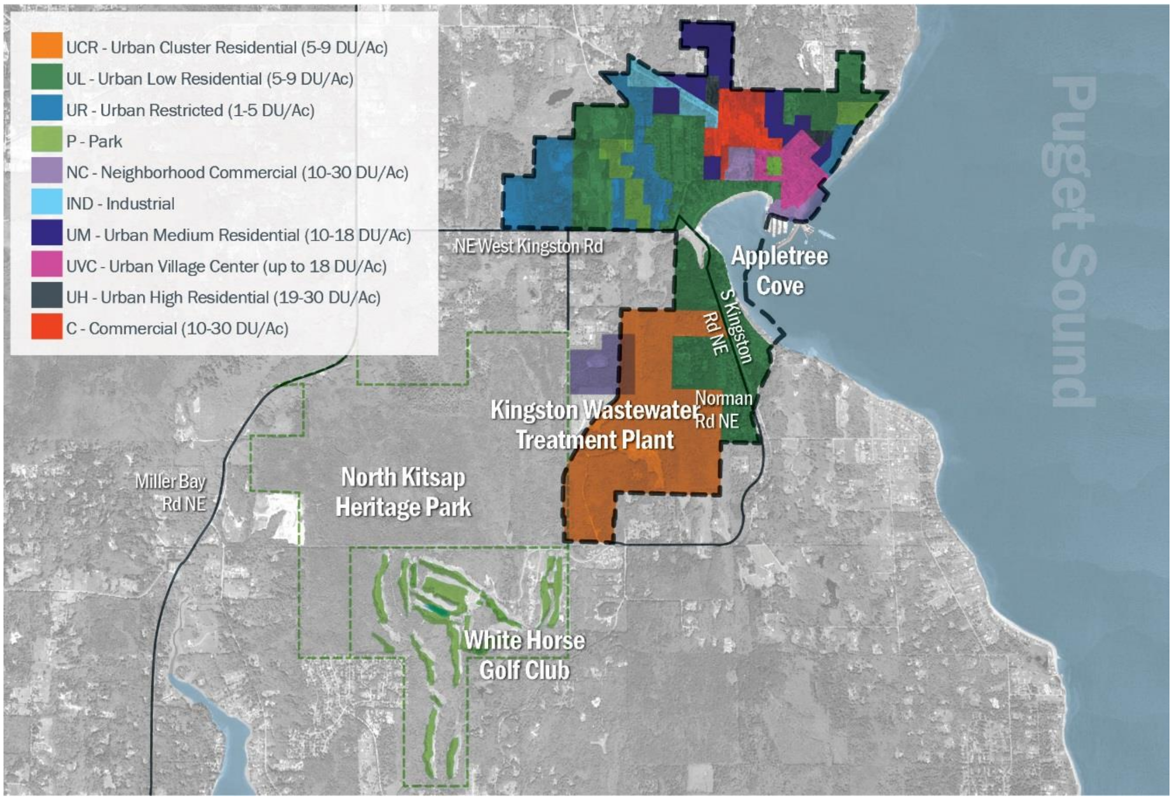


Figure 2-2. County zoning designations

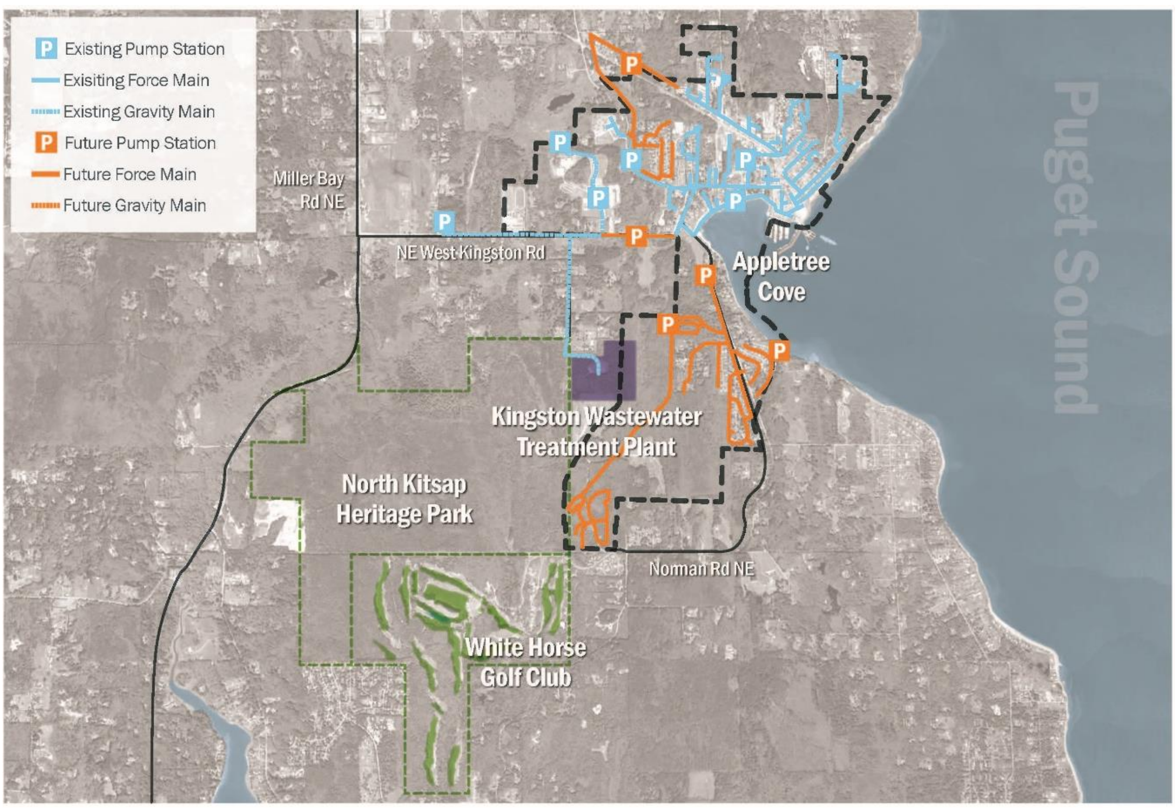


Figure 2-3. Collection system infrastructure

2.2 Recreation and Open-Space Alternatives

The Project area has numerous opportunities for active and passive recreation activities. NKHP is a 799-acre park located in the Project area. This park is largely undeveloped with several miles of developed trails and existing logging roads. This park provides opportunities for walking, hiking, and trail running along the trails and logging roads. WHGC, owned by the Tribe, is an 18-hole golf course with putting greens, chipping area, and clubhouse. The county also has many popular bike routes.

2.3 Environmental Setting

This section discusses the environmental setting for the proposed recycled water improvements at the existing Kingston WWTP and in the vicinity of conveyance and beneficial-use alternatives.

2.3.1 Topography and Geology

This section summarizes the *Hydrogeologic Site Characterization Report* prepared to support evaluation of potential groundwater recharge facilities (see Appendix D). Site-specific investigations for potential recharge areas were used to develop conceptual design analyses presented in Section 8.

2.3.1.1 Topography

Topography in the vicinity of the Project ranges from sea level to approximately 400 feet above mean sea level (amsl) and is reflective of flat-topped rolling hills and ridges originating as glacial drumlin features. In the area near Kingston, steep slopes rise from Puget Sound to more than 400 feet within 0.25 mile of the waterfront. Upland areas are predominantly recharge areas where water percolates downward until reaching a lower-permeability zone and forming discharge areas. Surface water features in the area generally coincide with the local groundwater levels in the adjacent uplands and serve as the overall drainage network for the uplands recharge.

2.3.1.2 Geology

The surficial geology of Kitsap County consists primarily of glacial deposits and includes complex sequences of low-permeability tills and lacustrine sediments and higher-permeability outwash sequences that range from gravels to silty fine sand. The relatively low permeability of the glacial till units is attributed to both the finer textures and higher compaction from sub-glacial deposition. Throughout Kitsap County and most of the Puget Sound region, the Vashon Stade of the Frasier Glaciation advanced and retreated between approximately 18,000 and 14,500 years ago, overriding a thick sequence of older glacial sediments deposited over a period of more than 50,000 years. To a lesser extent, more recent alluvial deposits occur within the incised drainage systems. Throughout the Project area and surrounding regions, surficial geology generally consists of flat-topped rolling hills and elongated ridges characteristic of glacial drumlin landforms.

2.3.2 Climate and Precipitation

Climate within the vicinity of Kingston is characterized by mild weather conditions including short, cool, dry summers and prolonged, mild wet winters. Below-freezing temperatures occur infrequently and for short durations during the winter while summer temperatures rarely exceed 80 degrees Fahrenheit (°F).

The seasonal variation results from the position of the Pacific High, a high-pressure air mass that varies in position along the Pacific Coast. The Pacific High reaches its northernmost position during the summer months and brings with it typically clear and sunny days. During the winter months, the Pacific High recedes to the south and is replaced by a low-pressure system associated with rainstorms that cover paths several hundred miles in width. Transitions between the wet and dry seasons occur in early fall and late spring. Approximately 70 to 80 percent of annual precipitation occurs in 6 months, between October and March.

Table 2-1 summarizes monthly temperature and precipitation data.

Table 2-1. Monthly Climate Summary

Month	Average High Temperature (°F)	Average Low Temperature (°F)	Average Precipitation (in.)
January	47	37	4.8
February	50	37	3.4
March	54	39	3.5
April	59	43	2.8
May	64	48	2.2
June	70	52	1.6
July	76	56	0.8
August	76	57	1.0
September	71	53	1.5
October	60	47	3.4
November	51	41	5.8
December	46	36	5.4

2.3.3 Water Resources

This section provides information with respect to various surface water and potential connection to groundwater resources. A more detailed discussion of groundwater resources is provided in Appendix D.

2.3.3.1 Surface Streams

Kitsap County surface water is characterized by small rivers and creeks that drain directly to Puget Sound. Many surface waters are connected hydrologically to systems of wetlands and areas of shallow groundwater. Kingston WWTP is located on the topographic divide between the Grovers Creek drainage to the west discharging to Miller Bay and Carpenter Creek to the east discharging to Appletree Cove. The proposed recycled water facilities discussed herein would be located within the Grovers Creek watershed.

The mainstem of Grovers Creek consists of approximately 5.1 miles of stream channel, plus numerous small tributaries, flowing to the south and discharging to Miller Bay. Grovers Creek is classified as a Class AA stream under WAC 173-201A, with designated uses including:

- Salmon and trout spawning, core and non-core rearing, and migration
- Wildlife habitat and shellfish harvest
- Primary contact recreation, boating, and aesthetic values
- Domestic, industrial, and agricultural water supply, and stock watering
- Commerce and navigation

Stream flows in Grovers Creek have been monitored by the Washington State Department of Natural Resources (1991–96) and the Suquamish Tribe (2004–05). Summer low flows in Grovers Creek

(1.5 cubic feet per second [cfs]) do not meet minimum instream flows (2 cfs) established in WAC 173-515. Grovers Creek is listed as impaired for fecal coliform and dissolved oxygen (DO) immediately upstream of the mouth at Miller Bay, and for fecal coliform at two additional upstream reaches.

The Tribe operates the Grovers Creek Salmon Hatchery, a fall Chinook and chum salmon hatchery, located as shown in Figure 1-1.

2.3.3.2 Marine Environments

Puget Sound is a complex estuarine system of interconnected waterways and basins. Puget Sound circulation is driven by tidal currents with surface outflow of freshwater from rivers discharging to Puget Sound and deep inflow of saltwater from the Pacific Ocean. Deep, dense saltwater enters Puget Sound through the Strait of Juan de Fuca and Admiralty Inlet, which is located to the north of the Project area.

Local flow patterns and density conditions have been studied primarily to support design of the existing Kingston WWTP outfall discharge to Appletree Cove (CH2M Hill 2000). The mean predicted tidal range for the area is approximately 7.3 feet. Currents flow alongshore and generally mirror bathymetric contours. During flood tide, net currents are to the north and west, reversing direction to the south and east during ebb tide. In general, ebb tides are stronger than flood tides. Density measurements indicate lower-density waters to a depth of 33 to 50 feet, with denser marine waters below.

Puget Sound is classified as Extraordinary water quality with respect to water quality standards for aquatic life uses identified in WAC 173-201A. Additional designated uses include shellfish harvest, primary contact recreation, wildlife habitat, navigation, boating, and aesthetic uses. Ambient concentrations of toxic parameters (primarily metals) used to evaluate compliance with water quality standards and support outfall design were very low.

Puget Sound provides habitat to numerous plant and animal species. Discussion of all of these species is beyond the scope of this Plan; however, shellfish are of particular interest with respect to the potential impact of effluent discharge from Kingston WWTP on commercial shellfish resources. A shellfish closure zone, where all shellfish are decertified for human consumption by Health, currently is in effect within Appletree Cove (see Figure 2-4). The closure zone is due to presence of the Port of Kingston marina, Washington State Ferries terminal, and associated commercial activities. With the extension of the Kingston WWTP outfall in 2005 to deeper waters outside of Appletree Cove, discharge of effluent from Kingston WWTP no longer affects shellfish within the commercially harvestable zone (depths less than 70 feet).

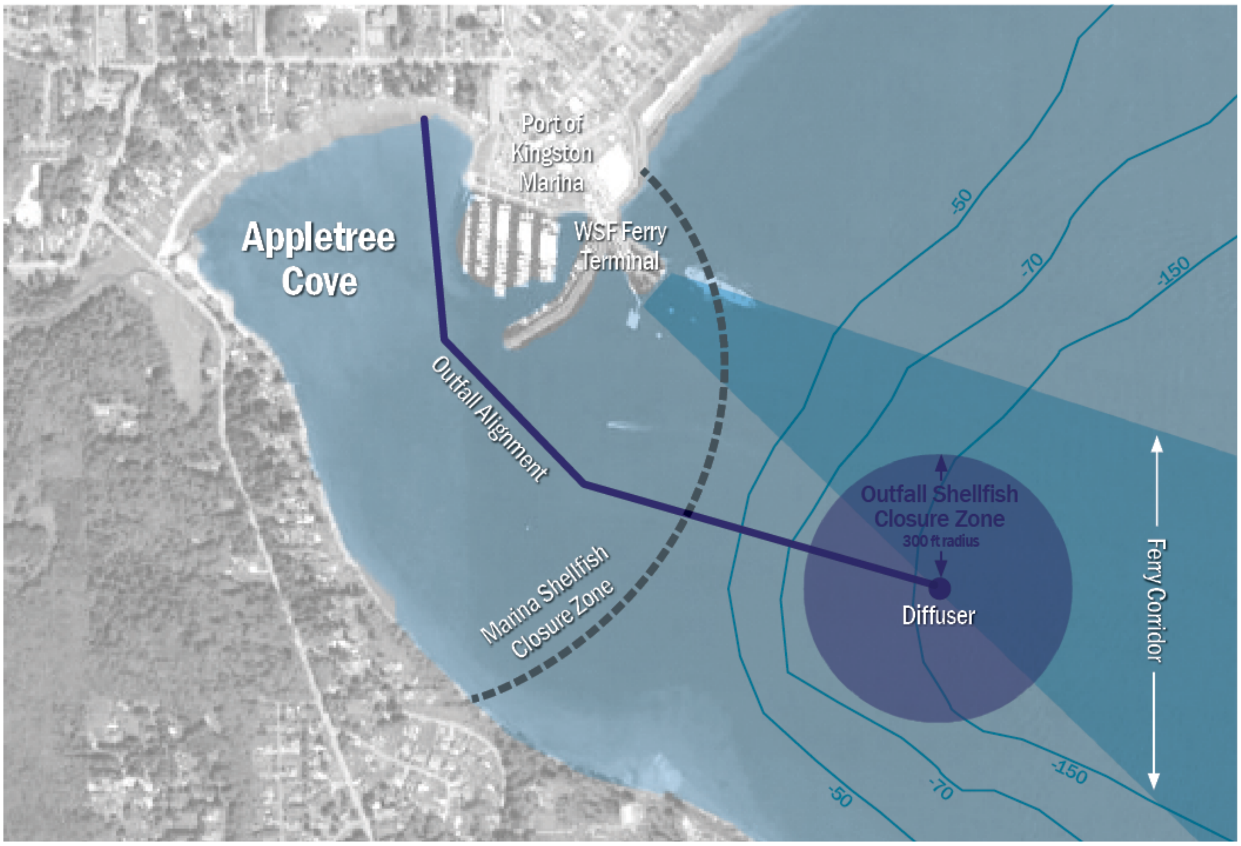


Figure 2-4. Shellfish closure zone

2.3.3.3 Wetlands

A wetland reconnaissance was conducted in February 2018 along the potential pipeline alignments from the WWTP to WHGC. No wetlands were delineated as part of this effort, but wetlands were identified for location. Nine wetlands and three streams were identified between the WWTP and the intersection of the Spine Line and Whitehorse trails in the vicinity of proposed conveyance alignments. The four northernmost (1–4) wetlands are believed to be headwaters of small tributaries to Grovers Creek. The northernmost wetland (1) contains segments of open water, emergent vegetation, and scrub shrub vegetation, with mature trees located near the wetland edges. The other three wetlands (2–4) are forested, scrub-shrub, and slope wetlands that are near the existing Spine Line Trail. The five southern wetlands (5–9) are forested scrub-shrub and depressional wetlands.

Locations of the wetlands and details of the reconnaissance are provided in Appendix E.

2.3.4 Sensitive Areas

Sensitive areas include floodplains, aquifer recharge areas, and Shorelines of the State. Floodplains, also known as Special Flood Hazard Areas (SFHAs), are defined as geographic areas that are identified by varying levels of risk and are identified using a Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map. No identified SFHAs are located in the vicinity of conveyance and beneficial-use alternatives, or near Kingston WWTP.

Aquifer recharge areas are portions of the land that contain hydrogeologic conditions that facilitate aquifer recharge and/or potentially transmit contaminants to an underlying aquifer. In Kitsap County, aquifer recharge areas are sorted into two categories, including Category I critical aquifer recharge areas, which are defined as areas where the probability that groundwater may be adversely impacted by certain land use activities is high. Kingston WWTP is located in a Category I critical aquifer recharge area, and each of the conveyance routes crosses portions of Category I areas. Category II critical aquifer recharge areas are areas that provide recharge to aquifers that are currently or potentially will become potable water sources and are vulnerable to contamination based upon the type of land use activity.

Washington's Shoreline Management Act (SMA) aims to protect the state's shorelines by providing a universal state standard in the approach to preserving water quality and enhancing recreation opportunities in the state shorelines. The SMA establishes a broad policy giving preference to uses that protect the quality of water and the natural environment, are water-dependent uses, and maintain and increase public recreation access to the shorelines and nearby areas. No Shorelines of the State are located in the Project vicinity.

Sensitive areas are shown on Figure 2-5 with reference to the Kingston WWTP, conveyance and beneficial use improvements. Analysis of potential conveyance routes is presented in Section 6.

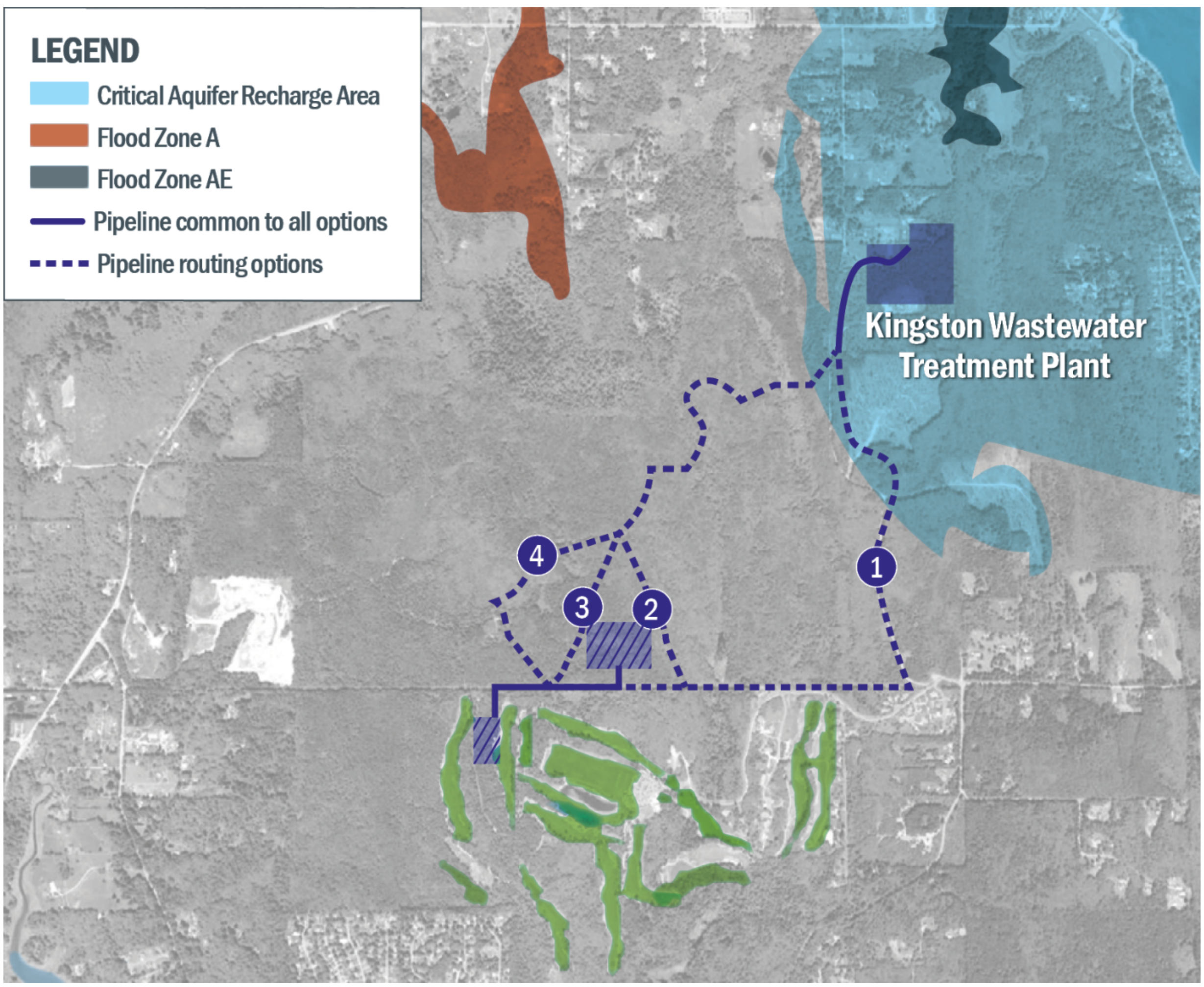


Figure 2-5. Sensitive areas map

2.3.5 Wildlife Habitat

Fish and wildlife habitat conservation areas are summarized in WAC 365-190-130, and Class I wildlife habitat conservation areas are defined in Kitsap County Code 19.300.310 to include the following areas:

- Habitats recognized by federal or state agencies for federal and/or state listed endangered, threatened, and sensitive species documented in maps or databases available to Kitsap County, including but not limited to the database on Priority Habitats and Species provided by WDFW
- Areas targeted for preservation by the federal, state and/or local government that provide fish and wildlife habitat benefits, including but not limited to important waterfowl areas identified by the U.S. Fish and Wildlife Service and WDFW wildlife areas
- Areas that contain habitats and species of local importance that have not been identified at this time, and may be identified at a later date through a public process when information necessitating such identification is made known

WDFW is tasked with keeping a list of priority habitats provided to WDFW by agency biologists and other sources of scientific data about species and habitat locations.

The conveyance routes for Alternatives 1, 2, and 3 cross the priority habitat for cutthroat trout (see Figure 2-6). No other state endangered, threatened, sensitive, and candidate species; animal aggregations considered vulnerable; or species of recreational, commercial, or tribal importance that are vulnerable were found in the vicinity of the conveyance and beneficial-use options. A bald eagle nesting area is located approximately one-half mile northeast of Kingston WWTP.

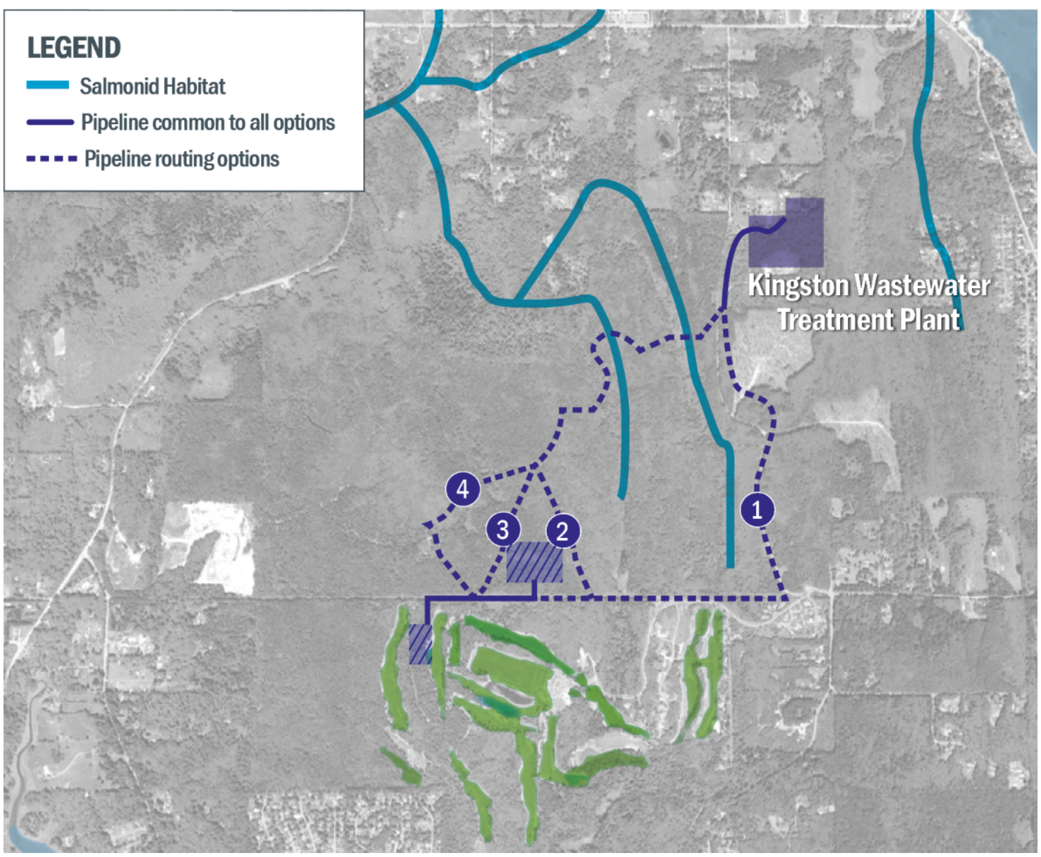


Figure 2-6. Wildlife habitat map

2.3.6 Prime and Unique Farmland

The Farmland Protection Policy Act (FPPA) was passed in 1981 as part of the Agriculture and Food Act (Public Law 97-98). The goal of the FPPA is to minimize the impact of federal projects on farmland caused by conversion to non-agricultural uses. Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, oilseed, and other agricultural crops. Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops. The Natural Resources Conservation Service (NRCS), the federal agency tasked with applying the FPPA, uses the criteria listed in Code of Federal Regulations (CFR) Title 7 Section 658.5 to identify the farmland and gauge impacts.

Land that does not meet the criteria for prime or unique farmland may still be considered to be "farmland of statewide importance" for the production of food, feed, fiber, forage, and oilseed crops, as determined by appropriate state or local government agency or agencies and the Secretary of Agriculture.

Prime and unique farmland, as well as farmland of statewide importance, are shown on Figure 2-7. Most of the Project area is forested and does not constitute prime or unique farmland.

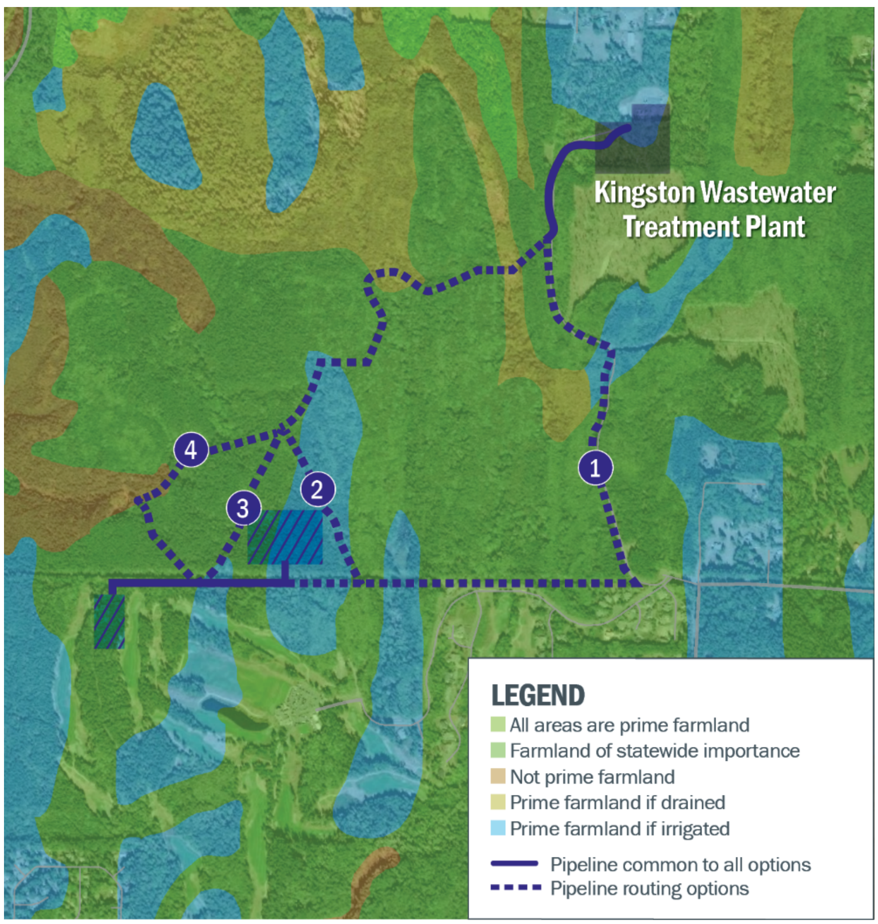


Figure 2-7. Prime and unique farmland map

2.3.7 Archaeological and Historical Sites

No recorded archaeological sites are located in the Project area. Figure 2-8 is a probability map showing the likelihood of encountering a buried, cultural resource in the Project area. This map is a tool produced by the Department of Archaeology and Historic Preservation (DAHP) that is commonly used as a "first step" in cultural resources investigations. The probabilities are calculated using data such as landform and proximity to known activity areas. The model does not, however, account for modern impacts. For example, a road corridor may be considered "very high risk," but it actually would be low risk because of impacts caused by road construction and utility installation. The model is a guide and should not be used in isolation. Based upon the predictive model, all of the conveyance alternatives would be considered a moderately low to high possibility of encountering buried archaeological resources.

Once a preferred alternative has been determined, a more comprehensive examination of that area will be performed. The comprehensive examination would include a review of previously recorded archaeological sites and cultural resources surveys conducted in the area, a landform and geomorphological study, historic research, and a review of available geotechnical logs. The results of that examination guide cultural resources recommendations, which can vary from subsurface investigation, archaeological monitoring, or no additional work.

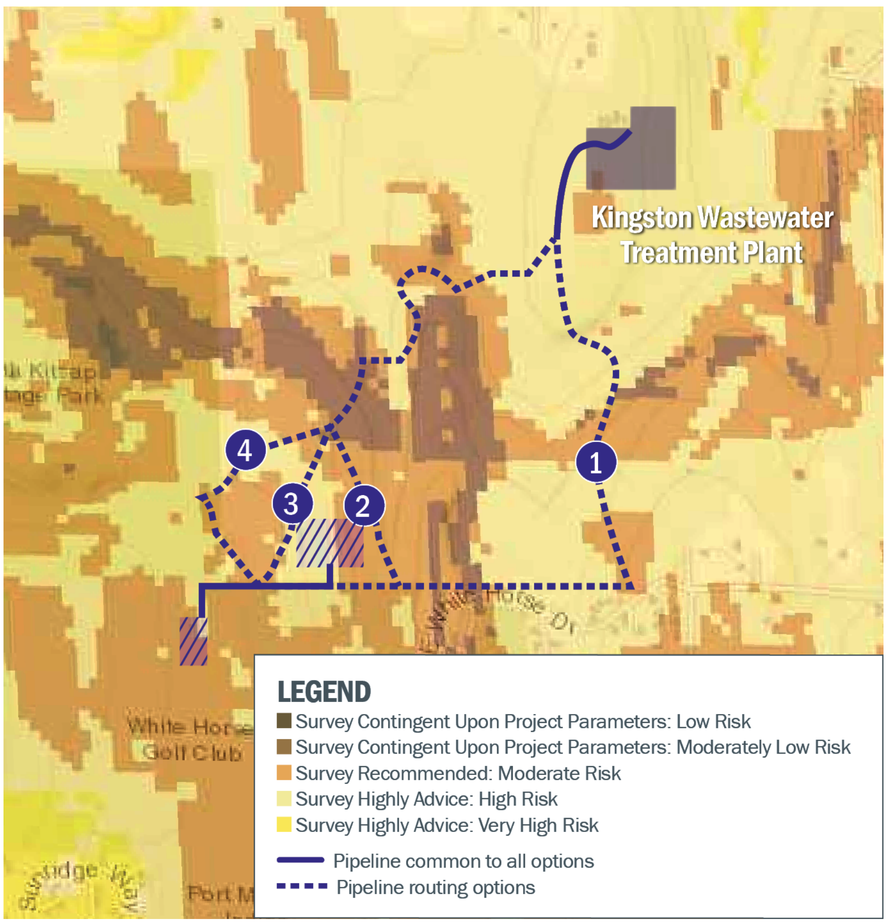


Figure 2-8. Archaeological and historical site probability map

The Suquamish Tribe was contacted in September 2018 to inquire about ethnographic and/or cultural information they may have and wish to share with regard to the project area. The statement below was provided by the Suquamish Tribe's Tribal Historic Preservation Officer (THPO), Dennis Lewarch on October 1, 2018.

"The Suquamish Tribe does not have specific ethnographic period references or place names for the potential project elements. Areas with wetland habitats may have been or may continue to be used by Suquamish people. The Suquamish Tribe's cultural resource sensitivity model incorporates soil types to estimate native vegetation that may have been used by hunter-fisher-gatherers and does not rely as heavily on distances to sources of fresh water, unlike the predictive model used by DAHP."

2.3.8 Wild and Scenic Rivers

The national Wild and Scenic Rivers system was created in 1968 by Congress through the Wild and Scenic Rivers Act (Public Law 90-542; United States Code [USC] Title 16 Section 1271 et seq.); this system includes special protections for rivers that have remarkable scenic, recreational, geologic, fish and wildlife, historic, or other similar characteristics. No Wild and Scenic Rivers are located in the Project area.

2.4 Air Quality and Public Health

The Federal Clean Air Act of 1992 requires that all federally funded projects be in compliance with state and regional air quality plans. The local air-quality authority for Kitsap County is the Puget Sound Clean Air Agency (PSCAA). PSCAA regulates construction and modification of potential air contaminant sources in King, Kitsap, Pierce and Snohomish counties. PSCCA must be notified of construction projects so that it may review whether a permit is required. However, under Article 6, Section 6.03(c) of PSCAA regulations, municipal sewer systems, including treatment plants, are exempt from new source review provided that they do not use anaerobic digesters or chlorine (Cl_2) disinfection. The Kingston WWTP will not utilize anaerobic digestion or chlorine disinfection.

Section 3

Wastewater Characteristics

This section includes review of existing wastewater flows and loadings to Kingston WWTP, population projections, and projections of future flows and loadings through 2040. These flows and loadings are used as a basis to develop the water balance for recycled water use alternatives and treatment alternatives at Kingston WWTP to produce recycled water.

3.1 Historical Wastewater Flows and Loadings

Kingston WWTP data were reviewed to assess current wastewater characteristics and peaking factors for flows and loadings. Figure 3-1 shows the monthly average and peak day flows from January 2010 to September 2017. The plot indicates the typical seasonal variation, but otherwise Kingston WWTP flow has remained about the same on average over the almost 8-year period. With the exception of 2012, the maximum month flow in each year has been less than half of the current permitted maximum month flow of 0.292 million gallons per day (mgd).

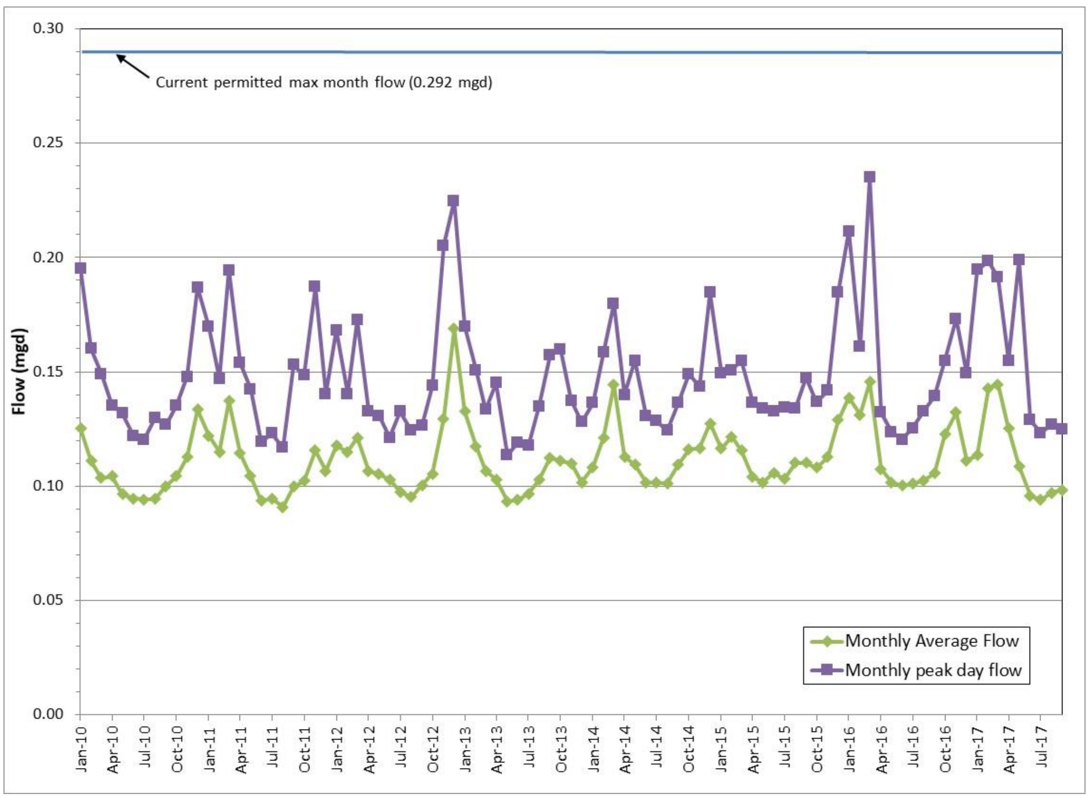


Figure 3-1. Kingston WWTP influent flows, 2010–17

Figure 3-2 and Figure 3-3 show the monthly average and daily peak 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) and total suspended solids (TSS) loadings, respectively, from January 2010 to September 2017. $CBOD_5$ data are shown instead of 5-day biochemical oxygen demand (BOD_5) data as $CBOD_5$ is measured more frequently (typically three times a week while BOD_5 is measured only twice a month). The average $CBOD_5$ to BOD_5 ratio is approximately 0.83. Unlike Kingston WWTP flows, both $CBOD_5$ and TSS loadings have gradually increased over the 8-year period, with more notable increases in $CBOD_5$ loading. Monthly average $CBOD_5$ and TSS loadings have remained significantly below the current permitted maximum month loadings (even after accounting for the $CBOD_5$ to BOD_5 ratio); however, Kingston WWTP has occasionally received some very high daily TSS loadings as shown Figure 3-3.

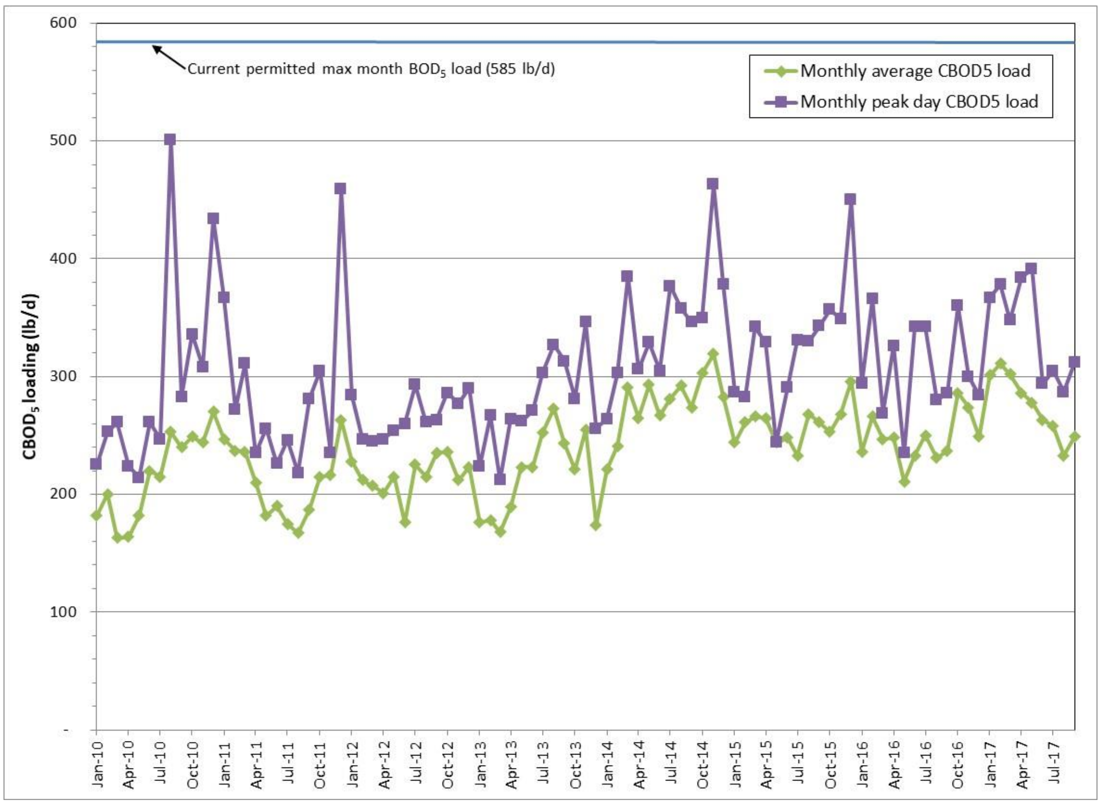


Figure 3-2. Kingston WWTP influent $CBOD_5$ loadings, 2010–17

(Note: $CBOD_5$ data plotted as CBOD are measured more frequently. Average $CBOD_5$-to-BOD_5 ratio is approximately 0.83.)

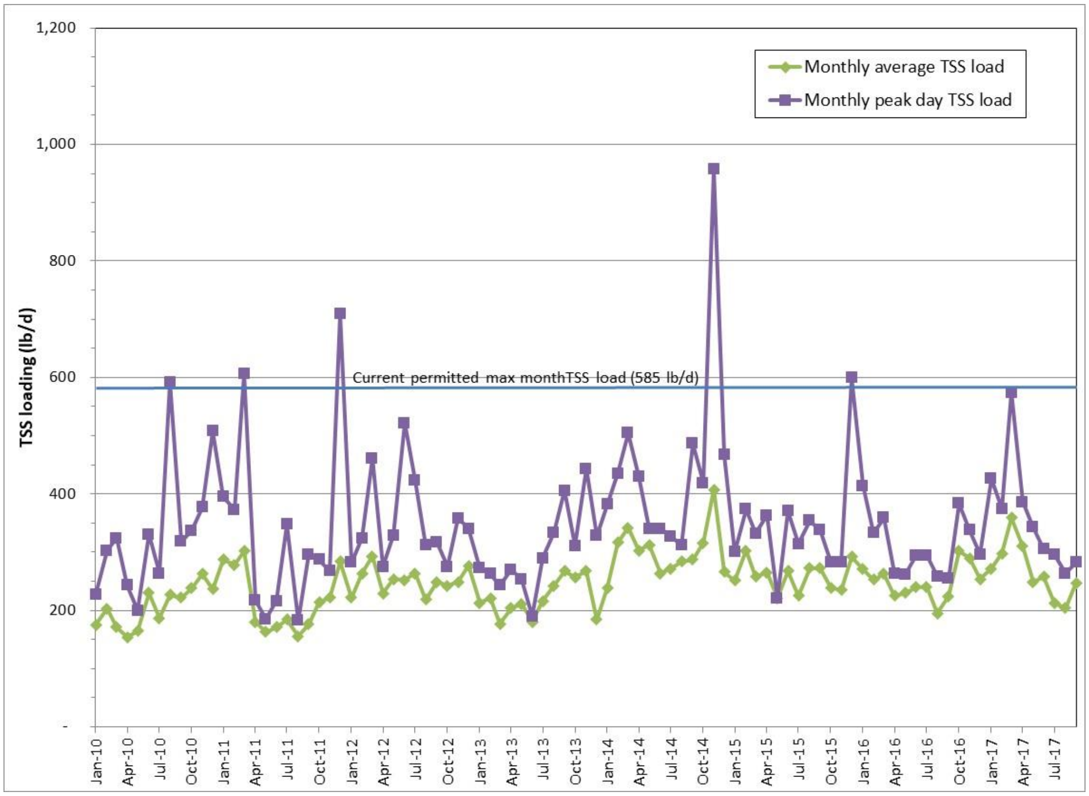


Figure 3-3. Kingston WWTP influent TSS loadings, 2010–17

Flow and load peaking factors were developed from Kingston WWTP data. These peaking factors, summarized in Table 3-1 and Table 3-2 for flows and loadings, respectively, were used to calculate future flows and loadings as described in Section 3.3.

Table 3-1. Flow Peaking Factors

Parameter	Value
Minimum day/AAF	0.75
Average sanitary/AAF	0.95
ADWF/AAF	0.92
MMF/AAF	1.30
PDF/MMF	1.40

Peaking factors derived from 2010–17 Kingston WWTP data, except for the average sanitary flow to AAF ratio, which is calculated from the 2010 average sanitary flow as calculated in the 2013 Facilities Plan Update and the actual 2010 annual average flow.

AAF = annual average flow (average daily flow computed for a calendar year).

Minimum day = minimum daily flow in a calendar year.

Average sanitary = average sewer base flow without I&I.

ADWF = average dry weather flow (average daily flow occurring in dry weather season, May–October).

MMF = maximum month flow (average monthly flow for the month with the highest average monthly flow in a calendar year).

PDF = peak day flow (maximum daily flow in a calendar year).

Table 3-2. BOD_5 and TSS Loading Peaking Factors		
Parameter	BOD_5 [a]	TSS
Average dry weather to annual average	1.00	0.96
Maximum month to annual average	1.20	1.30
Peak day to maximum month	1.50	2.00

Loading peaking factors were derived from 2010–17 Kingston WWTP data.

a. *BOD_5 peaking factors were developed based on $CBOD_5$ data as $CBOD_5$ is more frequently monitored than BOD_5 (3 times per week for $CBOD_5$, 2 times per month for BOD_5). It was assumed that the peaking factors for BOD_5 are the same as those for $CBOD_5$.*

3.2 Population Forecasts

Population forecasts for the Kingston service area are based on the same assumptions used in the Facilities Plan Update, adjusted based on data developed by the Kitsap County Department of Community Development (DCD) in 2016 and population data available on the U.S. Census Bureau website (census.gov). Baseline residential population corresponds to 1,858 for the year 2016 based on data provided on the census.gov website. Residential population in 2040 was then calculated by adding the growth capacity projected by DCD to the 2016 number. Total sewered population consists of sewered residential population, employment, and students. For the baseline year 2016, the sewered residential population was estimated by assuming that 40 percent of the residential population was sewered, the same percentage calculated from the 2010 population data given in the Facilities Plan Update. All residential population was conservatively assumed to be sewered in 2040. Table 3-3 summarizes the 2016 and projected 2040 sewered population used to develop future flows and loadings. It was assumed that the residential population and number of employees increases linearly from 2016 to 2040.

Table 3-3. Sewered Population Forecasts		
Parameter	2016 [a]	2040 [b]
Sewered residential population	743	4,710
Employees	632	1,317
Students	2,034	2,034
Total sewered population	4,904	8,541

a. *2016 sewered residential population based on population data from census.gov website, with the sewered population assumed to be 40% of the total population of 1,858 (same percentage for the 2010 population data given in the Facilities Plan Update). 2016 employment and students assumed to be the same as the 2010 numbers given in the Facilities Plan Update.*

b. *2040 sewered residential population and employment calculated from the 2016 numbers, plus the growth capacities projected by DCD (2,852 for residential population, 685 for employment), with all residential population sewered by 2040. Student population was assumed to remain the same through 2040 (same assumption used in the Facilities Plan Update).*

3.3 Flow and Loading Projections

In deriving future flows from the projected sewered population, the following assumptions were used:

- 60 gallons per capita per day (gpcd) for residential sewer flow
- 30 gpcd for employee sewer flow
- 16 gpcd for student sewer flow
- 1.5 peak hour factor for sewer base flow only (no inflow and infiltration [I&I])
- 1,100 gallons per acre per day (gal/ac/d) unit flow for peak hour I&I for existing sewered area
- 560 gal/ac/d unit flow for peak hour I&I for new sewered area

With the exception of the I&I unit flow for new service area, the values of these unit flow parameters are the same as those used in the Facilities Plan Update. The per capita flows for the residential and nonresidential population were used to calculate the average sanitary flows (without I&I). In the Facilities Plan Update, the 1.5 peak hour factor and a unit flow factor for peak hour I&I were used to calculate the peak hour flow. In this analysis, it is assumed that the I&I unit flow for new sewered area will be lower than that for the existing areas. The I&I unit flow rate for the new sewered areas was adjusted to obtain a peak hour to annual average flow ratio that matches the peak hour to annual average flow ratio recommended in the Orange Book, published by Ecology in 2008, for the corresponding equivalent population. The equivalent population was calculated to include the residential population, employees, and students, where the latter two were adjusted based on sewer flow contribution. Besides the average sanitary sewer flow and peak hour flow, other wastewater flow parameters were calculated from historical peaking factors given in Table 3-1 above. The current design and projected 2020 to 2040 wastewater flows, in 10-year intervals, are summarized in Table 3-4.

Table 3-4. Projected Wastewater Flows

Parameter	Current Design [a]	2020	2030	2040
Equivalent population	-	2,320	4,115	5,911
Annual average flow (mgd)	0.235	0.146	0.259	0.372
Minimum day flow (mgd)	0.424	0.110	0.194	0.279
Average dry weather flow (mgd)	-	0.134	0.238	0.342
Maximum month flow (mgd)	0.292	0.190	0.337	0.484
Peak day flow (mgd)	0.424	0.266	0.472	0.677
Peak hour flow (mgd)	1.340	0.513	0.855	1.197

*Equivalent population calculated as the sum of residential population, employees, and students, while the latter two are adjusted based on sewer flow contribution. Equivalent employees = employees * 30 / 60; equivalent students = students * 16 / 60.*

a. Design flows provided on the "Kingston Wastewater Treatment Plant and Pump Station no. 71" as-built drawings (June 2003).

Future wastewater loadings, including those for BOD_5 and TSS, were derived based on per capita loading rates and peaking factors given in Table 3-2 above. Loading projections were not provided in the 2013 Facilities Plan Update. The per capita BOD and TSS loading rates were thus derived based on assumptions used in the earlier *Final Kingston Wastewater Facilities Plan* (December 1999). In that document, a value of 0.20 pound per capita per day (ppcd) was assumed to calculate maximum month BOD_5 and TSS loading rates. The same value was used for this analysis, and load peaking factors as summarized in Table 3-4 above were used to calculate other BOD_5 and TSS loading parameters. The projected 2020 to 2040 wastewater BOD_5 and TSS loadings, in 10-year intervals, are summarized in Table 3-5.

Table 3-5. Projected Wastewater BOD_5 and TSS Loadings

Parameter	Current Design [a]	2020	2030	2040
BOD_5 loading (lb/d)				
Annual average	471	387	686	985
Average dry weather	-	387	686	985
Maximum month	584	464	823	1,182
Peak day	848	696	1,235	1,773
TSS loading (lb/d)				
Annual average	471	357	633	909
Average dry weather	-	343	608	873
Maximum month	584	464	823	1,182
Peak day	848	928	1,646	2,364

a. *Design flows provided on the "Kingston Wastewater Treatment Plant and Pump Station no. 71" as-built drawings (June 2003).*

Section 4

Recycled Water Market Analysis

This section describes the existing potable water providers, existing wastewater facilities, and potential recycled water users in the region.

4.1 Potable Water Facilities

KPUD provides potable water to the Project area via the North Peninsula water system. KPUDs Suquamish, Miller Bay and Indianola water systems are located south of the Project area. The existing facilities, projected water supply and demands for the region, and water quality are described in this section.

4.1.1 Existing Facilities

Existing regional potable water facilities are described in the Water System Plan Update (KPUD 2011) and Coordinated Water System Plan (Kitsap County 2005). KPUD wholesale and retail service areas are aligned with the boundaries of Kitsap County. KPUD has 26 Group A water systems and 25 Group B water systems. The North Peninsula, Suquamish, Miller Bay, and Indianola water systems are the primary districts in the region as shown in Figure 4-1. The North Peninsula Water System, located on the northern end of the Kitsap Peninsula, serves approximately 5,400 residential and commercial customers, including WHGC. KPUD manages many other major water systems outside of this Project area. Although not currently connected, KPUD has plans for a series of interties that will connect the Vinland, North Peninsula, and Suquamish water systems.

Recycled water produced as part of the proposed Project would replace potable water use at WHGC provided through the North Peninsula Water System. The North Peninsula Water System has a source capacity of 1,880 gallons per minute (gpm) and a storage capacity of 2.6 million gallons (MG) (Kitsap County 2005). A total of 19 active wells supply the North Peninsula Water System.

The Silver Springs Estates water system is located west of the project area, just north of the northern most reach of Miller Bay. The Silver Springs Estates water system has approximately 30 connections serving approximately 80 residential customers with a single groundwater well (60 gpm capacity). The water system is owned and managed by Washington Water Service Company.

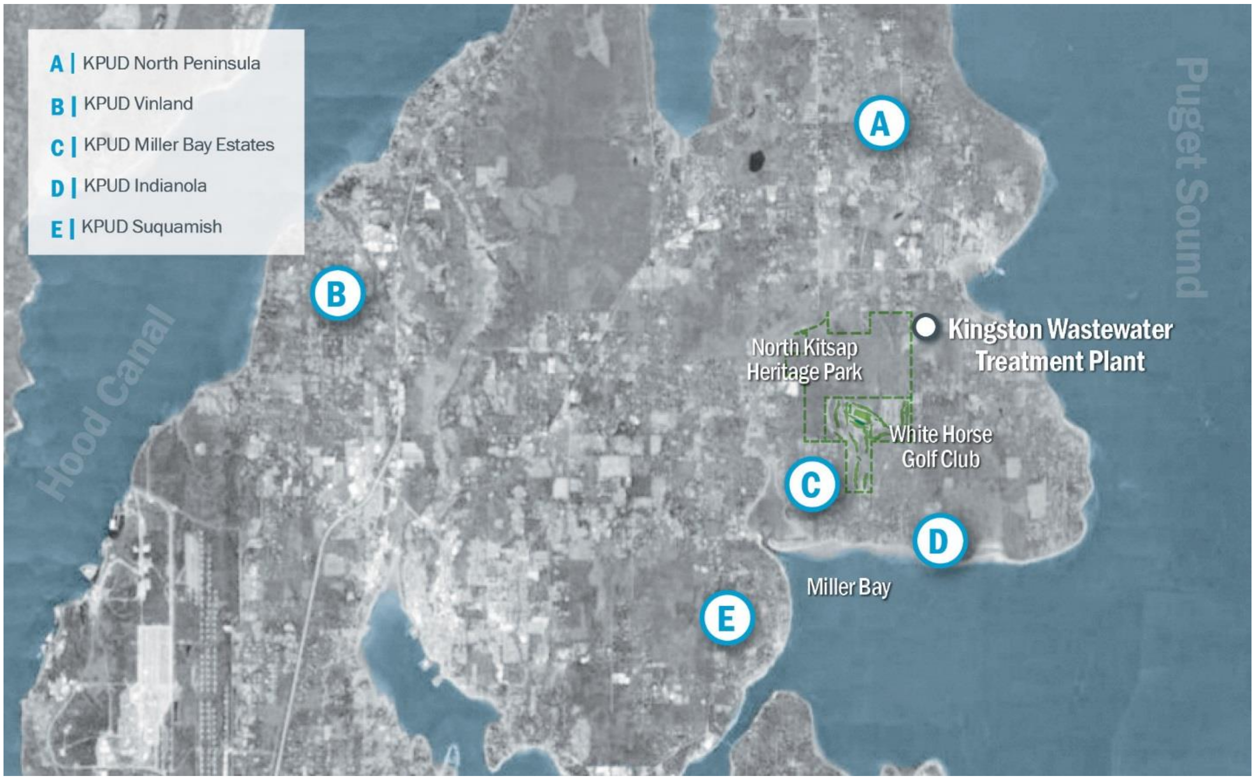


Figure 4-1. KPUD water systems

4.1.2 Regional Water Supply and Demand

Table 4-1 inventories the annual quantity (Q_a) and instantaneous quantity (Q_i) of water rights from the 2012 Kitsap County Capital Facilities Plan. The water rights are inclusive of all water rights, permits, and certificates within Kitsap County including municipal, commercial/industrial, domestic, irrigation, and rights for all other purposes of use.

Table 4-1. Summary of Existing Water Rights Information

Type of Water Right	North Kitsap	Bainbridge Island	Central Kitsap	South Kitsap	Total
Groundwater Rights					
Q_a (mgd)	9.78	9.17	23.77	15.2	57.93
Q_i (mgd)	18.52	16.73	38.05	33.77	107.08
Surface Water Rights					
Q_a (mgd)	0.68	0.09	0.64	0.56	1.97
Q_i (mgd)	0.04	0	0.05	0.06	0.16
Total					
Q_a (mgd)	10.46	9.26	24.41	15.76	59.9
Q_i (mgd)	18.57	16.73	38.1	33.83	107.24

Table 4-2 shows the projected water demands for Kitsap County developed by the Kitsap County Water Utility Coordinating Committee in 2005. Based on previous analyses, existing water sources are sufficient to meet demand through 2030. However, climate change and the potential for saltwater intrusion into groundwater sources (see Section 4.4) have the potential to affect previous supply and demand assumptions. The proposed Project would reduce demand, extending available water supply, and minimize the impact of large peak day demand swings to the local Suquamish Water System.

Table 4-2. Water Demand Projections for Kitsap County

Year	Average Day Demand (mgd)	Maximum Day Demand (mgd)
2010	30.03	69.67
2020	37.57	87.16
2030	42.89	99.5

Source: Kitsap County 2005.

4.1.3 Water Quality

KPUD has a wellhead protection program in accordance with WAC 246-290-135 that includes susceptibility assessments, wellhead delineations, and an inventory of potential sources of contamination on file for all KPUD-owned wells. KPUD staff maintains the file database at the KPUD office.

KPUD chlorinates 19 of the Group A systems with sodium hypochlorite for disinfection and maintains a trace residual throughout the distribution system. Coliform sampling and chlorine residual tests are measured on a weekly basis and reported to Health on a quarterly basis. None of KPUD's water systems have a history of chronic Total Coliform Rule violations and none are under disinfection orders by Health. The North Peninsula system has no active compliance actions at the time of this Plan (Health 2018a).

Kitsap County groundwater frequently contains iron and/or manganese in levels exceeding the secondary maximum contaminant level (MCL). To comply with the secondary MCL requirements for iron and manganese, KPUD installed treatment plants on the following sources (as of 2011):

- **Keyport:** S02
- **North Bainbridge:** S05 and S07
- **Vinland:** S08
- **North Peninsula:** S09 and S10

4.2 Wastewater Facilities Summary

The existing Kingston WWTP is an extended aeration type activated sludge plant that discharges to Appletree Cove in Puget Sound. Kingston WWTP has a design capacity of 0.292 mgd on a maximum month basis. Treatment processes include preliminary treatment through a rotary screen and aerated grit chamber, biological treatment in an oxidation ditch followed by solids settling in two secondary clarifiers, and disinfection with an ultraviolet (UV) light disinfection system. Solids removed from the secondary clarifiers are thickened by a gravity belt thickener (GBT) and then transported to Central Kitsap Treatment Plant (CKTP) for further treatment and disposal. There are currently no tertiary processes for recycled water production. The current discharge permit limits apply to effluent pH, fecal coliform, $CBOD_5$, and TSS. While there are no nutrient limits, the current operating conditions of the oxidation ditch provide partial nitrogen removal. More detailed descriptions of Kingston WWTP, including its existing treatment capacity, are included in Section 5. Treatment alternatives for recycled water production are described in Section 6.

4.3 Recycled Water Uses and Demand

This section describes potential recycled water uses and demands.

4.3.1 Potential Recycled Water Uses

This section focuses on the largest potable water user in the region and expected recycled water user, WHGC. The County has developed a partnership with the Tribe, which owns and operates WHGC. Table 4-3 compares estimated WHGC irrigation demands to Kitsap recycled water projections for the years 2020, 2030, and 2040 on a seasonal basis. Historically, WHGC irrigates the golf course during the months of May through September.

Table 4-3. WHGC Water Demands and Kingston WWTP Projected Flows

Month	WHGC Average Water Demands[a] (mgd)	Kingston WWTP Projected Flows (mgd)		
		2020	2030	2040
January	-	0.162	0.287	0.412
February	-	0.156	0.277	0.399
March	-	0.164	0.291	0.418
April	-	0.141	0.251	0.360
May	0.112	0.134	0.237	0.341
June	0.178	0.130	0.231	0.332
July	0.313	0.129	0.229	0.330
August	0.230	0.131	0.232	0.334
September	0.077	0.139	0.246	0.353
October	-	0.145	0.256	0.368
November	-	0.156	0.276	0.397
December	-	0.165	0.293	0.420

Data based on water use information provided by WHGC for 2013 and 2014.

The region near the Kingston WWTP is primarily commercial and residential. There are few industrial users in the region. Additional potential recycled water users include NKHP and nearby schools, such as Kingston Middle School and Kingston High.

4.3.2 Barriers to Recycled Water Use

By comparing the wastewater projections to WHGC irrigation demands, there is a limitation (see Table 4-3). During the dry season when the golf course irrigates most, the wastewater projections are at their lowest. In 2020, WHGC will require more irrigation demand than what Kingston WWTP can provide. Therefore, potable water will be used to offset the difference between recycled water supply and irrigation demands. Proper cross-connection and backflow prevention will be utilized to eliminate the risk of contamination of the potable water supply (more details are provided in Section 8.5.1).

Moving forward into the planning horizon, the wastewater projections can meet all WHGC projected irrigation demands. Figure 4-2 presents the water balance for the year 2040. When outside of the irrigation season or summer months, recycled water can be infiltrated to recharge nearby streams.

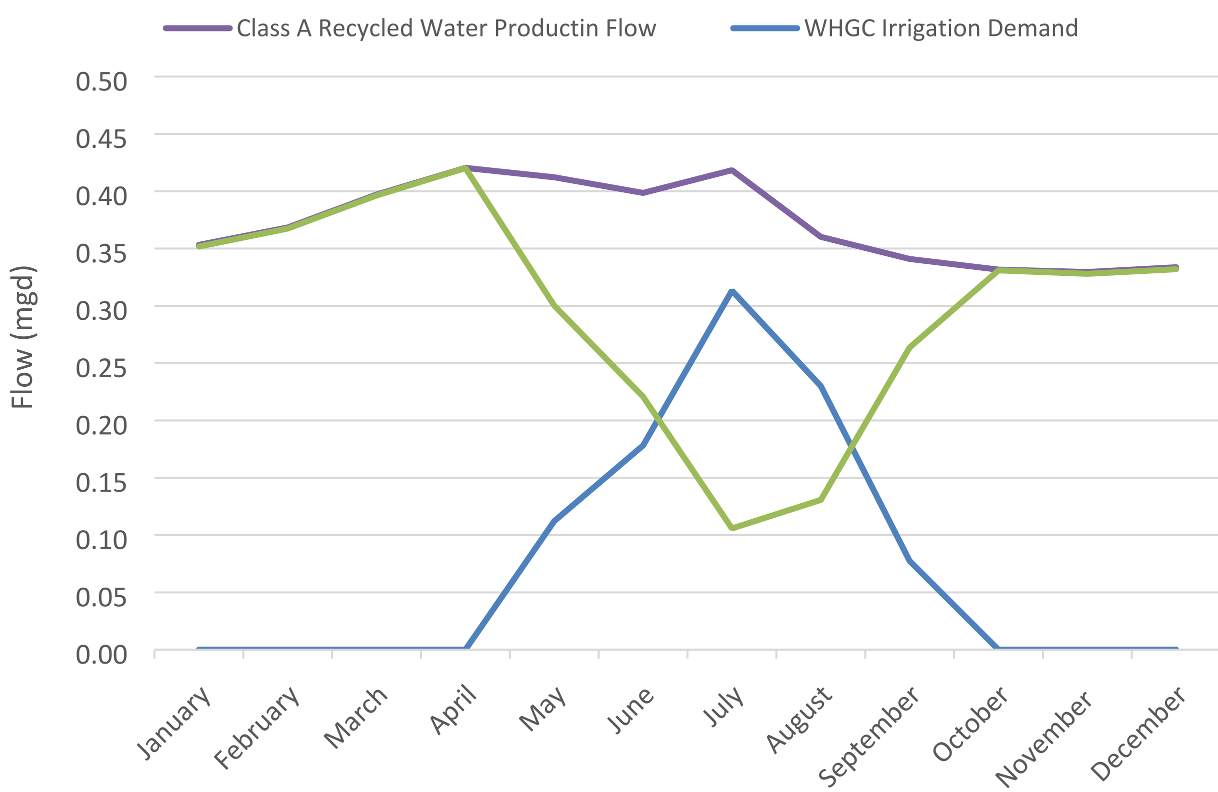


Figure 4-2. Water balance for 2040

4.4 Project Need

This Project would help improve the following issues:

- Water supply scarcity/reliability
- Environmental issues
- Water quality concerns
- Future economic viability

WHGC, owned by the Tribe, currently uses potable water from KPUD to irrigate the golf course. KPUD sources this water from groundwater wells that draw from the sea-level aquifer. The sea-level aquifer is widely used and mostly confined (USGS 2014). Therefore, the quantity of usable groundwater is limited and, eventually, as the local demand for groundwater supplies increases, this water source could decline because it is not being adequately replenished. Additionally, with increased withdrawals from the sea-level aquifer, there is a concern of saltwater intrusion and the associated impacts to groundwater quality over time. There is no evidence of extensive seawater intrusion in the county, but localized seawater intrusion is found in a few areas such as Jefferson Beach in the Kingston sub-area (Ecology 1997). Climate change impacts further compound these issues. Rainfall is projected to be increasingly intense and to result in a greater portion of the precipitation leaving the system directly into Puget Sound as runoff. Additionally, longer and hotter summers from climate change impacts will result in a greater water demand over time, putting even greater stress on the finite potable water supply. This water usage averages approximately 29 MG annually.

Ecology's 2016 *Washington State Water Quality Assessment* (Ecology 2016) placed Grovers Creek in the following categories:

- Category 5 (polluted water that requires a total maximum daily load [TMDL]) because of low DO concentrations.
- Category 4-B (polluted, but has a pollution control that is expected to solve the problem) because of elevated fecal coliform concentrations. Kitsap County's Pollution Identification and Correction (PIC) program is expected to reduce fecal bacteria concentrations in the creek.
- Category 2 ("water of concern") because of elevated temperature and turbidity.

Like many streams in the Puget Sound lowlands, Grovers Creek suffers from insufficient baseflow during the dry season. Flow often falls below 2 cfs, which is the minimum instream flow for Grovers Creek established in state regulations (WAC 173-515-030) (Washington State Legislature 2003). Golder (2010) reported summer flows as low as 1 cfs in August 2005.

Low DO concentrations have caused fish kills in areas with limited water circulation like Hood Canal. The *Washington State Water Quality Assessment* identified Appletree Cove as a "water of concern" because of low DO (Ecology 2016).

There are many benefits from reducing the discharge to Puget Sound and beneficially using recycled water to irrigate WHGC and infiltrate recycled water:

- Conserve limited groundwater resources by minimizing groundwater withdrawals to preserve stream flows and prevent saltwater intrusion
- Divert nutrients away from the marine environments to where they are needed by reducing the Kingston WWTP outfall to Appletree Cove
- Restore and replenish streams and fish habitats by restoring Grovers Creek through infiltration
- Enhance marine life ecosystems and salmonid habitat
- Create a community asset that also addresses future concerns related to growth and climate change

A detailed benefit analysis is described in Section 7.

4.5 Customer Outreach

The County and Tribe held stakeholder coordination and public involvement meetings (see Section 1.5) as part of the development of this Plan. Public outreach meeting materials, including attendee list, meeting notes, and presentation slides, are provided in Appendix C. The County and Tribe would continue to work with their planning partners and involve and inform the public in the planning process through continuing future stages of the Project.

Section 5

Existing Wastewater Facilities

This section describes the existing collection system and treatment facility, as well as assessment of the existing capacity and condition.

5.1 Existing Collection System

The existing collection system services the northern portion of the Kingston UGA. The southern portion of the UGA is currently unsewered. The system consists of more than 12 miles of gravity sewer and force main pipe of which 60 percent is 8-inch-diameter gravity sewer. Approximately 95 percent of the existing collection system was constructed in 1974, including primarily asbestos-cement pipe and shorter lengths of 10- and 12-inch-diameter cast-iron pipe. The remaining 5 percent of the system, built between 1978 and 1984, was constructed using 6- and 8-inch-diameter polyvinyl chloride (PVC) pipe. There are six pump stations, the largest of which (LS-71) is located at the old Kingston WWTP site and discharges to a force main that transfers wastewater from the old Kingston WWTP site to the current Kingston WWTP.

Conveyance system improvements were evaluated in the 2013 Facilities Plan Update. The improvements were developed to provide sewer service to the entire UGA by 2025, including part of the northern UGA that did not have sewer service and the southern UGA. Recommended improvements include pump station upgrades (for LS-41 and LS-71), new manholes along existing gravity sewers, and five new pump stations and associated force mains. The upgraded LS-71 will have a capacity of 630 gpm, while the capacities of the new pump stations range from 10 to 510 gpm. Figure 2-3 above shows the current and projected future collection system infrastructure as discussed in the 2013 Facilities Plan Update.

5.2 Existing Treatment System

The original Kingston WWTP was constructed in 1974 in downtown Kingston. The current facility, located on South Kingston Road, was constructed in 2005. Raw influent enters the headworks, which includes a rotary screen with 1/4-inch openings and a vortex grit chamber. Screenings are washed and grit is separated and dewatered in a grit classifier, with the combined dewatered grit and screenings collected in a dumpster and subsequently disposed of in a local landfill. The screened and degritted wastewater is sent to the oxidation ditch for secondary treatment. The oxidation ditch provides extended aeration biological treatment, typically operated at long solids retention times (SRTs). There are two oxidation ditches but only one of them is currently equipped with two mechanical brush rotors for aeration. The other ditch is not currently in service and can be placed into service in the future when aerators are installed. Mixed liquor from the oxidation ditch is routed to two secondary clarifiers for solids separation. Secondary effluent is disinfected in a UV system consisting of two UV banks of low-pressure lamps. Final effluent is discharged to Appletree Cove via an 18-inch-diameter outfall pipe that extends 5,350 feet into Appletree Cove to a depth of 169 feet below mean lower low water (MLLW).

Waste activated sludge (WAS) from the secondary system is sent to one of two WAS storage tanks. Scum removed from the secondary clarifiers is also sent to the WAS storage tanks. WAS and secondary scum are thickened in a GBT. The thickened sludge is sent to a thickened waste activated sludge (TWAS) storage tank. The GBT is operated approximately once per week and TWAS is hauled to the County's CKTP for further treatment and disposal.

Figure 5-1 shows a process flow schematic of Kingston WWTP. Design data for the major unit processes are given in Table 5-1.

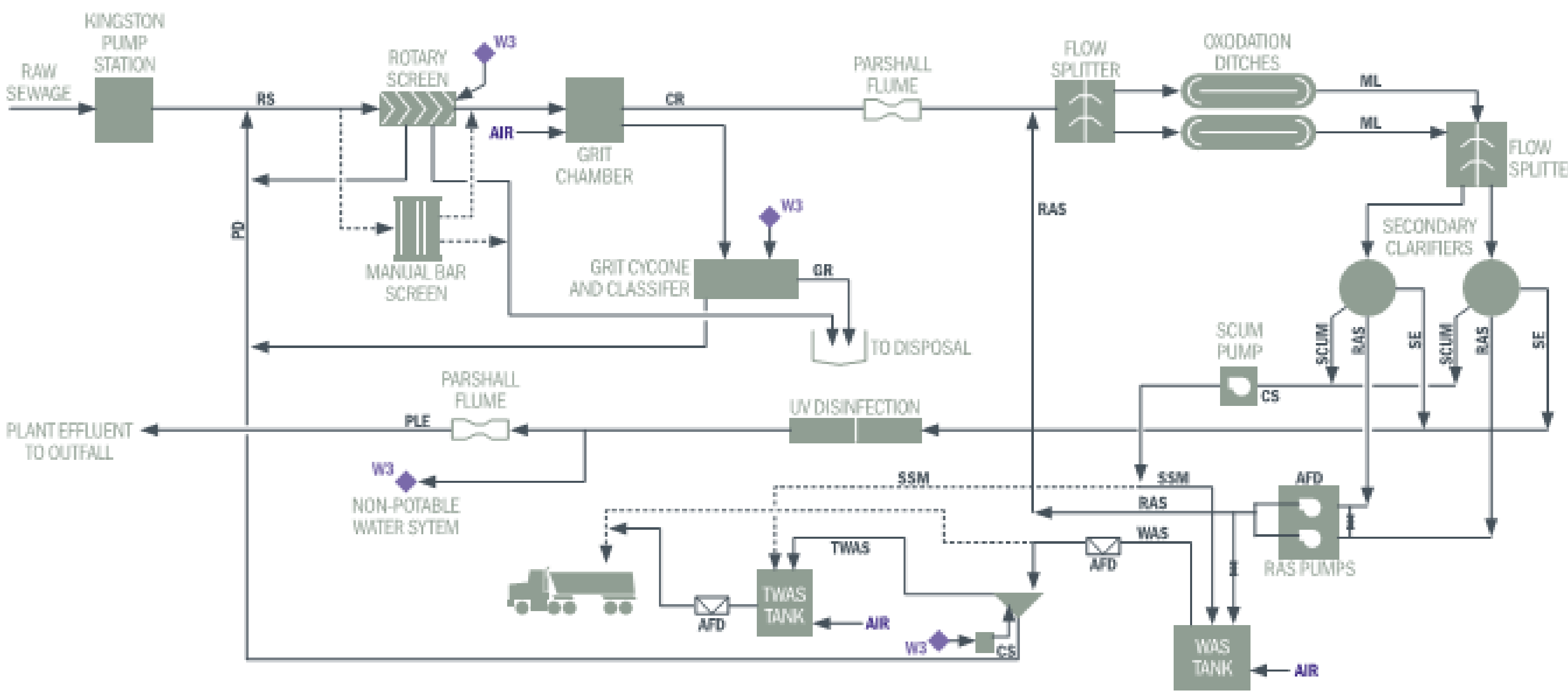


Figure 5-1. Kingston WWTP process flow schematic

Table 5-1. Kingston WWTP Major Equipment Design Data	
Process Element	**Design Value**
Mechanical screens	
Type	Rotary
Number of units	1
Opening size, in.	¼
Grit chamber	
Type	Vortex
Number of units	1
Capacity, mgd	2.26
Oxidation ditches	
Number of basins	2
Dimensions, ft	121 x 35 x 13 (SWD)
Volume, each, gal	262,000
Aeration system (in oxidation ditch only)	
Type	Mechanical brush rotors
Number of units	2
Oxygen transfer efficiency, percent	12
Airflow capacity, scfm	250
Power, each, hp	40
Return activated sludge (RAS) pumps	
Type	Centrifugal, horizontal
Number of units	2
Capacity, each, gpm	275
Power, each, hp	5
Secondary clarifiers	
Type	Circular with spiral-shaped sludge scraper
Number of units	2
Dimensions, ft	35 (dia), 13 (SWD)
Surface area, each, ft^2	1,924
UV disinfection	
Lamp type	Low-pressure mercury
Capacity, mgd	1.6
Design UV dose, mJ/cm^2	37
Number of channels	1
Number of banks	2
Number of lamps per bank	56
WAS storage tank	
Number of tanks	2
Capacity, each, gal	25,000
Mixing system	Coarse-bubble diffusers
Airflow rate, total, scfm	215
Gravity belt thickener	
Number of units	1

Table 5-1. Kingston WWTP Major Equipment Design Data	
Belt size, m	1
Hydraulic capacity, gpm	200
TWAS storage tank	
Capacity, gal	1
Number of tanks	16,000
Mixing system	Coarse-bubble diffusers
Airflow rate, scfm	200

a. Design data provided on the "Kingston Wastewater Treatment Plant and Pump Station no. 71" as-built drawings (June 2003).

Kingston WWTP is currently rated for a maximum month flow of 0.292 mgd and maximum month loadings of 585 pounds per day (lbs/d) for both BOD_5 and TSS. Table 5-2 summarizes the rated capacities and effluent limits in the current NPDES permit.

Table 5-2. Kingston WWTP Rated Capacities and NPDES Effluent Limits

Design Criteria	Value	
Max month flow	0.292 mgd	
Max month BOD_5 loading [a]	585 lbs/d	
Max month TSS loading [a]	585 lbs/d	
Parameter	Effluent Limits	
	Average Monthly	Average Weekly
$CBOD_5$ [a]	25 mg/L 61 lbs/d	40 98 lbs/d
TSS [b]	30 mg/L 73 lbs/d	45 mg/L 110 lbs/d
pH	6.0 (minimum)	9.0 (maximum)
Fecal coliform [c]	200/100 mL	400/100 mL

Based on NPDES permit effective 12/1/2015.

a. Design max month loading values as shown in the permit are slightly different from those shown on the 2003 as-built drawings (which are shown in Table 3-5).

b. The average monthly effluent concentrations for $CBOD_5$ and TSS shall not exceed 25 and 30 mg/L, respectively, or 15% of the respective influent concentration taken over the same calendar month, whichever is more stringent.

c. Limits for fecal coliform are monthly and weekly geometric means, with units defined as colony-forming units (CFU) per 100 mL.

5.3 Treatment Capacity Assessment

This section summarizes the capacity assessment of the major unit processes at Kingston WWTP. The assessment was performed based on the original design criteria and modeling of the secondary treatment system. As the biological process model was not calibrated with detailed sampling data, default parameter values were assumed, and a safety factor is included to provide conservative results. The results provide a framework for determining existing capacity and upgrade requirements to facilitate development of alternatives described in Section 6. More detailed evaluation will be performed during the design phase to fine-tune the requirements.

5.3.1 Preliminary Treatment

Preliminary treatment consists of screening and grit removal. The headworks include a rotary screen with 1/4-inch openings and a manual bar screen in a bypass channel. Grit removal is achieved in a vortex-type grit chamber. The screens and grit removal system were sized for the original peak design flow of 2.26 mgd. As the 2040 design peak hour flow is 1.2 (refer to Table 3-4) mgd based on the most recent projections, the preliminary treatment processes have considerable excess capacity.

5.3.2 Secondary Treatment

Secondary treatment consists of an oxidation ditch and two secondary clarifiers. As mentioned above, there is a second ditch, but it is not equipped with aerators and is not in use. Process modeling indicates that the secondary system currently has excess capacity based on the current permitted effluent requirement. The two secondary clarifiers are predicted to become overloaded with respect to solids loading rates around 2030 to 2035. Aeration limitations in the existing oxidation ditch may occur sooner. To increase the aeration capacity, the second ditch could be placed into service after installing aerators in that ditch, or the aeration system in the existing ditch could be converted from mechanical aeration to fine-pore aeration. Additional analysis would be needed to evaluate any aeration system capacity upgrade. In addition to increasing aeration capacity, placing the second ditch in service will reduce solids loading to the clarifiers and thus avoid overloading the clarifiers through the planning period (through 2040).

5.3.3 Disinfection

The existing low-pressure UV system was originally designed for a peak hour flow capacity of 1.6 mgd with two UV banks in service. The system was designed to accommodate additional lamps in the future (from 56 to 96 lamps per bank) to treat a peak hour flow of up to 2.54 mgd. These design flow rates are based on a UV dose of 37 millijoules per square centimeter (mJ/cm^2) to meet the current disinfection requirements. As the 2040 design peak hour flow is 1.2 mgd based on the most recent projections, the UV system has considerable excess capacity.

5.3.4 Sludge Thickening

The GBT receives WAS and secondary scum from the WAS storage tanks. The GBT was sized for a maximum hydraulic loading rate of 200 gpm. Preliminary solids mass balance calculations show a hydraulic loading rate of less than 200 gpm through 2040, assuming an operational schedule of 4 days per week and 6 hours per day. Therefore, the existing GBT is expected to have significant excess capacity. There is, however, currently no redundancy in the thickening system as there is only one GBT. When the GBT needs to be taken out of service for maintenance, the waste sludge can be hauled to CKTP for processing.

Section 6

Alternatives Development and Analysis

Several alternatives were considered for this Project, including to maintain the status quo ("no action" alternative) and various end uses for the recycled water that vary seasonally. Alternatives that evaluated the beneficial uses for recycled water are discussed in detail in Sections 6.2 and 6.4. Treatment alternatives to meet recycled water quantity and quality objectives were also considered as described in Section 6.3. Several pipeline alignments were evaluated and are presented in Section 6.5.

6.1 Project Objectives and Evaluation Criteria

The objective of the County and this Project is to "**treat water as a resource rather than a waste stream**" to address water quality and quantity concerns specific to Kingston, and other related water resource issues throughout the county. Based on several years of stakeholder engagement with the community and Kitsap County's key partners, such as the Suquamish Tribe, the following objectives were developed:

- Enhanced water quality in Puget Sound
- Improved sustainability of the deep sea-level aquifer
- Enhanced local stream habitat

Evaluation criteria for the Project primarily centered on triple bottom line considerations of environmental, social, and financial attributes of the Project. Although the County and Suquamish Tribe did not develop a formal "weighting" criteria, through Project discussions it became apparent that the priority was on environmental and social considerations. The following key factors were considered as part of each criteria and the decision-making process:

- **Environmental:** the extent to which an alternative met the Project objectives of preserving groundwater resources for potable uses, enhancing marine life ecosystems, and restoring stream flows and fish habitat
- **Social:** the extent to which an alternative was supported by the major Project stakeholders (e.g., the County and the Tribe)
- **Financial:** the extent to which an alternative minimized capital and operational costs; see Section 6.2.2 for a description of this "business case evaluation" (BCE) process

6.2 Beneficial Uses Alternatives Analysis

In 2003, the County began assessing opportunities to use recycled water that could be produced at the Kingston WWTP to address long-term County water quantity and water quality goals. Beneficial uses of the Kingston recycled water project were identified based on these assessments and current understanding of area stakeholder interests. Implemented alone or in combination, these beneficial uses include:

- **Irrigation.** Water recycled at the Kingston WWTP would offset groundwater withdrawal by meeting summer irrigation needs at the WHGC (approximately 29 MG/year) and other potential sites, such as NHKP ball fields. During the winter, flows could be stored for irrigation use the following summer.
- **Infiltration.** Preliminary investigations in the area north of WHGC indicate favorable subsurface conditions for indirect groundwater infiltration (winter only or year-round). Infiltration in this area is anticipated to result in subsurface migration of Class A recycled water to Grovers Creek, potentially providing a significant benefit in the summer when stream flows are below minimum instream flow requirements. Infiltration through the soil column would also provide additional treatment and thermal cooling of the water.
- **Wetlands.** Providing that water temperature and quality regulations would be achieved, directing Class A recycled water through the wetlands located to the northwest of the Kingston WWTP would provide benefits such as improved water quality (through wetland treatment), hydrologic storage, thermal cooling, and seasonal wetland hydration.

Several alternatives were considered that evaluated these various beneficial end uses for the recycled water. The evaluation also included the "no action" alternative (Alternative 1) where the Kingston WWTP effluent would be continued to be discharged to Puget Sound. This alternatives evaluation builds on a 2016 study included in Appendix A, which investigated recycled water opportunities for the Kingston WWTP (BC 2016). The following six alternatives were considered for this Project:

- Alternative 1 - Continued discharge of wastewater to Puget Sound ("no action")
- Alternative 2 - Winter discharge to Puget Sound and summer irrigation at WHGC
- Alternative 3 - Winter infiltration and summer irrigation at WHGC
- Alternative 4 - Winter storage of produced recycled water and summer irrigation at WHGC
- Alternative 5 - Infiltration year round
- Alternative 6 - Discharge to wetlands year round

6.2.1 Beneficial-Use Alternative Screening

The six alternatives for various uses of the recycled water were further evaluated through a screening process for feasibility. Each of the alternatives was screened against the evaluation criteria discussed in Section 6.1 and the relative benefits qualitative assessment provided in Table 6-1.

Table 6-1. Benefits of Beneficial-Use Alternatives					
Discharge Alternatives			Relative Benefits		
Alternative	Summer	Winter	Puget Sound (Quality)	Vashon (Deep) Advanced Aquifer (Quantity)	Shallow Aquifer and Streams (Quantity and Quality)
1. Puget Sound wastewater discharge (“no action”)	Puget Sound	Puget Sound	+	N/A	N/A
2. Winter discharge, summer irrigation	Irrigation	Puget Sound	++	++	N/A
3. Winter infiltration, summer irrigation	Irrigation	Infiltration	+++	++	+
4. Irrigation and storage	Irrigation	Storage	+++	+++	N/A
5. Infiltration	Infiltration	Infiltration	+++	+	++
6. Wetlands	Wetlands	Wetlands	+++	N/A	+++

The number of “+” notations represents the relative benefits for each option.

Based on discussions with major stakeholders (County and Tribe), a strong preference was expressed for alternatives that included elements of irrigation and infiltration to benefit not only Puget Sound water quality, but also the aquifer and area streams. Therefore, there was significant support for Alternative 3 based on this initial screening exercise. Alternative 3 was the “baseline option” presented to stakeholders in 2016 that also received unanimous support.

To streamline the evaluation and focus on alternatives that met the primary stakeholder objectives, Alternatives 4, 5, and 6 were removed from further evaluation based on the following limitations:

- **Alternative 4: irrigation and storage.** This option would irrigate WHGC in the summer and then, during other times of the year, store recycled water at WHGC for irrigation during the following summer. Based on the water balance analysis presented in Table 4-3, the WHGC potable water irrigation demands are less than the yearly wastewater produced at Kingston WWTP. Therefore, there is not enough irrigation need for the entire wastewater production flow and another beneficial use would need to be identified to take advantage of a storage option. Additionally, storage volume would need to be quite large (greater than 75 MG to store flow outside of the summer season in 2040). Given this significant storage requirement and associated cost and siting issues) and because this alternative does not benefit area streams, this alternative was eliminated from further consideration.
- **Alternative 5: infiltration year round.** Although infiltration would benefit local stream flow, this alternative would not reduce pumping from the aquifer. This alternative would infiltrate recycled water at NKHP year round. Additionally, it has less benefit to the deep aquifer, which is mostly confined. Infiltrated water is expected to replenish the shallow aquifer, which is not used as a drinking water source in the area. Therefore, this option was screened out for further consideration.

  Alternative 6: wetlands. Providing that water temperature and quality regulations would be achieved, directing Class A recycled water through the wetlands located to the northwest of Kingston WWTP would provide benefits, such as improved water quality (through wetland treatment), hydrologic storage, thermal cooling, and seasonal wetland hydration. The recycled water would ultimately be conveyed to Grovers Creek and help address low summer stream flow issues. Although this is a benefit from a water quantity standpoint, there is remaining concern regarding the water quality impacts to the stream that would require additional testing and monitoring. In addition, there is concern that the temperature of Class A recycled water would need to be lowered between June and September from 70°F to 61°F–64°F to meet state and federal criteria for delivery to salmon-bearing streams (Golder 2010). Technologies to cool the recycled water effluent flow from 70°F include mechanical cooling with refrigeration technology and evaporative cooling using cooling towers. These options are energy-intensive (not helpful for climate change resilience/mitigation) and would add cost to the Project. For these reasons, along with the concern that this alternative would not reduce pumping from the aquifer, this alternative was eliminated from further consideration.

The following sections outline the treatment options for producing Class A recycled water (Alternatives 2 and 3). Based on the treatment evaluation, life-cycle costs were produced for each alternative, which are presented in Section 6.5.

6.3 Recycled Water Treatment Alternatives

The level of additional treatment needed to produce recycled water depends on the anticipated uses of the recycled water and how it will be discharged. Table 6-2 summarizes the treatment required for the potential discharge options. Although endocrine-disrupting compounds (EDCs) and other emerging contaminants of concern are not addressed by current regulations, the Project would include provision for future installation of EDC removal treatment beyond what soil aquifer treatment (SAT) will provide via infiltration (see Section 7.7 for a discussion on SAT). At this time, the Project would include provision only for future installation of EDC removal processes.

Table 6-2. Level of Treatment for Different Discharge Options for Recycled Water

Discharge Option [a]	Nitrogen Removal	Filtration	Disinfection Method Options
Discharge to Puget Sound through outfall	Not required currently	Not required	UV
Irrigation	Not required	Yes	UV, Cl_2, or both
Infiltration	≤ 10 mg/L TN monthly average	Yes	UV, Cl_2, or both

Treatment level for irrigation and infiltration in accordance with Reclaimed Water Rule, WAC 173-219 (effective 2/23/2018).
Cl_2 = chlorine (chlorination).
TN = total nitrogen.

To produce recycled water at Kingston WWTP, upgrades to the existing secondary treatment and disinfection systems will be required and a new tertiary filtration will need to be added. These upgrades are described in the following sections.

6.3.1 Secondary Treatment System

Currently, limited nitrogen removal is provided in the oxidation ditch by air on/off cycling. To meet the total nitrogen (TN) limit required for indirect infiltration (Alternative 3), modifications of the existing treatment system would be required. As Table 6-2 shows, nitrogen removal is not currently required for discharge to Puget Sound or irrigation uses.

The following modifications are recommended to upgrade the secondary treatment system to allow for nitrogen removal:

- Adjust aeration air on/off cycles
- Add aerators in the second ditch to allow operation of both ditches
- Add mixers to the oxidation ditch to provide more effective anoxic cycles

Preliminary process modeling indicates that sufficient TN removal may be achieved with a second ditch in operation and optimization of the air on/off periods without supplemental carbon addition. A supplemental carbon system is not included in the site layout and cost estimates for the recycled water facilities. If supplemental carbon is needed, it is recommended that a system feeding non-hazardous, proprietary chemicals (e.g., MicroC products) be added.

6.3.2 Tertiary Filtration System

A new tertiary filtration system is needed to produce Class A recycled water. Different types of filters are available, including sand filters, cloth media filters, membrane filters, and compressible media filters. A comparison of the different types of filters is provided in Appendix F. An upflow sand filter (with continuous or intermittent backwash) is the preferred alternative, mainly because the same type of filters have been installed at CKTP to produce recycled water. Having the same type of filters at the two facilities is beneficial to the County in terms of operational consistency and equipment maintenance.

Sizing of the filtration system is based on the anticipated hydraulic loading at Kingston WWTP. The filters could be sized to treat the design peak hour flow or a flow rate less than the design peak hour flow. In the latter case, an EQ tank would be included to equalize any flow that exceeds the filter maximum hydraulic capacity. In both cases, the system is sized with one filter cell out of service to meet redundancy requirements. An EQ tank or redundant filter cell would not be needed if any flow exceeding the filter capacity is discharged through the outfall. However, in developing the treatment options, it was assumed that all flows will be filtered and thus be reclaimed to limit flow discharged to Puget Sound. Flow discharged to Puget Sound would be for exercising the outfall only. To optimize the required filtration capacity, flow equalization is thus included in the treatment options discussed below.

As discussed below concerning disinfection, the existing UV system can be retrofitted to provide a higher UV dose required for reuse up to a certain flow rate. The new filtration system can thus also be sized to match the UV system capacity.

The filtration system will include the filter cells installed in concrete basins, air compressors, chemical feed system, and filter feed pump station.

6.3.3 Disinfection

The existing UV system at Kingston WWTP has a design dose of 37 mJ/cm^2 at a design capacity of 1.6 mgd. To meet Class A recycled water requirements, a higher dose (at least 100 mJ/cm^2 to achieve 4 log virus removal) would be required when media (non-membrane) filtration is used as part of the treatment process stream upstream of disinfection (NWRI 2012). According to the UV equipment manufacturer (Trojan), the existing UV system can be modified to provide the required dose (for up to 0.5 mgd) by adding eight UV modules to the system. Disinfection can also be achieved by means of chlorination. Therefore, there are three general disinfection options to achieve Class A recycled water requirements:

- Add a new UV system designed to meet the requirements for recycled water production. Chlorination will also be required to address biofilm control in the pipeline.
- Modify the existing UV system to provide the higher level of disinfection for a portion of the flow (0.5 mgd). Flows in excess of 0.5 mgd would be equalized in a new EQ tank. The EQ tank can be sized to accommodate the design peak hour flow or a flow rate lower than the design peak hour flow, such as the design peak day flow. In the latter case, when Kingston WWTP flow exceeds the design peak day flow, all flows would be sent directly to the UV system without filtration and the

effluent would be discharged to the outfall. Similar to the previous option, chlorine would be added to provide a residual in the distribution pipeline to prevent re-growth.

- Provide disinfection of all recycled water by adding chlorine only.

For chlorine addition, the existing sodium hypochlorite tank and metering pumps currently not in use at Kingston WWTP may be used for any of these options, so that a new chemical addition system will likely not be needed for disinfection.

The existing chlorination system can also be used to maintain a chlorine residual in the reclaimed water distribution system. The new Reclaimed Water Rule requires a free chlorine residual of 0.2 mg/L or a total chlorine residual of 0.5 mg/L in the distribution system, or a waiver can be granted. A waiver may be able to be granted for this reclaimed water system. However, operation and maintenance implications would need to be considered if no chlorine residual was provided, such as the ability to periodically apply a chlorine residual for pipe cleaning/maintenance to minimize biofilm growth and corrosion. In the state, there are a few facilities that practice groundwater recharge and the chlorine residual requirement is not required for this intended use (i.e., LOTT Martin Way's Groundwater Recharge Facility).

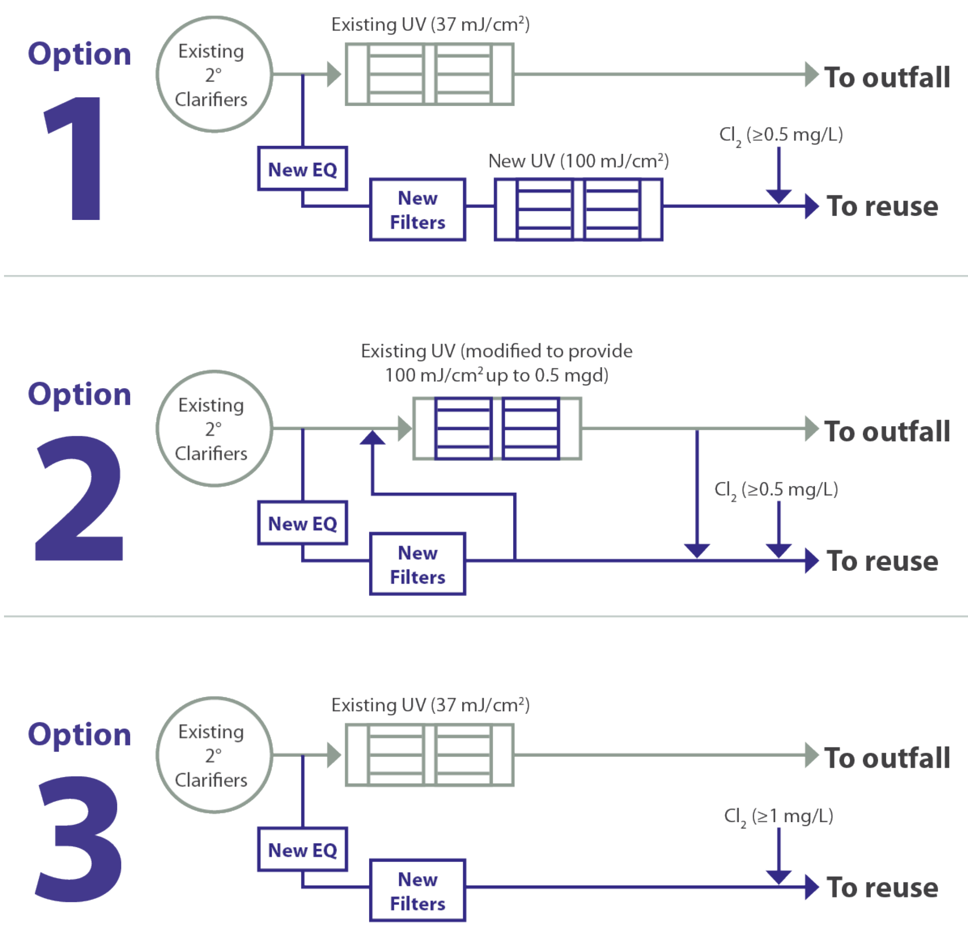
6.3.4 Tertiary Filtration and Disinfection Process Flow Options

Three tertiary treatment schemes related to filtration and disinfection systems were evaluated. Oxidation ditch improvements are common to all three options. Table 6-3 summarizes the design criteria for each option. Figure 6-1 illustrates the options and summarizes the advantages and disadvantages of each option.

Table 6-3. Design Criteria for Tertiary Filtration and Disinfection Process Flow Options

Parameter	Option 1: Add Parallel Filters and UV Disinfection	Option 2: Add Filters and Upgrade Existing UV System	Option 3: Add Filters and Chlorinate for Disinfection
Existing UV system	(used only as backup)		(used only as backup)
Maximum flow (mgd)	1.6	0.5	1.6
Design UV dose (mJ/cm^2)	37	100	37
EQ tank			
Maximum volume (gal)	93,000	359,000 (equalize all flows above 0.5 mgd) 38,000 (equalize flows between 0.5 and 0.7 mgd)	93,000
Tertiary filters			
Maximum flow (mgd)	0.7	0.5 or 0.7	0.7
New UV system			
Maximum flow (mgd)	0.7	None	None
Design UV dose (mJ/cm^2)	100		

For treatment options 1 and 3, an EQ tank volume of approximately 93,000 gallons was estimated if the filters (and new UV system) are sized to treat up to a flow of approximately 0.7 mgd (2040 peak day flow). Flow equalization would not be needed until around 2026 based on Kingston WWTP flow projections. For option 2, if all flows beyond 0.5 mgd are equalized, an EQ tank volume of approximately 359,000 gallons was estimated. If only flow up to 0.7 mgd is equalized, then the EQ tank volume can be reduced substantially to approximately 38,000 gallons. However, in that case, when flow exceeds 0.7 mgd, all flow would be sent directly to the UV system and subsequently to the outfall (no flow to reuse), as the UV system must then be used to disinfect all flows for discharge to the outfall.



	Advantage	Disadvantage
Option 1	• Can keep existing UV system operating during construction • Minimal generation of DBP	• High capital costs • Existing UV system used only as backup (if normally no outfall discharge) • Large overall footprint
Option 2	• Can keep existing UV system operating during construction • Existing UV system will continue to be used year-round (no intermittent operation) • Minimal generation of DBP	• Less flexible to take existing UV system out of service for any future upgrade • Requires very large EQ tank (if all flow above 0.5 mgd is equalized) or no reuse at high flow (if flow above 0.7 mgd is not equalized)
Option 3	• Low capital costs • Less yard piping	• Higher generation of DBP • Existing UV system used only as backup (if normally no outfall discharge)

Figure 6-1. Comparison of UV and tertiary filter process flow options

Comparing the three options, option 1, with a new UV system, would have the highest capital cost, while option 3, using chlorination only for disinfection of the recycled water, would have the lowest capital cost. For options 1 and 3, the existing UV system would serve only as a backup and would be used only when the filtration system or new UV system (for option 1) is taken out of service or when the outfall is “exercised” intermittently to maintain its functionality. The potential for generating disinfection by-products (DBPs) is the highest for option 3 with the highest expected chlorine (as hypochlorite) dose requirements, although DBPs are currently not regulated for reclaimed water and their generation is expected to be relatively insignificant for all three options with filtration of the secondary effluent. Option 2 would allow continued use of the existing UV system but would generate only up to 0.5 mgd of recycled water. Future expansion would require replacement of the UV system. Based on preliminary evaluation, option 1 was selected as it would provide the most flexibility in terms of meeting future DBP limitations in reclaimed water and a conservative cost estimate for facility planning purposes.

6.4 Infiltration Investigation

To assess the feasibility of groundwater recharge and stream flow augmentation, site-specific testing including shallow test pits and infiltration testing, and test drilling and installation of a groundwater monitoring system were conducted. This site-specific testing provided hydrogeologic data to support the feasibility assessment and groundwater modeling.

The data collected during hydrogeologic site characterization activities were also used to update the United States Geological Survey (USGS) 2016 Kitsap Peninsula groundwater flow model. To simulate Project-specific conditions and increased model resolution within the Project area, a finer-scale MODFLOW UnStructured Grid (USG) was incorporated into the original model. Following this process, regional features and overall model calibration were maintained while building a high-resolution grid within the Project area. Within the USG zone, model updates included refinement to surface elevations and hydrostratigraphic units, incorporation of smaller unnamed tributaries within the Grovers Creek watershed, adjustments to the model recharge to simulate Project scenarios, and adjustments to the hydraulic properties for the clay layer beneath the targeted unconfined aquifer within the Project area. Original model properties, including hydraulic conductivity of the aquifer units and leakance of the lower confining units, remained consistent with the USGS model outside of the USG zone. The updated model was used to process simulations for (1) existing background conditions, (2) year-round groundwater recharge at 0.5 mgd, and (3) seasonal recharge (irrigation/recharge) at a rate of 0.5 mgd.

The model was used to assess groundwater mounding and transport of the recharged water within the shallow unconfined aquifer system beneath the Project area to tributaries within the Grovers Creek watershed. Results indicate that both year-round and seasonal groundwater recharge alternatives result in net increases in stream flow within Grovers Creek. Both the continuous recharge and seasonal recharge scenarios produce the greatest increased stream flow over base conditions in December, with the magnitude of the benefit decreasing during the spring season. Based on preliminary feedback from Ecology, a supplemental analysis of particle tracking and transport to surface water is included in Appendix H. Transport within the groundwater system was estimated with conservative particle tracing that indicates a range of transport paths to approximately 1.93 miles of tributary length receiving benefits from additional baseflow within the watershed. Time of travel within the aquifer, based on the cumulative volumes contributing to baseflow with time, indicates that approximately 40 percent of the induced recharge becomes baseflow after approximately 55 days, reaching a peak contribution to baseflow of approximately 90% of the recharge after approximately 200 days. Contribution to baseflow appears to follow a slightly bimodal pattern, based on the different tributary reaches receiving benefit. Based on the range of aquifer travel times, the recharge benefit to baseflow occurs year-round, as shown in Figure 6-2 and Figure 6-3. Under both the continuous and seasonal recharge scenarios, the greatest dry season benefit occurs in August, while other summer season benefits remain relatively consistent from month to month between April and November. The earliest travel time of the recharge within the groundwater system was estimated at approximately 6 to 12 months based on the average hydraulic gradients and aquifer properties, and 1 to 3 months based on the modeling results. The transport of recharge within the groundwater system is dependent on seasonal and year-to-year changes in aquifer hydraulic gradients. Based on the modeling results, all reclaimed water recharging the aquifer system eventually becomes 1) base flow to the Grovers Creek system, 2) discharge to Appletree Cove, or 3) after a period of approximately 30 years of mixing and transport in the groundwater system, captured by one pumping well (KPUD Well 6). Based on the modeling results, the proposed recharge alternatives have little potential for transport to drinking water sources or other sensitive receptors.

The Hydrogeologic Site Characterization Report is included in Appendix D. The groundwater modeling methodology and results are provided in Appendix H, including the supplemental analysis of aquifer travel time. Results of the hydrogeologic characterization demonstrate that groundwater recharge and stream flow augmentation is feasible, and the proposed recharge alternative is outside of the influence of other groundwater wells, including shallow domestic-use wells in the area.

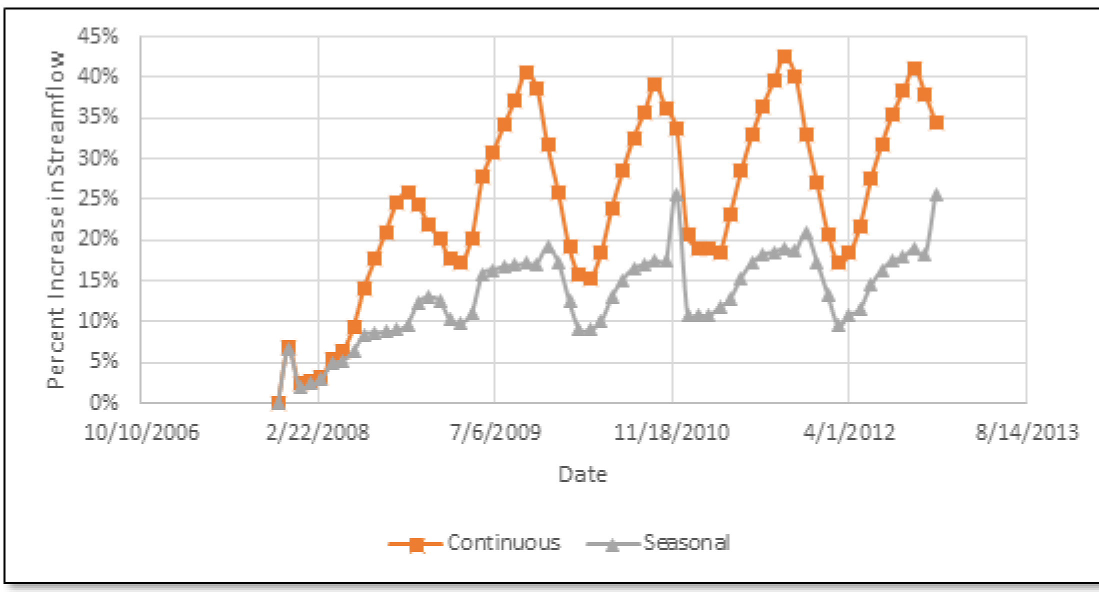


Figure 6-2. South Fork Grovers Creek at Confluence with Mainstem Grovers Creek

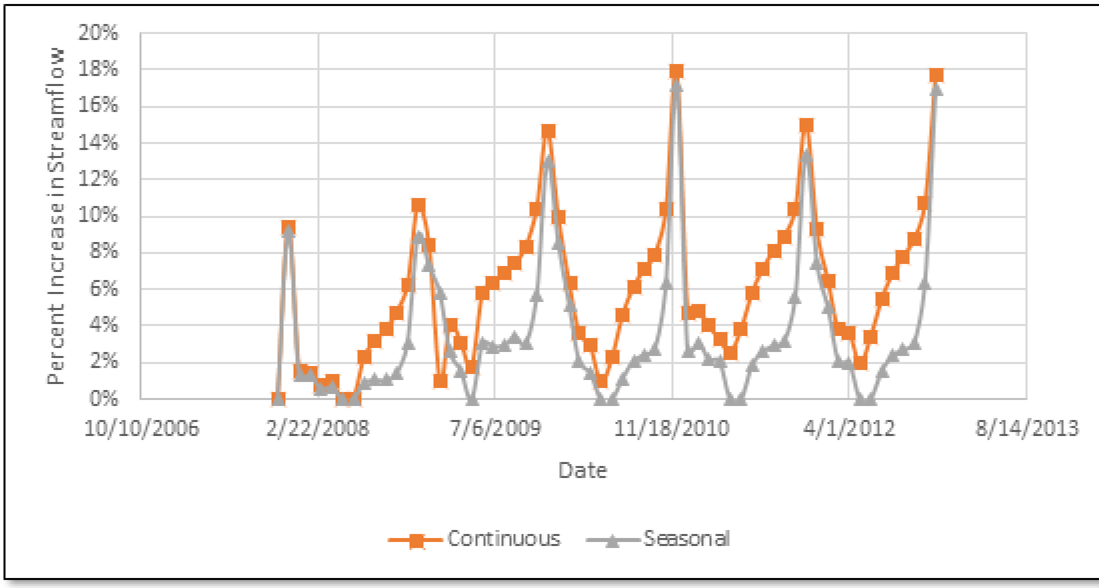


Figure 6-3. Mouth of Grovers Creek at Appletree Cove

6.5 Beneficial Use Business Case Evaluation Analysis and Results

A BCE was used to further analyze beneficial-use Alternatives 1, 2, and 3 resulting from the screening analysis discussed in Section 6.2.1, incorporating the treatment option selected in Section 6.3 for each alternative. The capital cost and life-cycle cost presented as a net present value (NPV) are presented in Figure 6-4. The capital cost is based on construction during 2021 and 2022. Life-cycle costs assume the reclaimed water system is operating through 2040.

As shown in Table 6-2, Alternative 3 requires nitrogen removal when the recycled water is being infiltrated (see Section 6.3.1). For Alternatives 1 and 2, it was also assumed that nitrogen removal would be required in 2030 because of new permit requirements based on concerns about DO concentrations in the Puget Sound. Therefore, all three alternatives require nutrient removal, but the timing of implementation effects the NPV. The capital cost difference between Alternatives 2 and 3 is a result of the estimated cost for the infiltration basins and additional pipeline (1,650 feet) to extend to the infiltration galleries.

There are several considerations for the operations and maintenance (O&M) costs. Alternative 1 includes costs for purchasing potable water by the WHGC. Alternative 1 also assumes that KPUD (which provides potable water to WHGC) increases potable water costs at an annual rate of 2 percent per year. Alternative 2 has additional treatment and monitoring and compliance costs for 150 days (the summer period) when reclaimed water is produced for irrigation at WHGC. Alternative 3 assumes year-round treatment with increased nitrogen removal outside of the summer season when reclaimed water is used for infiltration.

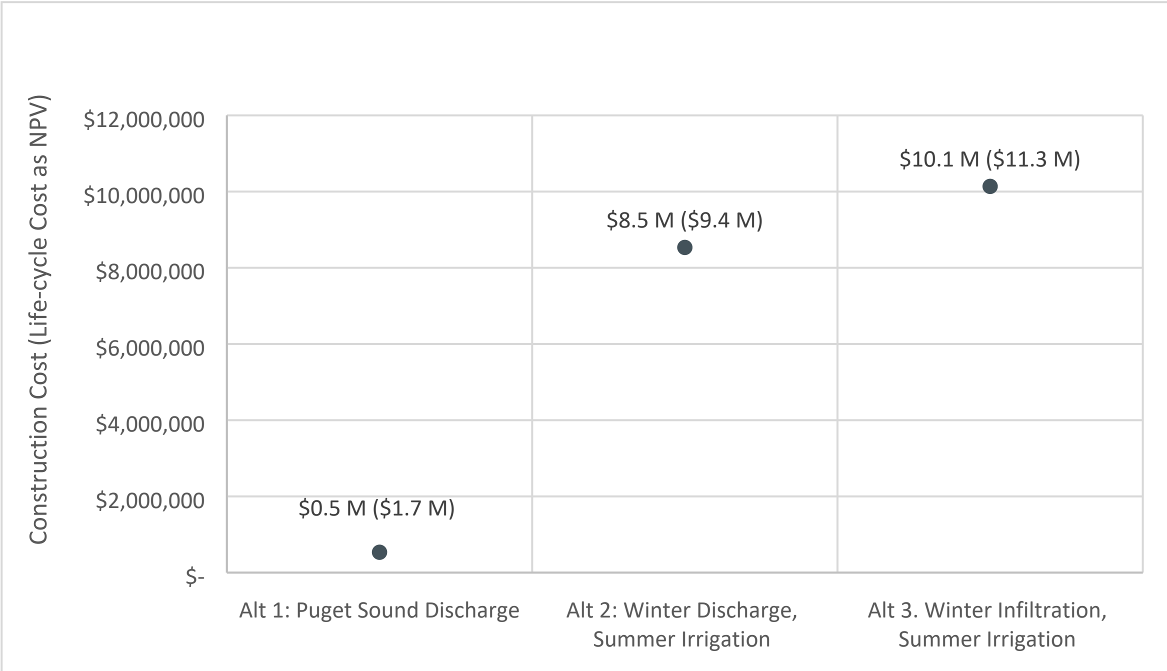


Figure 6-4. Beneficial Uses BCE results

As indicated earlier, significant support was expressed for Alternative 3 based on the multifaceted benefits that this alternative provides to area streams, the aquifer, and Puget Sound. The BCE results reinforced this preference by major stakeholders because the additional cost for infiltration was considered relatively nominal for the benefits that are described in Section 7. Therefore, the preferred alternative for implementation is Alternative 3.

6.6 Conveyance Alternatives

This section outlines the conveyance alternatives to route reclaimed water to WHGC (applicable to both Alternatives 2 and 3). Three conveyance route alternatives were identified and determined to be viable in the *Kingston Recycled Water Project* Report (BC 2016). All three alternatives (Alternatives 2, 3, and 4 in **Error! Reference source not found.**) use the existing Spine Line Trail for the first 60 to 70 percent of the conveyance route starting at the Kingston WWTP. The route then diverges along separate trails (Alternatives 2 and 3) or cuts through forested area (Alternative 4). At the time of development of the BC 2016 report, Alternative 2 was selected as the baseline option for further analyses because it maximized construction along trails that will be widened and paved in the future as part of the Kitsap County Parks Department's efforts to extend its trail network.

The present planning analysis added a fourth alternative that maximizes use of power line right-of-way (Alternative 1 in Figure 6-5). The present planning analysis reviewed all four conveyance alternatives with respect to environmental impacts (see Section 2.3) and timing with Parks Department trail revitalization efforts. The environmental review did not identify a significant difference in impact among the four alternatives. Furthermore, the Parks Department plans for the trail network are not yet at a level where conveyance improvements can be scheduled to maximize the benefit of planned paving activities.

Further analysis of the conveyance alternatives will be performed in subsequent design analyses, including coordination with the Parks Department. For the present analysis, Conveyance Alternative

1 was selected as the basis for cost estimates because it utilizes more power line right-of-way should trail improvement coordination prove infeasible and provides a conservatively higher cost because of its length.

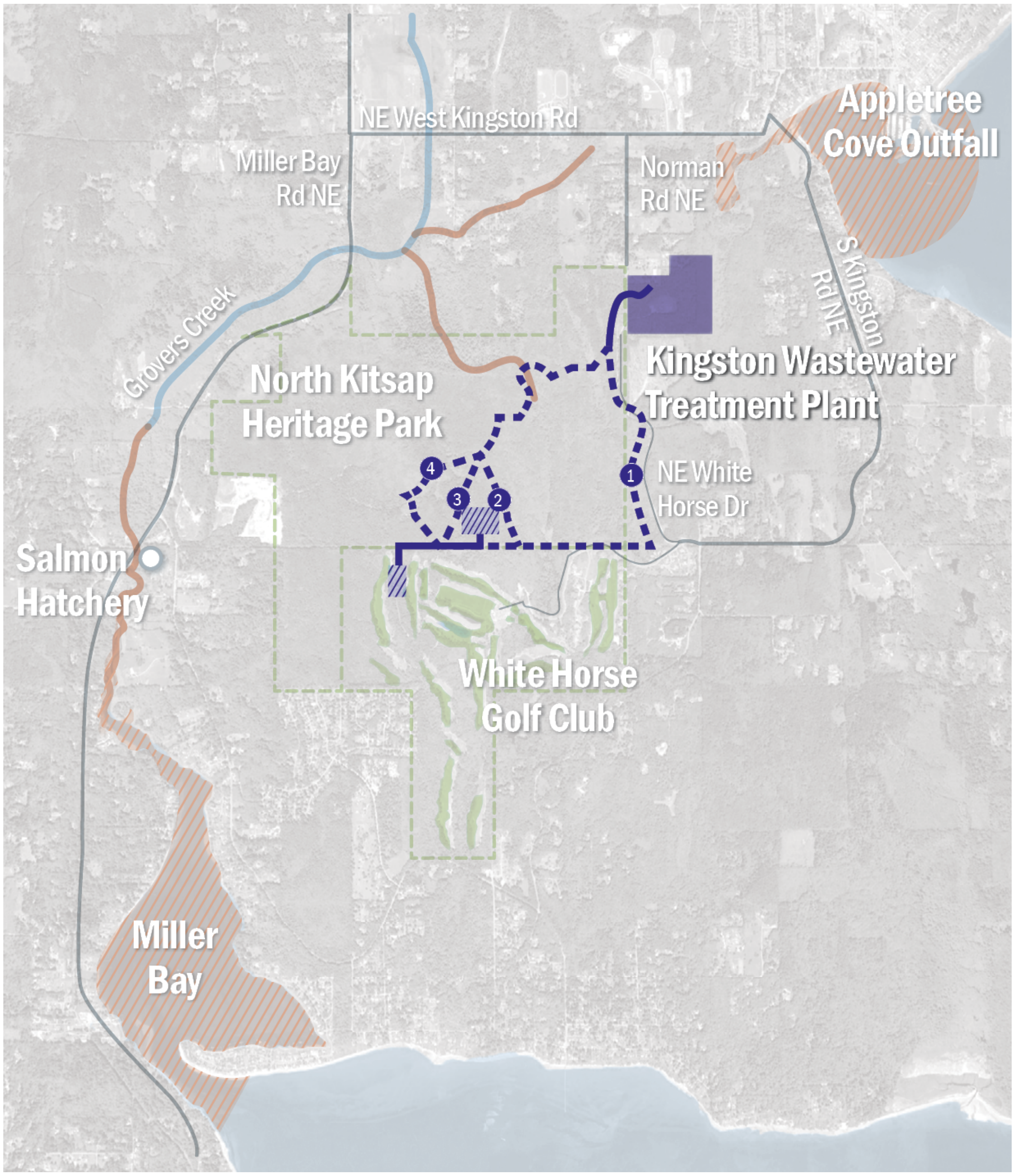


Figure 6-5. Conveyance alternatives

Section 7

Recycled Water Project Benefits

The proposed Project represents a unique opportunity to achieve new, far-reaching benefits for multiple stakeholders. Wastewater would be further treated, recycled, and managed as a valuable resource rather than treated and disposed of as a waste product. This water management approach represents a fundamental shift in how wastewater is managed on the Kitsap Peninsula, deriving multiple benefits while eliminating a direct discharge to Puget Sound.

Seldom do the technical and stakeholder elements of a project all align for a “win-win” situation. This section describes the exceptional geographic and stakeholder setting that makes this Project a distinctive and rare opportunity with immediate and long-term benefits for the region.

7.1 Current Approach to Water Resource Management

As Figure 7-1 shows, water on the Kitsap Peninsula is pumped from a limited groundwater source and used for potable and non-potable uses, such as landscape and lawn irrigation. Under this current water management approach, the portion of pumped water that ultimately gets treated at Kingston WWTP as wastewater is “lost” from the watershed once it is discharged to Puget Sound. This discharge to Puget Sound occurs year round and includes nutrient and pollutant loadings, even though Kingston WWTP successfully meets or exceeds permit requirements. Over time, this current practice will impact Puget Sound water quality and the availability of the limited potable water supply, because freshwater resources are being exported out of the watershed. This practice does nothing to address the low stream flows in the area. Furthermore, nutrients will continue to be discharged into Puget Sound, not on lawns where they can be beneficially used.

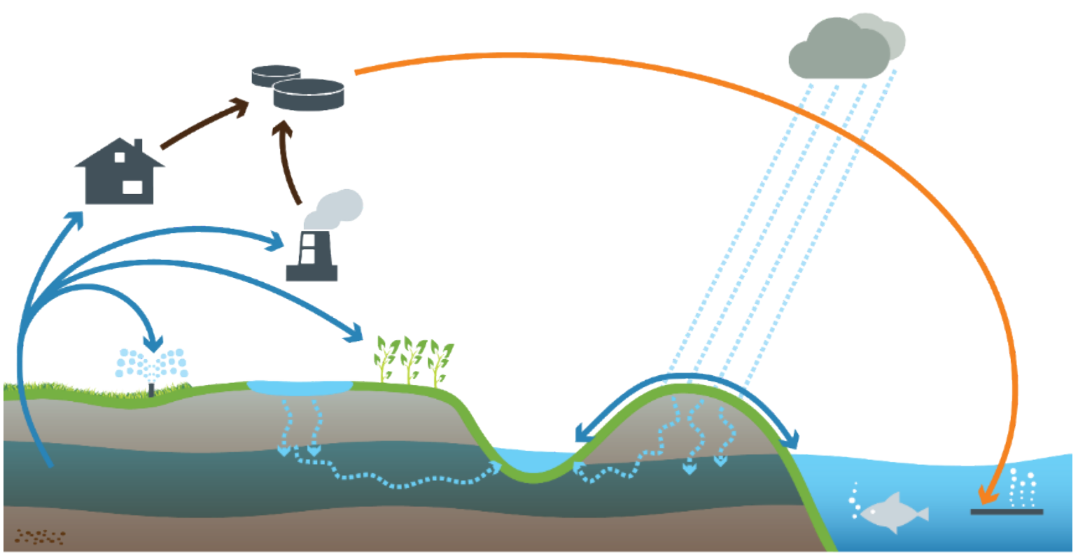


Figure 7-1. Water cycle showing current water management approach

All water resource usages are taken from groundwater and then, after treatment, a significant portion is “lost” into Puget Sound.

7.2 Pressure on Our Water Supplies and Environment

The long-term impacts of this current water management practice on water supply and water quality are a concern, especially when considering factors such as population growth, effects of climate change, pollutant accumulations, and the possibility of saltwater intrusion into the aquifer. A shift to a sustainable water management approach is needed to consider the multifaceted nature and value of water, and to preserve a resilient/reliable water supply and environmental quality as fundamental community assets.

There is a better way of doing things—where we treat all water as a resource.

7.3 Treating Water as a Resource

The proposed Project is an important element of a more holistic water resources management approach in the region (Figure 7-2). This Project is also a direct outgrowth of Kitsap County's Water as a Resource Policy (Kitsap County Resolution 109-2009) (Kitsap County 2009). Irrigation of WHGC during the summer and groundwater infiltration north of WHGC during other times of the year is the beneficial use considered for the Project.

This option provides significant and tangible benefits relative to the current water management approach—serving as an example of sustainable 21st century water resources management.

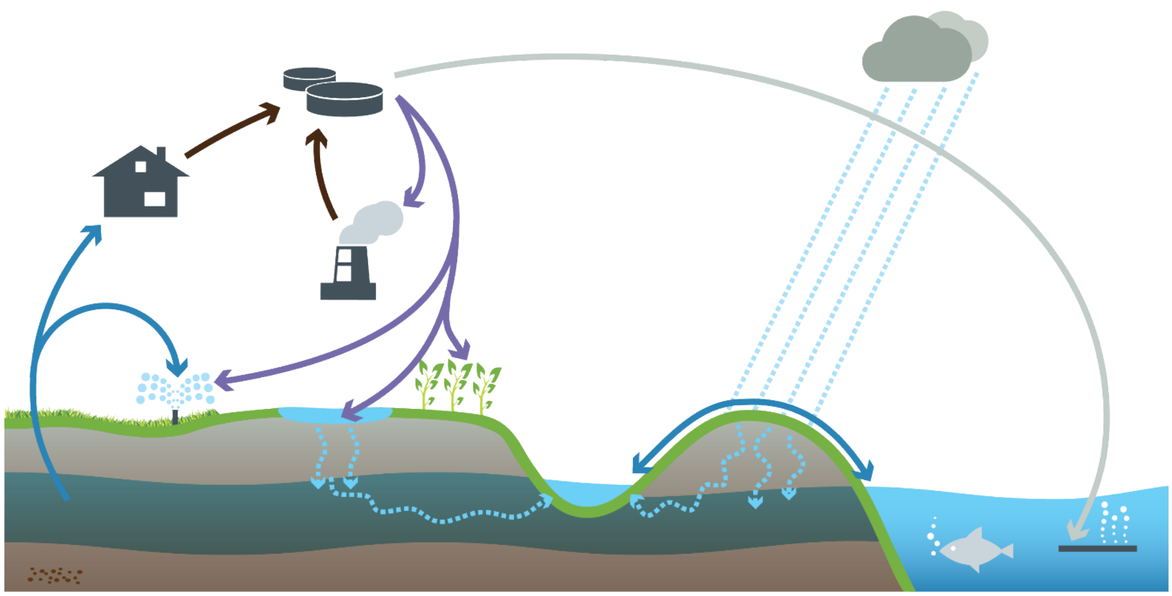


Figure 7-2. Water cycle showing proposed holistic water resources management approach

Freshwater resources are largely recycled in the watershed and water is treated as a resource.

Moreover, one unique aspect of this Project is the strong partnership between Kitsap County and the Suquamish Tribe. Beginning at the initial planning stages, these two entities have collaborated to assess the feasibility and benefits from this Project. They also have a history of successfully partnering to improve the community including:

- Augusta Avenue stormwater replacement project
- Totten Road pedestrian path
- Suquamish Way and Division Street intersections and traffic lights

- Trail paving within WHGC of pedestrian path between Kingston and Indianola.

Beyond the strong stakeholder partnerships, the Kingston geography from a logistics and hydrogeology viewpoint is highly conducive to implementing a recycled water program. The relatively short distance from Kingston WWTP to WHGC, of less than 2 miles, minimizes the conveyance needed to distribute recycled water for irrigation. Furthermore, the ideal locations for infiltration are in the general WHGC area, so conveyance infrastructure needed for irrigation can also be used to accomplish winter infiltration. Often a significant “purple pipe” system is needed to distribute recycled water to willing users but, in this case, a single conveyance pipe from Kingston WWTP to WHGC addresses most of the infrastructure needed to serve the identified beneficial end uses. The proximity of a significant recycled water user at WHGC coupled with the Tribe’s strong advocacy and commitment for recycled water use make this an ideal situation for efficiently and effectively implementing a recycled water Project.

The proposed Project supports many goals of the community including:

- Conserve limited groundwater resources
- Divert nutrients away from the marine environments and to where they are needed
- Restore and replenish streams and fish habitats: Grovers Creek
- Enhance marine life ecosystems
- Engage the community about our critical water resources
- Create a community asset and maintain a healthy economy

7.4 Conserve Limited Groundwater Resources

Using the right water for the right use would reduce withdrawals of potable water used for landscape irrigation from the confined groundwater aquifer. The Kitsap Peninsula is essentially an “island,” surrounded by salt water with little freshwater sources other than direct rainfall to recharge local aquifers and surface water impoundments. More than 80 percent of the potable water being used in Kitsap County comes from groundwater—a percentage that will increase in the future as new surface water sources are limited.

Currently, irrigation water for WHGC is purchased from KPUD and is sourced from groundwater wells in the area that pump from the sea-level aquifer. The sea-level aquifer is widely used and mostly confined (USGS 2014). Therefore, the quantity of usable groundwater is limited and, eventually, as the local demand for groundwater supplies increases, this water source could decline because it is not being adequately replenished.

Additionally, with increased withdrawals from the sea-level aquifer, there is a concern of saltwater intrusion and the associated impacts to groundwater quality over time. There is no evidence of extensive seawater intrusion in the county, but localized seawater intrusion is found in a few areas such as Jefferson Beach in the Kingston sub-area (Ecology 1997). Climate change impacts further compound these issues. Rainfall is projected to be increasingly intense and to result in a greater portion of the precipitation leaving the system directly into Puget Sound as runoff. Additionally, longer and hotter summers from climate change impacts will result in a greater water demand over time, putting even greater stress on the finite potable water supply.

WHGC is located close to Kingston WWTP and the Tribe is strongly advocating for recycled water irrigation. WHGC currently uses approximately 29 MG of water to irrigate the golf course annually (based on historical irrigation data from 2015 to 2017). This annual water usage equates to the volume of filling 44 Olympic-sized swimming pools; with this same water volume, one could fill a skyscraper that is 100 feet long, 100 feet wide, and 360 feet tall. As climate change increases temperatures and evapotranspiration in the region, the kind of drought that was observed in 2015 is likely to occur more frequently and water demand for irrigation is expected to increase.

During the irrigation season, peak day water demands approach 0.5 MG. During peak irrigation periods, daily demand can exceed KPUD's delivery capacity and the system must rely on existing storage to buffer the peak irrigation flow. Delivery of recycled water to WHGC would preserve 29 MG per year of potable water from KPUD's groundwater supply system and eliminate the stress to the supply system imposed by dramatic swings in potable water system demands during the irrigation season.

Following this recycled water approach, each source of supply would be allocated to its highest and best use, enhancing regional sustainability and providing good stewardship of our precious resources with the following outcomes:

- Decrease the irrigation demands from the regional aquifer system and thereby preserve groundwater supply for future potable uses
- Decrease the risk of saltwater intrusion within the regional sea-level aquifer
- Extend the useful life of existing potable water infrastructure

An example of a utility that transitioned from relying solely on groundwater to using more renewable water resources is the Albuquerque Bernalillo County Water Utility Authority (Albuquerque). Prior to implementation of the Water Resource Management Strategy, groundwater in the Middle Rio Grande was declining an average of 1 to 3 feet per year. To diversify water supply, Albuquerque developed two reuse and reclamation projects, providing non-potable water for most of the large irrigated turf. Albuquerque has one operating infiltration project and is designing a large-scale injection project. Since 2008, groundwater levels in the aquifer have continued to rebound and have increased by as much as 10 feet throughout the region. Figure 7-3 highlights how groundwater withdrawals have decreased with population growth. Creating and maintaining a groundwater drought reserve using diversifying water supplies has led to a complete reversal in the groundwater aquifer (Albuquerque 2013).

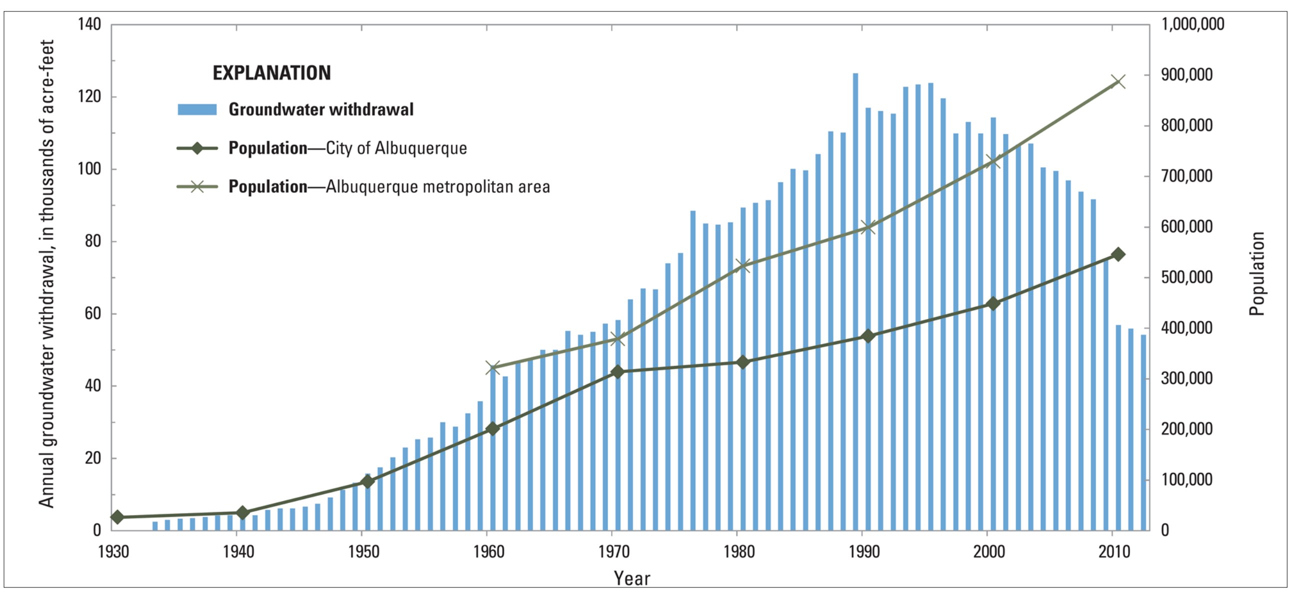


Figure 7-3. Groundwater withdrawal levels after implementation of recycled water program

Source: Albuquerque 2013.

7.5 Divert Nutrients Away from the Marine Environment and to Where They Are Needed

Nitrogen and phosphorus are essential to plant growth. Fertilizer (often produced using petroleum) is commonly applied to golf courses, gardens, farms, and landscaped areas to maintain healthy plant communities. However, too much nitrogen and phosphorus in our water bodies causes excessive aquatic plant growth, which ultimately reduces DO concentrations. Excessive aquatic plant growth can lead to a wide range of ecological problems and reduce or preclude human uses such as swimming, fishing, shellfish harvesting, and water supply.

The proposed Project would virtually eliminate the direct discharge of nutrients to Puget Sound (the existing Kingston WWTP outfall would be used only intermittently to "exercise" the outfall and keep it operational for emergency situations until such time that a year-round land application or storage site is identified). As a result, the potential negative impacts of excess nutrients on marine life would be avoided and instead, nutrients would be beneficially used as a fertilizer for irrigation purposes during the summer or irrigation season.

Phosphorus is a finite material. In the United States, domestic phosphorus reserves will likely be depleted within 25 years, which will drive up fertilizer costs (Stewart et al. 2005; Jasinski 2010).

Under the irrigation alternative, during the WHGC irrigation season, Kingston WWTP would "turn off" the nutrient removal treatment processes so more of the nutrients would pass through Kingston WWTP and serve as fertilizer in the recycled water for WHGC. The irrigation option could not only reduce operating costs for Kingston WWTP (to avoid nutrient removal treatment), but it would also reduce fertilizer use and costs for WHGC.

More than 2,300 golf courses in the United States use recycled water for irrigation to take advantage of these types of benefits. Recycled water accounts for 25 percent of total golf course irrigation use in the United States (GCSAA 2015), including world-class golf courses such as Pebble Beach in California. Recycled water is also used to irrigate landscapes at Disney theme parks.

Figure 7-4. Golf courses are ideal examples of using recycled water for irrigation

Source: Willows Run Golf Course 2018

Puget Sound area recycled water irrigation examples include the Tumwater Valley Municipal Golf Course, which is irrigated with recycled water provided by the LOTT Clean Water Alliance. Starfire

Sports (the Seattle Sounders' practice center), Willows Run Golf Course (the largest user of recycled water in the Pacific Northwest), and TPC Snoqualmie Ridge Golf Course are all irrigated with recycled water provided by King County. When the Willows Run Golf Course switched to recycled water (see Figure 7-4), it reduced its fertilizer application by 50 percent (*Redmond Reporter* 2015). King County estimated that by reducing application of fertilizer, the Willows Run Golf Course took the equivalent of seven cars off the road (King County 2018a). The Willows Run Golf Course became Salmon-Safe certified after switching to recycled water (salmonsafe.org 2018). The certification inspires a new level of environmental innovation in golf course management with respect to protection of urban water quality and preservation of imperiled West Coast salmon through controls of fertilizer and chemical use and preservation of salmon habitat. Washington State has three Salmon-Safe certified golf courses: Willows Run, Salish Cliffs, and Druids Glen.

7.6 Restore and Replenish Streams and Fish Habitats: Grovers Creek

Through the infiltration component of the Project, aquatic habitat in Grovers Creek would be improved. Grovers Creek supports Chinook, chum, and coho salmon and steelhead, and cutthroat trout. The Tribe has a fall Chinook and chum hatchery near the mouth of the creek, which ultimately flows into Miller Bay. The Project would improve habitat in Grovers Creek and Miller Bay by recharging the aquifer that feeds the creek, increasing the flow of cool, clean water.

Ecology's 2016 *Washington State Water Quality Assessment* (Ecology 2016) placed Grovers Creek in the following categories:

- Category 5 (polluted water that requires a TMDL because of low DO concentrations.
- Category 4-B (polluted, but has a pollution control that is expected to solve the problem) because of elevated fecal coliform concentrations. Kitsap County's Pollution Identification and Correction (PIC) program is expected to reduce fecal bacteria concentrations in the creek.
- Category 2 ("water of concern") because of elevated temperature and turbidity.

Like many streams in the Puget Sound lowlands, Grovers Creek suffers from insufficient baseflow during the dry season. Flow often falls below 2 cubic feet per second (cfs), which is the minimum instream flow for Grovers Creek established in state regulations (WAC 173-515-030) (Washington State Legislature 2003). Golder (2010) reported summer flows as low as 1 cfs in August 2005.

The hydrogeologic conditions near WHGC, NKHP, and the surrounding Grovers Creek watershed are ideal" for infiltration. Appendix D describes the hydrogeologic conditions of the area.

The proposed irrigation and infiltration alternative assumes summer season irrigation at WHGC and infiltration the remainder of the year. Based on the 2013–17 period of record for WHGC, irrigation demands occur from May through September. During this period all recycled water produced at Kingston WWTP will be used for irrigation.

The proposed Project would infiltrate about 107 MG per year of highly treated recycled water into the shallow aquifer that provides baseflow to Grovers Creek and its tributaries (Figure 7-5). Assuming an average infiltration volume of 0.3 mgd (107 MG per year divided by 365 days), the Project could increase baseflow in Grovers Creek by roughly 0.5 cfs. The location of the infiltration facility would determine the specific creek reaches that receive the additional baseflow. Ongoing field investigations and groundwater modeling should enable a more accurate estimation of baseflow benefits from infiltration of recycled water.

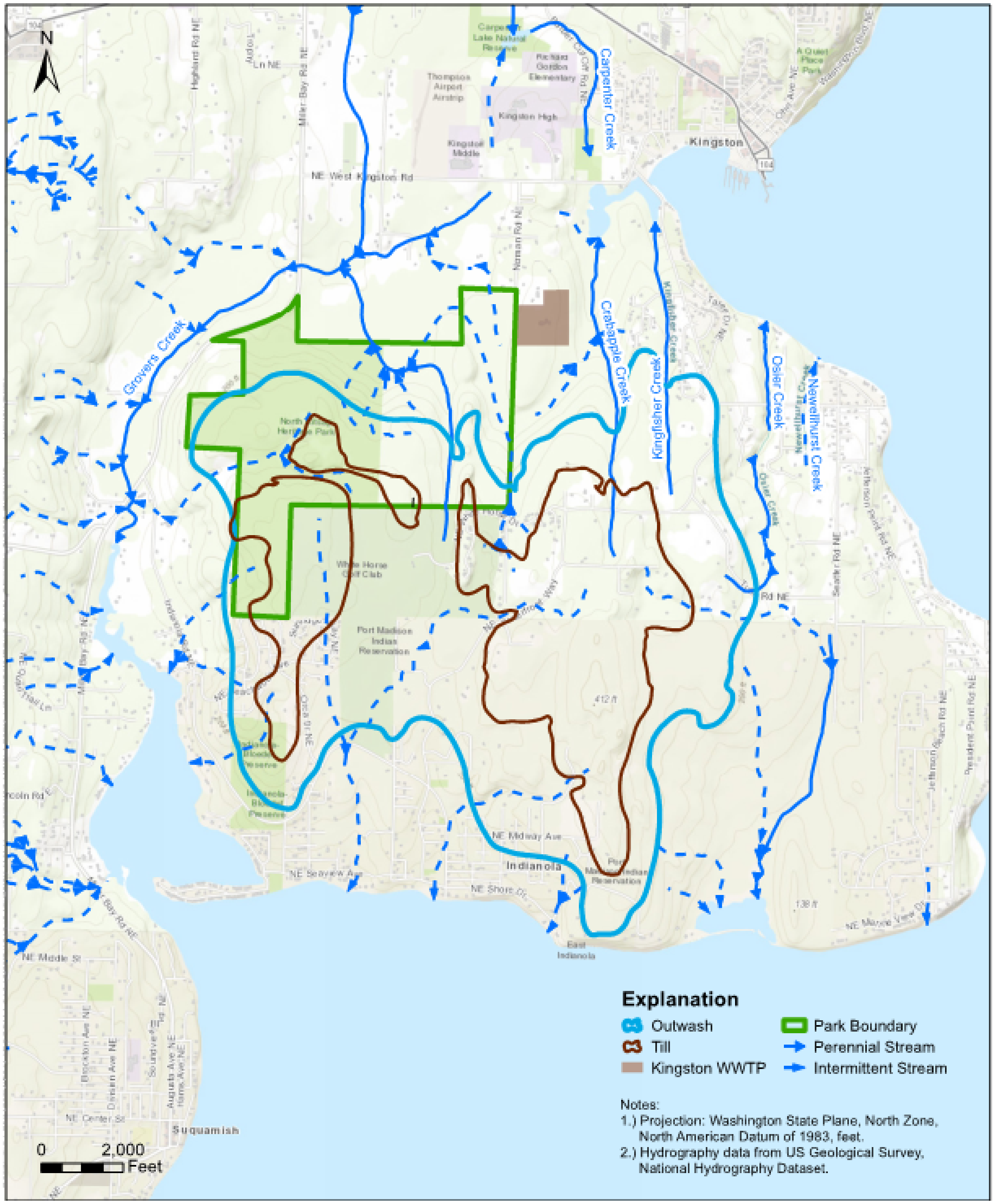


Figure 7-5. Groundwater infiltration area will serve to replenish nearby streams

In general, increasing baseflow in Grovers Creek through infiltration would provide multiple benefits:

- More baseflow would increase the amount of physical habitat available for fish, insects, and other aquatic life. Increasing the depth of pools and the width of the stream would provide more habitat for salmonid rearing and more wetted area for growth of aquatic prey for juvenile salmonids. Increased baseflow may also aid adult salmon returning to the stream in the fall and winter months.
- As the recharged water travels through the soil, it will undergo natural cooling and additional vadose zone adsorption and biological treatment before emerging as baseflow in Grovers Creek. The increased discharge of cool groundwater would reduce water temperatures in Grovers Creek, which the *Washington State Water Quality Assessment* identified as a "water of concern" because of elevated temperature (Ecology 2016). The Grovers Creek hatchery relies on the stream to supply water for holding adult salmon to maturity, when water temperature is critical prior to spawning.
- Reducing creek water temperatures would help increase DO concentrations because cool water can hold more DO than warm water. The *Washington State Water Quality Assessment* listed Grovers Creek and Miller Bay as "polluted" because of low DO (Ecology 2016); therefore, measures that increase DO would be very beneficial.
- Increased baseflow would help to reduce fecal coliform and toxic pollutant concentrations in Grovers Creek and Miller Bay. Grovers Creek has been listed as "polluted" because of high fecal coliform concentrations (Ecology 2016). The baseflow would have very low concentrations of fecal coliform bacteria because the recycled water would be disinfected before entering the recharge basin and it would receive additional natural treatment as it moves through the soil. Consequently, the increased baseflow would help to dilute the fecal coliform concentrations in Grovers Creek. The groundwater discharge would also help to dilute toxic pollutants from road runoff, which has been identified as a likely cause of pre-spawn mortality for coho salmon.

A successful regional example of improving stream flow through infiltration is LOTT's Martin Way Reclaimed Water Plant. Class A recycled water is infiltrated near the headwaters of Woodland Creek in the city of Lacey, with the purpose of recharging groundwater that provides base flows to Woodland Creek. Infiltrating 1.3 mgd during dry months (summer) and 0.3 mgd during wet months (winter) was predicted to increase Woodland Creek flow by 66 percent of the summer infiltration rate and 85 percent of the winter infiltration rate (City of Lacey 2010). Woodland Creek provides critical habitat for Chinook salmon, as well as coho, chum, winter steelhead, and sockeye salmon. The Woodland Creek Groundwater Recharge Facility received the 2014 Excellence in Engineering Award from the American Water Works Association's Pacific Northwest Section (City of Lacey 2014).

7.7 Enhance Marine Life Ecosystems

As described above, the Project would virtually eliminate the direct discharge of treated effluent to Appletree Cove and Puget Sound and effectively reduce nitrogen loads by an estimated 3,300 lbs/yr in 2018 and 6,800 lbs/yr in 2040. This is aligned with the State's initiative to clean up and restore Puget Sound. By eliminating direct discharge to Puget Sound, the Project would provide a wide range of environmental benefits:

- **Improved fish habitat:** The proposed Project would help increase DO concentrations in Appletree Cove and Miller Bay. Low DO concentrations have caused fish kills in areas with limited water circulation like Hood Canal. The *Washington State Water Quality Assessment* identified Appletree Cove as a "water of concern" because of low DO (Ecology 2016).

By reducing the nitrogen load to Puget Sound, the Project would help avoid overpopulation of phytoplankton (floating, microscopic plants) and zooplankton (small animals that eat phytoplankton). When the phytoplankton and zooplankton die, they settle to the bottom, where they are decomposed by bacteria that consume DO from the water column (Dunagan 2018b). This process can create areas where DO concentrations are too low to support fish and other marine life.

The Project would also help protect eelgrass, kelp, and other plant species important to Puget Sound salmon, crab, and other marine life. The 2016 *Washington State Water Quality Assessment* listed Appletree Cove as impaired by excessive growth of ulvoid algae and reduced eelgrass beds associated with human causes (Ecology 2016). The Project would reduce the nitrogen loads that can cause plankton to become so dense that it blocks sunlight and limits the growth of eelgrass and kelp.

Reducing the nitrogen load would also help to avoid shifting the plankton composition to favor species that herring and other forage fish do not eat (Dunagan 2018a). Therefore, the Project would help protect the food supply for salmon, birds, and other species.

- **Improved shellfish habitat:** By reducing nitrogen loads, the proposed Project could also help to reduce ocean acidification, which harms shellfish and other marine organisms that need calcium carbonate to form their skeletons and shells. Decomposing algae release carbon dioxide (CO_2), which dissolves to form carbonic acid, which in turn reduces carbonate ion concentrations in the seawater. This makes it harder for oysters and other shellfish to form shells. Climate change is causing increased ocean acidification as roughly 25 percent of CO_2 in the atmosphere is being adsorbed into oceans (Peabody 2018). A 2-year ocean acidification monitoring program completed by the Puget Sound Restoration Fund (PSRF) (in partnership with the National Oceanic and Atmospheric Administration [NOAA], University of Washington, Taylor Shellfish, Baywater, Inc., Pacific Shellfish Institute, and Pacific Coast Shellfish Growers Association) in 2010 indicates that ocean acidification is contributing to changing seawater chemistry in Puget Sound (PSRF 2011). The study also found that mechanisms driving more acidic conditions including human-driven activities, such as nutrient loading, were amplifying the effects of changing water quality conditions in Puget Sound (PSRF 2011).
- **Decreased shellfish toxicity:** Excess nitrogen can trigger blooms of algal species that release toxic substances, such as domoic acid. These substances can cause illness or death in people or animals eating shellfish from the affected waters. They can also be harmful to animals that are directly exposed to the toxins in the water column. The Project would help reduce the potential for shellfish toxicity associated with excessive nitrogen loading.

The Project could also contribute to reducing shellfish harvesting restrictions triggered by elevated fecal coliform bacteria concentrations in Miller Bay. Miller Bay has been closed for shellfish harvesting because of fecal pollution and marine biotoxins (Health 2018b). The Project would provide higher wastewater treatment, which would further reduce fecal coliform concentrations in the produced wastewater. The Project would also increase the discharge of clean groundwater discharge into Grovers Creek, diluting fecal coliform present in the creek. The increased stream flow would also help to improve flushing of Miller Bay. As an example of the benefit to water quality, after removal of a WWTP discharge into Hood Canal by KPUD, 90 acres of shellfish harvesting were opened (*Kitsap Sun* 2017). Although it is not expected that increasing Grovers Creek stream flow would open the bay for shellfish harvesting, it could be an important component of a broader strategy to improve water quality in Miller Bay. Friends of Miller Bay has indicated support for the concept of increasing flows in Grovers Creek.

Proactive regulatory compliance: Reducing the nitrogen load from WWTPs is a high priority for Ecology because wastewater effluent is the largest local human source of dissolved inorganic nitrogen to Puget Sound (Ecology 2018). Future discharge permits for Kingston WWTP will likely include stringent nutrient limits that would require costly Kingston WWTP upgrades. Failure to meet permit limits can trigger fines and increase the risk of third-party lawsuits. These costly nutrient removal upgrades would reduce the nutrient discharge only; they would not address any water supply concerns through a full recycled water project. The Project provides a unique opportunity to avoid prescriptive future permit requirements and protect local water resources in ways that provide additional benefits and align with the values and priorities of the local community. The LOTT Clean Water Alliance's Hawks Prairie recycled water recharge facility has provided similar benefits (Figure 7-6).

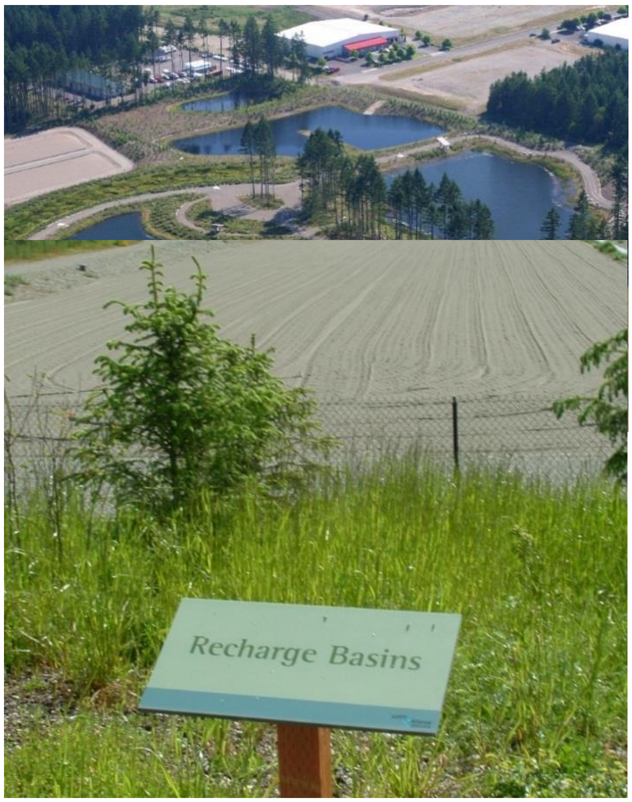


Figure 7-6. The Hawks Prairie recycled water recharge facility helped the LOTT Clean Water Alliance avoid costly nitrogen permit limits while providing multiple benefits

Reduce loads of other constituents: In addition to eliminating the direct discharge of nitrogen and BOD, the Project would eliminate the direct discharge of other constituents, such as pharmaceuticals and personal care products (PPCPs), that could affect human and ecological receptors. Recently mussels in Puget Sound tested positive for prescription opioid oxycodone, along with containing synthetic surfactants, antibiotics, and antidepressants (CNN 2018). However, concentrations were quite low; for example, a person would need to eat 150 pounds of mussels to get even a small dose (CNN 2018). Research is ongoing to understand the impact to mussels and other aquatic life. According to Jennifer Lanksbury, a WDFW biologist, a significant source of these pharmaceuticals is from people flushing their drugs down the toilet. A benefit of the Project is that the enhanced treatment required to produce recycled water can also remove 30 to greater than 80 percent of EDCs and PPCPs (Wang et al. 2005; Lubliner et al. 2010) that would otherwise enter sensitive marine environments.

The Project would include aquifer recharge through an infiltration basin, which would provide additional treatment (as shown in the schematic in Figure 7-7). After seeping through the bottom of the basin, the highly treated (Class A) water would undergo SAT, which provides multiple barriers for protecting surface water and drinking water. The infiltration interface provides the first barrier. In this first zone, recycled water is filtered by the recharge basin bedding materials. In addition to providing additional filtration, the surfaces of the soil particles provide binding sites for multiple constituents. Phosphorus, for example, is readily adsorbed by the common iron-based minerals in soil. Next, the downward migration of recharge water through the unsaturated, or vadose zone that provides a percolation barrier. The percolation barrier provides constituent reduction and removal through aerobic degradation, and additional sorption. After moving through the unsaturated zone, the recharge water interfaces with the regional groundwater flow system. The groundwater system provides a mixing and transport barrier. Within the zone of mixing and transport, anaerobic degradation occurs, as well as additional sorption. Other aqueous geochemical reactions may occur in the mixing and transport zone as the recharge water equilibrates with the regional flow system.

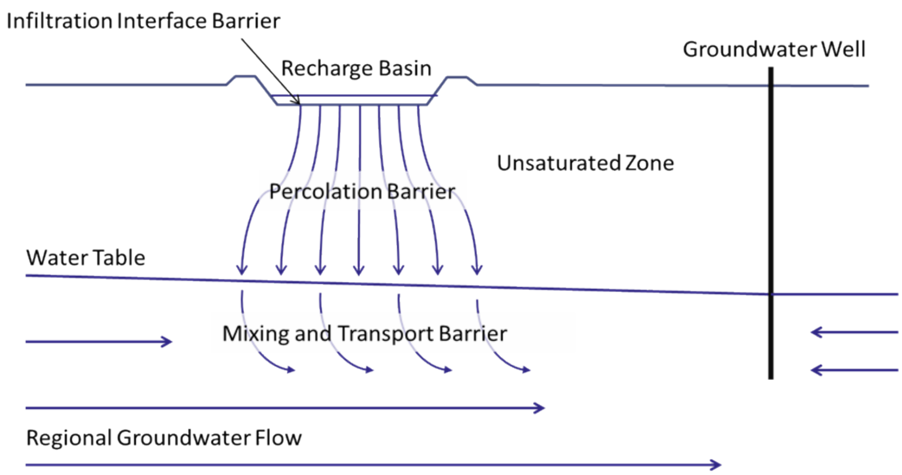


Figure 7-7. Groundwater infiltration through recharge improves stream flow and SAT provides multiple barriers for protecting surface water and groundwater

The efficacy of SAT for the removal of common constituents of concern as well as trace compounds such as PPCPs and other EDCs has been studied at several sites where managed aquifer recharge projects have been established. Many of these facilities have been in operation for more than 50 years, with the focus of providing managed aquifer recharge using recycled water as a vital mechanism for sustaining drinking water supplies (e.g., Orange County's Groundwater Replenishment System). These long-established facilities have been the subject of much research in the industry. Within the last 5 to 10 years, studies have shown that SAT is a reliable method for removing a broad range of constituents, including those classified as "emerging contaminants." Many studies report removal efficiencies ranging from 50 to 80 percent for constituents like antidepressants, beta blockers, insect repellant, tranquilizers, antibiotics, anti-epileptics, nonsteroidal anti-inflammatory drugs (NSAIDs), lipid regulators, and flame retardants (Dickenson et al. 2008; WERF 2006).

A study on Oahu investigated the use of recycled water instead of groundwater for landscape irrigation. Concerns over aquifer protection, resulting from historical use of agricultural pesticides that have caused groundwater contamination, was the motivation for the study that evaluated water quality differences between irrigating with recycled water and groundwater. Concentrations of microconstituents in potable water aquifers under recycled water irrigated lands did not change drastically, even where irrigated recycled water had higher concentrations of organic compounds than the well water (Crites et al. 2006). This study represents the potential worst-case scenario conditions for transmission of soluble constituents downward. It was found that nearly all attenuation of microconstituents occurs in the top layers of soil where biological activity in the aerobic zone leads to decomposition (Crites et al. 2006), and the authors found that irrigation posed no water quality risk to groundwater.

7.8 Engage the Community About Our Critical Water Resources

The Project would represent a transformative shift from the traditional “waste treated and discharged to Sound” approach to a “resource recovery” approach. With this Project, the community is not just reacting to regulatory requirements, but is taking the initiative to produce recycled water and use it as an integral part of the near- and long-term water supply management plan for the area (i.e., use it as a valuable resource). Kitsap County established a Water as a Resource Policy in 2009 to further this cause (Kitsap County 2009).

Community education, particularly at the grade school level, is critical to demonstrating the values of the region and highlighting how agencies are acting as stewards of the environment. This Project would allow the County and stakeholders to showcase the importance of preserving the area’s water supply and water quality for future generations. Without a venue or showcase project for this type of communication, the message is less tangible and meaningful to residents and children, who will be charged with being stewards of our future water resources and this special ecosystem. This Project would provide a range of opportunities to inform the public about how the Project benefits the environment, public health, and local economy. For example:

- Signs at WHGC would inform golfers about the recycled water irrigation system and its benefits (e.g., reduced demand on the limited potable water supply, reduced fertilizer use, no direct discharge to Appletree Cove).
- Signage and/or kiosks at NKHP and the Tribe’s Grovers Creek fish hatchery and Cowling Creek Center facilities could inform visitors about the Project and its environmental benefits. The park and tribal facilities could be places to take school-age kids and educate them about our environment. The LOTT Clean Water Alliance has created a similar educational program, as shown in Figure 7-8.
- A public engagement component at Kingston WWTP could inform and encourage tour groups. As an example, King County’s Brightwater WWTP includes an Education and Community Center to “educate and motivate the public to environmental stewardship and build community,” as shown in (King County 2018b).
- The Kitsap County and stakeholder websites could provide a wide range of information about the Project, its uses in the region, and its benefits.

Figure 7-8. Community outreach examples

Left: Public education is an important component of the LOTT Clean Water Alliance's recycled water program. *Right: King County's Education and Community Center is a resource for the community*

7.9 Create a Community Asset

Water is life and a critical aspect of a vibrant region and healthy economy. Having a long-term and sustainable plan to supply water to the community is important to:

- Maintain economic prosperity
- Keep long-term costs down for water resource management
- Retain and attract new business to the region

Using water for its "highest and best use" and planning for future resilience keeps long-term costs down for water resources management and controls utility rates. Businesses (and ratepayers) are interested in controlled utility rates, so by planning ahead and investing in resilient supplies, the County will not be forced into emergency investments (and corresponding drastic utility rate spikes) in the future. Making these investments now in a thoughtful and strategic manner will result in the maximum environmental and financial benefit to the area for long-term value.

The City of Nampa, Idaho, recently studied the potential economic benefits of generating Class A recycled water for reuse. The study concluded that the availability of Class A recycled water could help attract new businesses and retain existing businesses, providing substantial economic benefits from more jobs, labor income, and property tax revenue (ECONorthwest 2016).

7.10 Conclusion

The County, Tribe, and other stakeholders are excited to embark on this unique opportunity. Through previous stakeholder outreach efforts, unanimous and enthusiastic support has been expressed for advancing the Project and realizing the multiple benefits that are anticipated from this Project. This Project is a microcosm of the broader goal where Tribal and State government partnerships are coming together to support these agencies' and organizations' initiatives. These actions are also in alignment with the broader goals of Ecology, Governor Jay Inslee's Shellfish Initiative, West Central Local Integrating Organization, and the Puget Sound Partnership's Strategic Initiatives to:

- Prevent pollution from stormwater
- Protect and restore habitat
- Recover shellfish beds

A transformative shift in the area's approach to water management from "waste treated and discharged to the Puget Sound" to "treating water as a resource" is feasible given the unique geographic and stakeholder characteristics of the Project. And with this shift would come a community asset that would offer immediate and long-term benefits for the Kingston area.

Section 8

Recommended Recycled Water Facilities

This section summarizes the key features of the recommended recycled water facilities.

8.1 Recycled Water Quality Design Criteria

Recycled water quality design criteria are based on the Reclaimed Water Rule adopted by Ecology on January 23, 2018 and given in WAC 173-219. This rule applies to all existing and proposed facilities that are or will be designed, constructed, operated, and maintained in the state of Washington to generate, distribute, and/or use recycled water. Two different classes of recycled water are defined: Class A and Class B. For landscape irrigation with direct or indirect public access (such as in a golf course), Class A recycled water is required, while for indirect groundwater recharge (through surface or subsurface percolation or vadose wells), either Class A or B recycled water is required. Recycled water production at Kingston WWTP will meet the Class A requirements for all anticipated uses.

Treatment methods for Class A recycled water include biological oxidation, followed by coagulation, filtration, and disinfection, demonstrating a 4-log virus removal or inactivation. In lieu of coagulation and filtration, membrane filtration could be employed. At Kingston WWTP, biological oxidation will be achieved in the current oxidation ditch extended aeration system. The performance standards for Class A recycled water are given in Table 8-1.

Table 8-1. Class A Recycled Water Performance Standards

Biological Oxidation		
Parameter	**Monthly Average**	**Weekly Average**
BOD_5	30 mg/L	45 mg/L
$CBOD_5$	25 mg/L	40 mg/L
TSS	30 mg/L	45 mg/L
pH	6 (min)	9 (max)
Coagulation/Filtration (applicable for sand filtration)		
Parameter	**Monthly Average**	**Sample Maximum**
Turbidity	2 NTU	5 NTU
Disinfection		
Parameter	**7-day Median**	**Sample Maximum**
Total coliform	2.2 MPN/100 mL or CFU/100 mL	23 MPN/100 mL or CFU/100 mL
Virus removal	4-log removal or inactivation	
Denitrification [a]		
Parameter	**Monthly Average**	**Weekly Average**
Total nitrogen	10 mg/L	15 mg/L

a. Applicable only for release to wetlands, surface water augmentation, and groundwater recharge.

The disinfection requirements can be achieved by chlorination, UV light treatment, or other processes demonstrated to be equivalent to or better than chlorination or UV light treatment. For UV disinfection, the treatment process is to meet the criteria given in *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse* published by the National Water Research Institute (NWRI), which includes the UV dose of 100 mJ/cm^2 described in Section 6.3.3.

8.2 Design Overview

The recycled water system is designed for a capacity of 0.7 mgd (representing the predictions for 2040 peak day flow). The recycled water system consists of the following components:

- Modifications to the existing oxidation ditch
- EQ tank
- Filter feed pumps station
- Tertiary filtration
- UV disinfection followed by sodium hypochlorite addition for recycled water distribution system residual
- Recycled water pump station
- Recycled water pipeline

A process flow schematic for the proposed recycled water system is shown in Figure 8-1. Recycled water would be produced year-round with the goal to have limited discharge to Puget Sound.

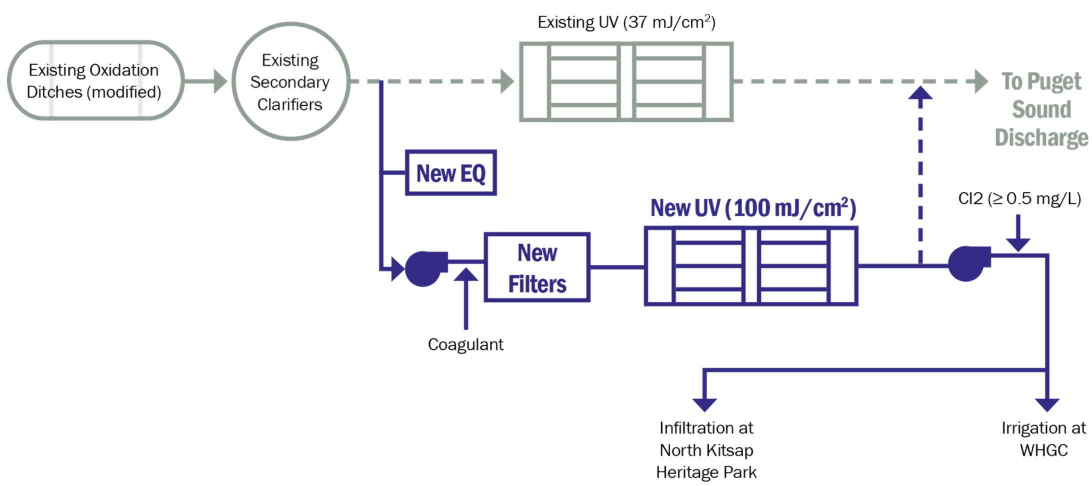
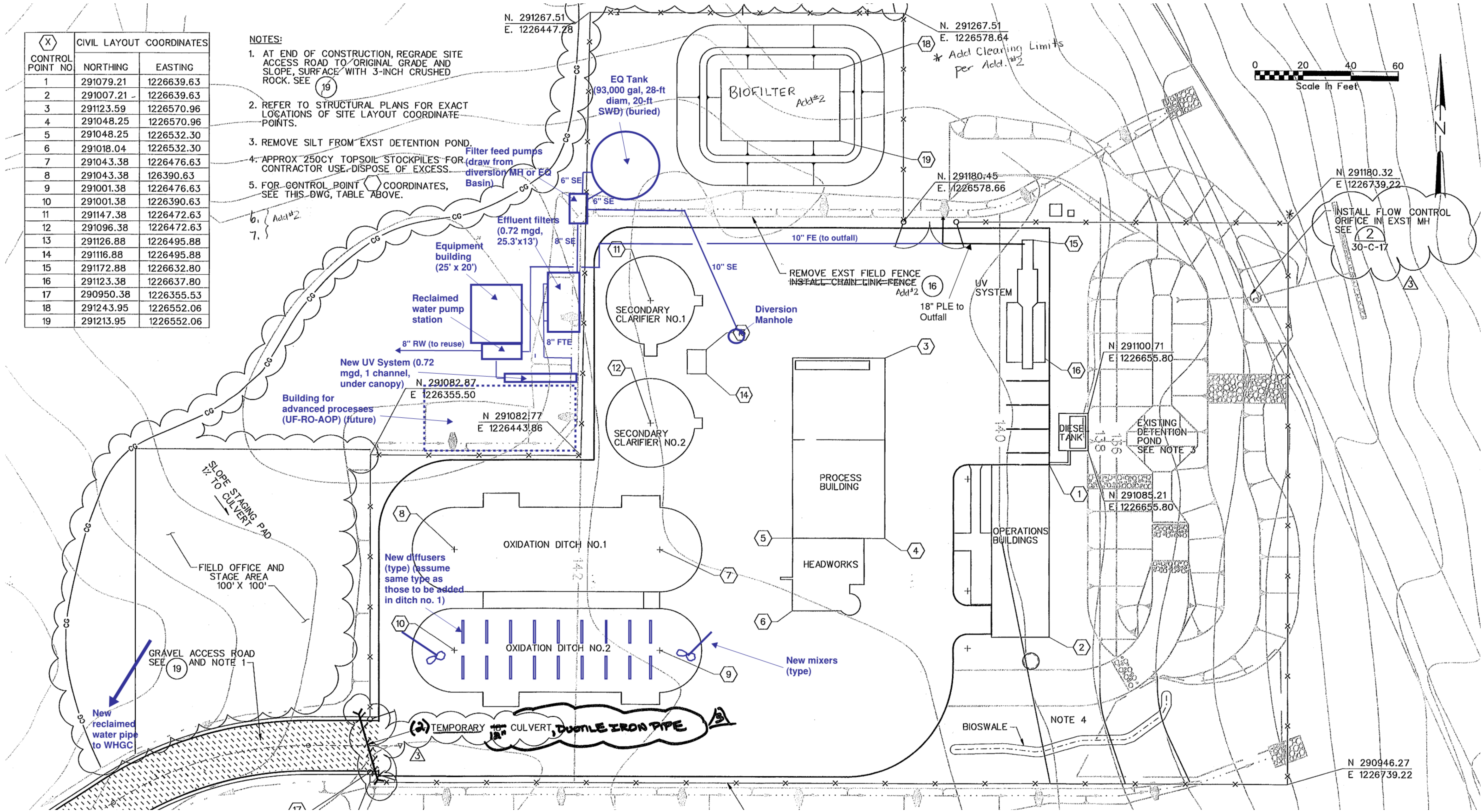


Figure 8-1. Recycled water facilities process flow schematic

8.2.1 Facilities Layout

Figure 8-2 shows the preliminary layout of the recycled water facilities within Kingston WWTP. The layout shows in blue new or retrofitted facilities as well as new major yard piping on the Kingston WWTP site. The new filters, UV channel, and equipment building would be located on the west side of the site, next to the secondary clarifiers. A new final effluent pipe would carry effluent from the recycled water pump station to the outfall when needed. The layout provides space for any future advanced processes to meet more stringent requirements, mainly related to removal of organic chemicals that are not readily removed in secondary treatment and sand filtration. It is assumed that the future processes would include ultrafiltration (UF), reverse osmosis (RO) and advanced oxidation process (AOP).



CONTROL POINT NO.	CIVIL LAYOUT COORDINATES NORTHING	EASTING
1	291079.21	1226639.63
2	291007.21	1226639.63
3	291123.59	1226570.96
4	291048.25	1226570.96
5	291048.25	1226532.30
6	291018.04	1226532.30
7	291043.38	1226476.63
8	291043.38	126390.63
9	291001.38	1226476.63
10	291001.38	1226390.63
11	291147.38	1226472.63
12	291096.38	1226472.63
13	291126.88	1226495.88
14	291116.88	1226495.88
15	291172.88	1226632.80
16	291123.38	1226637.80
17	290950.38	1226355.53
18	291243.95	1226552.06
19	291213.95	1226552.06

Figure 8-2. Preliminary site layout of recycled water facilities

8.2.2 Redundancy

Per the Reclaimed Water Rule (WAC 173-219), bypass of inadequately treated wastewater from the recycled water facility to the distribution system is prohibited. To maintain adequate treatment, redundancy would thus be provided for the tertiary processes. The level of redundancy can be reduced or removed if the County preserves the option to discharge secondary effluent to Puget Sound. For this facility planning effort, it was assumed that all flows would be reclaimed. The outfall would be used for exercising purposes only. The treatment systems could be downsized if redundancy is provided by allowing outfall discharge.

The tertiary filters are sized to treat the peak design flow (0.7 mgd for option 1 as selected in Section 6.3.4), with one cell out of service. The filter feed pumps would similarly be sized such that with one pump out of service, the remaining pumps would accommodate the peak design flow.

For the disinfection system, the new UV system is sized for the peak design flow of 0.7 mgd, with two UV banks in a single channel. It was assumed that when a UV bank is taken out of service for maintenance, disinfection would be provided by chlorination using existing equipment as discussed in Sections 6.3.3 and 6.3.4. The UV disinfection system will be validated using the water quality requirements outlined in Table 8-1 for total coliform and viruses. The chlorination system will be validated based on chlorine residual in the distribution system.

Recycled water pumps would be sized such that with one pump out of service, the remaining pumps would accommodate the design peak day flow.

Additionally, the outfall would be maintained so that treated wastewater can still be discharged to the Puget Sound if operational issues arise. The existing Kingston WWTP outfall would be used intermittently to “exercise” the outfall and keep it operational for emergency situations until such time that a year-round land application or storage site is identified.

8.3 Facilities Description

The following section provides a description of the proposed recycled water treatment processes and conveyance facilities.

8.3.1 Treatment

The existing secondary system would be upgraded to provide the necessary nitrogen removal. This includes replacement of the brush aerators in a currently operating oxidation ditch with fine-pore diffusers, addition of diffusers in the second oxidation ditch, and addition of mixers in both ditches. Preliminary analysis indicated that sufficient nitrogen removal could be achieved without supplemental carbon addition. Therefore, a supplemental carbon system is not included in the site layout and cost estimates for the recycled water facilities.

Secondary effluent would flow from the secondary clarifiers to a new diversion manhole. From there, the secondary effluent can be directed to either the filter feed pump station or the existing UV system for subsequent disposal at the outfall. When Kingston WWTP is producing recycled water, the secondary effluent is pumped to the upflow filters up to the design flow of 0.7 mgd. When flow exceeds 0.7 mgd, the excess flow is sent to the EQ tank. The filtered effluent flows to the UV system. The existing chlorination system can be used to dose chlorine for chlorine residual in the reclaimed water distribution system. After disinfection, the recycled water is pumped to the distribution system.

Table 8-2 summarizes the preliminary design data for the recycled water facilities.

Table 8-2. Kingston WWTP Recycled Water Treatment Design Data	
Process Element	**Design Value**
Oxidation ditches	
Number of basins	2 (existing)
Type of new aeration system	Fine-pore aeration
Number of mixers	2 per basin
EQ tank	
Maximum liquid volume, gal	93,000
Diameter, ft	28
SWD, ft	20
Discharge/mixing pumps	
Number of pumps	2
Motor, hp	7.5
Filter feed pumps	
Number of pumps	3
Capacity, each, gpm	250
Motor hp	10
Pump speed	Variable
Tertiary filters	
Type	Upflow sand, intermittent backwash
Number of filter cells	3
Peak hydraulic loading rate, gpm/ft^2	5.0
Maximum capacity with one cell out of service, mgd	0.72
UV disinfection	
Lamp type	Low-pressure amalgam
Capacity, mgd	0.72
Design secondary effluent transmittance, percent, minimum	65
Design UV dose, mJ/cm^2	100
Number of channels	1
Number of banks	2
Number of lamps per bank	20
Maximum power draw, kW	10
Chlorination system	
Number of storage tanks	1
Tank capacity, gal	2,500
Number of metering pumps	2
Target chlorine dosage range, mg/L Cl_2	2 – 6
Design average day demand, gpd	7.4 (as 12.5 percent sodium hypochlorite solution)
Design 2040 peak day demand, gpd	29 (as 12.5 percent sodium hypochlorite solution)
Reclaimed water pumps	
Number of pumps	3
Capacity, each, gpm	250
Motor, hp	20
Pump speed	Variable

Only the major equipment is listed. Auxiliary equipment, including coagulant chemical storage and feed system and hypochlorite feed system as well as air compressors for the tertiary filtration system, is not included in this table.

8.3.2 Conveyance

The reclaimed water can be conveyed to the following locations:

- WHGC for irrigation during the summer months
- North Heritage Kitsap Park for infiltration

Additional reclaimed water users could also be added in the future. Secondary effluent or reclaimed water can also be discharged to Puget Sound if there is an operational upset or for means of exercising the outfall.

The Class A recycled water would be pumped south from the southwest corner of the WWTP site to the WHGC and proposed infiltration area through an 8-inch pipeline. The new recycled water pump station would be located immediately downstream of the new UV system at the WWTP site. The currently proposed conveyance route would use power line right-of-way, but the benefits of additional conveyance alternatives utilizing existing paths through NKHP will be evaluated during subsequent design analyses. As discussed in Section 6.6, conveyance routing will be coordinated with the Kitsap County Parks Department's efforts to extend and improve its trail network within NKHP. Figure 8-3 shows the proposed pipeline alignment to WHGC and the infiltration area.

Conveyance components will be designed, inspected, and tested in compliance with the requirements of the Uniform Plumbing Code (Chapter 15), Health's *Water System Design Manual* (Health 2019) and WAC 173-219-360. Conveyance piping will be labeled as "recycled water" and will utilize appropriate cross connection control. Proposed cross connection control procedures are further described in Section 8.5.1.

8.3.3 Irrigation

At WHGC, the project includes a 700,000 gallon lined equalization (EQ) basin for irrigation. The EQ basin will allow WHGC to irrigate out of the existing large storage pond that serves as an aesthetic feature on the golf course without the level in the storage pond changing based on irrigation demands. The project also includes the following features for irrigation at WHGC:

- A new irrigation pump station, 1,500 gpm capacity with remote monitoring capabilities
- A new pond fountain pump and three subsurface pumps to promote circulation in the pond and increased dissolved oxygen
- Two chemical injection systems including chemical feed tanks, pumps, and controls
- Level control in the storage pond and EQ basin, flowmeters, and control valves for controlling operation of the irrigation system

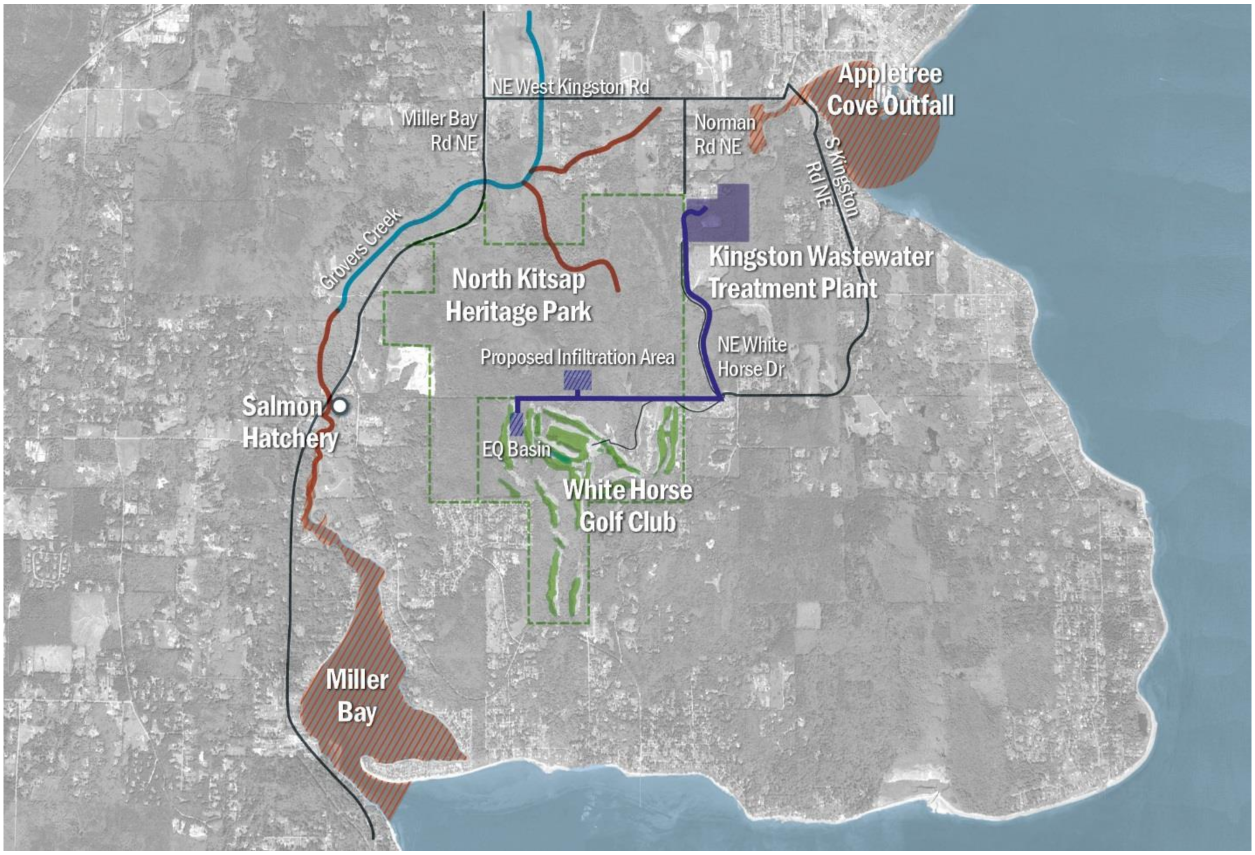


Figure 8-3. Proposed pipeline to WHGC and infiltration area

8.3.4 Infiltration

Recharge would infiltrate into the shallow unconfined aquifer system and would become available for baseflow to the Grovers Creek watershed. The unconfined aquifer identified during site characterization activities has a limited areal extent within the central and southern portions of NKHP and the northern portion of WHGC. A review of well log records revealed that no wells pump from the unconfined aquifer, with the nearest water wells pumping from the underlying confined sea-level aquifer. The recommended design of the proposed groundwater recharge facility has a footprint of approximately 2 acres and is located in the general vicinity of the boundary between NKHP and WHGC. Figure 8-3 depicts the proposed infiltration location.

The basis of design for the proposed groundwater recharge alternative, in terms of recharge basin size and geometry, is a function of the shallow stratified near-surface sand deposits. However, groundwater mounding and transport is based on the hydraulic properties of the shallow aquifer system. Based on the Project results, the recommended basin configuration consists of a primary recharge basin, with dimensions of approximately 100 by 400 feet and divided into two equal cells. Additionally, a secondary recharge basin, with dimensions of approximately 100 by 400 feet, is recommended as backup during maintenance of the primary basin, and handling of extreme flows during peak discharge and rainfall events. Each basin is designed with an engineered sand media at the surface followed by a gravel layer over the native soils. The surficial sand unit facilitates basin maintenance and vegetation control via seasonal tilling or disking of the sand. The underlying gravel unit facilitates the spread of recharge over the basin surface area. Discharge to each basin will occur at the surface via perforated pipes resting on the top of the sand layer.

8.4 Process Control Strategy

Control of the recycled water facilities would be based on the quality and quantity of water available (secondary effluent) and the recycled water demand and application. As the tertiary filters and new UV system are sized for approximately the projected 2040 peak day flow (0.72 mgd), when the secondary effluent flow is less than 0.72 mgd, all flows are sent to the tertiary system and subsequently to either the golf course or the infiltration basin. When the secondary effluent flow exceeds 0.72 mgd, the excess flow is directed to the EQ tank. This may be achieved by controlling the level in the filter feed pump wetwell. The pumps would be operated to maintain a constant wetwell level. When the operating level exceeds the set point level while the pumps are operating at the maximum flow rate, the excess flow is diverted to the EQ tank. When the operating level drops below the set point level while the pumps are operating at maximum flow rate and the EQ tank level is above a minimum set point level, equalized flow from the tank is returned to the wetwell to combine with the secondary effluent.

For the tertiary filters, flow rate to the filters is controlled by the filter feed pumps. Each filter cell is brought on or off line by manually operating or closing the associated valve. Backwash of the filters is performed intermittently and automatically by the filter control system. Typically, the operator can select the backwash initiation mode (timer or differential pressure) and the associated set points (backwash frequency, backwash duration, filter differential pressure).

The UV disinfection is typically also controlled automatically with the UV lamp output adjusted to maintain the required dose of 100 mJ/cm^2. An ultraviolet intensity (UVI) sensor would continually measure the lamp output, and the UV dose is calculated as UVI multiplied by retention time. A chemical/mechanical cleaning system is set to automatically clean the wiper sleeves. A motorized effluent weir gate is used to maintain the water level over the lamps.

The recycled water pump station receives flow from the UV system and pumps the disinfected effluent to the distribution system. The pumps would be equipped with variable-speed drives. The pump speed can be controlled to maintain a constant level in the wetwell. A bypass pipe and associated valve would be included to allow diversion of the disinfected effluent to the outfall when needed.

During the dry season, the extent of nitrogen removal could be reduced to increase the nitrogen content in the recycled water used for irrigation. This could be achieved by reducing the operating solids retention time (SRT) of the oxidation ditch secondary system, adjusting the aeration on-off cycle, and/or taking one of the oxidation ditches offline (if both ditches are on-line to provide nitrogen removal). If supplemental carbon is added to provide nitrogen removal, it will be stopped during irrigation season.

8.5 Additional Design Considerations

This section describes cross-connection control considerations and contingency planning.

8.5.1 Cross-Connection Control

Cross-connection control for recycled water systems is described in Washington's new Reclaimed Water Rule (WAC 2018). The potable water provider in the region is responsible for cross-connection between recycled water with potable water supplies (WAC 173-219-310(2)). The Reclaimed Water Rule (WAC 173-219-310(3)) also dictates that recycled water generators are responsible for protecting recycled water and partially treated recycled water from contamination via cross-connection with lower-quality supplies and preventing water under their control from contaminating potable water, starting in the generation facility, including all treatment stages, storage, and distribution facilities, and ending at the point of delivery to the user's recycled water meter at the property line of the use area.

The generator must notify its potable water purveyor of the proposed and ongoing recycled water treatment activity and facility location and comply with the purveyor's cross-connection control requirements under WAC 246-290-490 and any locally adopted regulations.

A cross-connection control specialist must be involved in the development of a written cross-connection control program and the recycled water system must be inspected annually to be submitted with the annual summary reports and backflow incident reports (WAC 173-290-310). Backflow prevention devices must also be tested annually by a backflow assembly tester (BAT) (WAC 246-290-490).

The proposed recycled water facilities would include proper cross-connection at Kingston WWTP. At WHGC, an air gap would be installed at the outlet of the recycled water distribution pipe. No other connections to the recycled water distribution system are proposed at this time. The existing KPUD potable water connections at the WHGC are equipped with a reduced pressure backflow preventers (RFBP).

8.5.2 Contingency Planning

The recycled water treatment system is being designed with redundancy as described in Section 8.2.2 so that the tertiary filtration system can operate with a feed pump out of service or a cell of the filtration system out of service.

Additionally, Kingston WWTP would maintain its current outfall to Puget Sound that can be used if recycled water performance objectives are not being met.

8.6 Staffing Requirements

Additional labor would be required to support operation and maintenance of the recycled water system. With the addition of the new filtration system, new distribution system, and infiltration gallery, the annual labor required would be 4 hours per week for compliance and monitoring, 8 hours per week for treatment operations, and 2 hours per week for maintenance, with a total staffing requirement of 728 hours per year or 0.35 full-time equivalents (FTEs).

8.7 Cost Estimates

A detailed cost estimate was developed for the recycled water facility including distribution and infiltration. In accordance with Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate, which is defined as a planning-level or design technical feasibility estimate. Expected accuracy for Class 4 estimates typically ranges from -30 to +50 percent, depending on the technological complexity of the project, appropriate reference information, and inclusion of an appropriate contingency determination.

8.7.1 Capital Costs

The primary capital costs for the recycled water treatment system include modifications to the existing secondary system, and addition of a tertiary filtration system and a new UV disinfection. Costs for the secondary system modifications include the costs for new aeration diffusers and mixers. The new EQ tank, sized for 28 feet diameter and 22 feet deep, is assumed to be buried with spray nozzle equipment and two 7.5-horsepower (hp) pumps to send equalized flow to the filter feed pump station and mixing of the EQ tank. Cost for the new tertiary filtration system includes the costs for the filter media, concrete basins, backwash system, air compressors, and chemical feed system (for the coagulant). The new UV system comprises one channel with two UV banks. The cost for the new UV system includes costs for the UV banks, concrete channels, grating, and gates. The coagulant feed system, air compressors, and electrical equipment would be housed in a new 450-square-foot (ft^2) prefabricated building. The cost estimate for the WWTP upgrade also includes costs for the filter feed pump station and reclaimed water pump station.

A new 12,600-linear-foot (LF), 8-inch-diameter force main would be constructed from the existing Kingston WWTP south to a new EQ basin to be used for irrigation. A 700,000-gallon lined equalization (EQ) basin including level control, flowmeters, and control valves allow for equalizing reclaimed water for irrigation to the existing storage pond at the WHGC. Upgrades to the existing irrigation system include a new irrigation pump station (1,500 gpm capacity), a new pond fountain pump and three subsurface pumps, and two chemical injection systems including chemical feed tanks, pumps, and controls.

The pipeline extends through an existing park owned by the County and follows an existing pathway to minimize the clearing required. An additional 1,650 LF of 8-inch-diameter pipeline routes recycled water from WHGC to NKHP. The recharge basin cost estimate includes site clearing, cut and fill, a gravel access road, sand filter media, and monitoring wells. An 800 LF discharge line of perforated pipe would discharge water within the recharge basin.

An estimate of probable construction costs, probable project cost, and probable unit cost are provided in Table 8-3.

Table 8-3. Estimate of Probable Construction Cost

Description	Cost [a]
Class A Recycled Water Treatment	
Oxidation ditch 2 modifications	$534,000
New Secondary Effluent EQ tank	$479,000
New filter feed pump station	$264,000
New filtration system	$863,000
New recycled water building	$172,000
New disinfection system (UV)	$818,000
New reclaimed water pump station	1,464,000
Miscellaneous improvements	$653,000
Conveyance	
New pipeline	$1,757,000
EQ basin and irrigation at WHGC	$1,565,000
Infiltration basins and associated piping	$1,567,000
Construction and Project Costs	
Total construction cost (accuracy range)[b]	$10,136,000 ($7,095,000-$15,200,000)
Total Project cost [c]	$13,648,000
Annualized Costs[d]	$630,000
Estimated unit cost ($/MG)[e]	$6,700

a. *Includes labor (15%), material (10%), subcontractor (10%), construction equipment markups (10%), contractor markups (15%), contingency (30%), escalation (12.5%), and other markups detailed in Appendix G, Cost Estimate.*
b. *Class 4 cost estimate, accuracy range of -30% to +50%.*
c. *Total Project cost includes predesign, engineering, construction services, legal, and administrative costs totaling 35%.*
d. *Based on NPV including capital and O&M costs and a 20-year life cycle.*
e. *Per USBR requirements, unit cost range based annualized costs and expected average annual yield over the life cycle.*

8.7.2 Operation, Maintenance, and Replacement Costs

O&M costs for winter infiltration and summer irrigation include labor costs, chemical costs, and energy costs. Table 8-4 tabulates the individual cost items in each category. The operational period is from 2023 to 2040. O&M costs are based on average annual flow. Flows are projected to increase from 0.18 mgd in 2023 to 0.37 mgd in 2040.

Table 8-4. Estimation of Annual O&M Costs

Description	Cost ($/year) [a]
Labor Cost	
Compliance/monitoring	4 hr/wk
Treatment operations	8 hr/wk
Maintenance	2 hr/wk
Total annual labor cost[d]	$37,000/yr
Chemical Cost	
Coagulant, polyaluminum chloride [b]	$7,000/yr
Sodium hypochlorite [c]	$5,000/yr
Total annual chemical cost	$12,000/yr
Energy Cost	
UV upgrade	$5,000/yr
Pumping, HVAC, and lighting	$68,000/yr
Total annual energy costs	$73,000/yr
Equipment Replacement Cost	
Equipment replacement	$29,000
Total O&M Cost	
Total annual O&M cost	$151,000

a. *Annual O&M costs represent an average value over the operating period (2023–40) based on escalating 2018 dollars using an escalation rate of 4% and a discount rate of 5%.*
b. *An average dose of 10 mg/L of polyaluminum chloride is assumed.*
c. *An average dose of 4 mg/L of sodium hypochlorite is assumed.*
d. *Annual salary of $60,000 was assumed.*

Section 9

Financial Analysis

This section presents the financial analysis for the proposed Project, including potential funding sources, a funding capability analysis, and a preliminary funding plan.

9.1 Introduction to Recycled Water Financing

The U.S. Environmental Protection Agency (EPA) has established guidelines for funding recycled water systems that are summarized along with USBR Title XVI Feasibility Study (Feasibility Study) project and Washington State specific information provided below.

Historically, wastewater utilities have entered into long-term agreements with agricultural and golf course customers to deliver recycled water at little or no cost to the customer because giving treated effluent away was viewed as mutually beneficial.

However, as water supplies are becoming scarce and more valuable, there is a growing opportunity to develop reasonable rates and charges for the alternative sustainable water supply created by recycled water. Recycled water is now widely recognized as a viable component of integrated water resources planning and providing adequate funding for recycled water systems is similar to other water services. EPA suggests the following guidelines for financing and operating a sustainable water system:

- Revenues from rates and charges should be sufficient to provide annual operating maintenance and repair expenses, capital improvements costs, adequate working capital, and required reserves.
- Accounting practices should separate recycled water funds from other governmental or entity operations for transparency and to prevent diversion of funds to uses for unrelated services; this concept is typically reflected by use of an enterprise fund, which may be standalone for the recycled water system or be combined with the County's wastewater system.
- Accounting practices should adhere to generally accepted accounting principles and comply with applicable regulatory requirements.
- Rates and fees should equitably distribute the cost of water service based on cost-of-service principles, compliance with legal requirements, and transparency of communication regarding non-quantifiable benefits to ratepayers.
- Budgeting should be adequate to support asset management, including planned and preventive maintenance, as well as infrastructure reinvestment.

Utilities often set recycled water rates lower than potable water rates to promote recycled water use. In general, recycled water is priced from 50 percent to 100 percent of potable water with the median rate 80 percent of potable water rates. This discount enables users to pay for retrofit costs, plus it serves as an incentive to use recycled water. However, the remaining costs of providing recycled water are typically borne by the wastewater system that benefits from treating its effluent to recycled water standards and/or reducing disposal costs or the water systems that benefits from an alternative water supply or groundwater/aquifer recharge. There are some jurisdictions where recycled water is priced the same as potable water, especially where recycled water is not subject to the potable water use restrictions during drought or available to offset peak use periods. Some utilities have large water users that may be willing to pay a large amount of the cost of providing recycled water to secure a stable long-term supply. Large customers that pay the bulk of a recycled water system costs, through a user agreement or direct capital contributions, may desire a latecomer agreement with the County to recoup some of their initial investment, or reduce their rates, as new customers connect to the system in the future.

Various funding sources are available to pay for implementation and operation of a recycled water system.

9.2 Funding Sources

While there are several sources for funding recycled water systems, County internal funding, debt funding, and grants/loans are the most common.

9.2.1 County Funding

County funding is based on revenue generated from customers, economic development funds, and reserves. The customers can be individual large-volume users or a wide network of users/beneficiaries within the water recycled area. Large-volume customers, if available, can finance a significant portion of a project and may have well-defined water quality objectives that would impact the nature and character of the treatment and distribution system or resource needs. Typically, these customers are industrial users, large-scale agricultural operations, or golf courses. The concern for the utility is the risk of losing the large-volume customer or the revenue from the service agreement once the project is underway. A “take or pay” clause (see more below) may need to be incorporated into any service agreements that is used to repay debt or other long-term fixed costs of the system. Internal funding is typically received annually or monthly, through an agreement with a large customer, from rates over the life of the project.

9.2.1.1 User Rates and Fees

Two methods are typically used for developing recycled water rates. The rate either fully covers the cost of recycled water production, distribution, administration, and operation, or rates are lowered by subsidizing the cost from other sources. Full cost recovery rates include the appropriate portion of capital and annual costs to plan, design, construct, administer, and operate a recycled water program. Capital costs include treatment, distribution, and possibly onsite facilities. The allocation of treatment facilities between recycled water and wastewater rates can be challenging, but it is generally accepted that facilities necessary for meeting NPDES discharge requirement levels are attributed to wastewater rates. Anything in addition to costs necessary to produce recycled water of a higher quality is attributed to recycled water rates. Costs saved from effluent disposal may be considered a credit. Indirect costs include a percentage of administration, management, and overhead. Another cost is replacement reserve, i.e., the reserve fund to pay for system replacement in the future. In many instances, monies generated to meet debt service coverage requirements are deposited into replacement reserves.

Several types of rate and fee structures have been used for the recovery of recycled costs, including a fixed monthly fee, volumetric rates, and connection fees. These are described below:

- **Fixed monthly fee:** Fixed monthly fees are used for a variety of purposes. In some cases, actual use is not metered, and the operation, maintenance, and replacement (OM&R) costs and/or capital costs are collected from this fee. Several methods are used to establish these fees, such as a cost per acre, cost per acre-foot, cost per pervious square foot, cost per equivalent residential connection, cost per meter size, or cost per customer. A combination of a fixed monthly fee and a volumetric rate can be charged with the fixed fee recovering fixed costs and the variable component reflecting cost that vary with usage.

- **Volumetric rates:** Volumetric rates may be the primary fee, with either OM&R and/or capital costs recovered. These rates may be charged per thousand gallons or per hundred cubic feet. The actual volumetric rates may differ per phase of connection. Initial recycled systems may offer incentives for early connections. This is specifically true when recycled water is the primary means of effluent disposal. Bulk users, such as agriculture, golf courses, and industrial applications, have benefited from these early connection rates. These large-volume users may also need rates that are competitive with the costs of groundwater use rather than potable water.
- **Potable water driven rates:** The dollar value of recycled water rates is typically based on the value of recycled water to those who have non-potable water demands, such as for irrigation or industrial applications. In some cases, water conservation pricing is used to further encourage efficient recycled water use. Recycled water rates are at their lowest values when the availability of fresh water and/or potable water is significantly greater than demand. As fresh and potable water supplies tighten relative to demand (for water systems) or regulatory and disposal costs increase for wastewater systems, there is pressure on the utility to use recycled water to meet demands. In areas with sufficient freshwater supply but limited wastewater effluent disposal options, recycled water is produced and applied to constructed wetlands, pastures, and irrigated areas to reduce effluent discharges to surface waters or nearshore coastal areas. The recycled water rates in these areas can be much lower than potable water rates and recycled water costs (if subsidized by wastewater customers) or closer to cost depending on the relative benefit customers receive.

In some cases, recycled water is provided at no charge or at a nominal charge that does not recover its full costs. As a result, the full costs are recovered through wastewater customers, water customers, or state or federal subsidies. For many utilities, recycled water use provides significant benefits to other customers by providing an environmentally safe alternative to wastewater effluent disposal, by reducing groundwater and surface water pumping and/or by delaying the need for additional water supply wellfields and water treatment plant facility capacity.

Nationally, recycled water rates as a percent of potable water rates range from 0 to at least 100 percent. According to a survey by the American Water Works Association (AWWA), the median recycled water rate charged by sampled utilities in 2000 and 2007 was 80 percent of the potable water rate.

Many non-potable water users are not fully aware of the benefits that recycled water provides. User benefits of recycled water may include the following:

- Having a guaranteed and reliable water supply
- Ability to conserve fresh water for other uses
- Ability to irrigate more frequently than if a traditional water source was used
- Ability to reduce fertilizer applications
- Ability to apply more water to the crop or landscape than with a traditional water source
- Typically costs less than potable water

As non-potable water users begin to understand the benefits of recycled water to their household or business, the amount of money they are willing to pay for recycled water will increase along with recycled water demand.

9.2.1.2 Service Agreements Based on Take or Pay Charges

Service agreements and cost recovery for utilities is a large part of the socioeconomic balance that is required by utilities to properly value a recycled water product. The high cost of treating wastewater is one of the reasons that utilities have historically not wanted to pass the entire cost of a system onto their recycled water customers. This situation is also prevalent in the costs of potable water systems and is a water industry-wide concern for the future.

Service agreements can be relatively simple with a single rate, but normally they are complex and multi-tiered, depending on water quality, supply and demand, specialized recycled districts, and peaking factors. Service agreements that include full cost recovery for recycled water should be promoted because recycled water is a recycled and delivered product that inherently includes all the costs from point of water withdrawal to point of use. A schedule of rates for each service agreement should include terms and conditions, covenants and restrictions, water quality parameters, allocations by intended use or service sector, and a dispute resolution clause.

9.2.1.3 Connection Fees for Wastewater Treatment Versus Distribution

Typically, connection fees for recycled systems are limited to recovering the costs of transmission and distribution. Treatment costs are generally the responsibility of the wastewater utility that provides recycled water; the wastewater utility and its customers assume financial responsibility for treating the wastewater to applicable standards, whether for discharge or recycled.

There are examples of utilities including the cost of recycled water treatment in their fees or splitting such costs with the wastewater utility. The recycled utility may be a separate agency that simply takes wastewater treated to discharge standards and provides the necessary extra level of treatment to produce recycled water. In that circumstance, connection fees would properly include treatment costs. Each situation is unique, and various costs must be identified to be sure a nexus exists between the cost and the ultimate service being provided to end users.

9.2.2 Debt Funding

There are several forms of debt funding, including revenue bonds and low-interest loans. The benefits of these funding instruments are that they are typically repaid over the long term with the funding received up front. Revenue bonds are supported by net operating income from utility rates and charges. Rates and funding resources must be in place prior to issuing debt. For the County, the requirement for issuing debt requires that the operation, maintenance, and debt repayment costs are covered by recurring user rates and charges, with a minimum 25 percent debt service coverage allowance over costs.

9.2.3 Grants and Loans

Grant programs are a good source of partially funding recycled water projects, but they require that the proposed system meets grant eligibility requirements. Grants reduce the total capital cost to be recovered from recycled water users and project beneficiaries and improve the affordability and viability of the project. Fortunately, many funding agencies are receiving a clear legislative and executive mandate to encourage water recycling in support of water conservation.

To be financially successful over time, a recycled water program must be able to “pay for itself.” While grant funds may be available to fund portions of the capital improvements for a recycled water project, they are not allowed to fund annual operating costs. Once the project is underway, the water recycling program is encouraged to achieve self-sufficiency as quickly as possible, to fund OM&R costs and debt service requirements, by generating a dedicated source of ongoing revenues.

9.2.3.1 Federal Funding Sources

The Clean Water Act (CWA) of 1977, as amended, has supported water recycled projects through the following provisions:

- Section 201 of PL 92-500 was amended to ensure that municipalities are eligible for "201" funding only if they have "fully studied and evaluated" techniques for "reclaiming and reuse of water." A facility plan must be completed to qualify for state revolving loan funds.
- Section 214 stipulates that the EPA administrator "shall develop and operate a continuing program of public information and education on water reclamation and reuse of wastewater…."
- Section 313, which describes pollution control activities at federal facilities, was amended to ensure that wastewater treatment facilities will utilize "reuse techniques: if estimated life-cycle costs for such techniques are within 15 percent of the most cost-effective alternative."

Various federal sources could be used to fund water recycling projects as described below. The Tribe may be eligible for additional funding that the County does not have access to. If the Tribe becomes a major consumer of recycled water, it may be beneficial for the County to work with it to secure joint funding for the Project. While there are many funding sources, only certain types of applicants or projects are eligible for assistance under each program, with annual funding dependent on congressional authorizations.

- **Economic Development Administration (EDA):** EDA supports projects that foster regional economic development strategies designed to create jobs, leverage private capital, and encourage economic development. The maximum grant amount is $3 million with a 50 percent match for a total project cost of $6 million. EDA will now also accept project proposals before requiring full applications. The short proposal form describes the project to determine if the project warrants EDA's competitive consideration. Applications are accepted year round on an ongoing basis.
- **EPA:** The Water Infrastructure Finance and Innovation Act (WIFIA) program supports wastewater projects that are eligible for the State Revolving Fund (SRF). Industrial projects are not currently eligible for SRF funds. Eligible applicants include corporations; partnerships; joint ventures; trusts; federal, state, or local government entities; agencies; tribal governments or a consortium of tribal governments; or state infrastructure financing authorities, as defined by the CWA and the Safe Drinking Water Act. EPA can provide federal loans or loan guarantees for eligible water/wastewater infrastructure projects with a 51 percent match. The program is better for very large projects because of the fees associated with the loan (over $350,000 in application and processing fees) and an interest rate equal to or greater than bond rates. The benefit of this program is that it can fund projects for a 35-year repayment term and the County can defer payments up to 5 years after the project is complete. The deferred payment can be ideal for communities needing upfront capital but that will take time to build a paying customer base. Priority is given to repairing, rehabilitating, and replacing aging infrastructure and conveyance systems.
- **USBR:** USBR offers some grants for water recycling projects that cover 50 percent of eligible project costs with a 50 percent local match. The County is currently completing a USBR Feasibility Study (this Study) for its potential recycled water project. The Feasibility Study results will help the County to be eligible to apply for USBR Title XVI (Title XVI) construction grants that are available to fund approved design and construction projects that reclaim or reuse wastewater and groundwater in 17 western states, including Washington. Title XVI offers grants up to $20 million as a 25 percent match. The County would be responsible for covering 75 percent of the cost through customer contributions, reserves, rates, non-federal grants and loans, or other sources. Title XVI projects no longer require official congressional approval. All

that is required is that a project have: (1) an approved USBR Feasibility Study (this study) and (2) that study has been transmitted to Congress and has been added to the 4009(a) and/or 4009(c) list. Construction costs must have been incurred after the application date to count toward the match. It is important to start planning to apply for this program early in the process to maximize the amount of funding the County can receive.

- **United States Department of Agriculture (USDA) Rural Development**: USDA has several programs that may provide financial assistance for water recycled projects in rural areas. Rural Utilities Service (RUS) offers funds through the Water and Waste Program in the form of loans, grants, and loan guarantees. The largest is the Water and Waste Loan and Grant Program, with approximately $1.5 billion available nationwide per year. Washington State gets approximately $25 million annually. This program offers financial assistance to public bodies, eligible not-for-profits, and recognized tribal entities for development (including construction and non-construction costs) of water and wastewater infrastructure. Unincorporated areas are typically eligible, as are communities with less than 10,000 people. Grants may be available to communities meeting income limits to bring user rates down to a level that is reasonable for the serviced population. The Kingston service area and its WWTP may be eligible even if the county population is too large. Interest rates for loans depend on income levels in the served areas (currently 2.38 to 3.88 percent). Grants are available in some cases (typical split is 70 percent loan:30 percent grant). Repayment term is up to 40 years. USDA does not fund industrial only projects.

Information about specific funding sources can be found in the Catalog of Federal Domestic Assistance (CFDA), prepared by the Federal Office of Management and Budget and available in federal depository libraries (CFDA, n.d.). It is the most comprehensive compilation of the types and sources of funding available.

9.2.3.2 State, Regional, and Local Grant and Loan Support

There are also state sources for grant and loan funding for recycled projects. A summary of state, regional, and local sources of grants and loans is provided below:

- **Washington State Department of Commence (Commerce)**: Commerce manages the state Public Works Assistance Account (PWAA), formerly known as the Public Works Trust Fund (PWTF), to help fund wastewater and recycling projects for counties, cities, special-purpose districts, and quasi-municipal organizations but not port districts or tribes. The Public Works Board (PWB) is updating its funding cycles, programs, and processes authorized by the passage of Engrossed Substitute Senate Bill (ESSB) 1677 and future funding under this program is unknown. The PWAA is currently funding pre-construction projects (engineering, design, environmental, etc..) and offering $1 million loans with a 5-year repayment term and variable interest rates. Pre-construction applications are accepted every 2 months until funds are exhausted. Loan repayments begin within 1 year of funds being dispersed. Commerce also administers the Community Economic Revitalization Board (CERB) grants that are available if the project creates jobs and the Community Development Block Grant (CDBG) if the project serves low to moderate income customers.
- **Washington State Department of Ecology State Revolving Fund**: The SRF provides loans to construct water pollution control facilities and to implement nonpoint source, groundwater, and estuary management activities, as well as recycled water and potable water facilities. Interest rates are below current market rates and may be as low as 0 percent (currently 0.7–2.0 percent). The amount of such loans may be up to 100 percent of the cost of eligible facilities. Loan repayments begin within 1 year of completion of the facility construction and are generally completely amortized in 20 years. Water conservation and recycled projects eligible under the

Drinking Water State Revolving Fund (DWSRF) include installation of meters, installation or retrofit of water-efficient devices such as plumbing fixtures and appliances, implementation of incentive programs to conserve water (e.g., rebates, tax breaks, vouchers, conservation rate structures), and installation of dual-pipe distribution systems as a means of lowering costs of treating water to potable standards. In addition to providing loans to water systems for water conservation and recycling, states can use their DWSRF set-aside funds to promote water efficiency through activities such as development of water conservation plans, technical assistance to systems on how to conserve water (e.g., water audits, leak detection, rate structure consultation), development and implementation of ordinances or regulations to conserve water, drought monitoring, and development and implementation of incentive programs or public education programs on conservation.

- **State budget appropriations:** Some communities are able to secure grants directly through the state annual budgeting process. Grant funds are available after the state budget is passed and do not require matching funds. The process for requesting funds is simple and typically involves a two-page letter to legislators representing the project area. However, getting funds is highly subjective and political, so many communities seeking this funding hire lobbyists and meet directly with legislators to promote their project and its benefits to the state (economic development, water quality, etc.).

9.3 Financial Capability Assessment

A Financial Capability Assessment, performed consistent with USBR standards, is included in Appendix J. USBR identifies a two-step approach to determine if the County is financially capable of funding the non-federal share of a project's construction and OM&R costs. The primary analysis is used to establish what type of secondary analysis must be performed. The primary analysis evaluates the County's bond rating or issuer credit rating and the debt service coverage ratio.

Financial statements of the County verify that the **credit rating and the debt service coverage ratio is in the acceptable high range.** Given that these two factors are acceptable, it is assumed that a cursory secondary analysis of the socioeconomic indicators in the Project area is sufficient. Both unemployment (UE) and median household income (MHI) indicators are good (see Appendix J). Should a more rigorous secondary analysis be required, the County will evaluate water service affordability, local water service rates, and the potential for rate shock.

9.4 Funding Plan

As described in the Financial Capability Assessment, several mechanisms are available for funding recycled water projects. The analysis shown for funding project costs in the Financial Capability Assessment Tables 1 and 3 is based on bond financing for the engineering and construction costs. Two funding scenarios are identified in Table 1: (1) total bond financing and (2) 75 percent bond financing and a 25 percent grant from the USBR Title XVI grant program. The funding plan shown on Table 3 of the Financial Capability Assessment shows that if the County can secure customers willing to pay the annual debt and O&M for the Project, with at least 25 percent grant funding, the financial indicators are considered good for the Project. The final combination of funding resources could vary depending on the amount of grants received, County or recycled water customer contributions, and the total cost of the capital Project. Additional financial analysis should be completed throughout the Project as those factors are determined.

To determine the viability of a recycled water program and establish reasonable rates for recycled water service, the County would benefit from an understanding of the technical, economic, and anticipated customer usage of the proposed system. Integrated resource planning (IRP) is often used as a means of developing this information going forward. IRP would allow the County to clearly communicate its funding strategy with potential customers and develop the costs and benefits of the recycled water program. Proper planning can also provide a framework to address uncertainty (e.g., economic volatility, climate change) and provide a sustainable funding strategy based on a combination of capital, OM&R considerations, and sources of revenue that provide the greatest value for the system and its customers.

It is important to identify and obtain commitments from future recycled water customers before undertaking the costs of design and construction. Those commitments will be critical to determining design capacity, facility sizing, and other decisions about future distribution branches. Securing these commitments often begins by conducting an initial survey in a service area, followed by a formal written agreement. These agreements may include a memorandum of understanding, particularly for customers with significant capacity requirements, such as golf courses, large industrial customers, or agricultural operations. These commitments ensure the long-term viability and financially sustainability of the Project. A recycled water purveyor can also employ participation incentives to help motivate users to convert to recycled water.

The County would benefit from seeking grants and direct customer contributions where possible to reduce the amount of the Project that would need to be funded via debt and customer rates. In particular, the County is encouraged to take the following steps:

1. Continue to engage the Tribe in discussions on its willingness to use and fund recycled water at WHGC
2. Position itself to be eligible to apply for USBR Title XVI grants, prior to design and construction, to maximize the amount of the Project that can be funded by grants over the life of the Project
3. Seek other grants and low-cost financing (via the County and/or Tribe)
4. Evaluate the benefit of the Project for the wastewater system, related to future capital, OM&R, and regulatory compliance costs to determine cost sharing advantages

Section 10

Environmental Analysis and Documentation

This section summarizes the environmental review process completed for the Project.

10.1 Summary of Potential Impacts of Recommended Facilities

Construction of the Project would result in typical temporary construction-related impacts including noise, dust, potential erosion, and sedimentation. Construction best management practices (BMPs) would be employed to minimize impacts and potential sediment leaving construction areas. Some vegetation clearing would occur; however, disturbed areas would be replanted and restored to existing conditions following construction. Construction of the conveyance pipeline, EQ basin and infiltration basins may occur within 200 feet of wetlands areas. Any stream or wetland buffer areas impacted as a result of construction activities would be restored to existing conditions with native vegetation, in accordance with County requirements.

Completion of the Project would ultimately result in greater use of recycled water for irrigation and groundwater recharge instead of discharging to Puget Sound. The Project would improve marine water quality by reducing the nitrogen load to Puget Sound, which would help to increase the DO concentrations in Appletree Cove. Implementation of the Project would result in beneficial impacts to stream baseflows, particularly Grovers Creek and its tributaries. Infiltration of the reclaimed water through the soil column would result in a natural cooling of the water before discharge into Grovers Creek and its associated tributaries. The increased discharge of cool water would help to reduce the temperatures in Grovers Creek.

The use of recycled water for irrigation would reduce the demands on potable groundwater for irrigation purposes.

The Project is compatible with existing land uses and would comply with all applicable state and local permitting requirements.

10.2 Environmental Review

The Project has undergone environmental review in accordance with WAC 197-11. A SEPA Environmental Checklist was prepared and the Kitsap County Public Works Department, the lead agency for review of the SEPA Checklist, issued a Determination of Non-Significance (DNS) on September 27, 2019 based upon review of this Plan and the SEPA Checklist. A copy of the SEPA Checklist and the DNS are included in Appendix I.

Environmental review was performed in accordance with USBR Title XVI Water Reclamation and Reuse Program Feasibility Study Review Process guidelines for a feasibility study report. The SEPA review included review of compliance with the Endangered Species Act and CWA; discussion of significant impacts on public health or safety, natural resources, regulated water of the United States, and cultural resources and historic properties; discussion of potential to affect water supply and water quality; and a discussion of public involvement throughout the feasibility study. The review of a Title XVI feasibility study report does not require National Environmental Policy Act (NEPA) compliance. However, additional environmental review consistent with a proposed action (construction) would be performed during subsequent design stages of the proposed Project and may include additional components consistent with NEPA requirements.

10.3 Anticipated Permits

Table 10-1 summarizes the anticipated permits that are likely to be required for the Kingston Recycled Water Project and their associated trigger activities. The actual permit requirements will be determined during the design phase of the Project. The Project will comply with all federal, state, and local environmental permitting requirements and conditions.

Table 10-1. Anticipated Permit Summary

Lead Agency	Permits/Approvals/ Reviews	Application/ Documentation	Trigger Activity
WA Departments of Health and Ecology	Reclaimed Water Permit	Reclaimed Water Permit application	Storage and application of reclaimed water.
WDFW	Hydraulic Project Approval	JARPA	Required for stream crossings.
WA Department of Ecology	National Pollution Discharge Elimination System (NPDES) General Construction Permit	Notice of Intent	Needed for disturbance of 1 acre or more.
Local Permits and approvals Kitsap County	State Environmental Protection Act	Environmental Checklist	Environmental documentation to be coordinated with the Suquamish Tribe.
	Critical Areas Review	Critical Areas Report	Work near critical areas (i.e., wetlands and streams)
	Shoreline Substantial Development Permit	JARPA with Shoreline Supplement	Work within 200 feet of a designated shoreline.
	Site Development Activity	Site Development Activity form	Grading, right of way use
	Right of Way permit	Right of Way Permit application	Work within a right of way.

10.4 Public Meetings

As described in Section 1.5, stakeholder outreach and public involvement has been conducted for the Project since 2016. Public outreach meeting materials, including attendee list, meeting notes, and presentation slides, are provided in Appendix C.

In addition, public comment was solicited as part of the SEPA process. SEPA public comments provided by the Suquamish Tribe, North Kitsap Heritage Park Stewardship Group, and interested citizens are included in Appendix I.

Section 11

Water Rights, Permitting, and Legal Considerations

This section summarizes water rights, permitting, and other legal considerations related to the proposed Project.

11.1 Water Rights Analysis

The water rights implications and analysis for this proposed Project are governed by Revised Code of Washington (RCW) Chapter 90.46 and by WAC 173-219-090 dealing with water rights protection. WAC indicates that the Project must demonstrate compliance with RCW 90.46.130, which states:

> Except as provided in subsection (2) of this section, facilities that reclaim water under this chapter shall not impair any existing water right downstream from any freshwater discharge points of such facilities unless compensation or mitigation for such impairment is agreed to by the holder of the affected water right.

Existing Kingston WWTP effluent is entirely and directly discharged to marine water in Puget Sound (not fresh water). Because there are no holders of any affected water right for this existing municipal wastewater effluent discharge nor are there any known water rights for Grovers Creek or any of the tributaries receiving baseflow benefit from the proposed infiltration system, there can be no impairment per RCW 90.46.130 and an impairment analysis required in WAC 173-219-090(4) is not required. Localized springs and seeps exist in the area, and there are approximately 10 to 15 water rights for irrigation, domestic, and fish propagation in the vicinity of the project, but are outside of the area influenced by the infiltration system. Therefore, it can be demonstrated that this Project would not infringe on existing water rights protection per the requirements of WAC 173-219-090.

11.2 Regulatory Requirements

Regulatory and institutional requirements for the proposed recycled water facilities and recycled water uses are governed by RCW 90.46 and WAC 173-219. WAC stipulates all requirements from Project inception, design, treatment standards, usage, operations, and recycled water permitting.

11.2.1 Legal and Institutional Requirements

Legal and institutional requirements associated with recycled water projects have been made law via RCW 90.46 as a result of legislation that has been passed by the state legislature and signed by the governor. WAC 173-219 is the administrative code or rule that is adopted by agencies to enact the requirements of RCW 90.46 legislation pertinent to executing recycled water requirements. WAC 173-219 defines all terms; establishes the purpose and scope of recycled water rules; and stipulates all rules for the administration, design, water quality standards, facilities operations, monitoring and reporting, and permits associated with recycled water use. Required permitting procedures are discussed in Section 11.2.2.

11.2.2 Permitting Procedures

Recycled water permits are required per WAC 173-219-070 with the lead agency issuing the permit defined in WAC 173-219-050. Per this latter reference, it is likely that Ecology would be the lead agency in this instance. Procedures for applying for a recycled water permit are described in WAC 173-219-080 and general terms and conditions for this permit are described in WAC 173-219-270.

Procedures for a new recycled water permit are summarized as follows:

- Prior to submittal of a recycled water permit application, the permit applicant must receive lead agency approval of a feasibility analysis per WAC 173-219-180
- Prior to, or in conjunction with, submitting a permit application, the applicant must submit an Engineering Report/Facility Plan per WAC 173-219-210 to the lead agency for approval
- Prior to, or in conjunction with, submitting a permit application, the applicant must submit a copy of the new use agreements per WAC 173-219-290
- Applications must be submitted to the lead agency no later than 180 calendar days before planned recycled water distribution
- The lead agency must assess the application for completeness within 90 calendar days after receipt of the application
- Fees charged by the appropriate review agencies are described in WAC 173-219-080(3)

Upon approval of the recycled water permit and the Engineering Report/Facility Plan, plans and specifications for construction of facilities must be submitted and approved by the lead agency prior to construction per WAC 173-219-220. Following construction, a Declaration of Construction is to be submitted per WAC-173-219-230.

11.2.3 Unresolved Issues

There are no specific unresolved issues with the proposed Project, other than the need to complete the permit application process and develop a Use Agreement as described in Section 11.3.

11.2.4 Wastewater Discharge Requirements

The proposed Project is to generate recycled water from the existing Kingston WWTP, which is currently governed by an NPDES discharge permit for treated effluent discharge into Puget Sound. Additionally, all current sludge streams are conveyed by truck to another municipal wastewater treatment plant (CKTP), owned by the County, for further treatment. Any liquid stream treated at Kingston WWTP that is not processed in the proposed recycled water facility would continue to be discharged to the existing Puget Sound outfall per the current NPDES discharge permit. Likewise, any waste streams from the proposed recycled water treatment process would be recycled to the head end of Kingston WWTP for further processing. All sludge streams (those from the wastewater treatment processes and any concentrated solids from the recycled water process) would continue to he hauled to CKTP for further processing.

11.2.5 Reclaimed Water Quality Requirements

The Class A reclaimed water quality criteria applicable to this Project are discussed in Section 8.1. The requirements for Class A reclaimed water are described in WAC 173-219-320, with performance standards and specific use-based requirements described in WAC 173-219-330 and WAC 173-219-390, respectively. Note that for the two primary Class A applications for this Project, golf course irrigation during the summer and indirect groundwater recharge, only the use for indirect groundwater recharge requires the TN control limits cited in WAC-173-219-330.

11.2.6 Rights to Wastewater Discharges

The County maintains the rights to wastewater discharges per the requirements of RCW 90.46.120(1):

> The owner of a wastewater treatment facility that is reclaiming water with a permit issued under this chapter has the exclusive right to any recycled water generated by the wastewater treatment facility.

11.3 Interlocal Agreements

This Project would require an interagency use agreement between the County and the Tribe in accordance with WAC 173-219-290. The recycled water would be generated by the County and the primary user of the water would be the Tribe. The Tribe plans to use the water during the summer months to irrigate its local golf course (WHGC). Any recycled water not used for golf course irrigation (including recycled water generated during non-irrigation seasons) would be recharged to the local aquifer to the extent possible. This agreement must be approved by the lead agency (identified in WAC 173-219-050). This use agreement between the County serving as the generator and distributor and the Tribe acting as the end user would identify sufficient detail to ensure compliance with RCW 90.46 and WAC 173-219 at the point of use. The agreement would at a minimum identify cross-connection control measures, monitoring points, parameters and sample times, identification of a site's inclusion in a wellhead protection area or critical aquifer recharge area, the County's notice to the potable water suppliers in the area, BMPs to ensure permit compliance, and general use-based requirements per WAC 173-219-380. It is also anticipated that the user agreement would stipulate a cost sharing or appropriate rate structure to support the long-term financial obligations of the involved parties.

Prior to submitting the use agreement to the lead agency for permit approval, the County and the Tribe would enter into negotiations governing salient features of this agreement including water quantities, the date and times of delivery, water quality, and any applicable rate structure commensurate with the financial contributions made to construct and operate these facilities.

Section 12

Research Needs

Following the adoption and approval of this Plan, the next steps to continue with this Project are as generally described above in Section 11.2.2. The use-based agreements are to be developed and information contained in this Plan will be used for further development of design plans and specifications, augmented by more detailed site-specific geotechnical and hydrogeological investigations, surveying, and right-of-way development. Additional investigations will be made to quantify specific irrigation demands for the design of all conveyance facilities and interties to backup potable water supplies (suitably protected by cross-connection prevention devices).

Section 13

Limitations

This document was prepared solely for Kitsap County and the Suquamish Tribe in accordance with professional standards at the time the services were performed and in accordance with the contract between Kitsap County and Brown and Caldwell dated October 23, 2017. This document is governed by the specific scope of work authorized by Kitsap County; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Kitsap County and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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APPENDIX J
OPPCS

Kitsap County General Sewer Plans
Kingston Basin

Replace PS-41 and Forcemain

Project Summary

- Replace the pump station to increase firm capacity to 630 gpm
- Construct new 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
- Replace 1,400 LF forcemain with 8-inch diameter pipe. Station upgrade will trigger forcemain replacement.

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
20	8" Force Main Sewer Upgrade	1400	LF	$ 260	$ 364,000
	SUBTOTAL				$ 1,467,100
	Contingency (50%)				$ 734,000
	Sales Tax (9.2%)				$ 202,501
	CONSTRUCTION SUBTOTAL				$ 2,404,000
	Design Services Engineering and Allied Costs (25%)				$ 601,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 601,000
	TOTAL PROJECT COST (ROUNDED)				**$ 3,700,000**

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.

Kitsap County General Sewer Plans
Kingston Basin

Upgrade PS-71 and Replace Forcemain

Project Summary

• Upgrade pump station to increase pump capacity of LS-71 to 790 gpm
• Replace pumps
• Replace electrical, instrumentation, and control equipment
• Replace 9,500 LF forcemain with 8-inch diameter pipe. Station upgrade will trigger forcemain replacement

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 49,000	$ 49,000
2	Valve and piping improvements	1	LS	$ 62,000	$ 62,000
3	Pumps	1	LS	$ 79,000	$ 79,000
4	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
5	Temporary Bypass Pumping	1	LS	$ 50,000	$ 50,000
6	8" Force Main Sewer Upgrade	9500	LF	$ 260	$ 2,470,000
	SUBTOTAL				$ 3,010,000
	Contingency (50%)				$ 1,505,000
	Sales Tax (9.2%)				$ 415,380
	CONSTRUCTION SUBTOTAL				$ 4,931,000
	Design Services Engineering and Allied Costs (25%)				$ 1,232,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,232,750
	TOTAL PROJECT COST (ROUNDED)				**$ 7,400,000**

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• 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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Kitsap County General Sewer Plans
Kingston Basin

Arness Pump Station and Conveyance

Project Summary

• Construct 1,850 LF of new 8-inch diameter gravity sewer.
• Construct new 20 gpm PS and 2,200 LF associated 4-inch diameter forcemain.
• Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction).
• Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 65,000	$ 65,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,000	$ 6,000
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	80	LF	$ 40	$ 3,200
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 2,000	$ 2,000
18	Site Restoration	1	LS	$ 13,000	$ 13,000
19	4" Force Main Sewer	2200	LF	$ 140	$ 308,000
	SUBTOTAL				$ 1,026,200
	Contingency (50%)				$ 514,000
	Sales Tax (9.2%)				$ 141,698
	CONSTRUCTION SUBTOTAL				$ 1,682,000
	Design Services Engineering and Allied Costs (25%)				$ 420,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 420,500
	TOTAL PROJECT COST (ROUNDED)*				**$ 2,600,000**

*Project cost for developer funded projects is provided to show an estimated valuation of assets only. The County is not expected to fund the project, therefore, Developer funded projects are not included in the CIP.

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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Kitsap County General Sewer Plans
Kingston Basin

Sewer to Arness PS

Project Summary

• Construct 1,850 LF of new 8-inch diameter gravity sewer.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 90,000	$ 90,000
2	Traffic Control	1	LS	$ 60,000	$ 60,000
3	Dewatering	1	LS	$ 22,000	$ 22,000
4	SWPPP & BMPs	1	LS	$ 4,000	$ 4,000
5	Sewer Bypass	1	LS	$ 19,000	$ 19,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	1,842	LF	$ 150	$ 276,300
7	6-inch Side Sewer Replacement	1,000	LF	$ 180	$ 180,000
8	Shoring and Trench Safety	1	LS	$ 8,000	$ 8,000
9	Imported Trench Backfill	1,500	TON	$ 25	$ 37,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	600	TON	$ 200	$ 120,000
12	Grind and Overlay, Channelization*	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 30,000	$ 30,000
	SUBTOTAL				$ 1,251,800
	Contingency (50%)				$ 626,000
	Sales Tax (9.2%)				$ 172,758
	CONSTRUCTION SUBTOTAL				$ 2,051,000
	Design Services Engineering and Allied Costs (25%)				$ 513,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 513,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 3,100,000**

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• 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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Kitsap County General Sewer Plans
Kingston Basin

Highway 104 Pump Station and Conveyance

Project Summary

- Construct new 61 gpm PS and 2,800 LF associated 4-inch diameter forcemain.
- Project would expand the area served by LS-41
- Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 65,000	$ 65,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,000	$ 6,000
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	80	LF	$ 40	$ 3,200
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 2,000	$ 2,000
18	Site Restoration	1	LS	$ 13,000	$ 13,000
19	4" Force Main Sewer	2800	LF	$ 140	$ 392,000
	SUBTOTAL				$ 1,110,200
	Contingency (50%)				$ 556,000
	Sales Tax (9.2%)				$ 153,290
	CONSTRUCTION SUBTOTAL				$ 1,820,000
	Design Services Engineering and Allied Costs (25%)				$ 455,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 455,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 2,800,000**

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Kitsap County General Sewer Plans
Kingston Basin

Gravity Sewers to Highway 104 PS

Project Summary

• Construct 1,300 LF of new 8-inch diameter gravity sewer.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 70,000	$ 70,000
2	Traffic Control	1	LS	$ 40,000	$ 40,000
3	Dewatering	1	LS	$ 16,000	$ 16,000
4	SWPPP & BMPs	1	LS	$ 3,000	$ 3,000
5	Sewer Bypass	1	LS	$ 14,000	$ 14,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	1,307	LF	$ 150	$ 196,050
7	6-inch Side Sewer Replacement	700	LF	$ 180	$ 126,000
8	Shoring and Trench Safety	1	LS	$ 6,000	$ 6,000
9	Imported Trench Backfill	1,000	TON	$ 25	$ 25,000
10	Manhole 48-inch diameter	4	EA	$ 15,000	$ 60,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	500	TON	$ 200	$ 100,000
12	Grind and Overlay, Channelization*	1	EST	$ 200,000	$ 200,000
13	Cleanup & Site Restoration	1	LS	$ 20,000	$ 20,000
	SUBTOTAL				$ 876,050
	Contingency (50%)				$ 439,000
	Sales Tax (9.2%)				$ 120,985
	CONSTRUCTION SUBTOTAL				$ 1,437,000
	Design Services Engineering and Allied Costs (25%)				$ 360,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 360,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 2,200,000**

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Kitsap County General Sewer Plans
Kingston Basin

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Taree Pump Station and Conveyance

Project Summary

• Construct new 26 gpm PS and 1,300 LF associated 4-inch diameter forcemain.
• Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction).
• Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 90,000	$ 90,000
2	Traffic Control	1	LS	$ 60,000	$ 60,000
3	Dewatering	1	LS	$ 23,000	$ 23,000
4	SWPPP & BMPs	1	LS	$ 4,000	$ 4,000
5	Sewer Bypass	1	LS	$ 19,000	$ 19,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	1,828	LF	$ 150	$ 274,200
7	6-inch Side Sewer Replacement	1,000	LF	$ 180	$ 180,000
8	Shoring and Trench Safety	1	LS	$ 8,000	$ 8,000
9	Imported Trench Backfill	1,400	TON	$ 25	$ 35,000
10	Manhole 48-inch diameter	9	EA	$ 15,000	$ 135,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	600	TON	$ 200	$ 120,000
12	Grind and Overlay, Channelization*	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 30,000	$ 30,000
	SUBTOTAL				$ 1,278,200
	Contingency (50%)				$ 640,000
	Sales Tax (9.2%)				$ 176,474
	CONSTRUCTION SUBTOTAL				$ 2,095,000
	Design Services Engineering and Allied Costs (25%)				$ 524,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 524,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 3,200,000**

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Kitsap County General Sewer Plans
Kingston Basin

Sewers to Taree LS Improvement 2

Project Summary

• Construct 1,830 LF of new 8-inch diameter gravity sewer

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 20,000	$ 20,000
2	Traffic Control	1	LS	$ 10,000	$ 10,000
3	Dewatering	1	LS	$ 4,000	$ 4,000
4	SWPPP & BMPs	1	LS	$ 1,000	$ 1,000
5	Sewer Bypass	1	LS	$ 1,000	$ 1,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	56	LF	$ 150	$ 8,400
7	6-inch Side Sewer Replacement	100	LF	$ 180	$ 18,000
8	Shoring and Trench Safety	1	LS	$ 1,000	$ 1,000
9	Imported Trench Backfill	200	TON	$ 25	$ 5,000
10	Manhole 48-inch diameter	1	EA	$ 15,000	$ 15,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	100	TON	$ 200	$ 20,000
12	Grind and Overlay, Channelization*	1	EST	$ 100,000	$ 100,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 213,400
	Contingency (50%)				$ 107,000
	Sales Tax (9.2%)				$ 29,477
	CONSTRUCTION SUBTOTAL				$ 350,000
	Design Services Engineering and Allied Costs (25%)				$ 88,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 88,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 600,000**

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Kitsap County General Sewer Plans
Kingston Basin

Taree Lift Station (26 GPM): New Lift Station and Force Main

Project Summary

• Construct new 26 gpm LS and 1,300 LF associated 4-inch diameter forcemain.
• Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 65,000	$ 65,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,000	$ 6,000
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	80	LF	$ 40	$ 3,200
16	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
17	Temporary Bypass Pumping	1	LS	$ 2,000	$ 2,000
18	Site Restoration	1	LS	$ 13,000	$ 13,000
19	4" Force Main Sewer	1300	LF	$ 140	$ 182,000
	SUBTOTAL				$ 900,200
	Contingency (50%)				$ 451,000
	Sales Tax (9.2%)				$ 124,310
	CONSTRUCTION SUBTOTAL				$ 1,476,000
	Design Services Engineering and Allied Costs (25%)				$ 369,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 369,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 2,300,000**

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Kitsap County General Sewer Plans
Kingston Basin

Extend Gravity Sewers Flowing to PS-41

Project Summary

• Construct 2,540 LF of new 8-inch diameter gravity sewers to expand the area served by PS-41
• Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 110,000	$ 110,000
2	Traffic Control	1	LS	$ 70,000	$ 70,000
3	Dewatering	1	LS	$ 27,000	$ 27,000
4	SWPPP & BMPs	1	LS	$ 6,000	$ 6,000
5	Sewer Bypass	1	LS	$ 26,000	$ 26,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	2,541	LF	$ 150	$ 381,150
7	6-inch Side Sewer Replacement	1,300	LF	$ 180	$ 234,000
8	Shoring and Trench Safety	1	LS	$ 11,000	$ 11,000
9	Imported Trench Backfill	2,000	TON	$ 25	$ 50,000
10	Manhole 48-inch diameter	9	EA	$ 15,000	$ 135,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	800	TON	$ 200	$ 160,000
12	Grind and Overlay, Channelization*	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 30,000	$ 30,000
	SUBTOTAL				$ 1,540,150
	Contingency (50%)				$ 771,000
	Sales Tax (9.2%)				$ 212,626
	CONSTRUCTION SUBTOTAL				$ 2,524,000
	Design Services Engineering and Allied Costs (25%)				$ 631,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 631,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 3,800,000**

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Kitsap County General Sewer Plans
Kingston Basin

Extend Gravity Sewers Flowing to PS-43

Project Summary

- Construct 2,500 LF of new 8-inch diameter gravity sewers to expand the area served by PS-43
- Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 70,000	$ 70,000
2	Traffic Control	1	LS	$ 50,000	$ 50,000
3	Dewatering	1	LS	$ 18,000	$ 18,000
4	SWPPP & BMPs	1	LS	$ 4,000	$ 4,000
5	Sewer Bypass	1	LS	$ 16,000	$ 16,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	1,540	LF	$ 150	$ 231,000
7	6-inch Side Sewer Replacement	800	LF	$ 180	$ 144,000
8	Shoring and Trench Safety	1	LS	$ 7,000	$ 7,000
9	Imported Trench Backfill	1,200	TON	$ 25	$ 30,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	500	TON	$ 200	$ 100,000
12	Grind and Overlay, Channelization*	1	EST	$ 200,000	$ 200,000
13	Cleanup & Site Restoration	1	LS	$ 20,000	$ 20,000
	SUBTOTAL				$ 995,000
	Contingency (50%)				$ 498,000
	Sales Tax (9.2%)				$ 137,356
	CONSTRUCTION SUBTOTAL				$ 1,631,000
	Design Services Engineering and Allied Costs (25%)				$ 408,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 408,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 2,500,000**

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Kitsap County General Sewer Plans
Kingston Basin

Gravity Sewers to PS 43 Improvement 2

Project Summary

• Construct 2,500 LF of new 8-inch diameter gravity sewers to expand the area served by PS-43
• Project expected to be paid for be developers.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 60,000	$ 60,000
2	Traffic Control	1	LS	$ 40,000	$ 40,000
3	Dewatering	1	LS	$ 14,000	$ 14,000
4	SWPPP & BMPs	1	LS	$ 2,000	$ 2,000
5	Sewer Bypass	1	LS	$ 10,000	$ 10,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	964	LF	$ 150	$ 144,600
7	6-inch Side Sewer Replacement	500	LF	$ 180	$ 90,000
8	Shoring and Trench Safety	1	LS	$ 4,000	$ 4,000
9	Imported Trench Backfill	1,700	TON	$ 25	$ 42,500
10	Manhole 48-inch diameter	4	EA	$ 15,000	$ 60,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	400	TON	$ 200	$ 80,000
12	Grind and Overlay, Channelization*	1	EST	$ 200,000	$ 200,000
13	Cleanup & Site Restoration	1	LS	$ 20,000	$ 20,000
	SUBTOTAL				$ 767,100
	Contingency (50%)				$ 384,000
	Sales Tax (9.2%)				$ 105,901
	CONSTRUCTION SUBTOTAL				$ 1,258,000
	Design Services Engineering and Allied Costs (25%)				$ 315,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 315,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 1,900,000**

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Kitsap County General Sewer Plans
Kingston Basin

Extend Gravity Sewers Flowing to Arborwood

Project Summary

- Construct 10,140 LF of new 8-inch diameter gravity sewers.
- Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction).
- Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 290,000	$ 290,000
2	Traffic Control	1	LS	$ 190,000	$ 190,000
3	Dewatering	1	LS	$ 73,000	$ 73,000
4	SWPPP & BMPs	1	LS	$ 14,000	$ 14,000
5	Sewer Bypass	1	LS	$ 66,000	$ 66,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	6,567	LF	$ 150	$ 985,050
7	6-inch Side Sewer Replacement	3,300	LF	$ 180	$ 594,000
8	Shoring and Trench Safety	1	LS	$ 27,000	$ 27,000
9	Imported Trench Backfill	5,000	TON	$ 25	$ 125,000
10	Manhole 48-inch diameter	33	EA	$ 15,000	$ 495,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	2,100	TON	$ 200	$ 420,000
12	Grind and Overlay, Channelization*	1	EST	$ 800,000	$ 800,000
13	Cleanup & Site Restoration	1	LS	$ 80,000	$ 80,000
	SUBTOTAL				$ 4,159,050
	Contingency (50%)				$ 2,080,000
	Sales Tax (9.2%)				$ 573,993
	CONSTRUCTION SUBTOTAL				$ 6,814,000
	Design Services Engineering and Allied Costs (25%)				$ 1,704,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,704,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 10,300,000**

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Kitsap County General Sewer Plans
Kingston Basin

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Gravity Sewers Connecting to Arborwood Improvement 2

Project Summary

• Construct 10,140 LF of new 8-inch diameter gravity sewers.
• Project would discharge to the infrastructure being planned as part of the Arborwood development (portions currently under construction).
• Project expected to be paid for be developers. Costs are developed in an attempt to show valuation of assets.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 160,000	$ 160,000
2	Traffic Control	1	LS	$ 100,000	$ 100,000
3	Dewatering	1	LS	$ 40,000	$ 40,000
4	SWPPP & BMPs	1	LS	$ 8,000	$ 8,000
5	Sewer Bypass	1	LS	$ 36,000	$ 36,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	3,572	LF	$ 150	$ 535,800
7	6-inch Side Sewer Replacement	1,800	LF	$ 180	$ 324,000
8	Shoring and Trench Safety	1	LS	$ 15,000	$ 15,000
9	Imported Trench Backfill	6,000	TON	$ 25	$ 150,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	1,200	TON	$ 200	$ 240,000
12	Grind and Overlay, Channelization*	1	EST	$ 500,000	$ 500,000
13	Cleanup & Site Restoration	1	LS	$ 50,000	$ 50,000
	SUBTOTAL				$ 2,263,800
	Contingency (50%)				$ 1,132,000
	Sales Tax (9.2%)				$ 312,414
	CONSTRUCTION SUBTOTAL				$ 3,709,000
	Design Services Engineering and Allied Costs (25%)				$ 928,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 928,000
	TOTAL PROJECT COST (ROUNDED)*				**$ 5,600,000**

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Kitsap County General Sewer Plans
Kingston Basin

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Annual Pipe Replacement

Project Summary

• Replace deteriorated and aging pipe.
• Project costs assume $1,000,000 per year totaled over 14 years
• Replacement assumes 0.5 percent of total system (450 LF) is replaced per year

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 30,000	$ 30,000
2	Traffic Control	1	LS	$ 20,000	$ 20,000
3	Dewatering	1	LS	$ 7,000	$ 7,000
4	SWPPP & BMPs	1	LS	$ 1,000	$ 1,000
5	Sewer Bypass	1	LS	$ 5,000	$ 5,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	450	LF	$ 150	$ 67,500
7	6-inch Side Sewer Replacement	225	LF	$ 180	$ 40,500
8	Shoring and Trench Safety	1	LS	$ 2,000	$ 2,000
9	Imported Trench Backfill	400	TON	$ 25	$ 10,000
10	Manhole 48-inch diameter	2	EA	$ 15,000	$ 30,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	300	TON	$ 200	$ 60,000
12	Grind and Overlay, Channelization*	1	EST	$ 100,000	$ 100,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 383,000
	Contingency (Approximately 50%)				$ 192,000
	Sales Tax (9.2%)				$ 52,900
	CONSTRUCTION SUBTOTAL				$ 628,000
	Design Services Engineering and Allied Costs (25%)				$ 157,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 157,000
	TOTAL PROJECT COST (ROUNDED)				**$ 1,000,000**
				14 Year Total:	**$ 14,000,000**

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
Kingston Basin

Replace UV System					
Project Summary					
• Replace obsolete UV system with new, more advanced model to reduce operating cost and O&M requirements					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Stainless steel channel reduction baffle	1	LS	$ 7,800	$ 7,800
2	Existing UV3000B Demolition	1	LS	$ 3,000	$ 3,000
3	New UV3000+ System	1	LS	$ 229,320	$ 229,320
4	UV Transmittance Probe	1	LS	$ 36,660	$ 36,660
5	EI&C Allowance	1	LS	$ 80,694	$ 80,694
	SUBTOTAL				$ 357,474
	Contingency (50%)				$ 179,000
	Sales Tax (9.2%)				$ 49,356
	CONSTRUCTION SUBTOTAL				$ 586,000
	Design Services Engineering and Allied Costs (25%)				$ 146,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 146,500
	TOTAL PROJECT COST (ROUNDED)				**$ 880,000**

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
Kingston Basin

Nitrogen Optimization Improvements

Project Summary

- Project will improve TIN monitoring and control to ensure effluent TIN can be consistently reduced to below 10 mg/L
- Install additional dissolved oxygen probe
- Install ammonia and nitrate probes in each basin

Item	Description	Quantity	Unit	Unit Cost	Total
1	On-line DO and Ammonia/Nitrate Probes	3	EA	$ 13,260	$ 39,780
	SUBTOTAL				$ 39,780
	Contingency (50%)				$ 20,000
	Sales Tax (9.2%)				$ 5,500
	CONSTRUCTION SUBTOTAL				$ 66,000
	Design Services Engineering and Allied Costs (25%)				$ 16,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 16,500
	TOTAL PROJECT COST (ROUNDED)				**$ 99,000**

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
Kingston Basin

Class A Reclaimed Water Improvements

Project Summary

- Use reclaimed water for irrigation at White Horse Golf Course and indirect groundwater recharge at North Kitsap Heritage Park
- Construct secondary effluent equalization tank
- Construct filter feed station and tertiary filtration
- Add additional UV disinfection
- Construct recycled water pump station and pipeline
- Implement CIP-K-WWTP-CAP-3 if not already completed

Item	Description	Quantity	Unit	Unit Cost	Total
1	Reclaimed Water Improvements	1	LS		
	SUBTOTAL				
	Contingency (50%)				
	Sales Tax (9.2%)				
	CONSTRUCTION SUBTOTAL				
	Design Services Engineering and Allied Costs (25%)				
	Construction Services and Allied Costs (25%, assumes full CM)				
	TOTAL PROJECT COST (ROUNDED)				**$ 13,661,000**

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
Kingston Basin

Replace Clarifier Drives

Item	Description	Quantity	Unit	Unit Cost	Total
	Project Summary				
	• Replace secondary clarifier drives, collection mechanism, walkway, platform, and weirs				
1	Replace Clarifier Drives	1	LS	$ 150,000	$ 195,000
	SUBTOTAL				$ 195,000
	Contingency (50%)				$ 98,000
	Sales Tax (9.2%)				$ 26,956
	CONSTRUCTION SUBTOTAL				$ 320,000
	Design Services Engineering and Allied Costs (25%)				$ 80,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 80,000
	TOTAL PROJECT COST (ROUNDED)				**$ 480,000**

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 K
SUMMARY OF STATE OF WASHINGTON GRANT AND LOAN PROGRAMS FOR DRINKING WATER AND WASTEWATER CAPITAL PROJECTS

consor

Funding Programs for Drinking Water and Wastewater Projects

Updated 9-17-2024

Type of Program	Pages
Planning/ Pre-Construction	2 - 6
Pre-Construction Only	7 - 8
Construction	9 - 16
Emergency	17 - 19

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