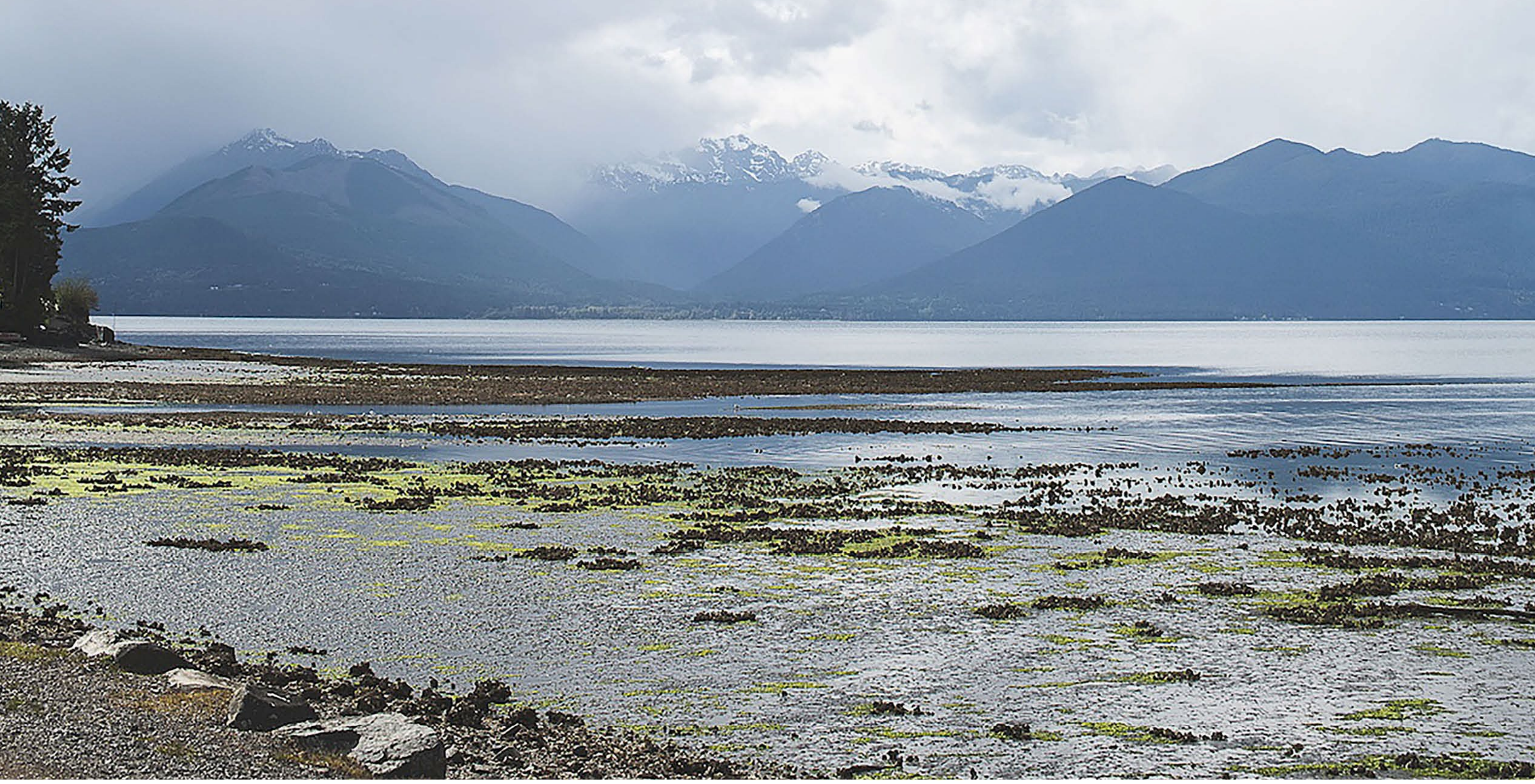
REPORT

FACET

Sea Level Rise Vulnerability and Risk Assessment

KITSAP COUNTY

JUNE 2025



Prepared for:
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DEPARTMENT OF ECOLOGY
State of Washington

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Report Limitations:

Use Limitations: This report was prepared to evaluate the anticipated sea level rise and extreme flood extents for Kitsap County based on the parameters requested by the Department of Community Development. No one other than Kitsap County staff and their agents should use this report for any purpose other than general information. The report does not incorporate existing groundwater conditions and is not considered to be inclusive of all facilities or infrastructure that may have been excluded from the referenced databases. This report is intended to provide high-level information and general adaptation strategies. The conclusions and identified strategies were based on the best available science and mapping resources. It is noted that the projections referred to in this report may change over time due to anthropogenic changes or future conditions.

Data Limitations: The information contained in this report is based on the application of technical guidelines currently accepted as the best available science and in conjunction with the manuals and criteria outlined in the methods section. All discussions, conclusions and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state, and federal regulatory authorities. No other warranty, expressed or implied, is made.

The data acquired from the National Oceanic and Atmospheric Administration (NOAA) is utilized with the accompanying disclaimer. The data and maps in this tool illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are relative to Mean Higher High Water (MHHW) (excludes wind driven tides). The data, maps, and information provided should be used only as a screening-level tool for management decisions. As with all remotely sensed data, all features should be verified with a site visit. The data and maps in this tool are provided "as is," without warranty to their performance, merchantable state, or fitness for any particular purpose. The entire risk associated with the results and performance of these data is assumed by the user. This tool should be used strictly as a planning reference tool and not for navigation, permitting, or other legal purpose (NOAA Office for Coastal Management, 2021).

Executive Summary

Kitsap County Department of Community Development received a Shoreline Planning Competitive Grant from the Washington State Department of Ecology to complete a sea level rise vulnerability and risk assessment under contract with Facet, formerly DCG/Watershed. This assessment was conducted to identify areas that are at risk of loss or damage (exposure), assess the ability for the asset to withstand or be adapted to withstand the potential impact (adaptive capacity) and characterize the extent of vulnerability. For the purposes of this assessment, three (3) different levels of certainty (1%, 50%, and 90%) were mapped to provide a visualization of what an increase in the daily average high tide or extreme flood event might look like by 2050 and 2100 under each planning scenario. Following the mapping exercises, several assets were evaluated to characterize the risks that may be associated with sea level rise or extreme flood events within the given timeframes. These assets were quantified and given a vulnerability score of low, medium, or high depending on the extent and timing of the inundation. Adaptation strategies were then identified to assist the County and community in their planning efforts to protect and preserve critical facilities by mitigating the anticipated climate change impacts. It is the intent of the Kitsap County Department of Community Development to use this report as a planning resource and a guide for considering amendments to development regulations in the future. It is the intent of Kitsap County to apply for future funding from the Department of Ecology to provide a more detailed assessment and community plan for areas designated to be most vulnerable to impacts of sea level rise and coastal flooding.

Acronyms and Abbreviations

CMZ	Channel Migration Zone
CIP	Capital Improvement Plan
DEM	Digital Elevation Model
e.g.	For example
Ecology	Washington State Department of Ecology
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
i.e.	In other words
LiDAR	Light Detection and Ranging
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
NAD	North American Datum
NAVD 88	North American Vertical Datum of 1988
NOAA	National Oceanographic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OSS	On-site septic system
PUD	Public Utility District
QAPP	Quality Assurance Project Plan
SLR	Sea Level Rise
TAC	Technical Advisory Committee
TIP	Transportation Improvement Plan
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington Department of Health
WDNR	Washington Department of Natural Resources
WSDOT	Washington State Department of Transportation
USACE	United States Army Corps of Engineers

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SECTION 1

Introduction

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1. Introduction

Kitsap County, with over 200 miles of marine shoreline, is already facing the effects of rising sea levels, including coastal erosion, flooding, and inundation. These hazards pose growing risks to public and private infrastructure, public health, and safety. The extent of sea level rise, its inland reach, and its frequency depend on various factors. Sea level rise mapping aims to assess potential impacts under future scenarios using the best available science. Coastal communities are expected to experience the most significant effects, and localized mapping projections are being developed to better understand vulnerabilities and inform adaptation strategies.

To support this, Facet, under contract with the Kitsap County Department of Community Development (DCD) and the Washington State Department of Ecology, has completed the Sea Level Rise (SLR) Vulnerability and Risk Assessment for the County. This assessment identifies the risk of loss and highlights the most vulnerable areas, including assets grouped within the following sectors:

- Transportation
- Structures
- Utility Infrastructure
- Environmental
- Land Use

The assessment will guide various planning efforts, including providing a suite of options for the County to consider during updates to County Codes and Plans.

The goal of the SLR Vulnerability and Risk Assessment is to understand the impacts of sea level rise and coastal flooding on the county's communities, infrastructure, and natural environments. The project evaluates at-risk areas, identifies vulnerable assets, and proposes strategies for risk mitigation and adaptation to future conditions. Key objectives include enhancing community resilience, protecting public and private property, and ensuring the long-term sustainability of the county’s coastal areas.

These efforts highlight the importance of recognizing risk factors in the County and the widespread community support for addressing sea level rise and climate change impacts. The SLR Vulnerability and Risk Assessment will guide future adaptation strategies to reduce the expected impacts of climate change. Facet has also developed a GIS-based model for localized sea level rise projections and coastal flooding hazards from extreme events, based on existing data. Additionally, Facet has created an ArcGIS story map to visually present the assessment results in an accessible and informative format.

For the purposes of this SLR Vulnerability and Risk Assessment, this project does not include the following in our analysis:

- Site-specific or property-level scale analyses
- Future bluff erosion rates due to sea level rise
- Analysis of tsunami or Cascadia Subduction Zone earthquake risks

- Economic analysis of sea level rise impacts
- Groundwater modeling or saltwater intrusion studies
- Analysis of impacts on riverine systems

U.S. Navy property and the City of Bainbridge Island were not mapped nor evaluated in this study due to having their own SLR assessments conducted separately. The rest of the County's shorelines were mapped for sea level rise projections. However, assets were only evaluated for unincorporated Kitsap County and Tribal lands.

1.1 Background

The Kitsap County Climate Change Resiliency Assessment (2020) examined how known climate drivers would impact biophysical components and lead to social and economic impacts. The climate drivers found to impact Kitsap County included:

- Sea level rise (SLR)
- Warmer marine waters and streams
- Ocean acidification and hypoxia
- Warmer air temperatures
- More extreme heat and cold
- Changing seasonal precipitation
- Changing seasonal streamflow
- Wildfire and
- Land use growth and development.

These drivers lead to impacts to the biological and physical environment such as impacts to fish and wildlife habitat, human habitat, and habitat-building processes.

Specific to sea level rise and increased coastal flooding, the Assessment noted that there is a wide variety of industries, leading to economic impacts, which may be at risk from rising seas and floods:

"Economic impacts

Values of property in low-lying or coastal areas may be adversely affected by future flooding and sea level rise. A wide variety of industries may be affected in the future, including construction and development, manufacturing, food and hospitality services, and natural resource economies. There is a broad range of future economic damages from climate change, most notably lost labor hours."

The assessment stated several other areas of interest that are at an elevated risk of impact due to rising seas and floods. These include:

- Archeological sites and historical sites and buildings,
- Parks and waterfronts,
- Physical, ecological, and infrastructure damages, and

- Bluff erosion and bluff-adjacent infrastructure damage.

Prior to this comprehensive summary of climate change impacts, the Task 700 Climate Change Assessment (2019) prepared by HDR analyzed impacts of projected sea level rise and assessed precipitation models on the County stormwater system. Elevation data for 556 outfalls was measured, then overlayed with both RCP 4.5 and RCP 8.5 SLR scenarios for 2030, 2050, and 2100 with 90% probability of exceedance. The results are included in Section 4.5.5 Stormwater.

This report assessed precipitation models (Intensity-Duration-Frequency (IDF) curves) and the UW CIG's precipitation model from "Regional Model Projections of Heavy Precipitation for Use in Stormwater Planning" (CIG, 2019), concluding that compared to past studies' projections of future climate scenarios, recent studies show an increase in precipitation intensities, particularly at the higher return frequencies (100-year event). The report contains mapping of a newly projected 24-hour, 100-year design event that is spatially distributed across the county on a 4-kilometer (km) grid to visualize the distribution of annual precipitation.

The 2025 Kitsap County Multi-Hazard Mitigation Plan (MHMP) discusses that in the coastal zone, the effects of sea-level rise, erosion, inundation, threats to infrastructure and habitat, and increasing ocean acidity collectively pose a significant threat to the region. With diverse landforms (e.g., beaches, rocky shorelines, estuaries), the Northwest coast may experience a wide range of climate impacts. Global sea levels have risen about 8 inches since 1880 and are projected to rise another 1-4 feet by 2100.

The 2025 MHMP further describes that Kitsap County has over 200 miles of saltwater frontage, which may be impacted by rising ocean temperatures and sea level changes. The County is surrounded by sensitive marine ecosystems that can affect water species, water quality, and the fishing industry. An increase in sea levels is expected to have consequences for coastal towns and beaches.

The Suquamish Tribe has developed a Multi-Hazard Mitigation Plan (2016) that included flood and severe storm events, and a Priority Climate Action Plan (2024) focused on carbon reduction.

The Port Gamble S'Klallam Tribe worked with UW's CIG to characterize climate projections, sea level rise and extreme precipitation throughout the year 2160. The Tribe also produced a Priority Climate Action Plan (2024) focused on greenhouse gas emissions and carbon reduction.

SECTION 2

Community Engagement

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2. Community Engagement

Early in the project, a Community Engagement Plan[1] was developed to guide County staff in gathering public input on Kitsap County's SLR planning initiatives. The Community Engagement Plan was intended to create positive community engagement, build trust, ensure transparency, foster healthy discussion about SLR in the County, and improve coordination between jurisdictions. The plan provided for robust public participation, vital to identification of vulnerable community assets and public supported planning actions.

Using a variety of engagement methods, County staff reached out to residents, community groups, businesses, and Tribes in Kitsap County, to inform, engage, and obtain input. The overarching goal of this outreach was to generate a SLR Vulnerability and Risk Assessment to educate the County and the public, inform planning, and identify potential actions for adaptability and resilience. During public engagement events, the following key topics were identified:

- Roadways that provide emergency access for communities should be prioritized.
- Permitting is a barrier for raising structures.
- Neighborhood plans should be developed for at-risk communities.
- Financial support is critical in implementing resiliency strategies.

This project included several public outreach events to educate and engage stakeholders (see Summary of Engagement Activities below). The events were advertised using a variety of methods including social media, County's website and project webpage, email distribution lists, press releases and flyers. Where appropriate, outreach materials were translated into Spanish. Outreach events focused on discussion of the additional assessment results, review of maps, and identification and review of proposed regulatory language. A component of these events also included education on adaptation strategies, particularly the limitations of bulkheads.

Summary of Engagement Activities:

Month / Timeframe	Activity / Event
June 2024	TAC formed
June 2024	TAC Meeting No. 1
July 2024	Webpage published
July 2024	StoryMap created
July 2024	TAC Meeting No.2
August 2024	Planning Commission and Board of County Commissioner (BOCC) Meetings
September-November 2024	Community Advisory Council (CAC) meetings (County-led)
September 2024	Article posted in the Kitsap Sun
September 2024	Community meeting No. 1: Port Orchard, WA (virtual and in-person)
September–November 2024	Community Survey

[1] 20240805_SeaLevelRise_Community_Engagement_Plan.pdf

October 2024	Frequently Asked Questions (FAQ) document published
December 2024	TAC Meeting No.3
December 2024	Community Meeting No. 2: Kingston, WA (in-person)
February 2025	TAC Meeting No.4
February 2025	Community Meeting No. 3: Hansville, WA (virtual and in-person)
May 2025	TAC Meeting No. 5
June 2025	Community Meeting No. 4/Planning Commission Workshop
June 2025	Board of County Commissioners Workshop

Technical Advisory Committee

The Technical Advisory Committee was formed to include stakeholders and Tribes who represent the interests of particular groups, can effect change, have relevant knowledge or skills, and/or are working to address the issues of coastal flooding, storm surge, and erosion damage within Kitsap County. The TAC was intended to help provide assistance on planning scenarios, assets included in the vulnerability assessment, mapping priorities, identifying specific areas of concern and gaps, and will provide feedback on future code and plan amendments. The TAC members included the following:

Organization	**Name**
Kitsap County Public Works	Michelle Perdue
Kitsap County Public Works	Anthony Burgess
Kitsap County Public Works	Joe Rutan
Kitsap County Department of Emergency Management	Jan Glarum
Port of Kingston	Greg Englin
Port of Kingston	TJ Quant
Washington Department of Transportation	Ally Bradley
Kitsap Public Utility District	Angela Bennink
Kitsap Public Utility District	Joel Purdy
Kitsap Public Utility District	Tom Colby
Shore Friendly Kitsap	Christina Kereki
Washington State Department of Ecology	Cinde Donoghue
Naval Base Kitsap	Anna Whalen
Skokomish Indian Tribe	Lisa Belleveau
Suquamish Tribe	Alison Osullivan
Suquamish Tribe	Steve Todd
Point No Point Treaty Council	Cynthia Rossi
Point Gamble S'Klallam Tribe	Benjamin Harrison
Kitsap County Department of Community Development	Heather Cleveland
Kitsap County Department of Community Development	Colin Poff

Kitsap County Department of Community Development	Kirvie Mesebeluu-Yobech
WA State Department of Fish and Wildlife	Lindsay Wourms

2.1 Community Meetings

The project team held a number of community events to gather input and provide information on the project. Events were held in Port Orchard, Kingston, and Hansville to ensure community engagement opportunities were geographically distributed across the County while also focusing on maximizing engagement by communities in areas where mapping results were showing significant potential impacts.

The Port Orchard meeting was intended to be a high-level overview of the methodology and project purpose. Maps were provided to the community where residents could indicate priority areas of concern, where existing flooding impacts are experienced, and what assets should be prioritized.

The Kingston meeting reviewed draft inundation maps and preliminary assets that were being evaluated. This allowed community members to review transects of areas most inundated to see if this information was consistent with what they would expect under future conditions.

The Hansville meeting focused on the impacts expected for this community. The project team received feedback on which assets should be prioritized for resiliency strategies and existing impacts experienced. The residents highlighted that permitting bulkheads is a concern and that a community plan should be developed to establish broad mitigation strategies.

Feedback from these meetings was used to inform the adaptive capacity discussions. For example, the actual length of roads that are potentially impacted by daily high tides by 2050 as determined by mapping was not a large amount. However, feedback from the community indicated that even infrequent road flooding significantly affects residents' sense of safety and well-being. This impacted the vulnerability characterization of the road assets.

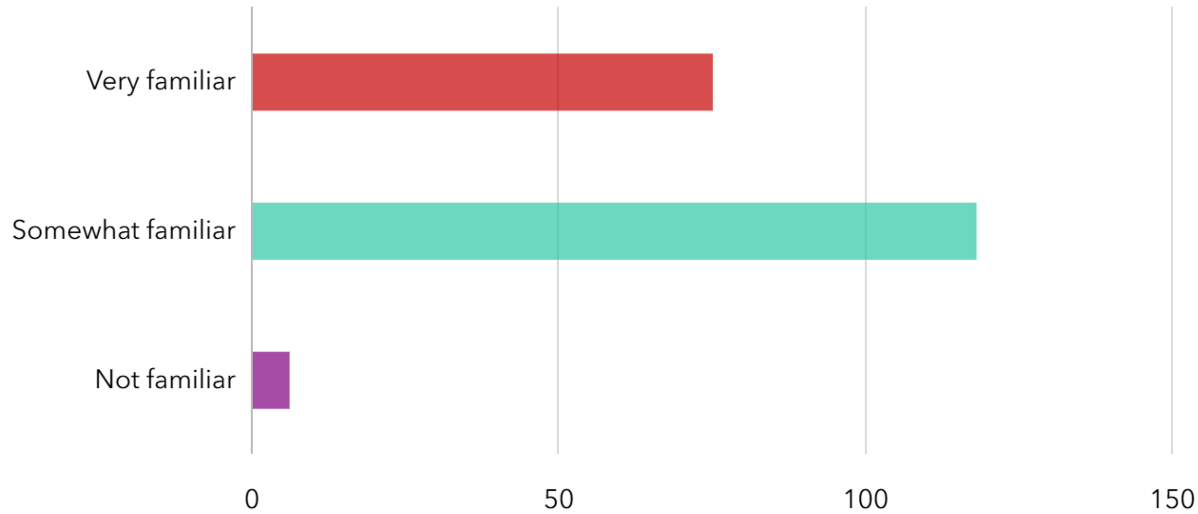
Community Survey

On September 5, 2024, an online community survey was launched to inform the public about the project and gather public input on concerns and priorities for sea level rise planning. A link to the survey was published on the County's website and distributed widely by email and social media. 200 responses were received by the closing date of November 10, 2024. Below is a summary of the key findings gathered from the results of the survey:

KEY FINDINGS

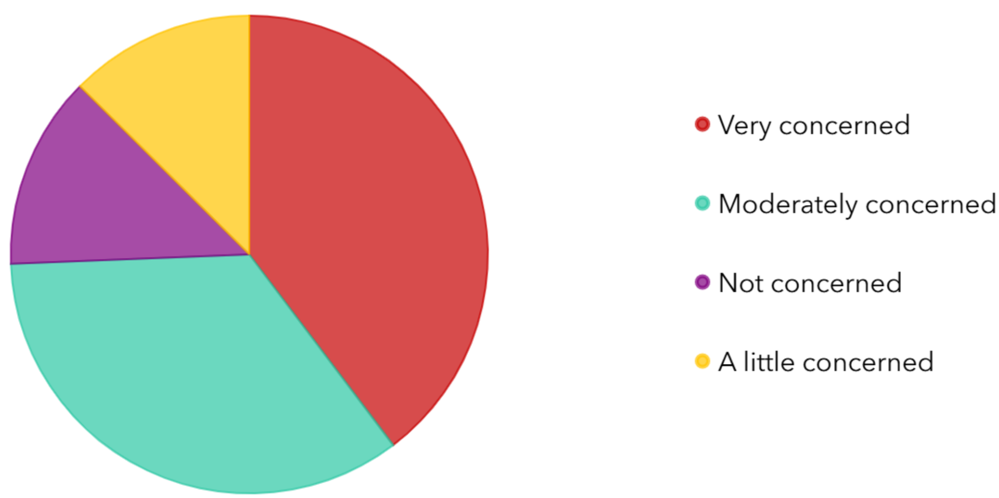
Familiarity with Sea Level Rise:

The concepts of sea level rise and coastal flooding are likely familiar to most residents, particularly shoreline property owners. The majority of respondents (96%) stated they are somewhat familiar or very familiar with the topic of sea level rise.



Concerns about the future impacts of sea level rise and coastal flooding:

Concerns around sea level rise and flooding impacts lean toward moderate and high. The majority of respondents expressed they are very concerned (39.5%) or moderately concerned (34.5%) about the future impacts of sea level rise. While 12% said they are a little concerned, only 13% said they are not concerned.



Specific topics or issues:

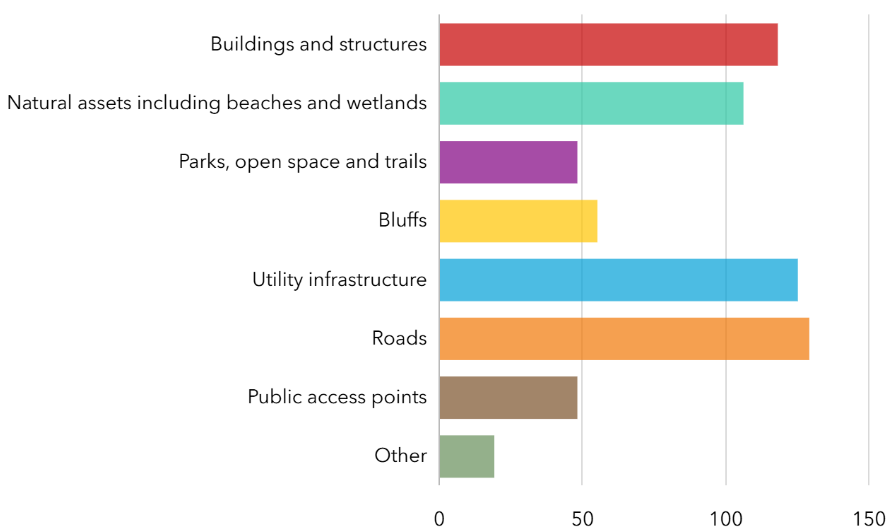
The most common specific topic or issues respondents said they would like to learn about sea level rise and coastal flooding in Kitsap County include:

- SLR/flooding impacts;
- County roads and infrastructure;
- Impacts on urban areas/communities;
- Mitigation strategies;
- Resources to address SLR, including financial help; and
- Property protection measures.

Priority of Assets:

Via a ranked choice format, the respondents ranked assets that should be prioritized including roads, utility infrastructure, buildings, and structures. From the following options, below is a list of assets rated in order of priority:

1. Roads (129 votes)
2. Utility Infrastructure (125 votes)
3. Buildings and structures (118 votes)
4. Natural assets including beaches and wetlands (106 votes)
5. Bluffs (55 votes)
6. Parks, open space, and trails (48 votes)
7. Public access points (48 votes)
8. Other[2] (19 votes)



[2] Respondents were given an option to provide a response to "Other." However, no responses were submitted.

Private property impacts:
28% of respondents said they have experienced coastal flooding on their property or the property of someone they know. Below are photos provided by a few respondents of flooding impacts. Figure 1 provides a visualization of areas of observed flooding by respondents. Dates of reported flooding ranged from 2003-2024.

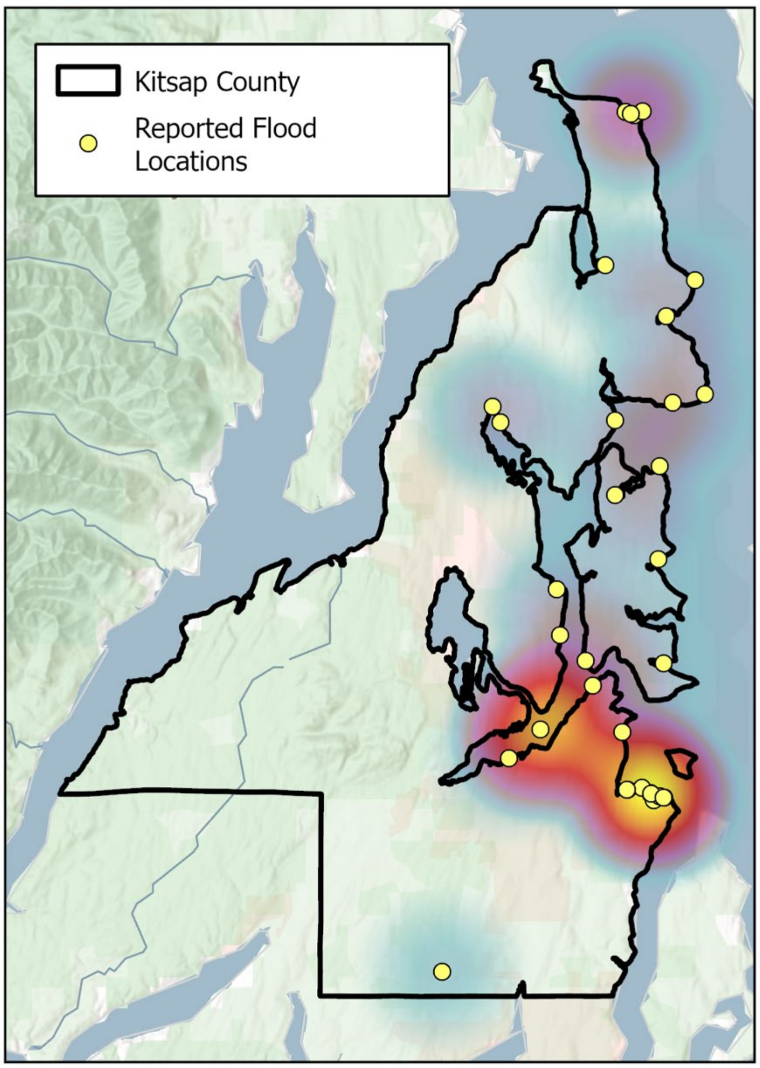


Figure 1. Heat Map of Areas of Observed Flooding Reported in the Survey

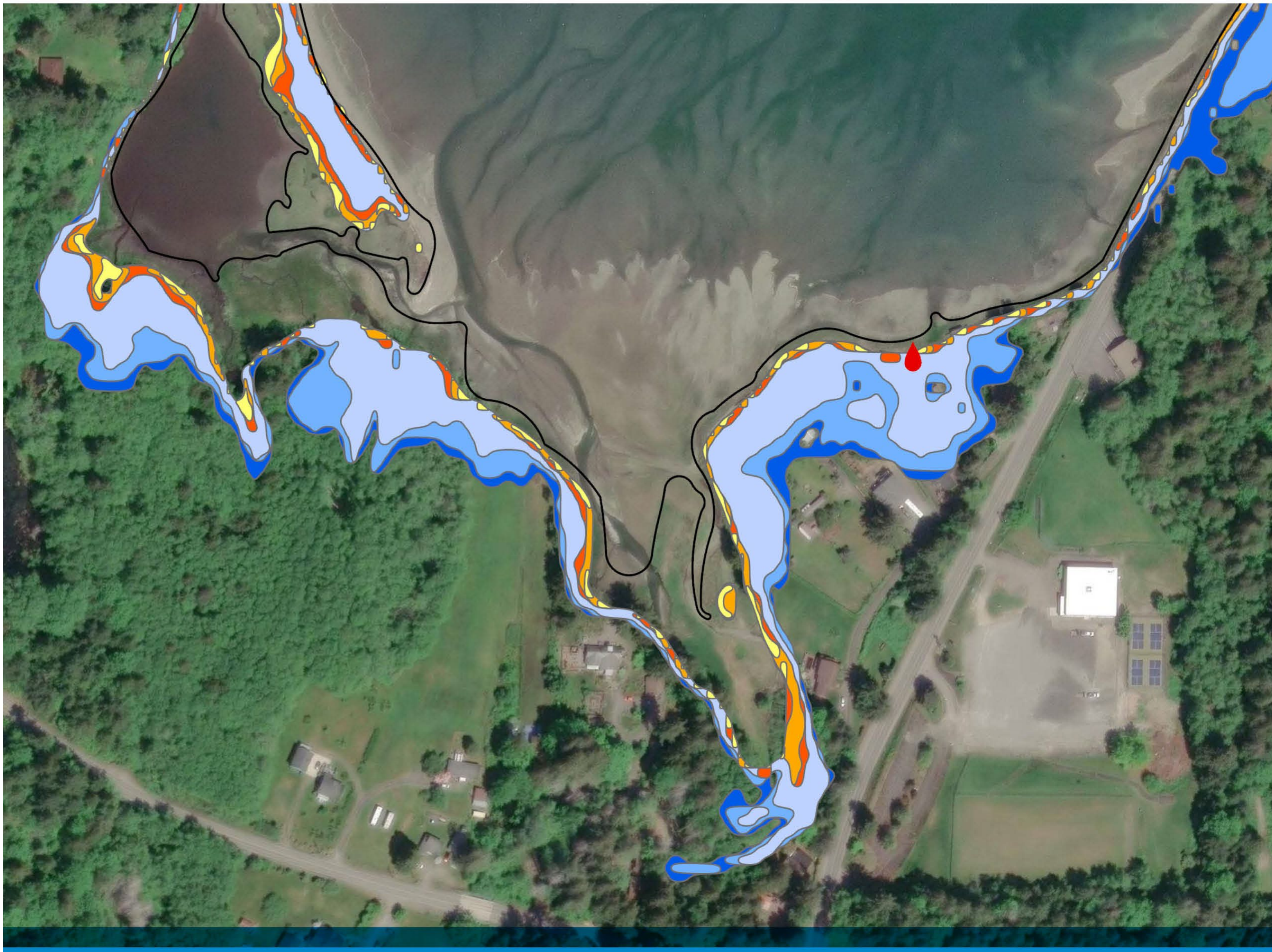
Demographics of respondents:

The survey included optional questions on demographic data, such as age and income. This information can provide context for results by identifying the characteristics of the respondents, allowing the County to understand how different groups within the community may perceive or respond to questions, thus enabling better interpretation of the data, including identifying trends and patterns based on factors like age, income and location. It can also help to determine if further outreach is needed if certain groups are not participating.

- 81% live and/or work in the County
- Age ranges of respondents varied from 20 -89, with 82.5% over the age of 50.
- 73% live in households with 2 or fewer people.
- Race: 76% white, 28% other

SECTION 3

Sea Level Rise Mapping



3. Sea Level Rise Mapping

Sea level rise mapping serves as a critical visualization tool that enables residents, County planners, and decision-makers to understand potential flood impacts in their area. This mapping process integrates several key components: existing tidal measurements, projected sea level increases, topographical data showing how far inland water might reach, and overlays of community assets (such as infrastructure, buildings, and natural areas) that could be affected. By combining these elements, communities gain valuable insights for future planning, emergency preparedness, and building long-term resilience.

This report discusses both sea level rise (SLR) and coastal flooding. Sea level rise is the long term increase in the average height of the ocean's surface, which means some coastal areas that are not currently under water become permanently inundated or inundated regulary at normal high tides (mean higher high water = MHHW). Coastal flooding occurs when sea water inundates land above the MHHW level driven by extreme weather. This type of inundation is temporary and sea waters will recede as tides go out and/ or water is infiltrated or moved through stormwater systems. Two factors significantly influence coastal flooding patterns.

- Sea level rise will exacerbate existing coastal risks including groundwater inundation, storm drain back flow, bluff and shore erosion, storm surge, and direct marine flooding
- Rising average daily tide levels will amplify the severity of storm surge events, particularly during periods of low atmospheric pressure and high wind-driven wave activity.
- King tides, which occur when lunar proximity to Earth coincides with solar alignment, create particularly strong gravitational effects that intensify tidal ranges. These King tides become especially problematic when they coincide with storms.

Given that climate change is expected to increase storm frequency while simultaneously raising sea levels, coastal areas should anticipate both more frequent and more extensive flooding compared to present conditions.

To understand these future impacts, the County commissioned an analysis focusing on several sea level rise scenarios that account for both SLR and coastal flooding. The specific details of the process used to determine these amounts of sea level rise are summarized at a very high level in this report. For more details, readers are encouraged to consult the associated technical reports cited below in the reference section and available at the Coastal Hazards Resilience Network's website[3].

3.1 Relative Sea Level Rise

Relative sea level rise (RSLR) projections were developed with associated probability ranges from 0.1% to 99% (Miller et al., 2018). These probabilities indicate the likelihood of sea level rise reaching or exceeding specific levels by a given year, with higher probabilities corresponding to lower projected rise amounts. For this assessment Kitsap County, based on the TAC recommendation and with

[3] https://wacoastalnetwork.com

guidance from How to Choose: A Primer For Selecting Sea Level Rise Projections for Washington State (Raymond et al., 2020), evaluated sea level rise scenarios for 2050 and 2100 at 1%, 50%, and 90% probability levels. The TAC discussed including projections for 2150 but decided the uncertainty around these projections were too large to include at this time.

RSLR calculations incorporate three key factors:

- Historical sea level rise rates from tide gauge recordings to identify the localized trend of increase in average sea height to date from nearby tide gauges,
- Local vertical land motion (VLM) rates[4] (Figure 2), and
- Projected future increases based on climate warming scenarios.

Coastal VLM, including a combination of uplift and subsidence, can impact relative sea level projections. VLM can be caused by various factors, including tectonic activities, glacial isostatic adjustment, sediment compaction, and the extraction of groundwater and other natural resources (Govorcin et. al 2025). However, this does not include land subsidence caused by earthquake events.

[4] VLM used in relative sea level rise calculations does not include a subduction earthquake event that would result in rapid, potentially dramatic, land movement up or down, but rather the small, incremental changes to land elevation as the tectonic friction alters land elevation.

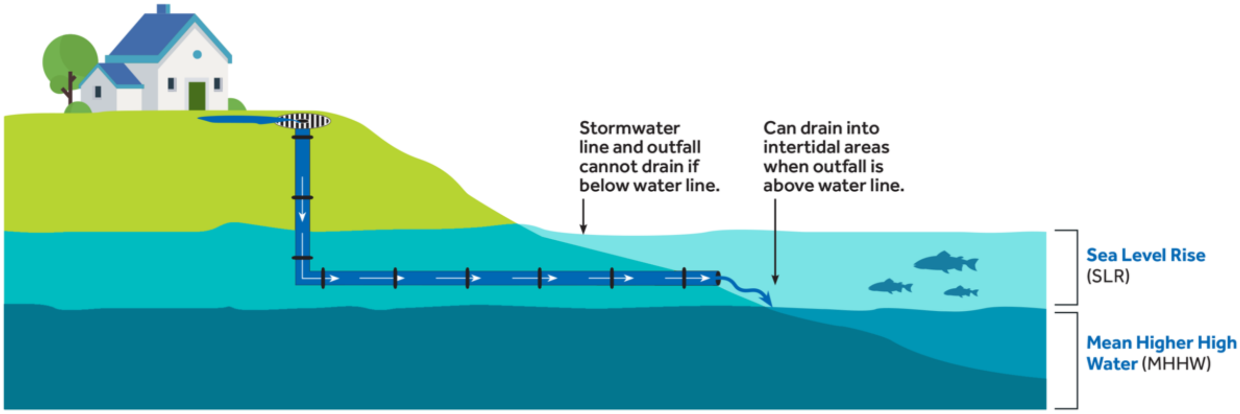


Figure 2. Impacts on Stormwater outfalls from SLR

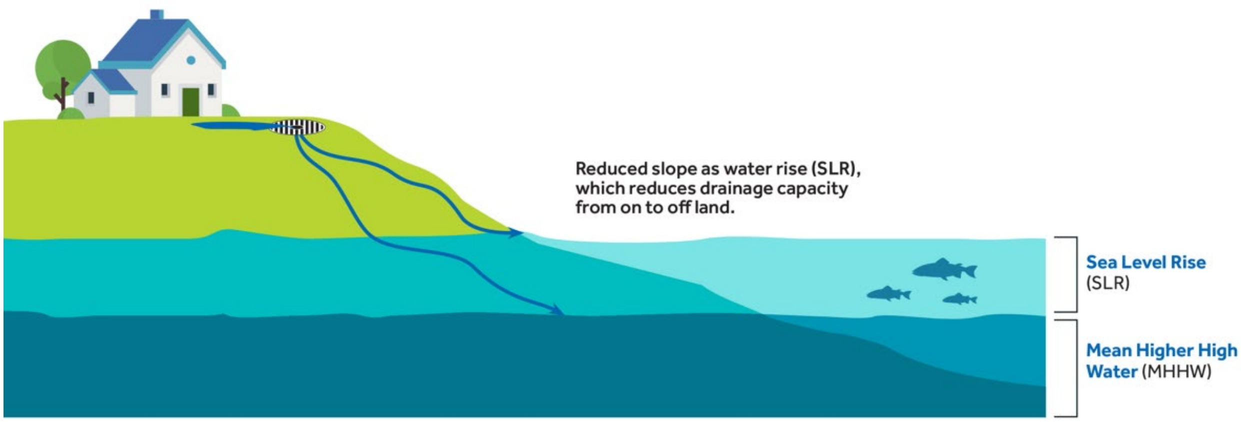
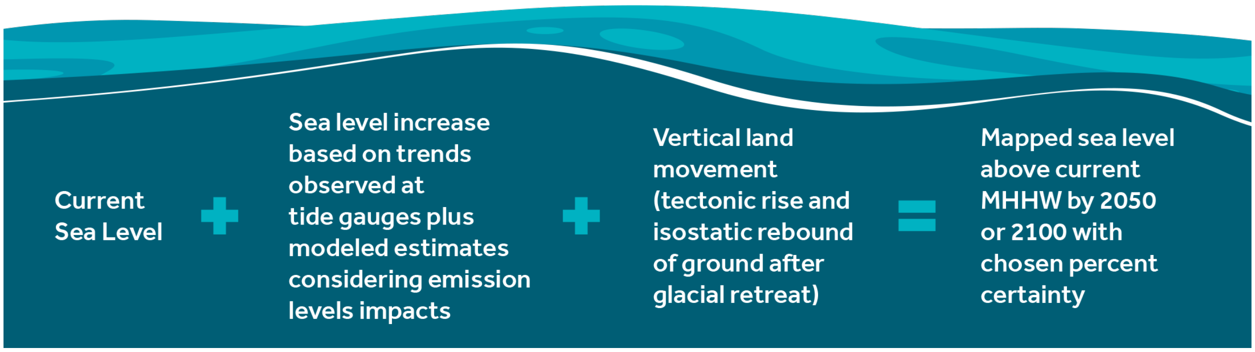


Figure 3. Drainage impacts from SLR.

Important considerations regarding these RSLR projections include:

1. The projections exclude potential subsidence from a subduction zone earthquake, which could cause an abrupt relative sea level increase by dropping land elevation.
2. The projections in this assessment are used to create a "bathtub" or "still water" mapping approach to determine the risk of exposure and do not account for wave run-up or storm surge impacts (Miller et al., 2018). This approach does not consider hydrodynamic factors such as waves, bathymetry, currents, or vegetation that could affect water level depth and inundation extent (Norheim, 2018). Wind wave modeling was not used in the quantification or assessment of impacted assets due to the extremely site-specific nature of wind-wave effects, which is discussed below in Section 3.4.

3. This methodology differs from FEMA's Base Flood Elevation (BFE) mapping approach. While FEMA's maps incorporate hydrodynamic effects and are based on historical 100-year coastal flood events, they do not account for future climate-driven changes in rate or level increases.



Sea level rise doesn't only impact surface tidal areas. Sea level rise also results in saltwater pushing inland below the surface through spaces in the sand and cobble, where it can push up on the fresh groundwater from below (Figure 4). Ponding of groundwater can become more common and longer lasting than previously. A comprehensive vulnerability assessment of groundwater impacts to underground infrastructure may be beyond the scope of this study; however, the reality of the physical phenomenon of permanent higher water table needs to be communicated. Even without severe storm events that overwash normal beach dunes and walls, higher water tables in low-lying areas will cause flooding from below. A compounding complication to drainage of surface water flooding occurs when storm drains and coastal outfalls are backwatered or spend shorter amounts of time in a low-tidal environment and have shorter periods to drain off surface water to the marine environment. Soils that spend more time saturated can impact on-site septic system infiltration functions, as well.

Figure 4. Groundwater impacts from SLR, causing areas disconnected from tidal influence to flood. Image from the Our Coast Our Future web platform (*Source: Point Blue Conservation Science and USGS 2025*).

The United States Geological Survey (USGS) developed the "Hazard Exposure Reporting and Analytics (HERA)" tool to visualize the impact of rising sea levels on natural hazards, such as flooding, groundwater shoaling and emergence, and erosion (Wood et al. 2021). While detailed groundwater impact assessments require hydrogeological expertise and is out of scope for this project, the Coastal Groundwater tool is available to review and provides high-level information for Kitsap County. It is an interactive tool that allows the user to select different sea level rise scenarios, each resulting in predicted groundwater rise along the shoreline. Using data dashboards, the HERA provides estimates of the number of people and amount of certain assets that are in the groundwater hazard zone. A groundwater hazard zone is defined in this tool as: *"an area that is estimated to have saturated soils below the ground or standing water on the land surface for a certain sea level rise scenario, groundwater depth of interest, and assumed groundwater geology."*

3.2 Future Extreme Flood Extent

Extreme flood events occur when factors such as tides, surge and wave run-up combine resulting in a higher-than-normal sea level. As sea levels rise, the impacts of these factors during extreme events are expected to be intensified compared to current conditions. Changes in climate conditions are anticipated to increase storm intensity and frequency, which will exacerbate impacts of coastal flooding and pose greater risks to coastal communities and ecosystems.

To assess the extent of an extreme flood, flood level projections from a follow-up report titled Extreme Coastal Water Level in WA State: Guidelines to Support Sea Level Rise Planning (Miller et al. 2019) were added on top of the RSLR projections from Miller et al 2018. This report refers to a "still water level" (SWL) and a "total water level" (TWL) (Figure 6). SWL is measured by tide guages and accounts for tides, storm surge, seasonal and annual water level cycles and long term average sea level trends. TWL also attempts to account for wave run-up. However, TWL is rarely measured directly (as it occurs between open water tide guages where the level is measured and upland areas where sea water inundates) and is more difficult to assess acurately. For this report, wind wave modeling was conducted to assess the TWL in seven (7) locations to determine the magnitude difference between the TWL and the SWL that is estimated by the projected SLR amounts (Figure 5). This effort is further discussed in Section 3.4 below.

Absolute Sea Level Rise *= MHHW + SLR increase*

Relative Sea Level Rise (RSLR) *= Absolute SLR + vertical land movement (excluding earthquakes)*

Still Water Level *= RSLR + Storm Surge*

Total Water Level *= RSLR + Storm Surge + Wave Runup*

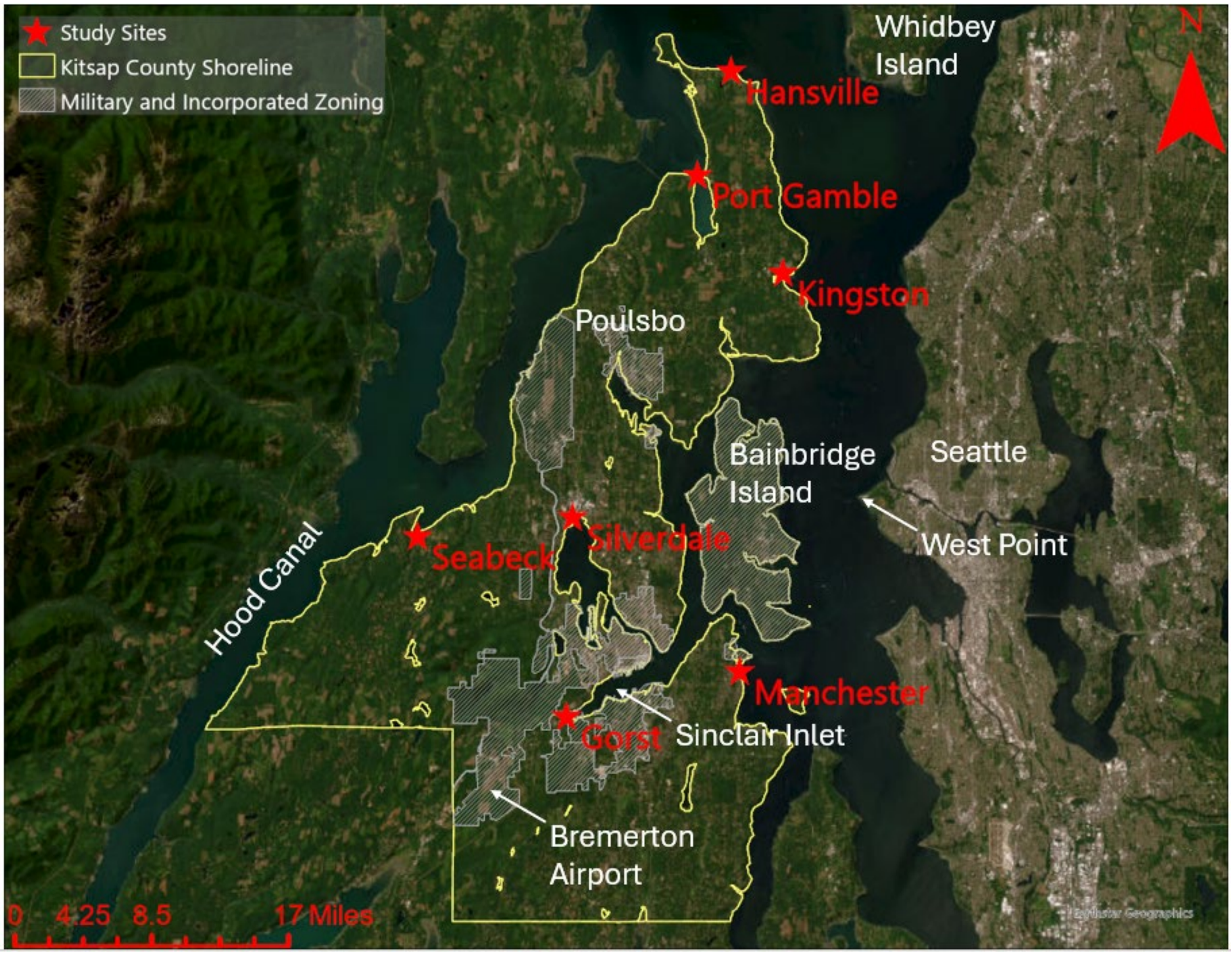


Figure 5. Map of selected sites for wind-wave evaluation.

For this assessment, Kitsap County chose to assess levels seen now during what would be considered an event with a 2% chance of occurring in any given year. These storms are commonly referred to as a "50-year" storm event. However, this terminology is misleading due to the fact that an area can see mulitple "50-year events" in a single year should there be a paritcularly active storm season. It is predicted that high-intensity storms will occur more frequently and for more prolonged durations in the future. So while the extent of current flooding during extreme events or mapped as the "100-year" floodplain on FEMA BFE maps may not differ drastically from the scenarios mapped in this assessment, it is important to note that **the increased frequency and duration of these events should be considered in maintenance, development and emergency planning efforts.**

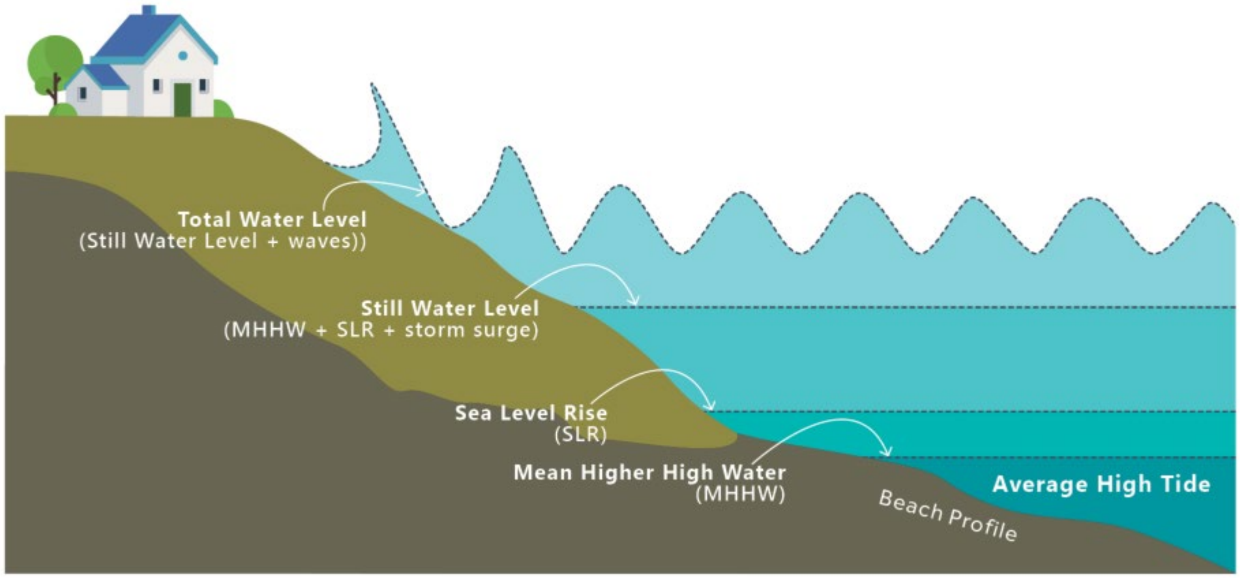


Figure 6. Illustration of the difference between tides, storm surge and wave runup. (Adapted from: *I.M. Miller et al 2019*).

To determine the exent of potential coastal flooding that may occur during a storm event, 3.1-feet was added to the SLR projections to account for potential flood impacts based on the projected sea level rise. The value of 3.1 feet represents the SWL for a 50-year return frequency flood from Table 1 of *Extreme Coastal Water Level in Washington State: Guidelines to Support Sea Level Rise Planning* (Miller et al. 2019).

However, according to Miller et al. 2019, the bays have historically experienced larger storm surges than other parts of the Puget Sound. Therefore, coastal flooding levels for Dyes Inlet, Sinclair Inlet, Agate Pass, Port Gamble Bay and Liberty Bay were mapped as 3.25 to 3.75 feet (rather than 3.1- feet like the rest of the shoreline) on top of the SLR projections. See Table 2 below for the spefics.

3.3 Sea Level Rise Scenarios

To determine the amount of rise to apply on top of MHHW in each scenario, projections from the Interactive Sea Level Rise Projection Tool, developed by the University of Washington's Climate Impact Group (UW 2018)[5] and based on the the Miller et al. 2018 Sea Level Rise Assessment, for the sixteen (16) different reaches around the Kitsap shoreline were averaged for each probabilty (1%, 50%, 90%) and for each year (2050 and 2100) (Table 1).

Projections were rounded to the nearest 0.5 foot. The rationale for this approach, in consultation with the primary author of the projections modeling cited in the previous section, was driven primarily by

[5] https://cig.uw.edu/projects/interactive-sea-level-rise-data-visualizations/

the fact that when mapping at a County-wide scale (e.g., 1:50,000 or greater), the differences between inches of tidal elevation would not be visible. Table 1 includes the inundation amounts used in each area below.

Sea level rise vector mapping layers were made available by NOAA's Office of Coastal Management (NOAA, 2025). The layers represent a set amount, in half foot increments, of SLR on top of the 2022 MHHW (12 ft NAVD88 in Hansville, 11 ft NAVD 88 in Sinclair Inlet). For example, the projected amount of SLR by 2050, with a 50% certainty is +1-foot. Which means the MHHW by 2050, with 50% certainty, will be approximately 13 ft NAVD88 in Hansville. The 1-foot SLR mapping layer from NOAA was used in the mapping modeling exercises.

Areas that are low topographically but disconnected from tidal waters are also included in the maps. These areas are hydrologically connected to the marine environment and as a result, water levels may fluctuate in response to MHHW increases or become flooded by storm surge.

Table 1. Kitsap County Sea Level Rise Scenarios. These values are mapped on top of 2022 MHHW (12 ft NAVD88 in Hansville 11 ft NAVD 88 in Sinclair Inlet)

SLR Projections	90% Certainty	50% Certainty	1% Certainty
2050	0.5 ft	1 ft	1.5 ft
2100	1.5 ft	2.5 ft	5 ft

Table 2. Kitsap County 50-yr Return Flood by 2050 Scenarios. These values are mapped on top of corresponding SLR amounts (Table 1).

Location	50-yr Return Flood (90% Certainty		50-yr Return Flood (50% Certainty		50-yr Return Flood (1% Certainty)	
	2050	2100	2050	2100	2050	2100
Shorelines not in an inlet	3.5 ft	4.5 ft	4.0 ft	5.5 ft	4.5 ft	8.0 ft
Dyes Inlet	3.5 ft	4.5 ft	4.0 ft	5.5 ft	5.0 ft	8.5 ft
Sinclair Inlet	4.0ft	5.0 ft	4.5 ft	6.0 ft	5.0 ft	8.5 ft
Agate Pass	4.0 ft	5.0 ft	4.5 ft	6.0 ft	5.0 ft	8.5 ft

Port Gamble	4.0 ft	5.0 ft	4.5 ft	6.0 ft	5.0 ft	8.5 ft
Liberty	4.0 ft	5.0 ft	4.5 ft	6.0 ft	5.5 ft	9.0 ft

3.4 Wind-Wave Modeling

The extreme flood inundation levels discussed in Section 3.2 do not include wave run-up. Blue Coast Engineering LLC (Blue Coast) was requested to assess the extent of TWL with wind-driven wave and wave runup in seven shoreline reaches with low-lying topography. Blue Coast's evaluation consisted of a coastal flooding evaluation utilizing a 1-D wind-wave hindcast and wave run-up analysis to determine the potential total water level at a selected shoreline reach. Sites were selected to be representative of shorelines throughout the county that may be subject to moderate or greater wind-wave energy and are low-bank. Wave run-up calculations were completed using empirical methods appropriate for the shoreline type (unarmored versus armored). The full methodology is detailed in Appendix B.

The analysis was completed for a single water level scenario, selected to provide a conservative upper limit for planning purposes as it combines a high likelihood (50% probability) SLR scenario combined with a lower likelihood extreme storm surge (50-year return event) and 100-yr wave event (1% probability). The sites assessed included:

- Hansville;
- Port Gamble;
- Kingston;
- Silverdale;
- Seabeck;
- Gorst; and
- Manchester.

The Blue Coast technical report concludes the following:

"The wave run-up values suggest approximately 1 to 3 feet (vertical extent) of additional flood inundation above the SWL can be expected in Kitsap County under the 100-year wind-wave event. The landward extent of this inundation varies depending on the shoreline slope, surface roughness, and crest elevation. At all of the sites except Manchester the total water level elevation exceeds the shoreline crest elevation which indicates a zone of potentially high wave velocity inland of the shoreline crest. In all cases the total water level exceeds the current Base Flood Elevation of 13 feet NAVD88 as mapped by the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM) for Kitsap County (FEMA 2017). The coastal BFE is calculated as the total still water elevation for a 1% annual chance flood plus the additional flood hazard from overland wave effects (storm-induced erosion, wave run-up, and overtopping) and does not account for SLR so this is the expected result." (Blue Coast 2025).

Table 3. Wave run-up and TWL calculation results and inputs for each site

Site	Armored Shoreline?	Site MHHW tidal datum (feet NAVD88)	Combined Storm Surge and SLR value (feet)[1]	Still water level (feet NAVD88)	Shoreline Crest Elevation (feet NAVD88	Wave Run-up R2% (feet)	Total Water Level (feet NAVD88)
Hansville		8.4	3.9	12.3	13.8	4.0	16.3
Port Gamble	Yes	8.2	3.9	12.1	13.8	3.3	15.4
Kingston		8.4	3.9	12.3	13.4	1.3	13.6
Seabeck		8.6	3.9	12.5	14.6	3.2	15.7
Silverdale	Yes	9.3	4.0	13.3	13.8	1.9	15.2
Manchester		8.9	3.9	12.8	20.9	4.5	17.3
Gorst		9.0	4.3	13.3	14.2 (inland crest elevation)	0.1	13.4

[1] Combined storm surge and SLR value (RCP 8.5, 50% probability for year 2050) provided by Facet (2025).

Wave run-up estimates in this memorandum are approximations with inherent uncertainties, derived from publicly available LiDAR data and non-site-specific wind measurements using a one-dimensional wave hindcast methodology. These calculations are intended solely for planning purposes and should not be used for engineering design, as they do not account for detailed topographic surveys or complex bathymetric wave interactions.

Cross profiles were produced for each of the seven areas assessed for TWL and are included along with the transect location in Appendix B. The cross profiles show the maximum shore crest height in relation to SWL. The percentage change between TWL and SWL for each site is summarized in Table 3.

3.5 Bluff Erosion

As a part of this assessment, the consultant team conducted an evaluation of potential impacts of rising sea levels on bluff erosion. This analysis is documented in Appendix B and is summarized here. As described in Appendix B, bluff recession is usually not a linear process and is more typically the result of one larger scale “change event” that occurs once every 15-25 years (MacLennan et al. 2018). Although smaller scale sloughing of bluff material may also occur more frequently causing bluff recession of a couple of inches per year. Long-term bluff recession rates are documented at nine locations throughout Kitsap County by MacLennan (et al. 2018) and are referenced in Table 4 below. The recession rates at these sites were measured using a combination of aerial photograph analysis and field-based methods. The average long-term erosion rate throughout Puget Sound was approximately 0.3 feet per year and in Kitsap County the average was slightly higher at approximately 0.4 feet per year and a median of 0.1 feet per year (MacLennan et al. 2018). The highest long term recession rate in Kitsap County is documented as approximately 1.6 feet per year at a bluff near Eglon, along the east facing shoreline of the Peninsula which is exposed to large wind-waves generated across the central basin in Puget Sound. The erosion rates provided by MacLennan et al (2018) can typically be applied to the bluffs within the same littoral drift cell[6].

Table 4. Long term bluff recession rates measured in Kitsap County (MacLennan et al. 2018)

Site No. and Location	Description	Erosion Rate (feet per year)[1]
8	Port Madison (Bainbridge Island)	-0.07
9	South Sinclair Inlet	-0.08
10	North Bremerton	-0.08
11	Keyport	-0.10
12	Liberty Bay (west of Poulsbo)	-0.11
13	Point Jefferson (near Indianola)	-0.22
138	Hood Canal (south of Coon Bay)	-0.36
143	Eglon	-1.63
149	Hood Canal (near Bangor)	-0.49
Median		-0.11
Average		-0.38

[1] The erosion rates are taken directly from the cited report but should be used as an approximation since the uncertainty of the methods ranges between 0.08 to 0.84 feet per year depending on the length of available data and the data sources.

As described in Appendix B, increased bluff recession rates resulting from SLR and other climate change impacts in Kitsap County have the potential to accelerate changes to the shoreline compared to static sea levels. This will in turn increase the potential vulnerability resulting from shoreline erosion of both public infrastructure and private property throughout the County compared to the inundation maps presented in the modeling results. When erosion hazards are considered, it is expected that additional areas and assets will be exposed, compared to mapping inundation alone. Bluff erosion can occur at both the toe and the top of the bluff, with each having distinct primary mechanisms. However, these processes are interconnected and can contribute to shoreline recession. Erosion at the toe of the bluff can destabilize the upper portions, exacerbating the overall erosion.

As sea levels rise, the face of the bluff may become saturated at higher levels, weakening the sediments and accelerating the rate of erosion. The greater intensity of heavy precipitation events is expected to increase the flow of surface water across the face of the bluffs which can result in more

[6] The stretch of shoreline in which sediment moves in one dominant direction and bounded by a change in geology and landscape.

frequent episodes of shallow and deep-seated landslides depending on the geology. Initially, the sediment eroded from the face of the bluff will be deposited on the shoreline and protect the toe of the bluff. Overtime, the deposited sediment will be mobilized and transported alongshore, exposing the toe of the bluff once again and the cycle will repeat.

It is important to recognize that bluff recession, landslides, and discharge of sediment to the beach are critical natural processes that sustain beach widths and shoreline habitats both at the toe of the bluff and further alongshore. However, as bluffs gradually recede landward, there will be a continued desire from infrastructure managers and property owners to protect their property and assets.

3.6 Saltwater Intrusion

While groundwater modeling or saltwater intrusion studies are not included in this report, this section is intended to provide a high-level overview of the risks associated with saltwater intrusion that should be modeled and monitored over time to determine when or where impacts will occur.

Seawater intrusion refers to the encroachment of saline water from the ocean into freshwater aquifers, leading to elevated chloride concentrations. Groundwater abstraction from coastal aquifers is particularly vulnerable to climate change impacts, including sea level rise, due to the heightened risk of saltwater intrusion and its effect on groundwater quality contingent on local hydrogeological conditions (Rasmussen et al., 2013).

Sea level rise introduces two primary pathways for seawater intrusion:

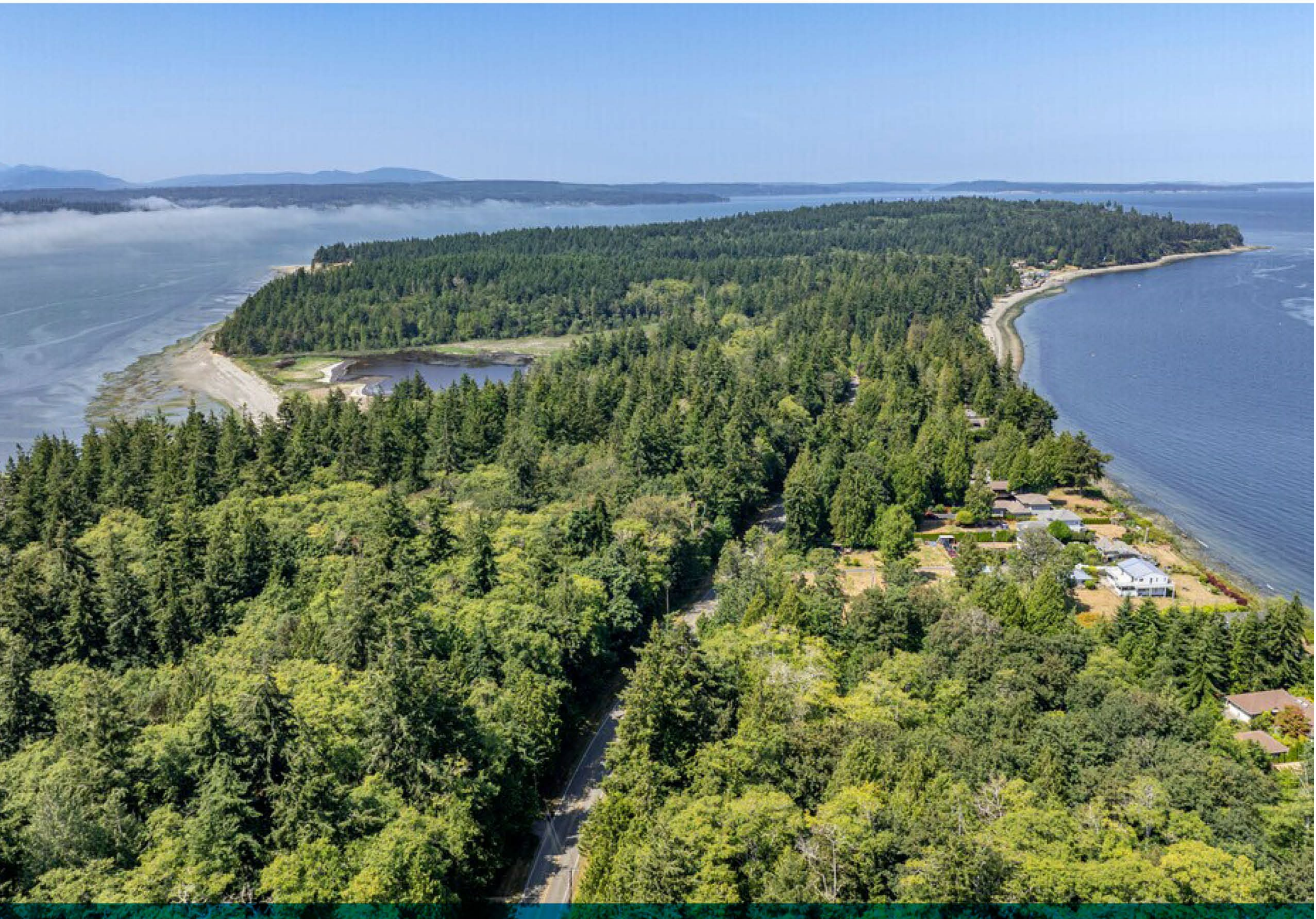
1. Vertical infiltration through overlying sediments caused by coastal or compound flooding.
2. Lateral intrusion driven by elevated water tables and landward shifts in the freshwater–seawater interface.

Coastal flooding associated with sea level rise, triggered by high tides, storm surges, increased wave heights, wave runup, and salt spray, intensifies the risk of seawater intrusion, particularly within shallow aquifers.

If future monitoring indicates rising chloride concentrations that exceed public health thresholds for drinking water, alternative water supplies may need to be sourced from deeper wells tapping into underlying freshwater aquifers. In coastal areas, like those in Kitsap County, where the water supply relies fully on fresh groundwater resources, saltwater intrusion may result in significant socio-economic impacts. The impacts of saltwater intrusion may be exacerbated due by increased frequency, length or severity of drought events as a result of a changing climate (Vera et. al., 2012 in Pulido-Velazquez et. al. 2022).

SECTION 4

Vulnerability and Risk Assessment



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4. Vulnerability and Risk Assessment

The vulnerability assessment methodology used in this project follows a modified version of the U.S. Climate Resilience Toolkit's "Steps to Resilience" framework (United States Global Change Research Program (USGCRP), 2016) where vulnerability is a combination of exposure likelihood and adaptive capacity (Figure 7). This assessment is primarily a spatial assessment that is vetted against a narrative assessment. The spatial assessment depended on mapping the location of assets. The narrative assessment depended on feedback from the community and subject matter experts gathered during meetings and through an online survey (Section 2). The list of assets included in this assessment was developed by the TAC and included below in Section 4.1.

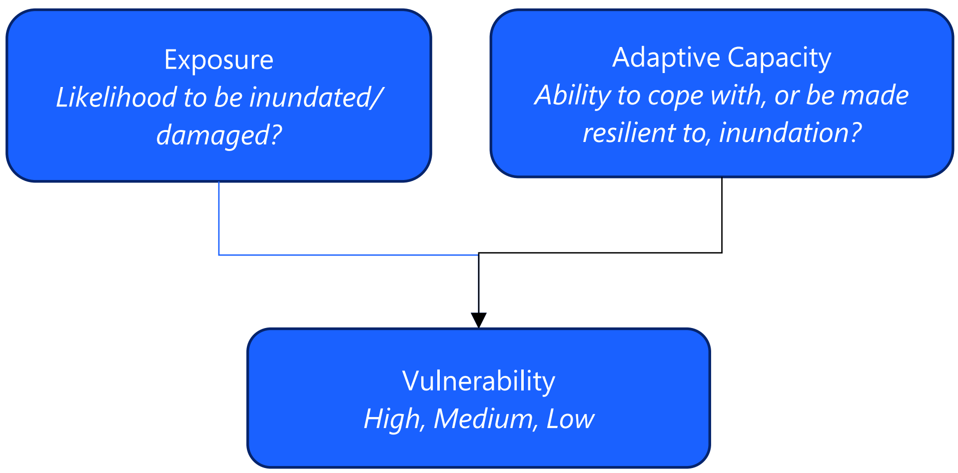

Figure 7. Vulnerability Criteria

For the spatial assessment, exposure likelihood was classified as high, medium, or low based on when assets would be exposed to SLR or coastal flooding based on the inundation mapping. The TAC and County staff had expressed that the timeframe (i.e., by 2050 or 2100), rather than using probabilities (i.e., 90%, 50%, or 1%), to gauge impact was more meaningful for management considerations. The ruleset for exposure risk developed are as follows:

Table 5. Exposure Ranking Criteria

Exposure Ranking	Description
High *– likely to be exposed sooner*	Asset may be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability.
Medium	Asset may be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability.
Low *-less likely to be exposed*	Asset may be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability

For some assets, exposure to inundation does not necessarily equate with an impact. For example, sewer system components such as stormlines or surface equipment that is elevated, that are in an inundation area, may be able to withstand inundation. The element of sensitivity of an asset was addressed within the adaptive capacity ranking process, described next.

Adaptive Capacity was classified as high, medium, or low based on a ruleset recommended by the TAC. The application of the ruleset developed for each asset was subjective. The ruleset for adaptive capacity developed are as follows:

Table 6. Adaptive Capacity Criteria

Adaptive Capacity Ranking	Description
Low - Does *not easily* adapt, or is difficult to adapt, *to new conditions*	Impacts on assets may lead to significant operational disruptions or loss of functionality. Adaptative solutions may need to be innovative and require collaboration with agencies and representatives. High costs are likely associated and may require significant capital improvements to mitigate impacts
Medium	Impacts on assets may lead to temporary operational disruptions or loss of functionality. Impacts can be reduced or mitigated to some extent, but adaptive solutions may only be feasible for certain components of the assets. Some assets may face challenges regarding cost and implementation. .
High *-More easily adapted*	Assets can adapt to impacts with minimal difficulty. Adaptive solutions are highly feasible for most assets with affordable costs

The vulnerability of assets can be determined using a matrix that looks at the level of exposure risk to the adaptive capacity of an asset (Figure 8).

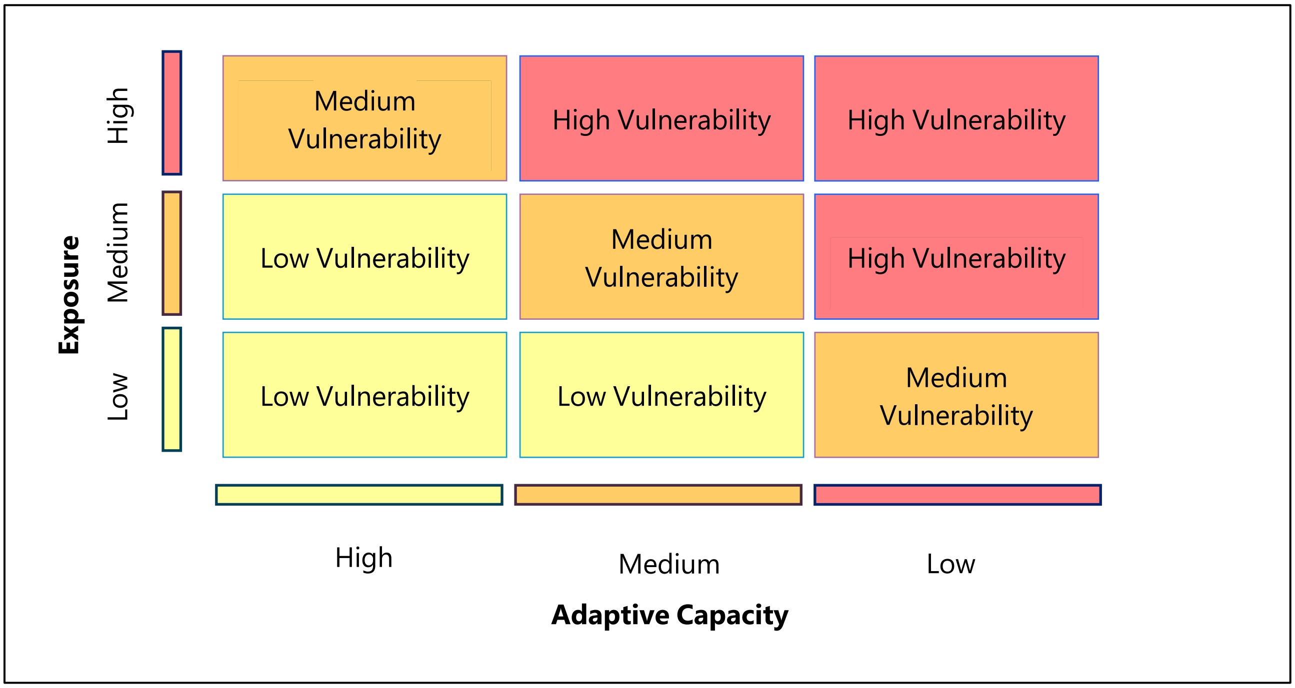

Figure 8. Vulnerability matrix

4.1 List of Assets

Based on input from the TAC, the following assets are included based on the themes from Section 2.1 included in the Community Survey. These assets were identified as priorities for assessment or may have significant impacts if they are inundated (e.g., critical facilities, emergency services, landfills, or brownfield sites, etc.). Potential impacts to bluff erosion rates and related mitigation strategies were evaluated separately in this report. Tribal cultural resources were not assessed due to the extremely sensitive nature of their locations.

Table 7. Assets assessed by exposure likelihood and adaptation capacity.

Type of Asset				
Transportation	**Structures**	**Utilities Infrastructure**	**Environmental**	**Land Use**
Roads and Transportation	Coastal Buildings	Coastal On-Site Septic Systems[7]	Beaches	Agricultural Land/Farmland
Airports	Police Stations	Group A and B Water Systems	Marinas and Boat Ramps	Brownfield Sites/Landfills/Toxic Cleanup Sites
	Fire Stations	PSE Substations	Wetlands	Parks
	Historic and Cultural Sites	Sewer Districts/Water Treatment Plants		Shellfish/Seafood Industrial Facilities
	Hospitals	Stormwater Facilities		
	Libraries			
	Schools			

[7] adaptive capacity discussion but insufficient data to assess exposure

Exposure likelihood of assets was quantified for assets located in unincorporated areas of Kitsap County and on Tribal reservations. Incorporated cities assets were not included in the vulnerability assessment. The City of Bainbridge Island recently completed a sea level rise risk assessment (City of Bainbridge Island, 2024). The US Navy has conducted a sea level rise assessment and developed strategies specific to the bases in Kitsap County.

The vulnerability assessment was conducted using the SWL projections. In other words, wind-driven wave runup was not included in the inundation mapping layers. Therefore, the flood and storm impact assessment should be considered conservative since the TWL usually extends past the SWL but to varying degrees based on how flat the topography is and what structures the water may encounter. Due to the location and specific nature of wind driven runup, calculating a general magnitude of runup for the entire County shoreline was out of scope for this assessment.

4.2 Areas Inundated

The increase in number of acres that may be submerged daily under MHHW will likely be between 84 (with 90% probability) and 227 acres (1% probability) by 2050. The 50% probability projection states that, with 1 foot of SLR above MHHW, 143 acres will be exposed to daily MHHW tides that are currently above the MHHW tideline. The County's shoreline jurisdiction in the marine environment is 200 feet inland from the marine shoreline. This shoreline length excludes the military's 7.5 miles and the City of Bainbridge Island's 53 miles from the 228 total shoreline miles. Currently approximately 5,230 acres are included in what is considered shoreline jurisdiction for the County and cities of Bremerton, Port Orchard, and Poulsbo. The 50% probability projection increase by 2050 of 147 acres represents an area increase of 2.8%.

By 2050, a 50-year return magnitude storm will inundate approximately 890 to 1,337 acres (90% and 1% respectively). A flood that inundates 1,050 acres is as likely to happen as it is not by the year 2050 (Table 8).

By 2100, the 50% probability projection for everyday MHHW (2.5 feet above current MHHW) will inundate 467 additional acres over the current MHHW and a 50-year return magnitude flood may inundate 1,537 acres.

These estimates do not include impacts to Bainbridge Island, which is outside the scope of this project because the City of Bainbridge Island conducted their own risk and vulnerability study in 2024. These estimates do not include impacts to shorelines within military installations. The U.S. Navy conducted their own assessment, and any information should be acquired from Department of Defense sources.

Table 8. Number of acres inundated by SLR or by a 50-year return flood above 12.0 ft NAVD88 (MHHW), by 2050 and 2100, by percent probability.

	MHHW+ SLR (acres)			Flood (acres)		
	90%	**50%**	**1%**	**90%**	**50%**	**1%**
2050	83.9	142.9	227.4	890.2	1049.8	1337.3
2100	227.4	466.9	1078.6	1202.9	1537.4	2553.3

[1] These amounts do not include additional acreage inundated by wind-driven wave runup.

Table 9. Number of acres of low areas disconnected from tidal influence that are at the same tidal elevation as MHHW (12.0ft NAVD88) plus SLR or 50-year return flood, by 2050 and 2100, by percent probability.

	Elevation of MHHW +SLR (acres)			Flood (acres)		
	90%	**50%**	**1%**	**90%**	**50%**	**1%**
2050	127.1	140.7	140.7	79.6	84.2	99.7
2100	140.7	81.4	71.6	94.7	85.7	41.3

[1] These amounts do not include additional acreage inundated by wind-driven wave runup.

Many areas around the Kitsap Shoreline are near vertical bluffs or steep incline and SLR mapping shows little if any inundation. Increased wave action against the bluffs is the main tidal action impact of concern. The areas that appear to be impacted by SLR to a greater degree are Hansville/Point no Point, Doe Kag Wats estuary, Port Orchard, Southworth, and the west side of Erland's Point.

An ArcGIS StoryMap developed for this project contains the inundation data[8]. Maps of certain focus areas are included in Appendix A and available from the County's Department of Community Development.

4.3 Transportation

The assessment covered transportation elements such as airports and roads. Bremerton National Airport and Apex Aviation's airstrip are located upland and not at risk from SLR or coastal flooding. The Poulsbo Seaplane Base is located within the City of Poulsbo so is out of scope for this assessment.

A total of approximately 23.0 miles of roads are considered to have a likelihood of being inundated. Seven (7) miles of roads are considered at high risk to exposure to coastal flooding by 2050 with a 50 or 90% level of probability. This includes roads that may be inundated by daily hightides (0.5 – 1 ft of SLR), flooded by a 50-year return frequency storm (4 ft along non-bay shorelines and along Dyes Inlet and

[8] https://storymaps.arcgis.com/stories/7c12a25acf634fa8a7732576ba8b0ef6

4.5 ft in Sinclair Inlet, Agate Pass, Port Gamble Bay and Liberty Bay) or intersect a low lying area that may be impacted (same SLR amounts as previously listed). Fourteen and half (14.5) miles of roads may be impacted by tidal inundation closer to 2100.

Table 10. Approximate miles of road by exposure risk level

Exposure Risk Level	Length of Exposed Road (Miles)[9]
High	7.0
Medium	1.5
Low	14.5
Grand Total	**23.0**

Roads with a high exposure likelihood are concentrated in Hansville, Port Orchard, Gorst, Rocky Point, and Southworth. There are some short road lengths that mapped as high exposure where they end along the nearshore. Some of these roads may be public beach access points, such as E Hemlock St in Manchester, Sunset St NE off of Beach Dr NE north of Lofall, and the western corner of Allan King Rd W in Holly, to name some examples.

Within the roads classified as having a high exposure likelihood are roads with roadbed elevations one (1) foot or less above current MHHW (12 ft NAVD88). These are roads that may be inundated by daily hightides by 2050 (with a 50% certainty). These roads include:

- Parts of SE Southworth Drive, north of SE Olympiad Drive
- SE Olympiad Drive, along the beach
- Beach Drive East northeast of E Blaisdell Rd
- Beach Drive, between Olney Ave E and Ahlstrom Rd E.
- Potentially Hwy 3 in front of W Sherman Heights Rd
- Illahee Rd NE, south of the marina
- NE Twin Spits Rd, between Norwegian Point Park and Killarney Ln NE

It is important to note the community stated they already experience flooding on roads that are not listed above. During community meetings, road flooding was the most frequently raised concern. The bulleted list of roads only represents the lowest in bed elevation according to the digital elevation model and does not represent surveyed results. For prioritization of roads where mitigation strategies

[9] Values were rounded to the nearest 0.5 mile.

should be considered, the list above is only one consideration. Roads other than those mapped may become inundated for a number of reasons, including:

- Wind-driven wave runup;
- Stormwater flooding due to reduced capacity to infiltrate or drain because of high tides backing up or occluding storm drains; and
- Storms more intense than those modeled (i.e., a 100-year return frequency flood).

Roads that flood, especially in populated communities or where the road that might flood is the only ingress or egress, should also be a high priority to address.

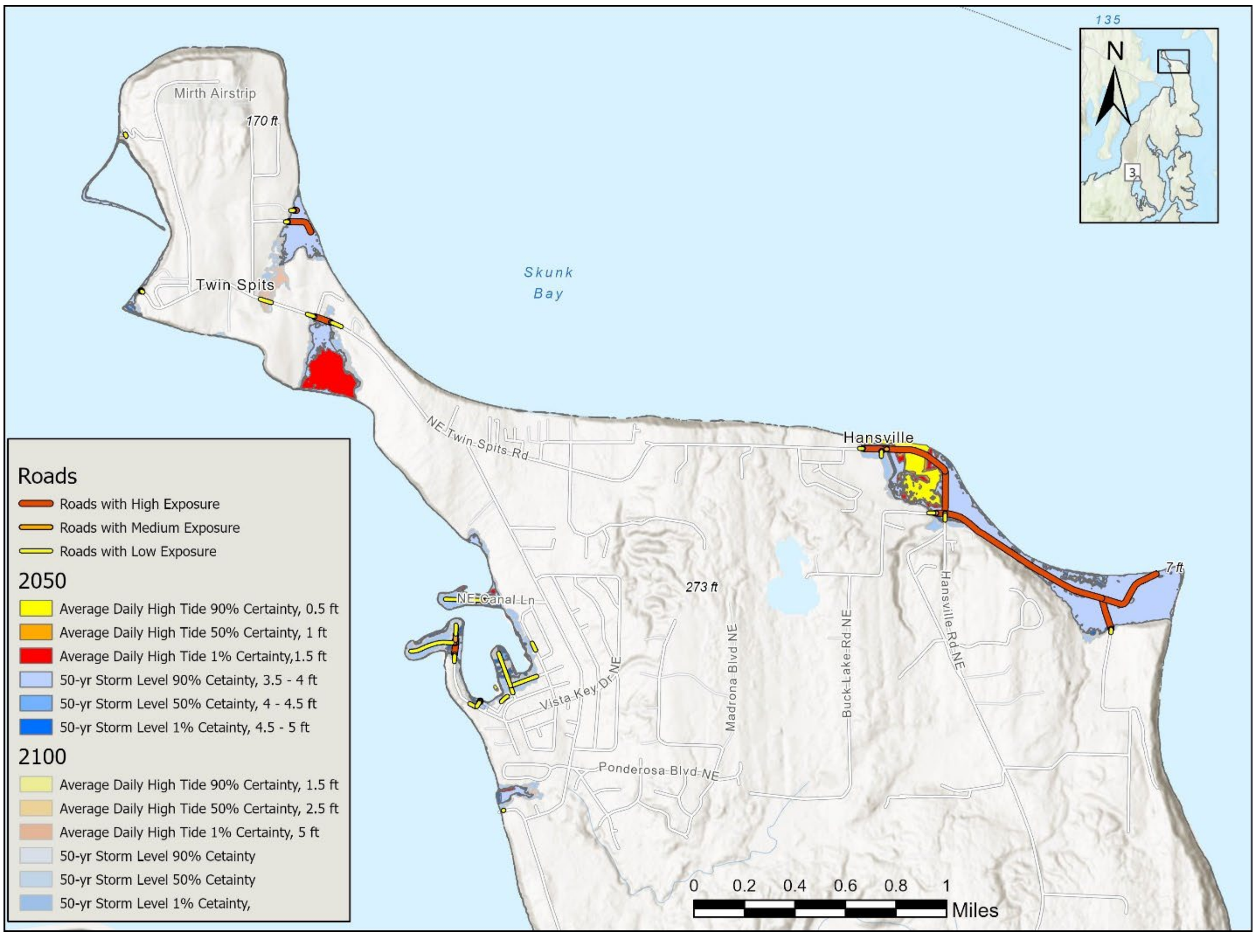

Figure 9. Roads with a high level of exposure risk near Hansville

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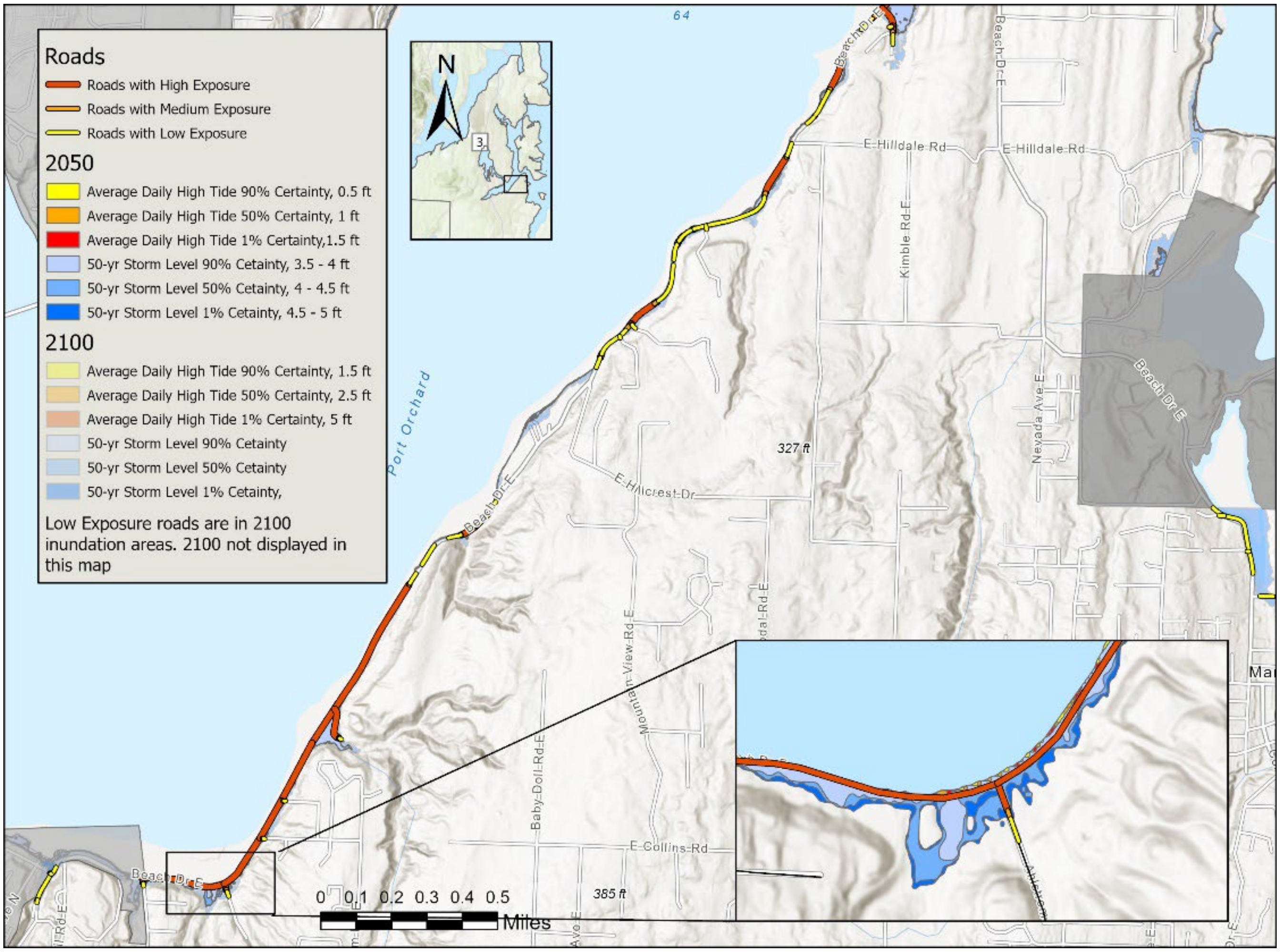

Figure 10. Roads with a high level of exposure risk near Port Orchard.

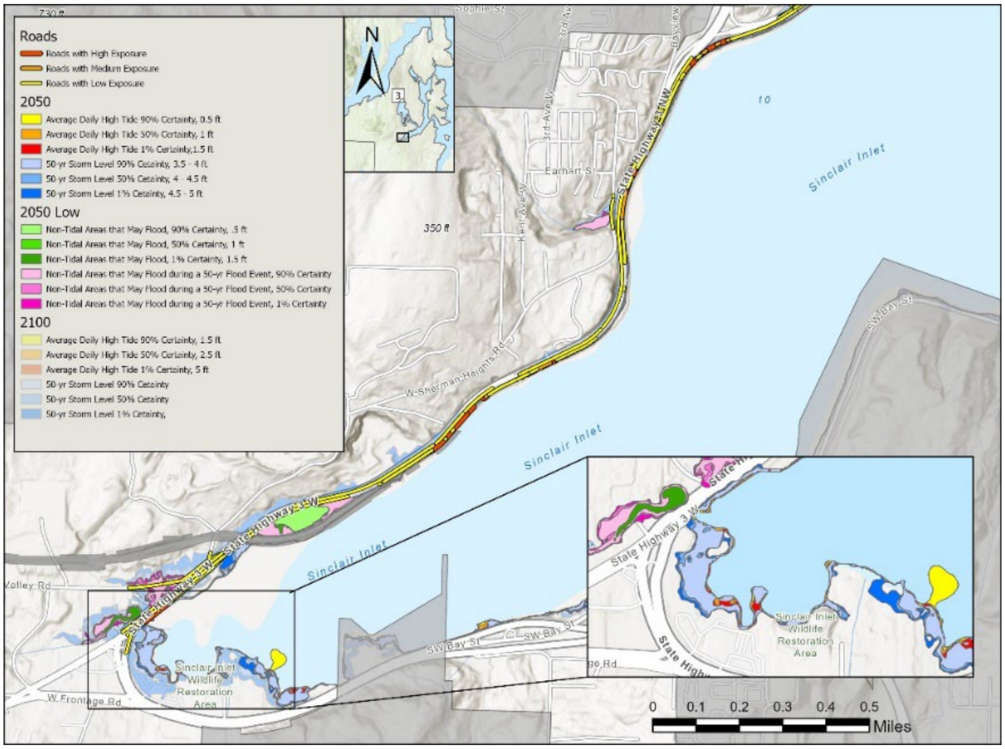

Figure 11. Roads with a high level of exposure risk around Sinclair Inlet

The community expressed concern regarding flooding in Gorst. Below is an elevation profile based on the digital elevation model that was created using Lidar data, not surveyed. The MHHW designation is from NOAA Office of Coastal Management.

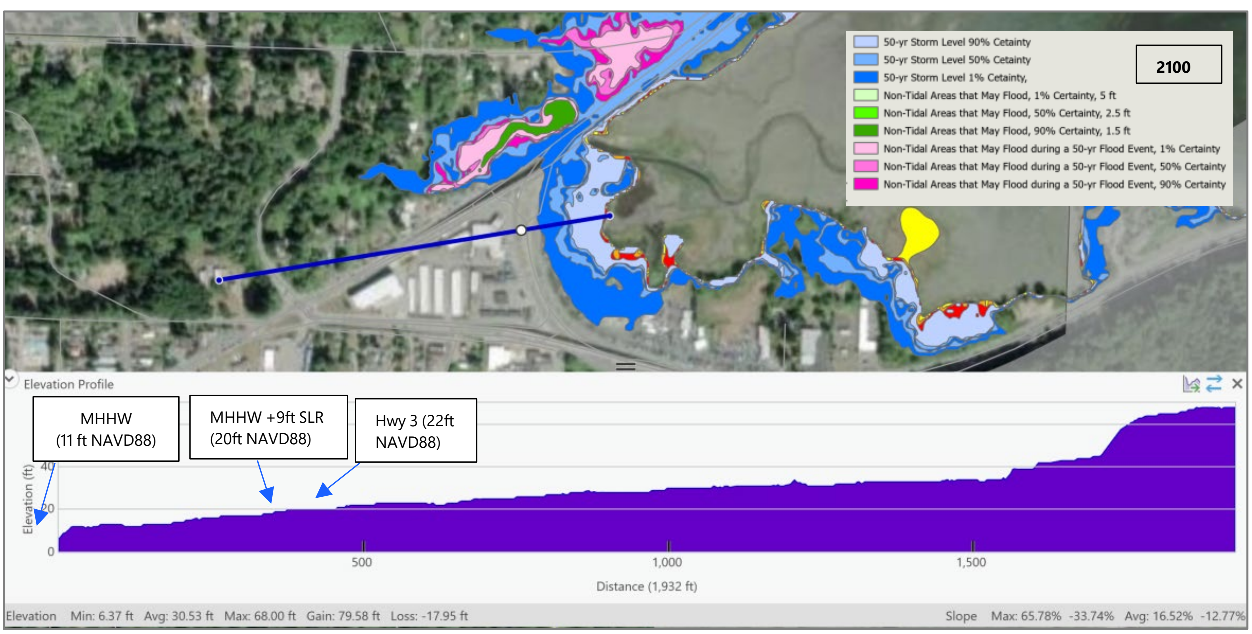

Figure 12. Elevation profile across Gorst.

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Flooding in Gorst is unlikely to be directly caused by sea level rise (SLR) inundation, as it would require over 9 feet of flooding or SLR to overtop Highway 3. However, SLR may still impact drainage in the area, with stormwater backup or elevated groundwater levels likely contributing to flooding. Hydrological analyses will be important to determine the causes and extent of compound, groundwater, or stormwater-related flooding.

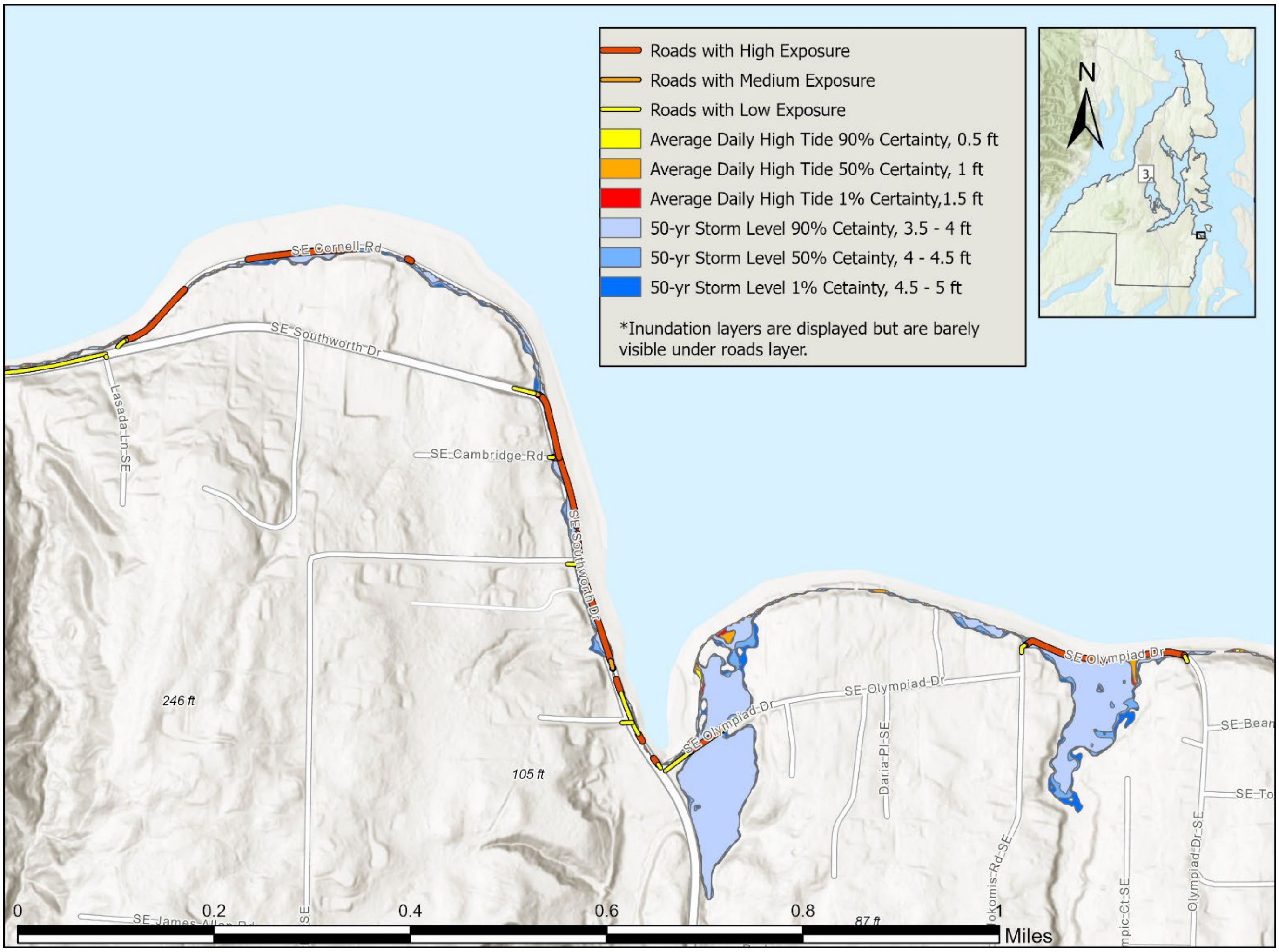

Figure 13. Roads with a high level of exposure risk near Southworth.

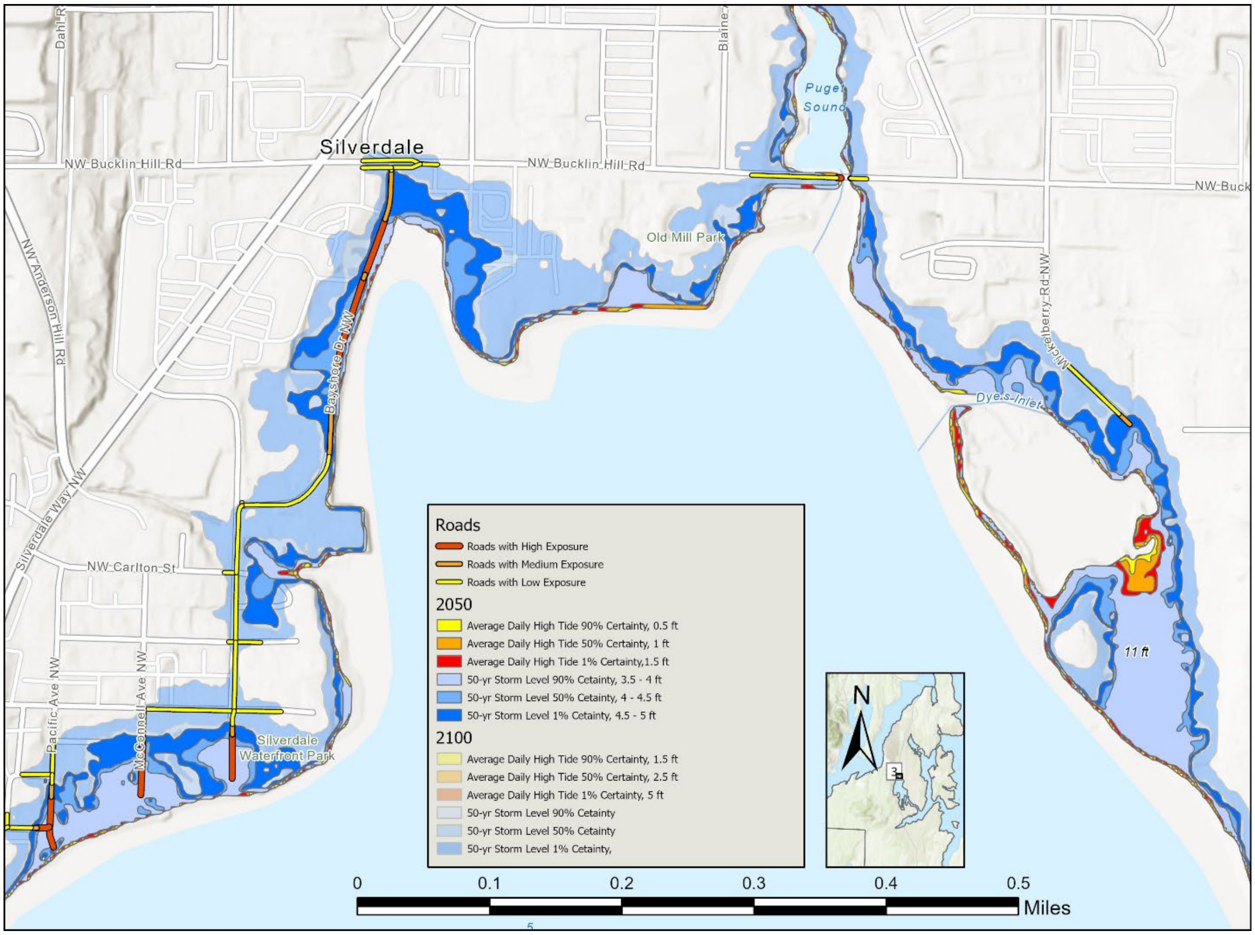

Figure 14. Roads with a high level of exposure risk near Silverdale.

Roads that serve as the sole ingress and egress for a neighborhood with high exposure risk are significant due to the potential challenges they pose for emergency evacuation or access. For example, Virginia Point in Liberty Bay has a 1% probability of becoming inundated daily but is at high risk for frequent flooding and would cut off the community's egress. The approach to the bridge on NE State Hwy 308 to Keyport is at high risk (See Figure 15). Should this road become inaccessible, the only exit for the Keyport community is through the base. Other high-risk roads that provide the sole egress out of a residential community include, but are not limited to, the following:

- NE William Rogers Rd and Chief Sealth Dr NE
- Kellerman Dr NE and NE Beach Cove Ln
- NE Appletree Point Ln
- Vista Key Dr NE
- NE Twin Spits Rd
- Shorebrook Dr NW
- NW Seclusion Cove Way
- Miami Beach Rd NW, north of NW Adrian Ln
- Hoodpoint Rd NW
- Nellita Creek Ln NW
- Allan King Rd W
- Marjorie Ln SE

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- E Caraway Rd, south of Corliss St.
- Beach Dr E and E Clam Bay Ct
- SE Fragaria Rd eastward of Banner Rd SE.
- Rich Cove Ln E and Rich View Dr. E
- E Blaisdell Rd
- E Sacco Ln
- E Lidstrom Hill Rd
- Ahlstrom Rd E
- NW Swiftshore Ct
- NW Paul Benjamin Rd
- Trails End Rd NW
- NW Linden Ln
- Katherine Ave
- Thorpe Rd NE

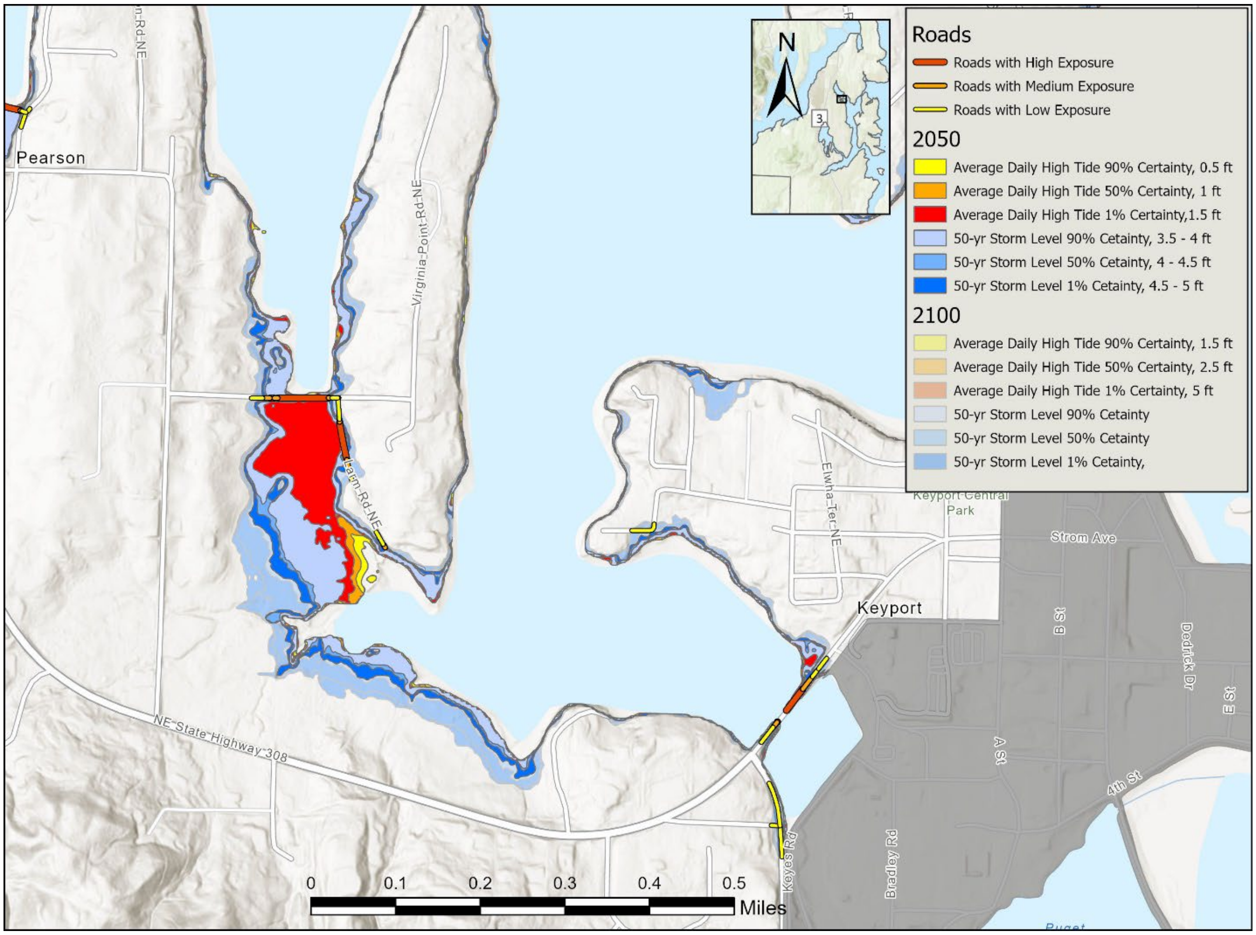

Figure 15. Roads with a high level of exposure risk near Liberty Bay.

4.4 Structures

Using the data supplied from Kitsap County, structural assets were evaluated for potential exposure risk and are summarized by type of structure below. **Areas mapped in this report as having a higher level of exposure are intended to support informed decisions and are not to be considered regulatory.**

4.4.1 Facilities

No schools, law enforcement, fire stations or community facilities are located in areas at high, medium, or low exposure risk to SLR or coastal flooding. Community facilities include community centers, hospitals and urgent care clinics, museums, libraries, Public Works Road sheds, solid waste disposal sites and the Kitsap County Fairgrounds.

4.4.2 Buildings

Building footprint data available from the County was used to assess the magnitude of exposure likelihood using the criteria contained within Table 5 of this report. This data is acquired from models based on satellite data and has a small margin of error (for example, a roof with 2 different shades was counted as two structures). The data does not differentiate between houses, commercial buildings and out-buildings like garages and sheds.

Shoreline designations[10] and Zoning[11] were used to provide potential context regarding the type of land use.

Table 11. Number of buildings at each exposure risk[12].

	High	**Medium**	**Low**	**Total**
Total # of buildings by each exposure risk	1190	260	1090	2540
Total # of buildings within Shoreline Jurisdiction	1070	230	905	2205
Total # of buildings outside of Shoreline Jurisdiction	120	30	185	335
Buildings within Shoreline Jurisdiction by Shoreline Environmental Designations (SED)				
Shoreline Residential	360	105	560	1025
Rural Conservancy	590	80	260	930
Urban Conservancy	75	25	55	155
High Intensity	25	10	25	60
Tribal	6	2	2	10
Natural	15	5	5	25
Buildings outside of Shoreline Jurisdiction by Zoning District				
Rural Residential	90	15	85	190

[10] https://www.kitsap.gov/dcd/Pages/Shoreline_Master_Program.aspx
[11] https://www.kitsap.gov/dcd/Pages/Kitsap-County-Zoning.aspx
[12] For rows with total counts over 10, numbers are rounded to nearest 5 to account for potential errors in building footprint data.

	High	Medium	Low	Total
Urban Low Residential	10	0	30	40
Commercial	5	5	25	35
Neighborhood Commercial		10	15	25
Rural Protection	5		5	10
Regional Center	1		8	9
Rural Commercial	9			9
Tribal Land	3		4	7
Low Intensity Commercial		1	5	6
Park	1		2	3
Manchester Village Low Residential	1			1
Manchester Village Residential			1	1
Rural Historic Town Waterfront			1	1
Urban Medium Residential		1		1
Urban Restricted			1	1
Urban Village Center		1		1

Out of the 123,673 buildings in the County's Building Outlines GIS data layer, 2,540 are in a high, medium, or low exposure risk area, which is 2.1%.

Unsurprisingly, 87% of the potentially impacted buildings are within a shoreline designation where land use development is regulated by the Shoreline Master Program (n=2,200). The remaining 13% (n=335) fall within zoning designations under the Comprehensive Plan.

Potentially impacted buildings are located primarily within residential and conservancy land use types (83%, n=2110). High Intensity and commercial zoning accounts for approximately 5% of the buildings with an exposure risk (n=135) and 1% are Tribal (n=17).

Areas with a high concentration of high-risk buildings include Hansville, Apple Tree Point, Fragaria, Southworth, Manchester, end of Miami Beach Rd., Skunk Bay, and around Coon Bay.

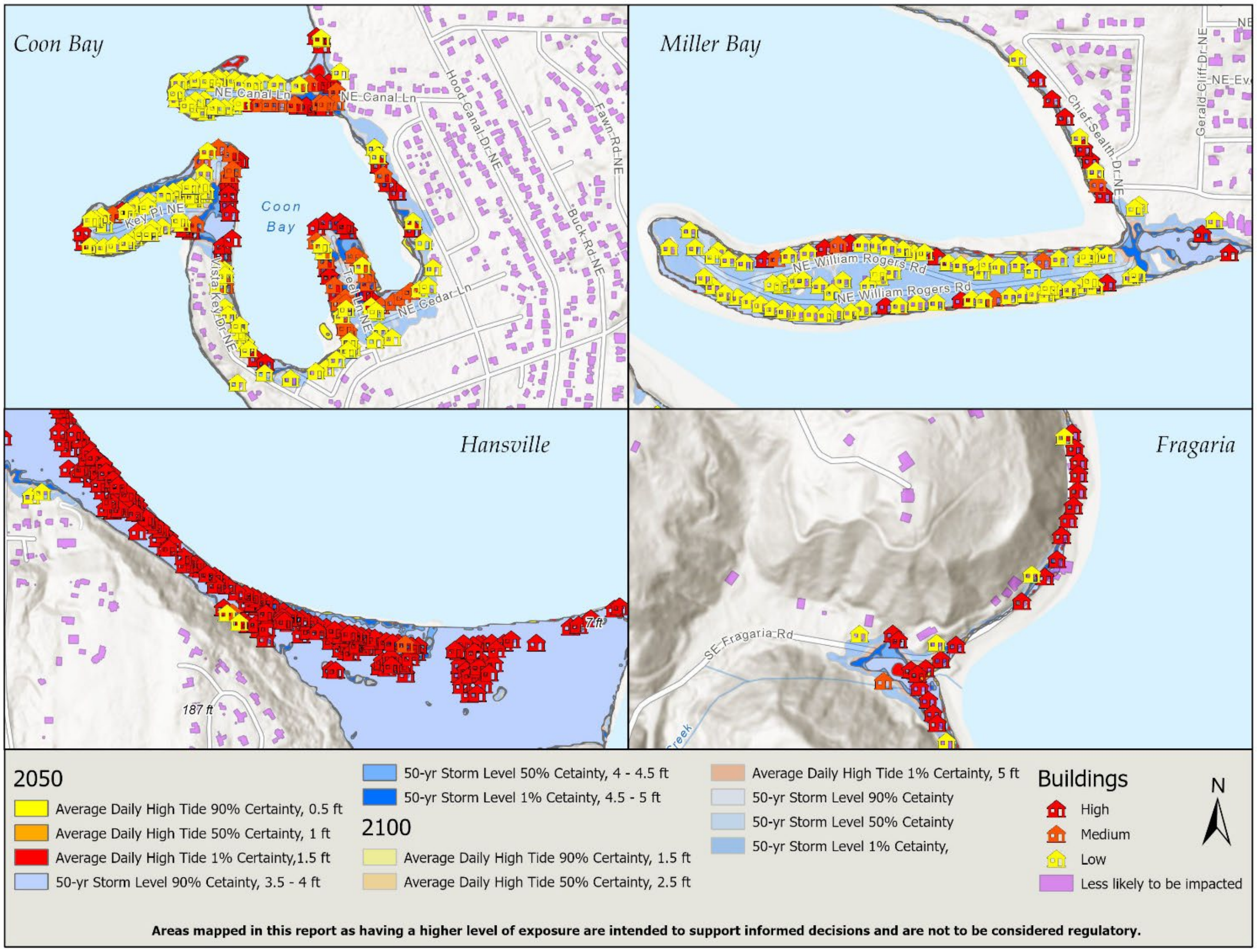

Figure 16. Buildings with exposed risk near Fragaria, Hansville, Miller Bay and Coon Bay.

It is important to note that rankings of exposure likelihood are for the purpose of quantifying the potential impact on this asset type for this report only. A different choice of SLR scenarios or other strengths of floods would change building classifications. Therefore, this assessment cannot be used for valuation or regulatory purposes.

When ranking buildings for adaptive capacity, shore armor was not considered due to the ineffectiveness of shore armor in preventing flooding, unless an entire shoreline is armored to prevent sea water from coming around ends of walls and flooding properties (Cameron and Le Maitre, 2022). Additional factors that influence the adaptive capacity of structures include lot size (e.g., whether the structure can be relocated further inland), construction features such as multiple chimneys (which may limit the feasibility of elevation), and occupancy status (primary residence vs. secondary home).

Structures that are not primary residences may be considered to have higher adaptive capacity, as impacts from flooding would not result in residents being displaced from their only home.

In 2023, Washington Sea Grant and Coastal Geologic Services published a report and data set that assessed and ranked the vulnerability of shoreline parcels in Puget Sound (Miller, Maverick, Johannessen, Fleming, & Regan, 2023). The Sea Grant assessment was limited to parcels within 200 feet of the shoreline. The County's assessment included building footprints within any of the exposure risk areas, which occasionally extend inland further than 200 feet. The Sea Grant assessment used similar SLR projections, but a 20-year return frequency extreme flood level as opposed to the 50-year return storm use for this report, and did not look at the 90% certainty probability like the TAC chose to use as assessment parameters. However, because the Sea Grant assessment framework included assessing erosion as a risk factor, parcels that are at a high elevation but within 200 feet of the shoreline were included in the Sea Grant assessment that are not included in the County's because the higher altitude would have prevented them from being included in an area considered at risk of coastal flooding. The Sea Grant study also included a social vulnerability adjustment to the final score for a parcel. The results are worth considering as a supplement to the results of the County's assessment.

The Sea Grant study calculated a score for each parcel up to 20. The highest scoring parcels in this report's study area agree with the results from this study. The most at-risk properties are in Hansville, Appletree Cove and Southworth with several parcels scoring 16 or above.

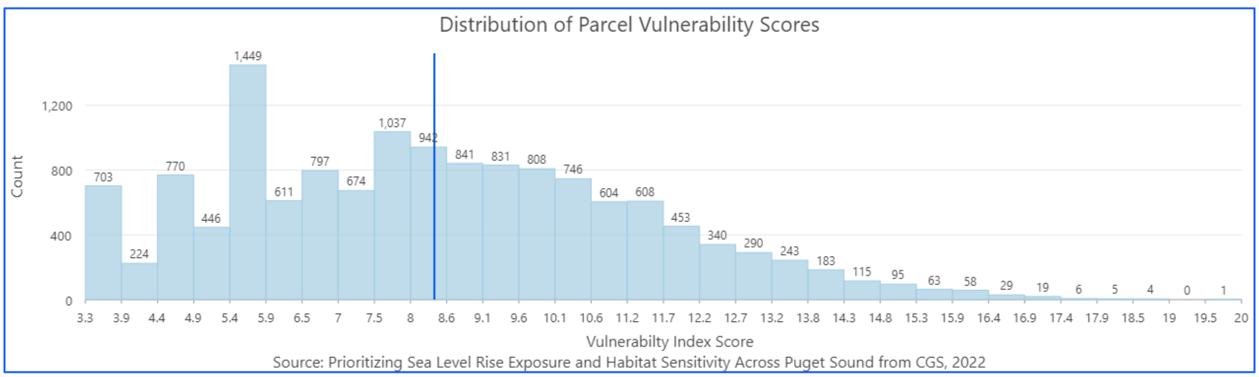

Figure 17. Distribution of Vulnerability Scores

4.4.3 Historic Structures

To evaluate the impacts on historic structures, data from the National Registry of Historic Properties (NRHP) and the Department of Archaeology and Historic Preservation (DAHP) were reviewed and compiled. The DAHP WISAARD[13] tool was utilized to sort and export properties that were inventoried and determined to be eligible, as well as those already registered public properties. Of the exported data from the WISAARD tool, 379 properties were deemed eligible and 54 were on the public registry. 24 properties were also reviewed from the NRHP list. After the data was compiled, properties that were located within city limits or federal properties were removed, as well as duplicate properties from the

[13] https://wisaard.dahp.wa.gov/Map

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different sources. As a result, 112 sites were mapped, three (3) sites were located in a high exposure risk area and one (1) were in the low category. No properties were in the medium exposure risk area. Additionally, the wind-driven wave runup modeling found that the Port Gamble Historic District was at risk of inundation. This may also impact the Port Gamble seawall that is included on DAHP's list.

Table 12. Historic Structures listed by exposure risk.

High	Medium	Low
Doe-Kag-Wats, Indianola *(Estuary -Suquamish Tribal Reservation)*		Norwegian Point Park Boathouse, Hansville *(Historic Structure)*
Point No Point Light Station *(Historic Structure)*		
Old-Man-House Site, Suquamish *(Cultural Site/Structure - Suquamish Tribe)*		

4.4.4 Electrical Facilities

Transmission line data from CBI (2025) was used to identify electrical substations and switch stations, which were cross referenced in the County's 1998 Comprehensive Plan Utility Appendix and verified using aerial imagery. Eighteen (18) electrical substations and two (2) electrical switch stations are located within the project area, and none are in areas mapped as having an inundation likelihood under the chosen scenarios.

4.5 Water Infrastructure

4.5.1 Drinking Water

The Washington Department of Health (DOH) has data on Group A and Group B water systems. Data for individual private wells is unavailable. As a result, this assessment is limited to the Group A and B systems. Group A water systems are defined under WAC 246-290-020 as systems that regularly serve 15 or more service connections or 25 or more people per day for at least 60 days out of the year. Group B are public water systems that serve fewer than 15 connections and fewer than 25 people per day,

According to the DOH Source Water Assessment Program (SWAP) database[14], there are 831 active Group systems in unincorporated Kitsap County and 11 are located within an inundation scenario. One (1) additional site was located by Kitsap PUD though it wasn't included in the SWAP database, where not all wellhead protection areas have associated drinking water system points associated, which is the

[14] SWAP Application

data used here. As a result, there may be some group systems missing in this assessment. Six (6) are within the high exposure likelihood area and five (5) are in the low area. All but one of these systems are Group B systems and have less than ten (10) connections each. There is one (1) Group A system, but it only has 2 connections. There are four wells that are shallower than 100 feet deep. Well sensitivity is increased when it is shallower because of the risk of salt water that is washed up with a flood or spray and is infiltrated through the soil to the aquifer. The sensitivity of wells also depends on whether they are constructed to recent standards, how they are constructed/cased, and if the seals are maintained. These factors cannot be determined from a mapping exercise and individual contact with the systems managers would be an appropriate next step to make them aware of potential exposure hazards.

The adaptive capacity of wells is generally low because of the significant cost for replacement and due to the fact, that once contaminated, repair can be costly and difficult. Interruption of operations has a significant impact on end users.

Table 13. Group B (except when noted otherwise) Wells listed by exposure risk.

	Water System	Number of Connections	Well Depth (ft)
High	EVANGER	3	197
	MISERY POINT HOA	7	116
	PRESIDENT POINT	4	40
	REDMAN	4	254
	RICHARDSON WATER	3	67
	SCANDIA COURT	5	70
Low	CONIFER CREST WATER	4	128
	KRISTENSEN	2	117
	OLALLA BAY MARKET (Group A)	2	51
	SLOMAN	3	245
	Kitsap PUD Keyport Well #1		>500

4.5.2 Stormwater

The County has geospatial data available for:

- Surface stormwater conveyance and outfalls
- Storm basins and rain gardens (from the Kitsap Conservation District)

Surface stormwater basins and conveyance systems functions cannot infiltrate stormwater runoff if they are inundated by coastal flooding. If they are located near enough to the shoreline, they may be impacted by increasing groundwater levels as a result of marine waters moving further inland due to SLR. However, the impact of SLR on groundwater is dependent on the subsurface geology of each site. A hydrogeologic assessment would be required to determine the potential groundwater impacts.

Stormwater conveyances that depend on gravity are susceptible to impacts from SLR as slope angles between the source and the outlet are reduced as SLR increases tidal heights. The reduced slope angle reduces the gravitational pull, and the system may back up (Pacific County DCD, 2025). Increases in rainfall over shorter amounts of time, as projected in the Kitsap County Climate Change Resiliency Assessment (2020) and in HDR (2019) will further challenge infrastructure that may have been appropriately sized for the stormwater hydrograph at the time of installation but that may be undersized in the future. Fortunately, a relatively small proportion of the 1,539 documented storm basins or 912 raingardens are likely to be impacted by SLR or coastal flooding. Only 1% of the storm basins and 11% of raingardens are in areas of any exposure risk. The rain garden data is documented by parcel. If any part of the parcel intersected a high exposure risk polygon during the GIS analysis, the raingarden within the parcel was classified as high exposure risk even though it might be located in an upland part of the parcel. The overall result is that the number of potentially impacted raingardens may be overestimated, though the exact extent remains unclear. Potentially impacted raingardens and storm basins are distributed throughout the shoreline extent with no obvious concentration in any one location.

The assessment of outfalls resulted in classifying 8% of the 2,342 mapped outfalls as being at high risk for exposure risk. Medium risk accounts for 0.7% and low risk is 3%.

The Task 700 Climate Change Assessment (2019), prepared by HDR, analyzed impacts of projected sea level rise and assessed precipitation models on the County stormwater system. Elevation data for 556 outfalls was measured, then overlayed with both RCP 4.5 and RCP 8.5 SLR scenarios for 2030, 2050, and 2100 with 90% probability of exceedance to obtain the number of outfalls potentially impacted by each scenario. Outfalls already lower than the current MHHW tidal surface (11-12 ft NAVD88) are excluded from the results. One of the projection scenarios used in the HDR assessment – the RCP 8.5 for 2050 with 90% certainty – parallels one of the scenarios used in this Vulnerability Assessment to determine a High exposure likelihood. Those results are shared from HDR's report below in Table 14. Figure 18 is one of the maps included in the full HDR report and is the scenario that most closely matches the scenarios used for this Vulnerability Assessment. The HDR report did not include quantification of outlets with elevations higher than 1.37 feet as extreme storms and corresponding storm surge height was not included.

There are concentrations of outfalls with a high exposure likelihood in Hansville, East of Port Orchard, Southworth and southwest of Silverdale.

Adaptive capacity of outfalls is impacted by the construction of the infrastructure. If the outfall pipe is under buildings, replacement and retrofitting is much more difficult and costly. Flooding as a result of blocked outfall outlets is often temporary in nature and resolves with low tide cycles. Impacts of operational interruptions can usually be mitigated to some extent. Stormwater flooding can be managed with storage, conveyance and pumping though this can be associated with a cost barrier.

Table 14. Outfalls impacted by the RCP 8.5 SLR Scenario with 90% probability of exceedance (Source: HDR, 2019).

Year	Outfalls	Projected SLR (feet)
2030	125	0.22
2050	130	0.48
2100	155	1.37

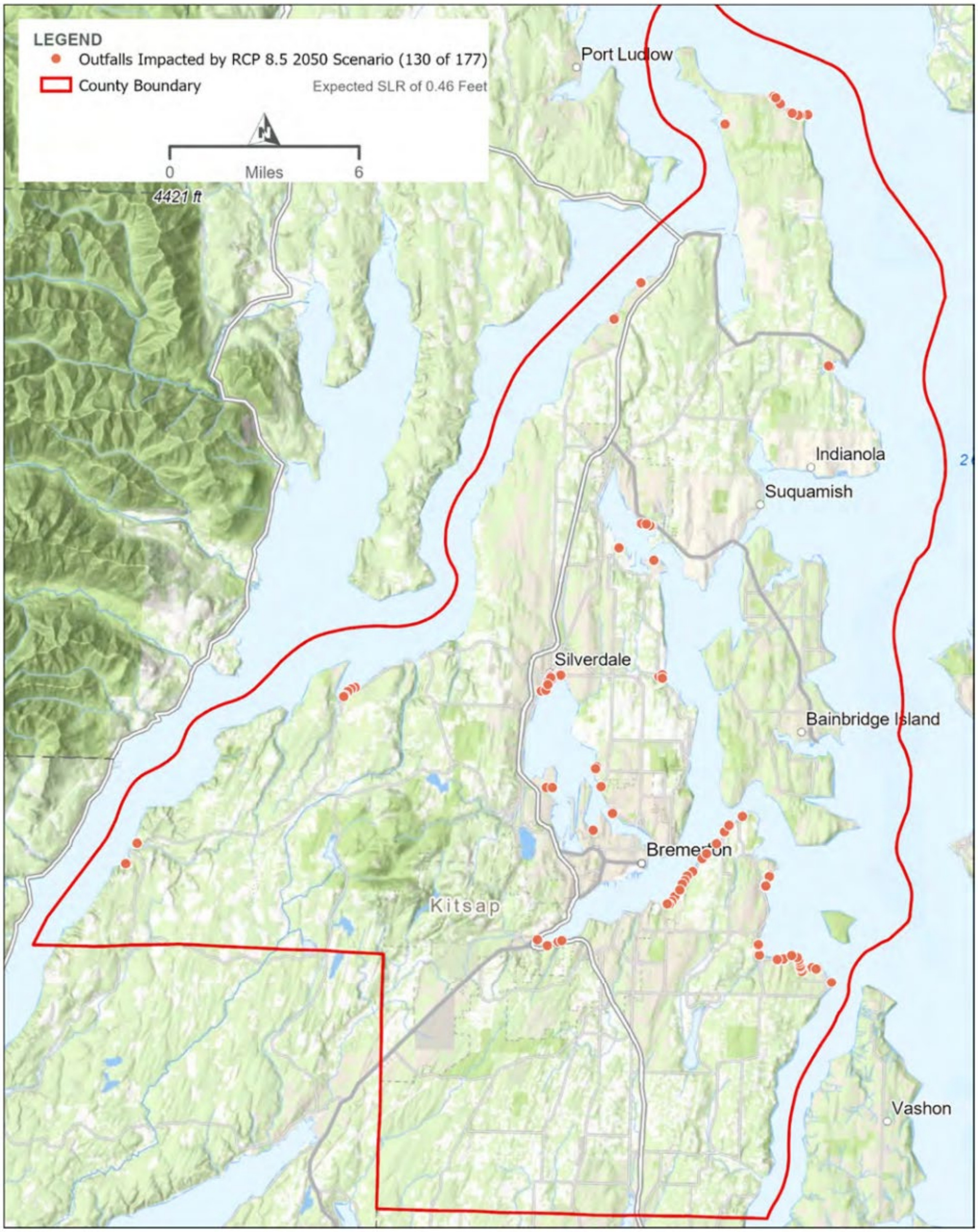

Figure 18. Locations of outfalls impacted by the RCP 8.5 SLR Scenario by 2050 in Kitsap County (*Source: HDR, 2019*).

Table 15. Stormwater assets listed by exposure risk.

	High	Medium	Low	Total
Storm Basins	11	1	5	17
Raingardens	86	2	9	97
Outfalls[15]	130	25		155

4.5.3 Wastewater

Sewer

The County has data for:

- Sewer facilities (treatment facilities, wet wells, and meters)
- Sewer cleanouts
- Sewer gravity mains and force mains
- Sewer service areas

Most wastewater infrastructure is subsurface and constructed to be watertight. Above ground components, such as treatment facilities and cleanouts, can be susceptible to flood inundation. Any part of the infrastructure can be damaged if located in an area close enough to the nearshore where erosion could happen.

Sewer gravity mains and force mains were considered to have a medium adaptive capacity since they are watertight, subsurface structures. However, these facilities may experience increased exposure if they are within an area where erosion may cause damage to the infrastructure.

Seven (7) wet wells and one (1) sewer clean out are in an area with an exposure risk. Wet wells are underground tanks that store wastewater until it is pumped to a treatment facility. If wet wells remain watertight and are not located in an area at risk for erosion, then their adaptive capacity should be high. However, if they are not sealed, and salt water can infiltrate the well displacing wastewater or preventing collection of wastewaters, then operational interruptions could be significant. Cleanouts are at risk if the lids elevations are insufficient. The one (1) clean out listed as potentially exposed does not have a lid elevation listed in the data. However, it is in an area where SLR would have to be +8 - +9 feet above MHHW for saltwater to reach it.

No wastewater treatment facilities are in an area with a likelihood of inundation.

[15] As calculated by HDR, 2019.

Table 16. Sewer assets listed by exposure risk.

Type of Sewer Component	High	Medium	Low	Total
Sewer Cleanouts	0	0	1	1
Sewer Wet Wells	6	1	0	7
Gravity Mains[1] (Feet)	9,750 (1.75 miles)	2,350 (0.5 miles)	11,900 (2.25 miles)	4.5 miles
Force Mains[1] (Feet)	22,775 (4.25 miles)	6,642 (1.25 miles)	11,375 (2.25 miles)	7.75 miles

[1]*Rounded to nearest 25 feet and 0.25 miles.*

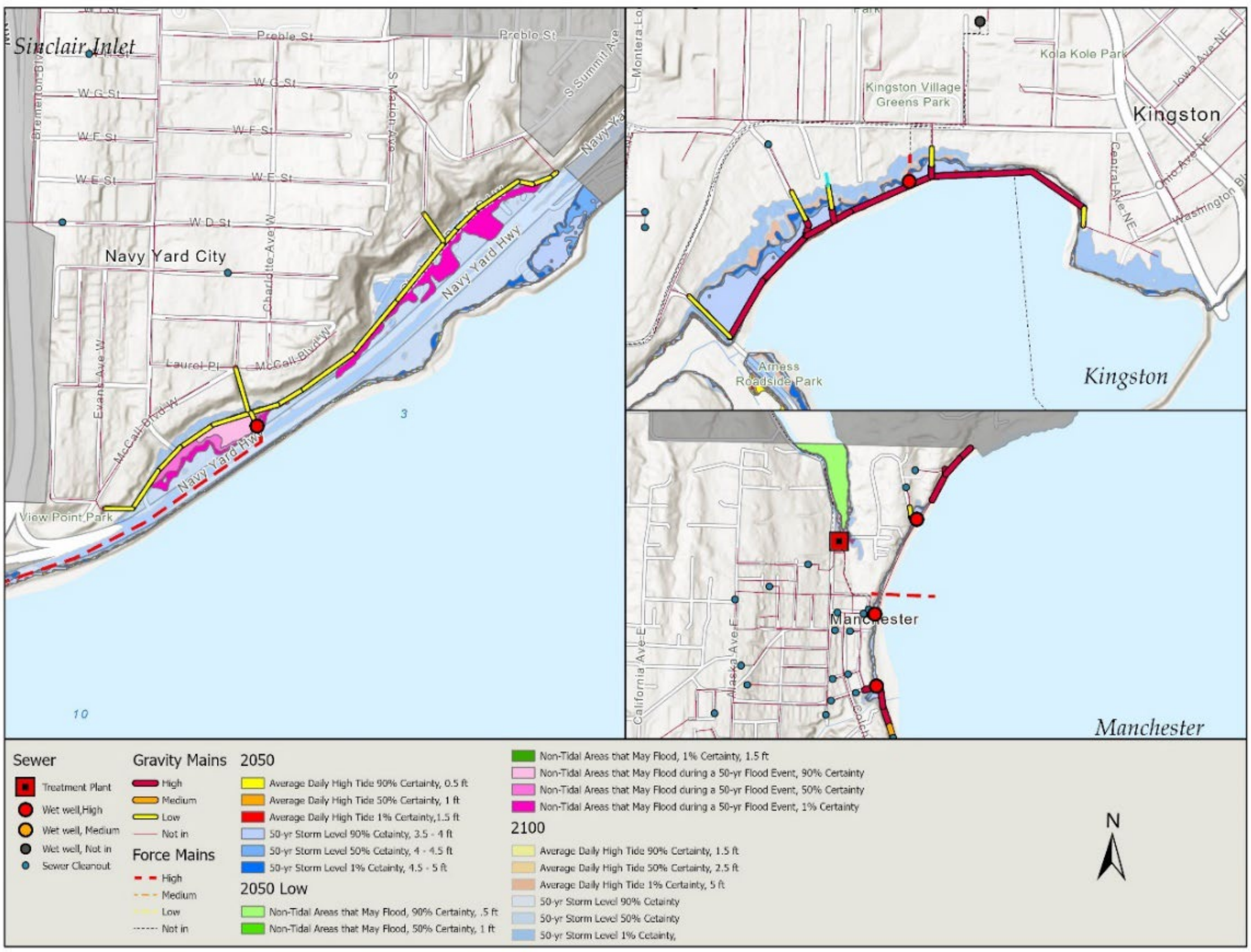

Figure 19. Maps that shows some areas of higher concentrations of potentially impacted wastewater components.

Areas where there are high concentrations of sewer mains and wet wells that may be impacted by inundation include Manchester, Sinclair inlet along Hwy 3, Suquamish, Kingston, and Silverdale. The length of sewer mains that may be impacted may be an overestimation if the mapping precision of that data set is off slightly. The precise location relative to the shoreline and the potential for erosion that may be exposed, and damage sewer mains should be verified (Figure 19).

The area around Silverdale Waterfront Park has the only sewer cleanout located within an exposure risk area, beside the Yacht Club Broiler restaurant. There is a concentration of stormwater and sewer water infrastructure in this area that may be at risk of flooding by SLR and extreme storms (Figure 20).

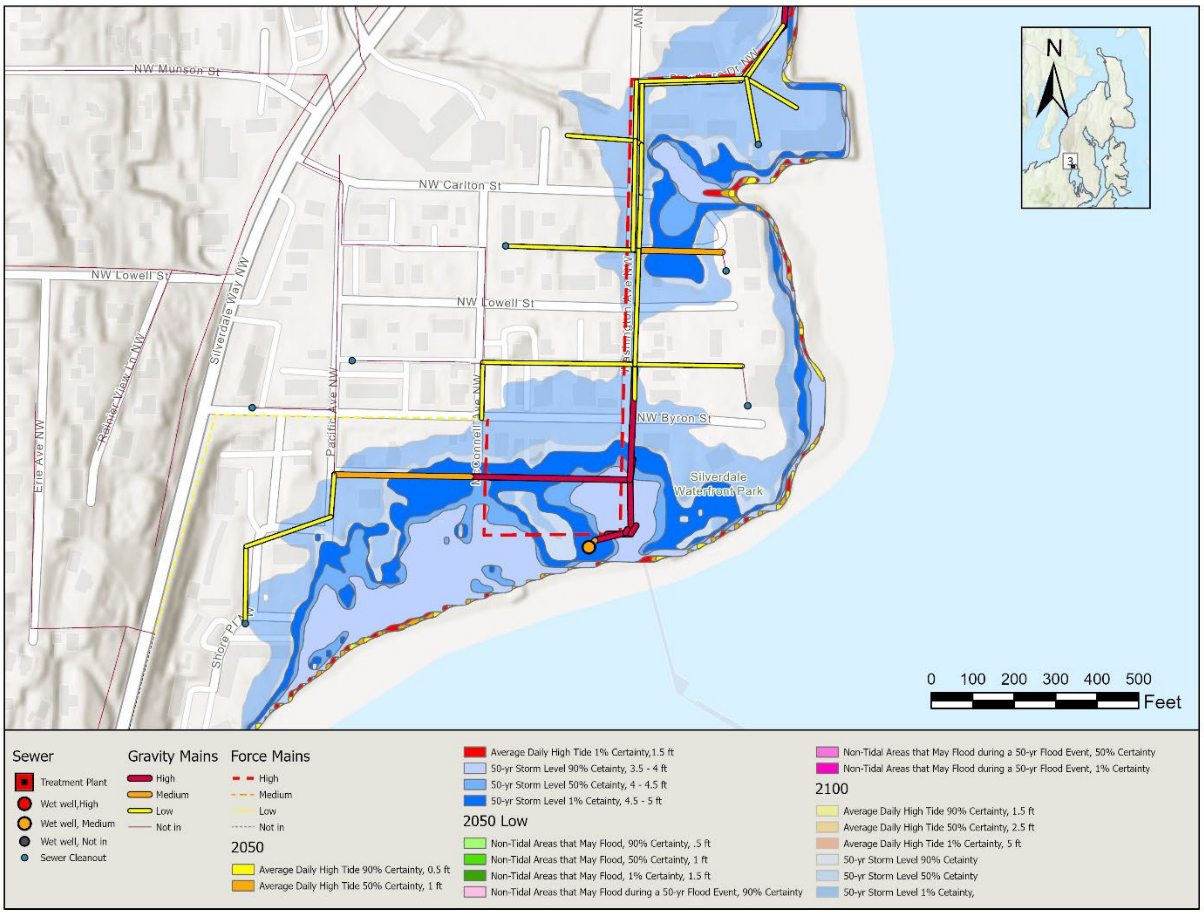

Figure 20. Map of Sewer and Stormwater Infrastructure near Silverdale Waterfront Park

On-Site Septic Systems

Developed parcels not within the service area are considered to use on-site septic systems. On-site septic systems are likely to experience increased vulnerability to sea level rise, particularly in coastal and low-lying areas where rising groundwater levels or saltwater intrusion can significantly impair their function. If septic drainfields are inundated, impacts to on-site septic systems may temporarily disrupt operations until flood waters recede, and soils drain. Inundation during coastal flooding can overwhelm systems, causing backups or overflows. Permanent inundation would cause adaptation strategies to be implemented to maintain functionality, such as raised systems, alternative treatment technologies, or connection to existing sewer infrastructure, where possible. However, these adaptation measures may incur significant costs and could cause public health risks if operational functions of the system are impacted for extended periods. Systems that have above ground components and drainfields outside of areas of inundation are likely to be at a reduced risk of vulnerability. However, the location and type of individual on-site septic systems are considered a gap in the available data, thus, the susceptibility to impacts has been generalized to a higher vulnerability for the purposes of this assessment.

4.6 Environmental

4.6.1 Wetlands

The National Wetlands Inventory GIS data[16] was used to assess acres of wetlands that may be impacted. While the County maintains a data layer, there were no attributes as to the type of each wetland. The "Estuarine and Marine Deepwater" and "Lake" types were not removed from this assessment. A nuance of the GIS analysis for this attribute was that the acres of wetland impacted by exposure risk level were calculated differently than other elements. The amount and location of wetlands impacted by saltwater inundation during the extreme flood scenarios was not modeled as these events result in only temporary and infrequent impacts. Ecosystems need to be exposed to more prolonged periods of salt inundation before converting from fresh to saltwater species dominant. The increased water velocities and wave energies associated with extreme flood events are expected to be the ecosystem change drivers in these situations. For the purposes of this assessment, if any area of the wetland intersected with a mapped polygon considered to be at high risk of coastal flooding, the entire wetland was classified as high and may extend past the boundaries of the high-risk polygon. As such, this may result in an overestimation of wetland acreage at risk of coastal flooding.

Table 17. Acres of wetlands, by wetland type, exposed to a risk of coastal flooding.

Type of Wetland	High (acres)	Medium (acres)	**Low (acres)**	Total (acres)
Estuarine and Marine Wetland	4366	1		4368
Freshwater Forested/Shrub Wetland	163		49	212
Freshwater Emergent Wetland	60	3	17	80
Freshwater Pond	38		1	38
Grand Total	**4627**	**4**	**67**	**4698**

The 163 acres of Freshwater Forested/Shrub and 60 acres of Freshwater Emergent wetlands are considered to be at high risk of frequent coastal exposure. These wetlands are predominately on the

[16] https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/

edges and inland tips of several embayment and lagoons. These areas include wetlands adjacent to Anderson Creek, Stavis Creek, Hansville, Foulweather Bluff Lagoon, Apple Tree Point, Doe-Keg-Wats, Olalla Creek, and Wilson Creek.

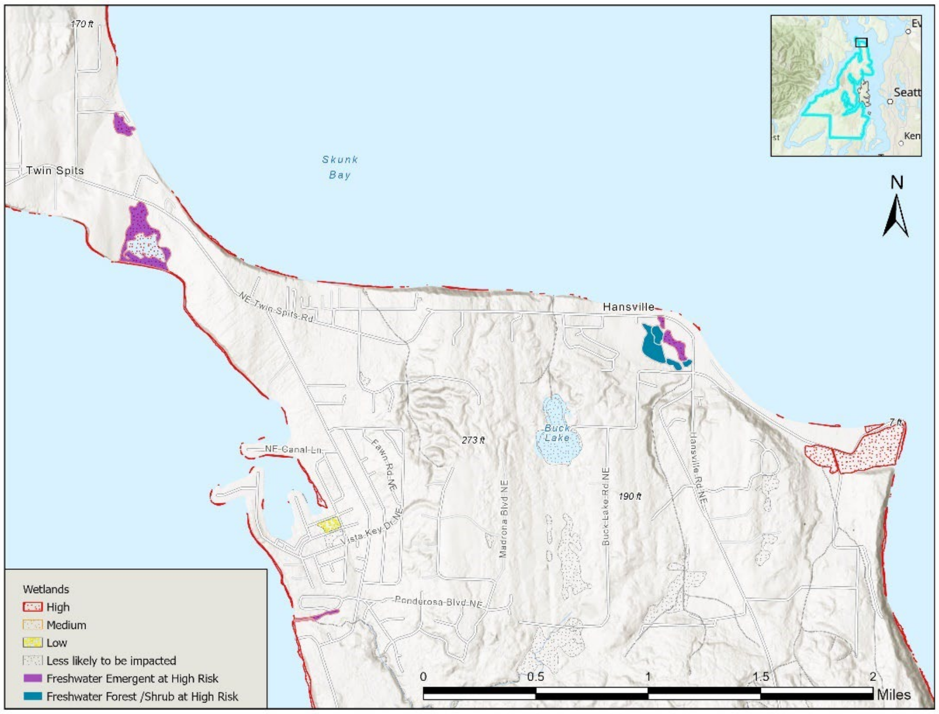

Figure 21. Wetlands in Hansville at risk of coastal flooding.

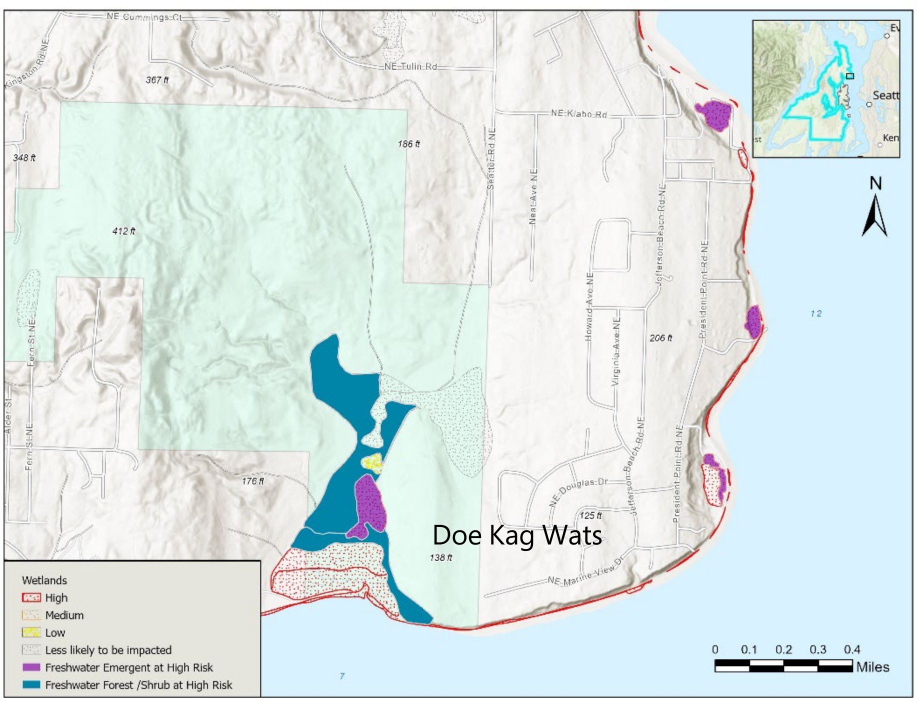

Figure 22. Wetlands at risk of coastal flooding in Doe Kag Wats estuary.

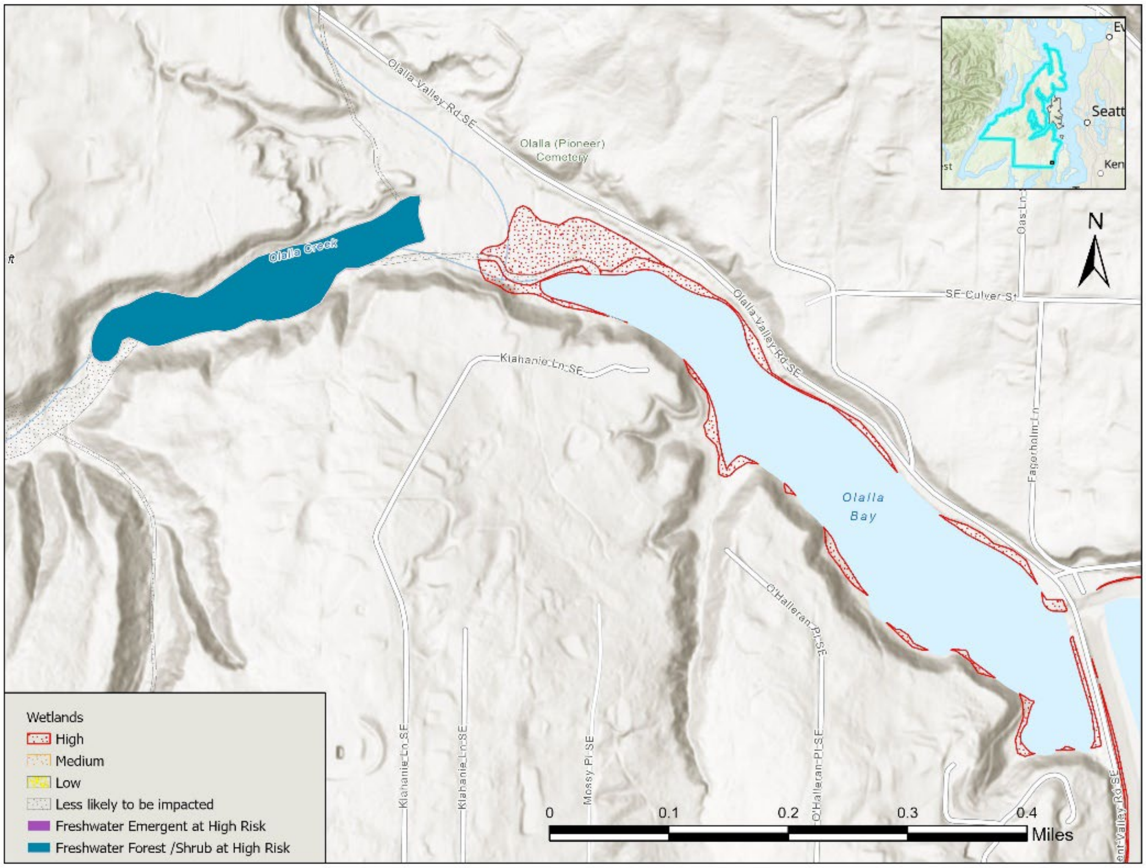

Figure 23. Wetlands at risk of coastal flooding in Olalla

4.6.2 Beaches

Beaches provide many important environments for many ecological functions. For example, juvenile salmonid use the beach and shallow intertidal areas for migration and foraging. Benthic invertebrates produced in beach and intertidal areas are critical to the marine food web, including juvenile salmonids. Forage fish use the intertidal beach substrate for spawning. Submerged marine vegetation, like eelgrass (*Zostera spp.*) is also dependent on specific beaches and intertidal environments. These examples are dependent on the depth of the water in these areas, as well as the correct wave energy to support the grain size and sorting of beach material to adhere roots and eggs to. Beaches can adapt by moving inland provided there is space to do so, like wetlands, as described above. However, on beaches with hard structures or vertical restrictions, beach material cannot be pushed inland. Instead, the water becomes deeper, and wave energy more intensely, washing away sand and gravel. Salmon have no refuge or benthic prey, forage fish have no substrate to spawn in, and eelgrass can't root. This condition is called "coastal squeeze."

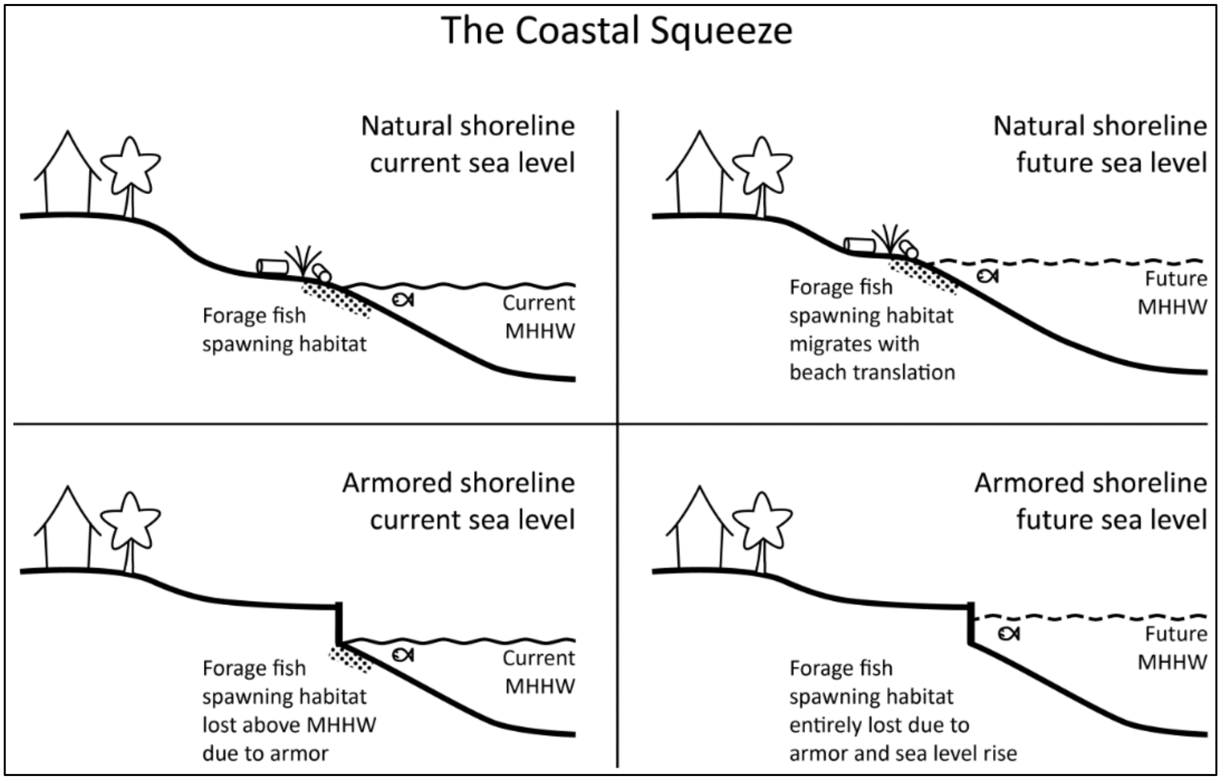

Figure 24. Coastal Squeeze *(Source: Coastal Geologic Services as published in https://www.eopugetsound.org/ magazine/armoring-sanjuans*).

Determining the extent of the coastal squeeze was not part of the initial scope of this project but would be worth doing in the future. While there is some data documenting where forage fish spawning has occurred, it does not capture where possible spawning could occur. To assess potential impacts to forage fish spawning areas, data on locations of appropriate substrate would need to be mapped and assessed alongside current beach armor data. Eelgrass migration potential would require bathymetric data and analysis that is beyond the scope of his project.

Through the outreach efforts, the community has indicated that beach access is also of importance. Beach access is often associated with road ends and parks, both of which are assessed in other dedicated sections this report. Boat ramps are included in the Marina data in Section 4.6.3.

4.6.3 Marinas and Boat Docks

Kitsap County lists thirty (30) marinas outside of incorporated and federal areas in their GIS data. The exposure risk for marinas at low, medium, or high risk are classified in Table 18 below. Boat dock usage during extreme storms is likely very low so the higher inundation values are less likely to have an impact on operations. Increases to high tide elevations on boat ramps may cause the ramp to become shorter but the ramp will most likely remain usable. Marina docks and boating infrastructure are usually constructed to be responsive to increases in tidal heights so not expected to be greatly impacted. Hardened infrastructure that may be associated with marinas, such as pipes or pilings, were not included in the data so were not assessed. This boat ramp data set does not include all end-of-road or private ramp access, so it likely underestimates the number of potentially impacted areas.

Table 18. Marinas and Boat Docks listed by exposure likelihood.

	Exposure Risk		
Name of Bay or Marina	High	Medium	Low
	Port of Manchester Boat Ramp, Port Orchard	Chico Boat Ramp, Bremerton	Lawrence Memorial Boat Ramp, Suquamish
	Eglon Boat Ramp, Kingston		
	Manchester Dock, Port Orchard		

4.6.4 Commercial Fisheries and Shellfish Facilities

Increases in SLR and extreme coastal storms may result in a loss of tidal flats and estuarine beaches. A reduction in estuarine beaches and increases in shoreline armoring may result in a loss of spawning grounds for forage fish and negatively impact other intertidal species (Glick, 2007). Inundation of tidal flats would impact on the commercial shellfish industry by reducing the number of suitable sites for aquaculture activities. Increasing rates of SLR are expected to contribute to loss of habitat, especially along developed shorelines where the ability of habitat to migrate inland is limited (Ridge et.al. 2015). As Dungeness crabs and juvenile salmon rely on estuaries as nurseries, changes in habitat composition in estuaries may lead to population reduction. Certain species may be able to adapt to changes in water levels by migrating to different areas with more optimal conditions. However, salinity changes for certain species may impact their overall survival and production rates. Changes in composition of tidal wetlands may reduce the capacity to support salmonids or other anadromous fish**.**

Most aquaculture facilities rely on a variety of shore-side infrastructure to conduct their day-to-day operations. SLR can threaten the function and longevity of this infrastructure through increased flood events which may cause service disruptions, increases in exposure to corrosive saltwater, and accelerated coastal erosion rates. In Kitsap, two (2) of the listed commercial facilities, Valhalla Seafood and Port Madison Community Shellfish Farm, are located within city limits so are outside the scope of this project. Suquamish Seafoods has facilities locate near the shoreline but at an elevation where a +9ft SLR increase will not reach the buildings. However, due to the nearshore location of the buildings, there is some risk should wind-wave runup and storm surges push marine water up the adjacent creek at a higher storm level than was used for this mapping exercise.

The two (2) hatcheries operate on tidally connected streams and may be subject to compound flooding because of high-tide backups. The Gorst Creek hatchery is within city limits, as well as far enough inland to not be near the extent of a +9ft elevation in seawater. The Grover's Creek hatchery does have a medium to low likelihood of being impacted by tidal inundation at a +4 -+9 ft sea level increase (Figure 25). A 50-year return frequency storm, by 2050, will likely reach the property's edge. By 2100, there is a possibility that daily high tides will reach the edge of the property, with a 1% certainty. These higher tidal waters will likely cause compounding flooding impacts in Grover's Creek and hatchery operations may be impacted.

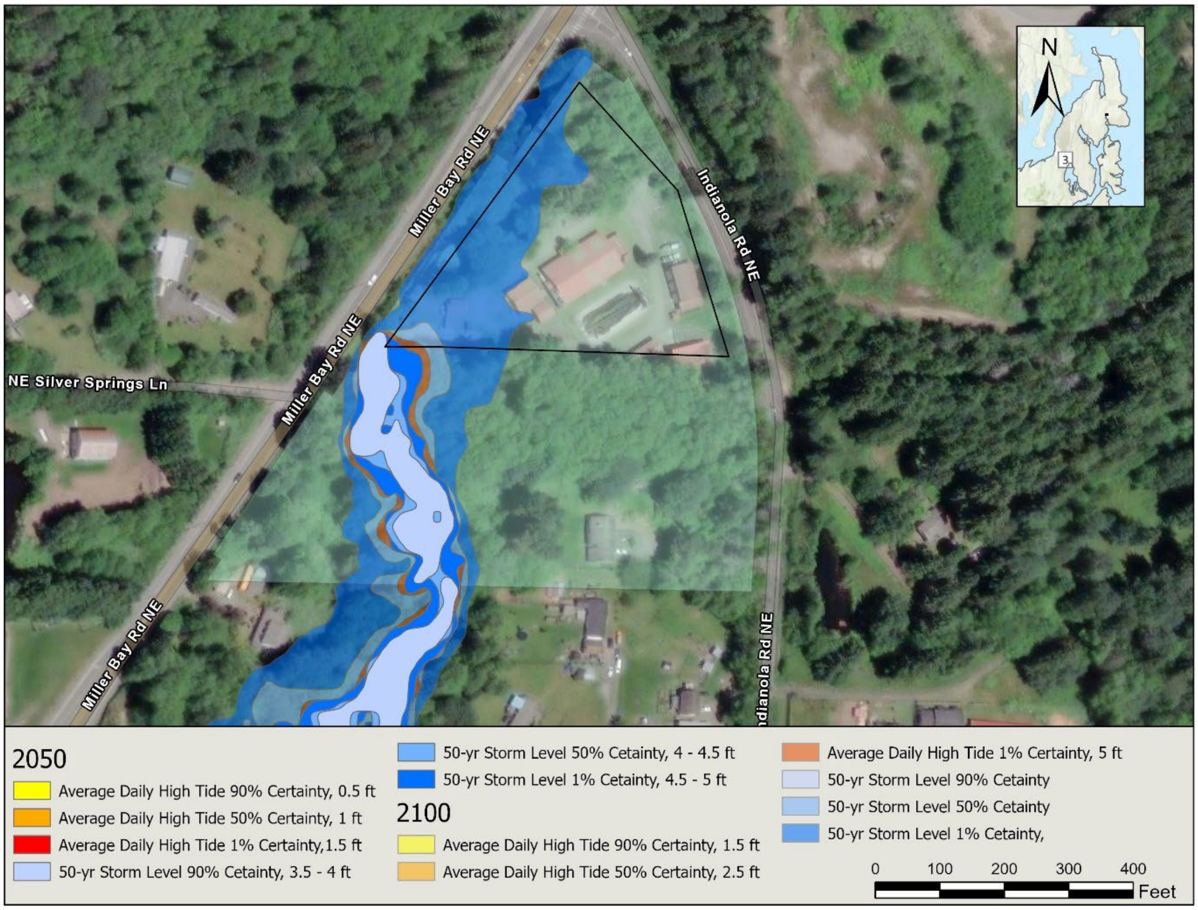

Figure 25. Map of SLR extent near Grovers Creek Hatchery.

4.7 Land Use

4.7.1 Parks

To assess park exposure, the GIS methodology was adapted slightly to provide a more accurate vulnerability ranking. A park was classified as having "high" exposure if more than one-third of its area was located within high or medium exposure criteria, or if the majority of the park was considered at any risk of exposure. A medium exposure risk was assigned if one-third or less of the park overlapped with high or medium exposure criteria, or if any portion of the park located beyond 100 feet from the shoreline was at any risk of exposure. Parks were categorized as having low exposure risk if the only area affected by risk zones was confined to the first 100 feet inland from the shoreline. This revised methodology was implemented to distinguish whether a majority or only a small portion of a park is at risk of exposure. Given that most parks are located along the shoreline and tend to cover large areas, this approach allows for a more accurate assessment of vulnerability by identifying when a significant portion of a park is exposed to risk. Using the County's GIS data, the exposure risk for parks connected to the marine environment that are considered to be at low, medium or high risk are listed in Table 19 below and shown in Figures 26 and 27.

Table 19. Parks listed by exposure likelihood.

	Exposure Risk		
Name of Park	**High**	**Medium**	**Low**
	Silverdale Waterfront	Pat Carey Vista	Kitsap Memorial State Park
	Arness Roadside Park		Scenic Beach State Park
	Anderson Point		Manchester State Park
	Keyport County Park		
	Salsbury Point Park		
	Point No Point Park		

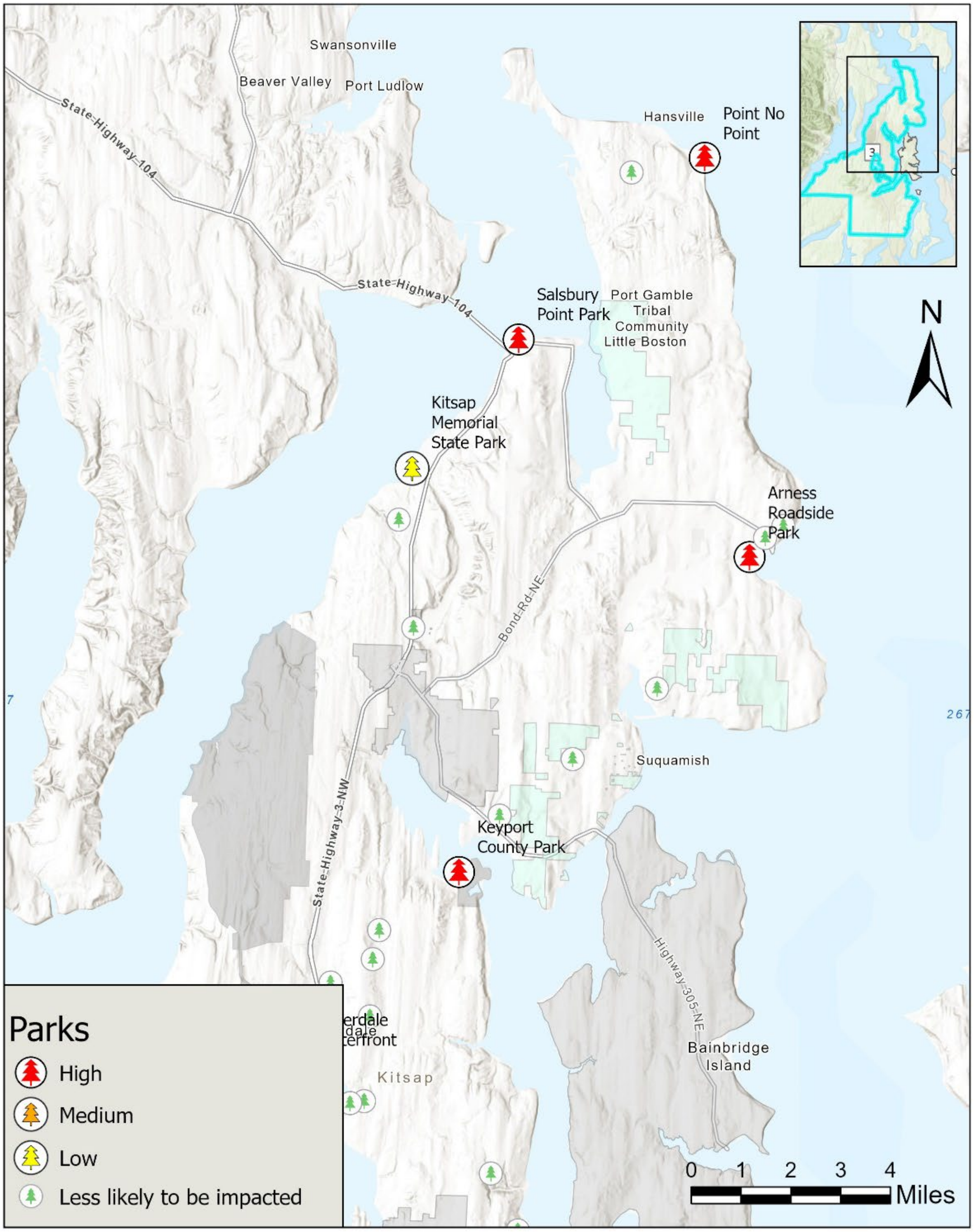

Figure 26. Locations of parks in North Kitsap County with exposure risks

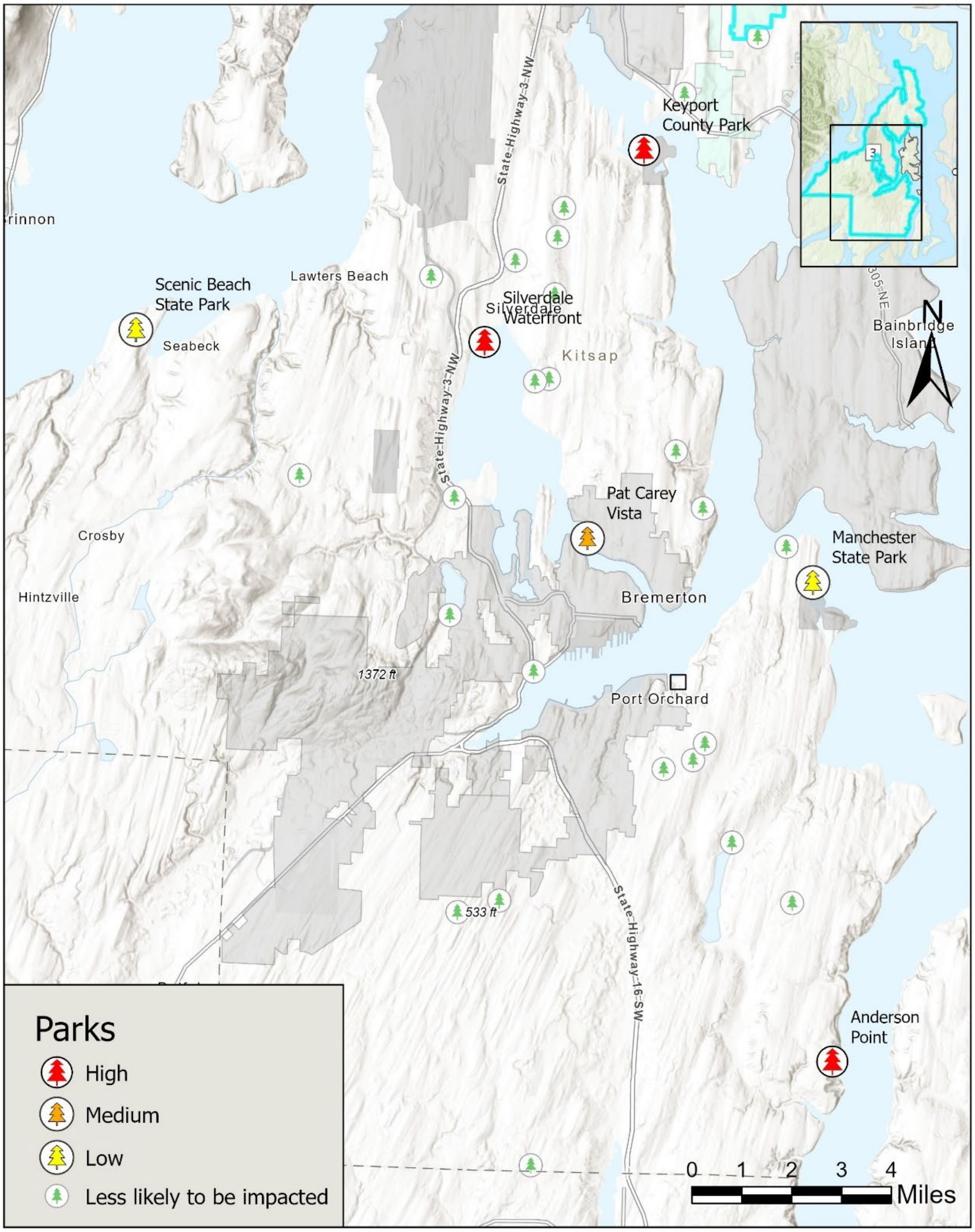

Figure 27. Locations of parks in South Kitsap County with exposure risks

4.7.2 Agricultural/Farmland

Data that identifies agricultural parcels is difficult to find. The County's zoning layer includes "Rural Employment Centers" and "Rural Protection Zoning" designations, but a significant portion of land within these two designations is timber land. According to the Kitsap Conservation District (KCD), the USDA National Agricultural Statistics Service (NASS) mapping data is not useful for Kitsap County because of the anonymization of data that requires smaller and identifiable individual farms to be excluded. The KCD did recently complete a windshield survey, and that data is probably the best source for this as it is an existing layer for the county GIS system and is ground-truthed (D. Fish, personal communication, April 9. 2025). Most of the parcels in this data set that were mapped as having a potential exposure likelihood are forested or have no agricultural land within an inundation area.

However, according to the KCD after reviewing the inundation layers, it appears that the biggest issue is not flooding of farmland but seawater intrusion with the potential to impact irrigation water, which could lead to salinization of farmland.

> *"This takes two forms - into the aquifer (wells) and up streams (surface water rights) adjacent to the farmland areas impacted by sea level rise. Obviously, the intrusion into aquifers has significant implications for drinking water from private wells, but there are a number of farms that have irrigation water rights from wells. Using this water for irrigation risks salinization of the farmland resulting in reduced yields and recycling of this salinized water back to the water table via infiltration. Seawater intrusion also takes place in streams and estuaries adjacent to the shoreline during high tide. Anyone with a surface water right from that stream is also at risk. For example, Petersen Farm, which has a surface right out of Clear Creek, would be impacted by this issue. This is already causing problems for farmers in Richmond and Surrey in the Lower Mainland in British Columbia. They have installed salinity monitoring stations along the Fraser River from the Delta upstream to Fort Langley because even with moderately high tides during low flow months they see seawater intrusion miles further upriver than in past years. They are unable to irrigate during these periods."* (D. Fish, personal communication, April 9. 2025).

Recommendations include monitoring wells for signs of saltwater intrusion. A monitoring plan should be developed ahead of time, so it can be implemented at the earliest signs of saltwater contamination in water sources used by agricultural producers.

4.7.3 Brownfields/Landfills

Ecology's data on Toxics Cleanup includes information on completed, ongoing and awaiting clean up actions for sites, including landfills and brownfield sites. There are 501 total sites listed but only seven (7) sites were found to have an exposure likelihood based on the chosen SLR scenarios (Table 20). There are 20 sites in Kitsap listed as landfills but only the one in Gorst is within a potential inundation area. The one brownfield site listed on Ecology's database for Kitsap County is on Burwell Street in the City of Bremerton and is outside the scope of the project. Details on the types and levels of contaminants are available from Ecology's online Webmap called "What's in My Neighborhood[17]."

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[17] https://apps.ecology.wa.gov/neighborhood/?lat=47.610290&lon=-122.558428&zoom=8&radius=false

Table 20. Toxics Cleanup Sites identified by Ecology.

Exposure	Location	Detail	Status
High	Hansville General Store	Petroleum and solvents	Cleanup Started
	Captain's Landing (Hansville)	Gasoline	Cleanup Started
	Seabeck Marina & Moorage	Petroleum	Cleanup Started
	U.S.C.G. Point No Point Light Station	Diesel, gasoline (both below cleanup levels)	Awaiting Cleanup
Medium	Pioneer Landfill (Gorst)	PAH, metals, Petroleum, Diesel, Inorganic contaminants, Arsenic, Lead, Mercury	Cleanup Started
Low	Port Gamble Bay and Mill Site	Organics, Metals, PCBs, PAHs, Phenolic Compounds, Petroleum, Arsenic	Cleanup Started
	Welding and Supply (Gorst)	Petroleum	Cleanup Started

Rising sea levels could impact water tables and eventually make direct contact with landfills and other sites identified for toxics cleanup. Depending on the protection measures in place and success of cleanup efforts, this could create an immediate public health risk and could release contaminants into the environment.

As described in the Environmental Protection Agency (EPA) *Effects of Coastal Sea Level Rise on US Hazardous Waste* (2023)[18], measures that can be taken to help protect vulnerable hazardous waste facilities from damage due to SLR could include:

[18] https://rcrapublic.epa.gov/rcra-public-web/action/posts/5

- Constructing physical barriers, such as a sand cap, retaining wall, to contain contaminants that are designed or constructed to withstand the projected SLR inundation.
- Placing engineering controls, such as pumps and electrical equipment, which are necessary for properly managing and containing wastes in locations that have a low likelihood of being exposed to SLR or coastal flooding;
- Designing containment, monitoring and treatment systems, and subgrade infrastructure to withstand SLR or coastal flooding events; and
- Designing caps that are resilient or resistant to inundation or accelerated coastal erosion.

SECTION 5

Adaption Strategies

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5. Adaptation Strategies

An assessment of potential adaptation strategies to address impacts from sea level rise and extreme flood events are summarized below. To address some of the adaptation strategies below, suggested revisions to County Codes and Plans have been included in Section 6.0.

CONSIDER REVISING DEVELOPMENT STANDARDS

Require assessments or reports to include sea-level rise projections for potentially impacted properties. When a reduced shoreline setback is requested, the County may consider requiring a report prepared by a qualified consultant that includes sea level rise projections to a minimum of the year 2050 to ensure adequate protection is being proposed. In the event of a subsequent study, the site-specific recommendations could create an additional setback based on the predicted inundation to prevent loss of structures or related residential appurtenances, including ancillary structures, wells, and on-site septic systems, where applicable. Shoreline stabilization systems already require an alternatives analysis and erosional trend analysis. At the direction of the County, this requirement could be incorporated into those code sections as recommended in Section 6.0.

Review development setbacks near geologically hazardous areas. It is recommended to review existing building setback requirements for areas adjacent to coastal bluffs. Development along coastal bluffs are likely to experience a higher risk of exposure from rising sea levels and increased rates of erosion. Geotechnical reports could include accelerated rates of erosion caused by increasing sea levels with consideration of increased storm intensity from a changing climate, as well as a factor of safety distance that is related to the cause of the erosion. The setback is recommended to factor in the design of life expectancy of the proposed development or redevelopment (approximately 75-100 years). Additional or increased building setbacks could be incorporated to increase resiliency in these areas. Section 6.0 includes a recommendation to provide a definition of life of a structure to strengthen regulatory requirements.

Limit redevelopment or expansion of existing legal non-conforming structures in vulnerable locations. Kitsap County could consider developing improved policies and regulations for non-conforming development near coastal areas that are vulnerable to sea level rise or extreme flood events. These regulations could consider limiting proposals for expansion or redevelopment of legal non-conforming structures that may be impacted by sea level rise in the near term. Regulations may require proposals to comply with the standards for new development, including regulations that minimize risk of anticipated sea level rise impacts and/or recorded deed restrictions to notify existing and future property owners of the subject limitations. The County could consider developing new shoreline environment designations during the next periodic update to document vulnerable areas and evaluate regulations within these designated areas.

Require special considerations when permitting critical infrastructure and facilities. It is recommended to incorporate sea level rise projections into the design and permitting of critical infrastructure to improve resiliency. Critical facilities and infrastructure, such as roadways with no alternative routes, bridges, public water and sewer facilities, and hospitals, are encouraged to be designed with measures to ensure their continued function over time. When considering repair or replacement of these facilities, it is recommended to plan for more extreme projections to prevent impacts to function as climate change impacts are observed or a longer design life to ensure these structures are protected. Short- and long-term considerations could be made for the construction of new or replaced public water or sewer supplies in proximity to shorelines and floodplains that may become vulnerable. Examples of adaptation strategies include for new subdivisions adjacent to shorelines, a shared public water supply could be required and may consider locating the well and related infrastructure as far from the shoreline as practicable, if municipal services are not available. Other strategies include off-site relocation for development of structures damaged by sea level rise or reoccurring flood events, and utility consolidation or relocation, where applicable. If municipal sewer services are not available, community drainfields could be required and may consider locating the facilities as far from the shoreline as practicable. Other strategies include advanced or anchored septic systems for properties that cannot meet development standards.

Develop and implement a repetitive loss program. A potential method for improving climate resiliency would be to develop regulations pertaining to prohibiting repairs of a structure continuously impacted by coastal hazards, particularly sea level rise related storm damage. An example of this program could include that for structures that are subject to repetitive loss, steps could be taken to require reduction (e.g., raising the structure) or elimination of the flood hazard from sea level rise or coastal flood events (e.g., relocating the structure). Initial permits to repair a structure following storm damage could be permitted. If the property is damaged a second time within a designated timeframe, conditions or additional development standards could be required to prevent future damage. The County could consider requiring a deed restriction. If the property is damaged a third time, repairs may not be permitted unless adequate documentation is provided that the proposed repairs would eliminate or significantly reduce future hazards.

Consider requiring structures that may be at high risk of exposure to increase floodproof requirements. One of the most effective long-term defenses to reduce the risk of flood damage in areas exposed to sea level rise is to elevate sites and structures above projected flood levels and floodproof any components that remain below the base flood elevation. Elevating structures is a recommended strategy for reducing flood risk in areas vulnerable to sea level rise (SLR), even if they fall outside of FEMA-designated flood zones. FEMA provides several retrofit options to address flood impacts, including raising foundations, repurposing first-floor spaces as garages, and elevating interior floor levels. Further, the Department of Ecology recommends adopting a minimum of two (2) feet above BFE (FEMA Flood Zone AE) as a building standard. The FFRMS is a federal rule and policy, effective September 2024, that states that development using federal funding must meet a new standard in order to protect projects, property, and taxpayer investments from current and future flood risks. The requirement currently applicable in Washington State states that development of non-critical actions or development are required to build the lowest floor two (2) feet above the BFE for development freeboard. Critical actions or facilities, as defined in § 55.2(b)(3)(i), are those activities *for which even a slight chance of flooding would be too great,* because such flooding might result in loss of life, injury to persons, or damage to property. Critical actions are required to build the lowest floor three (3) feet above BFE. Critical actions include police stations, fire stations, roads providing sole egress from flood-prone areas, hospitals, and nursing homes (Ecology 2024).

The County could consider requiring shoreline structures to incorporate two (2) feet of freeboard into designs to increase resilience in alignment with the Federal Flood Risk Management Standards, particularly in vulnerable areas. Additionally, the County could consider requiring the lowest floor of residential properties in the Special Flood Hazard Area or areas at high risk of exposure to be at least two (2) feet above base flood elevation (BFE) or be floodproofed to that extent.

Consider more detailed mapping of Channel Migration Zones. As described by Washington State Department of Ecology in Publication 14-06-028, widening of river channels can occur episodically in response to floods (in Konrad, 2012), as a long-term change due to increases in surface water runoff from upland development, climate change, or removal of riparian vegetation (Legg & Olson, 2014). As flood events are expected to increase in extent and frequency from a changing climate, it is important to plan for development to be located outside of Channel Migration Zones (CMZs). While Kitsap County has an existing planning level CMZ report, the County could benefit identifying areas where channel migration is a concern and applying a detailed CMZ delineation methodology to inform future hazards, integrated flood management, and restoration efforts. Additional recommendations for code amendments pertaining to CMZs are included in Section 6.0.

CLIMATE PLANNING IN HABITAT RESTORATION PROJECTS

Consider the anticipated climate change impacts in the design of habitat restoration efforts. Many restoration project sponsors are proficient at prioritizing projects based on ecological importance and vulnerability to sea level rise. During the planning of habitat restoration projects, it would be beneficial to consider consulting organizations with local experience implementing restoration projects. Examples of efforts that incorporate planning for climate change impacts could include expanding the area of planned restoration to accommodate for habitat migration, restoring a diverse array of habitat types to allow for adaptation during changes in compositions, and addressing upstream stressors that may impact the ability of estuarine habitats to respond to sea-level rise.

EVALUATE IMPACTS TO COMMERCIAL WATER-DEPENDENT INDUSTRIES

Consider further evaluating the anticipated impacts to commercial water-dependent industries. It is recommended to further evaluate the anticipated impacts to tidal mudflats and estuaries to inform resiliency and adaptation efforts around commercial water-dependent industries. This effort could include educating invested parties and investigating funding opportunities to reduce impacts on industries to the extent practicable. In future studies, it is recommended to evaluate the interaction between current groundwater conditions and predicted extreme flood events and sea level rise to predict potential impacts more accurately. The evaluation of this interaction through hydrodynamic modeling can also be used to determine loss of tidal mudflats or impacts to estuarine areas.

EDUCATIONAL OPPORTUNITIES AND INCENTIVES

Consider incentivizing Passive Management Strategies. There are several techniques that could be considered to mitigate impacts from erosion, flood events and sea level rise that involve minimal impacts to coastal habitats. Some of these techniques could include improvements in surface and groundwater management and vegetation management or retention. The improved management of stormwater and groundwater can reduce additional inputs that could exacerbate flood events or natural shoreline conditions. Management or retention of vegetation can help stabilize shorelines, particularly coastal bluffs, which are experiencing erosion. These techniques can often be implemented without a qualified consultant and limited permits. More involved management strategies include structure relocation or elevation to reduce impacts from flooding.

Encourage alternatives to hard shoreline stabilization measures. As extreme flood events become more frequent and sea level rises, requests for shoreline stabilization measures will become more common. However, hard structural armoring is intended to provide protection of erosion impacts caused by current, tides, stream flow, wind, or wave action, and is not intended to mitigate the impacts of coastal flooding. Techniques that can help mitigate impacts but preserve marine habitat could include beach nourishment, soft shore armoring or hybrid measures. Soft shore techniques could include placement of large wood root wads, re-sloping and/or revegetating existing slopes, or a combination of several measures. Nature-based solutions can also provide several related benefits such as improved nearshore habitat or recreation and beach access. However, it is noted that alternatives to hard armoring are not feasible in all instances. Prior to approving new hard armoring or replacement, it is recommended to encourage or require alternatives to be evaluated and implemented, where practicable. It is also critical that provisions be allowed for people to do routine maintenance of soft shore structures as part of their original permit approvals.

Provide support for education opportunities about raising vulnerable structures and identify incentives or funding opportunities, when available. Low lying areas will inevitably have existing structures with finished floor elevations lower than flood elevation. In some cases, these structures will be rebuilt at an adequate buffer from the shoreline and finished floor elevation. In cases where existing structures are desired to remain in place, foundations and finished floor elevations may need to be raised. This is becoming a more common practice and is feasible. The existing structure can be detached from the current foundation, supported by temporary beams, jacked up to adequate height and new foundations installed underneath. Kitsap County could consider distribution of educational materials on the topic partnering with private companies and consider grant assistance programs for those in need of financial support to implement new foundations. If changes in SMA rule making allow, potentially a shoreline permit exemption for projects of this kind, meeting certain low impact criteria could also be considered. Larger community grants could be applied for when community projects are identified, potentially through FEMA funding opportunities such as Flood Mitigation Assistance (FMA) or Building Resilient Infrastructure and Communities (BRIC).

Incentivize community flood control and adaptation strategies. Low lying areas will experience higher and higher flood events more and more often. Each lot will have to address adequate finished floor elevation and structural height, but the ocean does not respect property boundaries and will flood an entire community. Neighborhoods will need to evaluate their overall grade versus flooding elevations and determine if roads and common spaces can be filled to higher grades. The vulnerability of stormwater systems will need to be addressed as well. Buried storm pipes can back up and become conduits for floods to flow inland. Tideflex valves and other systems can be used to ensure that pipes only flow one way. If areas are to remain below flood elevation, community pump infrastructure may be needed to fight flood events. Pump stations can be installed to keep up with flood flows and protect communities from flood events. Community plans could be developed to implement broader mitigation strategies that enhance resilience across a targeted area.

Develop a Flood Buyout Program. Kitsap County could consider developing a Flood Buyout Program that offers voluntary acquisition of homes at risk of flooding that meets certain eligibility criteria. This program would help to reduce future flood damage and associated health and safety risks by purchasing flood-prone properties, removing all structures, and restoring the land to permanent open space. Further, this approach would increase available floodwater storage capacity and provide fish and wildlife habitat opportunities. The County could consider establishing eligibility criteria similar to King County that properties may qualify for the buyout if they are located in flood-prone areas within unincorporated Kitsap County, including properties situated within the delineated floodway or channel migration zone; or are identified as FEMA Repetitive Loss Properties. King County funds this program primarily by the King County Flood Control District with a limited amount of additional funding from FEMA.

INFRASTRUCTURE PLANNING AND IMPROVEMENTS

Prioritize transportation connectivity and resiliency. As outlined in this report, there are several instances where roadways or transportation facilities are likely to be inundated during flood events or with sea level rise projections. To protect public safety, alternative routes of transportation are encouraged to be evaluated or considered for low-lying coastal areas to ensure access to residences for emergency services. Vulnerable roadways that will restrict access to residences or portions of the County are recommended to be prioritized on the Kitsap County Transportation Improvement Plan and be constructed at a height that will be resilient to extreme flood events and sea level rise. For roadways that cannot be reasonably mitigated, relocation or abandonment may need to be considered.

Evaluate existing stormwater infrastructure and conduct maintenance, where needed. An increase in stormwater runoff is anticipated as a result of climate change from increased rainfall. Increased stormwater can exacerbate flood events and normal sea level conditions. It is recommended to evaluate the existing stormwater infrastructure to ensure the system has the capacity to convey additional stormwater runoff. Routine maintenance will ensure the system is functioning and is likely to prevent future complications. The County is encouraged to review the existing stormwater management requirements for residential and commercial development and consider incentivizing low impact development techniques, where possible. Future public infrastructure projects near the shoreline environment should consider sea level rise and extreme flood events when planning for future conveyance.

5.1.1 Recommendations to Address Bluff Erosion

Land use planning for coastal hazards typically includes three categories of mitigation strategies: reduce, retreat, and relocate. Potential planning recommendations to reduce risk from bluff erosion in these three areas are discussed below.

REDUCE:

- Bluff recession is accelerated by increased surface water runoff. As such, *controlling the surface water* is one of the primary ways to reduce the risk of increased bluff recession. Residential properties and roads can improve drainage management to avoid uncontrolled runoff over the slope. Typically, this strategy involves collecting surface water from impervious surfaces into a drainage pipe and tightlining down the face of the bluff to the toe of the slope with a diffuser tee at the terminus to dissipate the water.

- *Incorporating vegetation in upland areas, particularly large trees, can help reduce the risk of bluff recession* through erosion by stabilizing sediments through the tree roots, absorbing water through the root system, and dispersing precipitation across the land as it reaches the tree canopy.

- *Reducing shoreline access on the face of the bluffs* can also decrease recession rates. Shoreline access structures, such as trams or stairways, can increase weight on the bluff face, create holes, and destabilize sediments at anchoring points, and reduce overall vegetation. In addition, these structures require maintenance, which are expected to cause a regular disruption of the bluff. Creating community access points instead of individual access locations can reduce impacts.

- *Shoreline protection structures, such as bulkheads, seawalls, and revetements, can reduce wave erosion at the toe of the bluffs, but will not prevent landslides as the result of upland forces.* In addition, these structures prevent sediment from being deposited on the beach and thus starve the shoreline of sediment at the toe and within the drift cell. This loss of sediment at the bluff toe (also called colluvium) exacerbates erosion rates at the base of the bluff and affects shoreline habitats (i.e., shellfish, eelgrass, and forage fish) (Shipman 2018). As such, these types of structures are not typically recommended for bluffs and provide limited protection against SLR.

- *Nature based solutions, such as beach nourishment and placement of large wood,* can reduce shoreline erosion in some cases, but have limited applications. The toe of a bluff is typically in a dynamic location within a littoral drift cell and the toe of the bluff typically interacts with wind-waves at tidal elevations equal to MHHW and higher. Therefore, placing beach nourishment could provide a short-term solution, but would need to be repeated on a maintenance cycle of perhaps every 4 to 5 years to reduce recession rates. While large wood (not anchored) has proven to be efficacious in low bank beach shorelines, placing large wood at the toe of a bluff has not been particularly effective. This is because the beach at the toe of the bluff is a narrower swath than on beaches and buoyant wood moves under wind-waves and high-water levels.

RETREAT:

- *Proactively planning to move infrastructure and residences landward to increase the setback distance from the bluff crest,* sometimes known as shoreline retreat, can reduce the risk of loss or damage as bluff recession occurs. This approach requires sufficient space in the upland area to move the primary structures and related infrastructure (e.g., utilities). This is the most complex option as it involves abandoning the current land use and completing new land acquisition. However, there are organizations such as Great Peninsula Conservancy who focus on conservation of natural areas and are interested in purchasing properties which will provide long term protection to feeder bluffs.
- For areas that may be impacted in the short-term future, infrastructure could be reduced or abandoned to limit the amount of risk, particularly for infrastructure with life and safety concerns. For example, two-lane roads could be reduced to a one-way road.

SECTION 6

Audit of Kitsap County Codes and Plans

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6. Audit of Kitsap County Codes and Plans

The consultant team conducted an audit of the Kitsap County Comprehensive Plan, Shoreline Master Program (Title 22), Critical Areas Ordinance (Title 19), 2024 Multi-Hazard Mitigation Plan and Stormwater Comprehensive Plan to identify opportunities to amend policies and regulations to mitigate the risk of damage or loss from sea level rise and extreme flood events prior to the conclusion of this project. The following recommendations include many approaches that are policy-based, or best practice, as well as some that may be regulatory. These recommendations are intended to provide a range of options for the County to consider in the near, medium, and long term. The Washington State Department of Ecology is currently working on the state rulemaking process to amend Chapters under the Shoreline Management Act (SMA) to address frequently flooded areas, sea level rise and shoreline permits. As the proposed rulemaking language was not available at the time of this report, these recommended revisions to County Codes and Plans should be considered subject to change as additional information becomes available. Recommendations include, but are not limited to, the following:

SHORELINE MASTER PROGRAM (TITLE 22):

Table 21. Proposed revisions to consider during future updates to Title 22, Shoreline Master Program

SMP Reference	Section	Proposed Revision	Type of Mitigation Strategy
KCC 22.150	Definitions	Recommend including a definition for "Life of a Structure" to provide a specific timeframe that will be evaluated.	Proactive; Establish a timeframe for implementation of regulatory changes.
KCC 22.300.135, Policy SH-40	Restoration and enhancement	Recommend revising the policy to require shoreline ecosystem protection and restoration projects to consider the implications of sea level rise and other climate change impacts, and to encourage early coordination with Department of Emergency Management or emergency response entities to ensure public safety is preserved. Revisions should also consider incorporation of Ecology's newly proposed revisions to WAC 173-25-215 regarding limitations of restoration projects that shift the location of shorelines in urban areas.	Proactive; Incorporate SLR projections into restoration projects to improve resiliency over time and encourage early coordination to avoid unforeseen conflicts with public safety.
KCC 22.300.140, Policy SH-43	Transportation and utilities	Recommend including a new policy to consider the implications of sea-level rise and other climate change impacts in the placement and design of new or expanded transportation routes and essential utility facilities.	Proactive; Incorporate SLR projections into planning of transportation and essential facilities to protect critical services.
KCC 22.300.140,	Transportation and utilities	Recommend including a policy that public stormwater facilities should account for sea level rise, as well as the potential for increased storm frequency and intensity, when planning for future conveyance capacity.	Proactive; Incorporate SLR projections into stormwater facilities to ensure adequate conveyance and limit adaptations in the future.

SMP Reference	Section	Proposed Revision	Type of Mitigation Strategy
KCC 22.300.145, Policy SH-50	Shorelines of statewide significance – Countywide Policies	Consider revising the policy to require projects to consider incremental and cumulative impacts, including potential effects from sea level rise and other climate change impacts, while ensuring no net loss of shoreline ecosystem processes and functions.	Proactive; Consider effects of SLR during cumulative impact analyses of development activities.
KCC 22.300	General Goals and Policies	Include a new overarching policy in the SMP to monitor sea level rise and accordingly adjust development standards and building setbacks to minimize flooding potential.	Reactive; monitor impacts from SLR over time to determine if building setbacks and development standards need to be revised to reduce the risk of damage or loss.
KCC 22.300	General Goals and Policies	Include a new policy that redevelopment activities that increase resilience from sea level rise or extreme flood events, such as raising structures or relocating, should be expedited to the extent feasible. Retreat measures for highly vulnerable structures should be incentivized, where possible.	Reactive; For at risk structures, measures should be taken to incentivize mitigation strategies, including consideration of retreat, to reduce the risk of damage or loss.
KCC 22.300	General Goals and Policies	Include a new policy to limit the expansion of impervious surfaces within the shoreline environment and encourage conversion to pervious surfaces, where possible.	Reactive; Reduction of impervious surfaces within shoreline jurisdiction will increase the opportunities for infiltration, which can reduce the duration of flooding events in at risk areas.
KCC 22.400.100.B	Existing Structures	Consider including a new policy that encourages redevelopment of non-conforming structures to consider resilience strategies to mitigate risks	Reactive; encourage or incentivize existing,

SMP Reference	Section	Proposed Revision	Type of Mitigation Strategy
		associated with a changing climate, including sea level rise and extreme flood events.	lawfully constructed structures to take measures to increase resilience from climate related hazards.
KCC 22.400.105.2.	Proposed Development	Recommend expanding to include that new development be located and designed to avoid the need for future shoreline stabilization for the life of the structure, including consideration of sea level rise, increased storm intensity, and changes to coastal erosion and sediment supply.	Proactive; plan for development to avoid the need for future shoreline stabilization by considering SLR and increased coastal erosion.
KCC 22.400.105.4	Proposed Development	Recommend requiring new development on steep slopes or bluffs to consider sea level rise, increased storm intensity, and changes to coastal erosion and sediment supply in their geotechnical analysis to evaluate building setbacks.	Proactive; building setbacks should include SLR and changes in coastal erosion
KCC 22.400.105	Proposed Development	Recommend including a new policy that encourages new development on low or no-bank marine shorelines to locate the bottom of the structure's foundation higher than the expected future sea level rise for the life of the structure.	Proactive; encourage new development to build structures to be resilient to future conditions in high-risk areas.
KCC 22.400.105	Proposed Development	Include a new requirement that new plats or subdivisions must demonstrate that the residential development and all related infrastructure will not be impacted by sea level rise within an established timeframe. Land that is wholly within an area that is expected to be inundated by sea level rise within the designated timeline shall not be divided. Land that is partially within an area that may be inundated may be divided, provided that each resulting lot has sufficient building area for all related infrastructure outside of and will not be affected by sea level rise.	Proactive; prevent new lots from being created that will be at risk of sea level rise impacts over an established timeframe (e.g., 2050, 2100).

SMP Reference	Section	Proposed Revision	Type of Mitigation Strategy
KCC 22.400.120.B.2.	Reduced Standard Buffers	Consider including a new requirement for reduced standard buffers to demonstrate that the proposed expansion will not be impacted by sea level rise during the expected design life of the structure.	Proactive; Prevent expansion of structures that may be at risk during the life of the structure to reduce the risk of damage/loss.
KCC 22.400.120.C.2	Alternatives for Existing Buffers	Consider expanding the existing regulatory requirements to allow for a preexisting residential or appurtenant structure that is nonconforming with respect to dimensional standards to be enlarged only if such enlargement does not increase the extent of the nonconformity and does not increase the risk of damage from sea level rise for the life of the structure.	Reactive; Limit expansion of non-conforming development if it is going to increase the risk of damage from SLR over the life of the structure.
KCC 22.600.185	Utilities	Recommend including a policy to locate utility facilities outside of areas that may be subject to inundation from sea level rise or extreme flood events, or design facilities to withstand temporary or permanent water inundation, or other natural hazards.	Proactive; locating utility facilities outside of areas at risk will increase resilience over time and prevent significant costs to relocate or retrofit in the future.
KCC 22.700.120	Geotechnical Reports	Consider expanding the geotechnical report standards to evaluate coastal erosion rates with consideration of sea level rise and increased storm frequency and intensity for a minimum of 50-75 years.	Proactive; incorporate changes in coastal erosion rates when preparing geotechnical reports to reduce the risk of damage or loss for future development or redevelopment.

CRITICAL AREAS ORDINANCE (TITLE 19)

The Kitsap County CAO includes several regulations and policies that are intended to provide resiliency to a changing climate. The recent amendments to the CAO include the following:

KCC 19.100.105.13 was revised to include a policy to avoid potential conflict due to impacts from climate change by considering and planning for them during project development. This may include, but is not limited to, impacts of sea level rise, storm frequency, and wildfire.

Kitsap County currently regulates Channel Migration Zones (CMZs) as erosion hazard areas under KCC 19.400.420. Stream buffers are also currently required to measure buffer widths from the edge of the CMZ under KCC 19.300.315.A.2., which should provide additional protection as CMZs may be exacerbated by SLR.

Additional considerations that could be considered during future updates to the CAO might include the following:

- Require new subdivisions to be located outside of designated CMZs or have adequate buildable areas outside of the CMZ.
- Encourage floodproofing or elevation of structures for areas near special flood hazard areas (SFHA) or areas that may be inundated by sea level rise within the life expectancy of the structure.

KITSAP COUNTY COMPREHENSIVE PLAN

During the 2024 Comprehensive Plan Periodic Update, the County incorporated a new Climate Element with numerous goals, policies and strategies addressing the challenges posed by sea level rise. The County then took it a step further by adding new goals and policies on sea level rise and coastal flooding resiliency in other chapters, including the Capital Facilities, Utilities Element, and the Housing Element. Noting the Land Use Element and other elements are currently silent on the matter; the table below provides recommendations to bolster planning efforts and actions around sea level rise under these elements. The guidance is paired with increased support for inter-departmental coordination and cross-referencing of goals, policies, and strategies to account for the different functions and/or directives of each county department.

Table 22. Proposed revisions to consider in the Kitsap County Comprehensive Plan.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
Chapter 1 Land Use	No goals or policies currently identified	Land Use / Zoning /Development Regulations	Consider adding a goal to guide land use development and establish land use patterns that increase the resilience of the built environment, ecosystems, and communities to sea level rise. Potential policies to consider: 1. Prepare an adaptation strategy as a follow-up to the SLR Vulnerability Assessment. The adaptation strategy should provide a science-based community framework for addressing the challenges posed by sea level rise (SLR) related coastal hazards. Include a suite of potential measures ranging from passive management techniques to protective (soft shore to hardening). 2. Develop regulations for elevating or setting back new and substantially improved structures to reduce the risk of damage caused by sea level rise. 3. Direct new development into areas where impacts from sea level rise is low.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
Chapter 1 Land Use	No goals or policies currently identified.	Land Use/ Zoning / Development Regulations	Consider a new goal emphasizing the use of best available information and science to implement sea level rise management strategies in development proposals. Potential policies: 1. Require development to incorporate measures that will reduce risks and avoid future costs. 2. Consider climate change, including sea-level rise, extreme precipitation, increased winter streamflow, and other impacts, in floodplain management planning. 3. Require development to incorporate measures that will reduce risks and avoid future costs and to encourage acknowledgment of such risks by state and federal agencies.
Chapter 4 Housing	Goal 8. Homelessness. Make homelessness rare, brief, and one-time in Kitsap County. Policy 8.6. Evaluate and mitigate the impacts of climate change and natural disasters on the County's response to addressing homelessness, including factors like heat events and flooding.	Housing	Consider adding a strategy to take into account climate change and sea level rise when planning for emergency housing and shelters.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
Chapter 7 Capital Facilities and Utilities	Goal 2. Essential Public Facilities: Implement a countywide process for siting essential public facilities. Policy 2.10. Consider the effects of climate change, including enhanced risk from sea level rise, flooding, wildfire, and urban heat island, when evaluating and siting essential public facilities.	Protection of essential public facilities	Maintain and consider cross-referencing Strategy 2.c. with the Land Use Element.
Chapter 7 Capital Facilities and Utilities	Goal 5. Coordinated with Development. Coordinate capital facilities improvements with land development. Policy 5.6. Consider the use of alternative sewage treatment techniques in areas that contain a significant concentration of critical areas, will be impacted by extreme rain and coastal flooding, or which have topographic challenges or critical aquifer recharge areas.	Infrastructure, coordination on development proposals	Consider adding a policy to ensure the Planning and Public Works Departments are coordinating on infrastructure and development in areas impacted by sea level rise.
Chapter 7 Capital Facilities and Utilities	Goal 6. Utility Efficiency Policy 6.3. Support the use of alternative sanitary sewer techniques within UGA's, such as package plants, membrane, and drip systems, and/or community drain fields, in areas where public sewer systems may be more than 200 feet away. Strategy 6.B. Assess and plan for any impacts of climate change on sewer capacity, with coastal flooding and extreme rain events, through climate mitigation and adaptation measures.	Infrastructure Resiliency	Maintain existing goal and policy.
Chapter 7 Capital Facilities and Utilities	Goal 7. Service Quality: Maintain and enhance utility service and quality.	Utility resilience	Maintain existing goal and strategy.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
	Strategy 7.e. When making improvements to increase resiliency of utilities, evaluate how changes to the following hazards could change the lifespan and/or replacement cycle for facilities and equipment: sea level rise, flooding, wildfire, and urban heat island.		
Chapter 7 Capital Facilities	Goal 8. Environmental Protection Policy 8.2. Continue to utilize emerging science and technologies to mitigate impacts from pollutants, increased rain events, and coastal flooding that may occur with these systems. Policy 8.6. Ensure utility project designs address the extent of and mitigate for the recharge-limiting effect of impermeable surfaces and other factors affecting groundwater and surface water quantity and quality and consider increased flooding and rain events due to climate change. Policy 8.10. Protect the quality and quantity of groundwater used for domestic water supplies. Strategy 8.b. Explore long-term plans for stormwater controls at the watershed level and coordinate with neighboring jurisdictions. This should include consideration of facility capacity for increased extreme ran events and coastal flooding due to climate change. Strategy 8.e. Consider and adapt to the impacts of climate changes on TMDLs and nonpoint source pollution to increased rain events, coastal	Environmental protection	Consider cross-referencing the goal and policies with the Environment Element.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
	flooding, as well as potential impacts to utility facilities.		
Chapter 7 Capital Facilities and Utilities	Policy 9.6. Promote the siting of schools, institutions, and other community facilities that primarily serve urban populations within the UGA in locations where they will promote the local desired growth plans, except as provided for by RCW 36.70A.211. Strategy 9.a. Update county-owned and operated sewer facility plans to include capacity demand and needs, and also major collection of conveyance systems for the 2044 planning horizon, while accounting for extreme precipitation and coastal flooding events.	Land Use / Services / Facilities / Infrastructure	Maintain and consider cross-referencing or duplicating policy in the Land Use Element.
Chapter 7 Capital Facilities and Utilities	Policy 11.1. Plan for the adaptation and mitigation of the impacts of climate changes, including SLR, flooding, wildfire hazards, and urban heat on all new and existing development, infrastructure, and services.		Maintain. Consider adding this policy to the Land Use Element.
Chapter 8 Climate Change	Key Terms (Page 186)	Definitions	Consider adding “Sea Level Rise” to the list of key terms.
Climate Resilience and Adaptation Sub-Element	Introduction	Description of Systems	Impacts from SLR noted under the following systems: Public health, Economy, Public infrastructure, Cultural Resources, and Geologic and Natural Hazards.
Chapter 8 Climate Change	Adaptation Goals and Policies Climate Goal 1: Emergency preparedness and response.	Systems most vulnerable to climate change	Maintain. Consider cross-referencing with other applicable chapters.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
	Climate Strategy 1.b. Support development of mitigation funds for homeowners to raise properties or relocate out of flood zones or areas frequently flooded due to sea level rise.		
Chapter 8 Climate Change	Climate Change Goal 2. Public Health Strategy 2.g. Support the Kitsap Public Health District in assessing drinking water system vulnerability to SLR and provide information to the community about likely impacted areas to protect against saltwater intrusion.	Public Health	Maintain existing goal and strategy.
Chapter 8 Climate Change	Climate Change Goal 3. Economy Strategy 3.a. Assess the impacts of SLR on economic resources and develop strategies to mitigate the impacts.	Economy	Consider cross-referencing with the Economic Development chapter.
Chapter 8 Climate Change	Climate Change Goal 5. Public Infrastructure and Transportation Network Policy 5.5: Proactively manage the transportation system's risk exposure to SLR, coastal flooding, extreme precipitation, and extreme heat. Strategy 5. b. Coordinate with Public Works, utility providers, Kitsap Public Health District, and coastal communities to develop a SLR and coastal flooding vulnerability and risk assessment that identifies and maps areas of highest risk and outlines strategies to protect coastal infrastructure, communities, and natural assets.	SLR Vulnerability and Risk Assessment	Strategy 5.b. is currently being implemented. Suggest replacing it with a similar policy suggested for the Land Use Element to develop and an adaptation strategy using the results of the SLR Vulnerability Assessment.
Chapter 8 Climate Change	Climate Strategy 10.c. Update the SMP to address potential changes to shorelines from SLR and coastal flooding.	Shorelines	Suggested SMP strategies noted in Table 21.

Comprehensive Plan Element	Goal/Policy Reference	Topic	Proposed Recommendations
Chapter 8 Climate Change	Gorst Goal 3. Improve water quality and reduce flooding in the Gorst UGA. Gorst Policy 3.8. Implement adaptations to address potential effects of SLR on Sinclair Inlet properties. These may include, but are not limited to, accounting for SLR in the design of building and impervious areas, as well as roadways, flood management, and utility facilities.	Land Use, Utilities	Maintain. Consider cross-referencing with Land Use and Capital Facilities and Utilities Chapters.

RECOMMENDATIONS

Several of the goals and policies referenced above could be improved by highlighting their importance across the Land Use Element or Climate Element. The findings of this report or future assessments could be cross referenced to prioritize resiliency strategies or mitigation measures to protect infrastructure at risk. The recommendations for consideration in the Shoreline Master Program could also be reflected as goals or policies in the Comprehensive Plan.

KITSAP COUNTY MULTI-HAZARD MITIGATION PLAN

The 2024 Kitsap County Multi-Hazard Mitigation Plan (MHMP) includes hazard identification and vulnerability assessment for unincorporated Kitsap County as well as the Cities of Bainbridge, Bremerton, Port Orchard, and Poulsbo. The Kitsap County Multi-Hazard Mitigation Plan describes that flooding is the most common hazard occurring in Kitsap County, affecting all of the county. Approximately 10-15% of the county area lies within flood zones with a 1% and 0.2% percent chance of flooding annually.

Further, the MHMP classifies flood vulnerability and effect on Kitsap as "moderate" during the next 25 years for damage to infrastructure and individual residence. Given that there is not a dedicated section to sea level rise, it is likely that flood mitigation would be the most appropriate section to incorporate impacts from sea level rise. The recommended revisions could include, but are not limited to, the following:

- Revise Flood Mitigation Strategy 1 as follows: "*Convene an annual meeting of interested parties to discuss Local, State, and Federal regulatory requirements related to maintenance activities in flood-prone areas, including areas inundated by sea level rise and extreme flood events.* "
- Revise flood Mitigation Strategy 2 as follows: "*Identify high-risk areas for flooding and sea level rise inundation by 2050 on Geographic Information System (GIS). Update Local stormwater system plans and improve stormwater facilities in high-risk areas.*"
- Incorporate a new Flood Mitigation Strategy to develop, implement, and periodically update a plan to mitigate and adapt to climate change impacts to the coastline.
- Encourage development of protocols for preplanning and prestaging ahead of emergency responses.

It is also recommended to include a reference to the findings of this report and/or the online GIS map once developed to provide an additional resource for the community regarding the vulnerabilities associated with SLR and a changing climate.

The MHMP also notes that Kitsap County Public Works has recently updated the Stormwater Comprehensive Plan to identify areas that may require additional flood mitigation or water quality improvements including accounting for climate change, coastal flooding, and severe storm impacts.

KITSAP COUNTY STORMWATER COMPREHENSIVE PLAN

The Kitsap County Stormwater Comprehensive Plan outlines key challenges and strategies related to managing stormwater in a growing and changing region. The plan emphasizes infrastructure upgrades, regulatory compliance, climate resilience (including sea-level rise and extreme weather), and water quality improvements. The plan sets goals for adaptive management, community engagement, and long-term planning to protect natural resources, stormwater infrastructure, and public health.

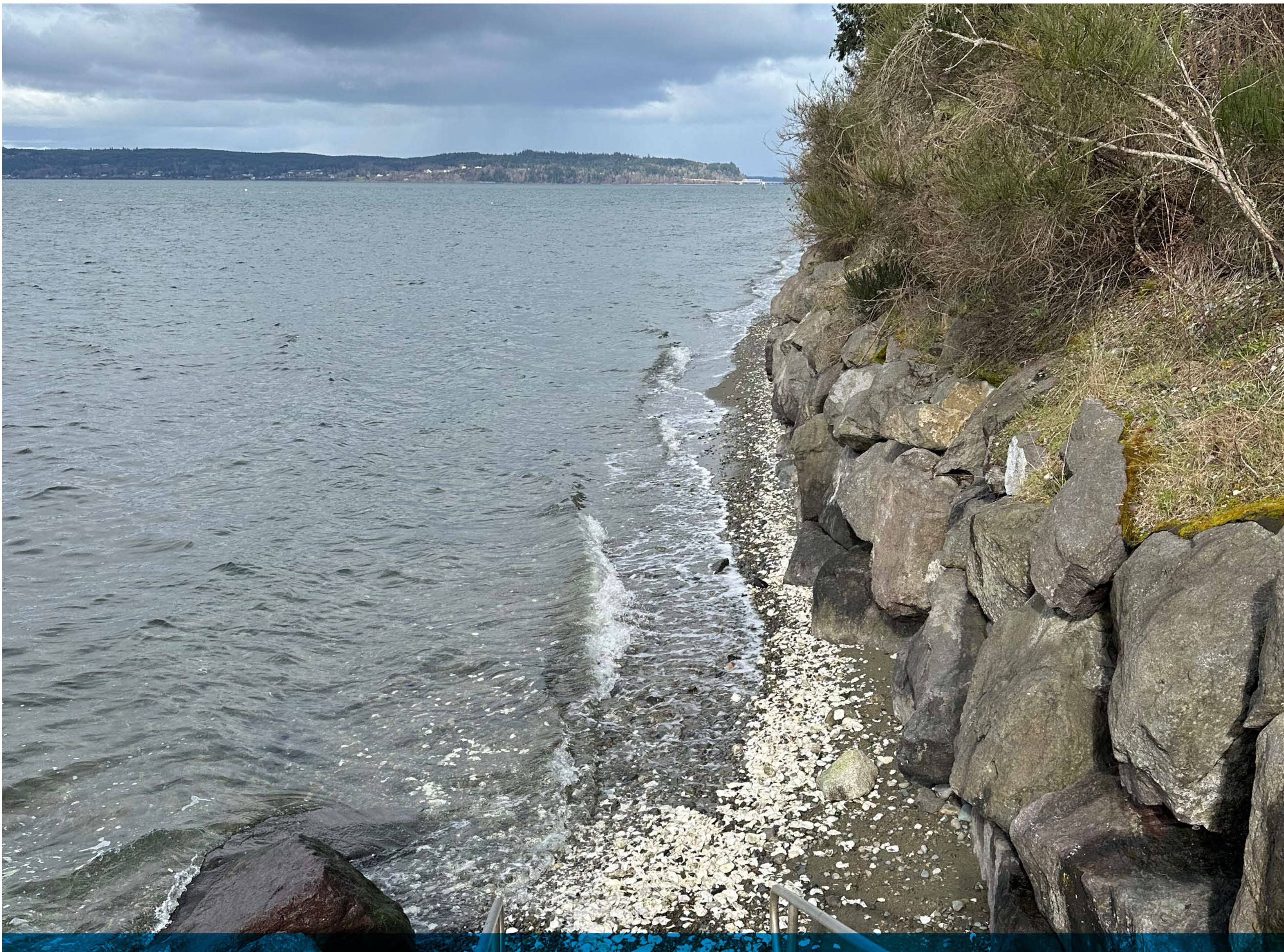
Studies performed on sea-level rise and precipitation levels show that impacts of climate change are currently and will continue to affect Kitsap County stormwater infrastructure. This finding indicates the need for adaptation planning. Stormwater outfalls are particularly susceptible to the effects of sea-level rise. HDR used sea level rise models from Washington Sea Grant and UW CIG, along with County stormwater outfall data, to assess potential impacts for 2030, 2050, and 2100 under two climate scenarios: moderate emissions with mitigation and high emissions without mitigation. Figures 5-2 to 5-8 of the plan show the number and location of outfalls affected.

The Stormwater Comprehensive Plan gives recommendations on how to address the ongoing impacts of sea-level rise and climate change on County stormwater infrastructure. To improve stormwater system resilience, maintenance should come first—many issues stem from neglected upkeep. Building resilience is a gradual, long-term effort requiring a strategic plan focused on cost-effective solutions. Potential infrastructure improvements include:

- Updating design standards to account for climate change.
- Incorporating green stormwater infrastructure (e.g., bioretention, green spaces, wetlands).
- Installing traditional infrastructure like pump stations in high-risk areas.
- Strengthening protections for natural features that reduce flooding impacts.

SECTION 7

Conclusions



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7. Conclusions

Table 22 below summarizes the likelihood of exposure, expected adaptative and vulnerability for each type of asset included in this report. This assessment does not include the impacts of social vulnerability in the overall ranking of vulnerability. rankings included below.

As described in *A Complementary Social Vulnerability Assessment to Support Sea Level Rise Planning in the Puget Sound Region of Washington State* (Fleming and Regan, 2022) certain areas within Kitsap County have a heightened social vulnerability, particularly in communities with lower income levels, limited access to education, and higher proportions of elderly residents. However, the overall social vulnerability of Kitsap County was found to be low compared to other counties in the region. In areas where social vulnerability is found to be higher, the susceptibility of these communities would be increased to the adverse effects of sea level rise or other climate-related hazards.

Table 23. Summary table of exposure, adaptive capacity, and vulnerability for all assets.

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
Roads	Approximately 7.0 miles of roadways within unincorporated Kitsap County are likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability. **(Exposure = High)**	Temporary or permanent impacts due to flooding of transportation routes Impacts can be reduced or mitigated to a certain extent. However, the cost and implementation to retrofit, relocate or expand capacity of stormwater systems is a significant investment. Relocation opportunities are severely limited or non-existent. Certain roadways may need to be elevated or relocated to improve resilience to flood events. **(Adaptive Capacity = Low)**	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	Approximately 1.5 miles of roadways are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability. **(Exposure = Medium)**	*See above.* **(Adaptive Capacity = Low)**	**High**
	Approximately 14.5 miles of roadway are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **(Exposure = Low)**	Many roads are in areas where alternate routes exist. Temporary impacts due to flooding may impact the accessibility of residents. Impacts can be reduced or mitigated to a certain extent. Cost and implementation to retrofit, relocate or expand capacity of stormwater systems is a significant investment. However, roadways that are at a medium risk of exposure will likely not be impacted except temporarily during extreme weather events. **(Adaptive Capacity = Medium)**	**Medium**
Airports	Bremerton National Airport and Apex Aviation's airstrip are located upland and not at risk from SLR or coastal flooding based on the projections included in this assessment. The Poulsbo Seaplane Base is located within the City of	N/A; assets are not likely to be exposed based on the projections included in this assessment.	**N/A**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	Poulsbo and therefore is not included in this assessment.		
Facilities: • **Schools** • **Law Enforcement** • **Fire Stations** • **Community Centers** • **Hospitals** • **Urgent Care Clinics** • **Museums** • **Libraries** • **County buildings and Fairground** • **Solid Waste Disposal Sites**	No schools, law enforcement, fire stations or community facilities listed in this table are expected to be located in areas at high, medium, or low exposure risk to SLR or coastal flooding.	N/A; assets listed are not likely to be exposed based on the projections included in this assessment.	**N/A**
Buildings	1,190 buildings are likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability. **(Exposure = High)**	Mitigation measures for buildings may require significant improvements to increase resilience from SLR and flooding impacts. Adaptations are possible, but cost is a challenge. **(Adaptive Capacity = Low)**	**High**
	260 buildings are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability.	Mitigation measures for buildings may require improvements to increase resilience from temporary flooding impacts in the near term. Adaptations are possible, but cost is a challenge. Long-	**Medium**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	(Exposure = Medium)	term planning efforts may be required as structures are redeveloped or replaced. **(Adaptive Capacity = Medium)**	
	1,090 buildings are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **(Exposure = Low)**	*See above.* **(Adaptive Capacity = Medium)**	**Low**
Historic and Cultural Sites	Three (3) historic structures and/or cultural sites are likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including: • Doe-Kag-Wats, Indianola *(Estuary – Suquamish Tribal Reservation)* • Point No Point Light Station (*Historic Structure)* • Old Man House Site (*Cultural Site/Structure – Suquamish Tribe)* **(Exposure = High)**	Historic structures and cultural sites are expected to have limited options for adaptation. Preserving these sites in place can be costly, and their cultural and historical significance is not easily replicated. Relocation is generally not feasible without compromising their historic integrity. **(Adaptive Capacity = Low)**	**High**
	The Norwegian Point Park Boathouse (*historic structure)* in Hansville is expected to be	*See above.*	**Medium**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **(Exposure = Low)**	**(Adaptive Capacity = Low)**	
Puget Sound Energy (PSE) Substations and Structures	Eighteen (18) electrical substations and two (2) electrical switch stations are located within the project area, and none are in areas mapped as having an inundation likelihood under the chosen scenarios. **N/A**	N/A; assets listed are not likely to be exposed based on the projections included in this assessment.	**N/A**
Group B Water Systems (No Group A systems mapped in inundation areas)	Six (6) Group B water systems are likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including the following: • Evanger (3 connections) • Misery Point HOA (7 connections) • President Point (4 connections) • Redman (4 connections) • Richardson Water (3 connections) • Scandia Court (5 connections) **(Exposure = High)**	The adaptive capacity of wells is considered low because of the significant cost for replacement and due to the fact, that once contaminated, repair can be costly and difficult. Interruption of operations has a significant impact on end users. **(Adaptive Capacity= Low)**	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	Three (3) Group B water systems are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability including: • Conifer Crest Water (4 connections) • Kristensen (2 connections) • Olalla Bay Market (2 connections) **(Exposure = Low)**	*See above.* **(Adaptive Capacity= Low)**	**Medium**
Stormwater Facilities	11 catch basins, 86 raingardens, and 130 outfalls are likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability. **(Exposure = High)**	*See above.* **(Adaptive Capacity = Low)**	**High**
	One (1) stormwater basin, two (2) raingardens and 25 outfalls are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability. **(Exposure = Medium)**	Impacts on these facilities are unlikely to occur within the short-term planning horizon but are likely to occur by 2100. Infrastructure improvements could be prioritized under Capital Improvement planning as infrastructure is repaired or replaced over time. **(Adaptive Capacity = Medium)**	**Medium**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	Five (5) stormwater basins and nine (9) raingardens are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **# of outfalls above 1.4 ft over MHHW were not quantified in HDR 2019* **(Exposure = Low)**	*See above.* **(Adaptive Capacity = Medium)**	**Low**
Sewer Facilities	Likely to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability. • Six (6) wet wells • 1.75 miles of gravity main • 4.25 miles of force main (Kingston, Manchester) **(Exposure = High)**	Buried infrastructure related to the municipal sewer service are likely to be resilient to periodic inundation. Material improvements may be required if infrastructure is permanently inundated in the future and should be monitored during temporary inundation events. Above-ground infrastructure improvements may be required for periodic or permanent inundation but could be planned for through Capital Improvement Funds. **(Adaptive Capacity = Medium)**	**High**
	Expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability including: • One (1) wet well	*See above.* **(Adaptive Capacity = Medium)**	**Medium**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	• 0.5 miles gravity main • 1.25 miles force main. **(Exposure = Medium)**		
	One (1) sewer clean out is expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability including: • One (1) sewer cleanout • 2.25 miles gravity main • 2.25 miles force main. (Sinclair inlet area) **(Exposure = Low)**	Sewer clean-outs are located above ground and may be at greater risk from impacts during temporary or permanent inundation. Adaptation strategies such as raising cleanouts above projected flood levels or upgrading surrounding infrastructure may be required to increase resiliency. Mitigation measures are possible but may be costly depending on the extent of infrastructure improvements required. **(Adaptive Capacity = Medium)**	**Low**
Wastewater Treatment Facilities	There are no wastewater treatment facilities within an area at risk of exposure. **N/A**	N/A; assets are not likely to be exposed based on the projections included in this assessment.	**N/A**
Coastal On-Site Septic Systems	Due to data limitations, the type and location of individual on-site septic systems were not available. As such, exposure ratings were not able to be applied.	If septic drainfields are inundated, impacts to on-site septic systems may temporarily disrupt operations until flood waters recede, and soils drain. Inundation during coastal flooding can also overwhelm	**N/A**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
		systems, causing backups or overflows. Permanent inundation would necessitate adaptation strategies to be implemented such as raised systems, alternative treatment technologies, or eventual connection to sewer infrastructure, where possible. However, these adaptation measures may be costly and could result in public health risks if operational functions of the system are impacted. **(Adaptive Capacity = Low)**	
Wetlands	Approximately 4,627 acres of wetlands are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including: • 4,366 acres of estuarine and marine wetlands; • 163 acres of freshwater forested/shrub wetlands; • 60 acres of freshwater emergent wetlands; and • 38 acres of freshwater pond wetlands.	Wetland ecosystems generally have some adaptive capacity to water level changes, but ecosystems that have undergone significant alteration or degradation can show reduced resilience when facing deeper water conditions or changing salinity, like SLR and more frequent coastal storm flooding. In some cases, wetlands can naturally migrate toward higher elevations as sea levels increase. However, this natural adaptation process may be severely constrained throughout a lot of the County's shoreline due to the presence of shore hardening infrastructure and vertical bluffs	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	(Exposure = High)	which block wetland migration inland. **(Adaptive Capacity = Medium)**	
	Approximately 4.0 acres of wetlands are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability, including: • 1.0 acre of estuarine and marine wetlands; and • 3.0 acres of freshwater emergent wetlands. **(Exposure = Medium)**	*See above.* **(Adaptive Capacity = Medium)**	**Medium**
	Approximately 67 acres of wetlands are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability, including: • 49 acres of freshwater forested/shrub wetlands; • 17 acres of freshwater emergent wetlands; and	*See above.* **(Adaptive Capacity = Medium)**	**Low**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	• 1.0 acre of freshwater pond wetlands. **(Exposure = Low)**		
Beaches	This assessment did not have data to quantify exposure for forage fish habitat. Data for most public access locations along beaches are included in Parks, Bays, and Marinas. Beach access at the end of roads is documented within the Transportation section.	Beaches can adapt by moving inland provided there is space to do so, like wetlands, as described above. However, on beaches with hard structures or vertical restrictions, beach material cannot be pushed inland. Instead, the water becomes deeper, and wave energy more intensely, washing away sand and gravels. Salmon have no refuge or benthic prey, forage fish have no substrate to spawn in, and eelgrass can't root. This condition is called "coastal squeeze." **(Adaptive Capacity = Medium)**	**High**
Bays and Marinas	Three (3) assets related to marinas and bays are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including: • Port of Manchester Boat Ramp, Port Orchard • Eglon Boat Ramp, Kingston	Boat ramps are generally expected to have greater adaptive capacity due to their design and intended function. Since they are built to accommodate some level of inundation for vessel launching, moderate increases in water levels may not significantly affect their operation. However, impacts may arise if water levels rise to the point that the ramp becomes non-functional if it is	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	• Manchester Dock, Port Orchard **(Exposure = High)**	permanently submerged or structurally compromised. Substantial investments may be required to modify or relocate these facilities if functionality is lost. **(Adaptive Capacity = Medium)**	
	The Chico Boat Ramp is expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability. **(Exposure = Medium)**	*See above.* **(Adaptive Capacity = Medium)**	**Medium**
	Lawrence Memorial Boat Ramp is expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **(Exposure = Low)**	*See above.* **(Adaptive Capacity = Medium)**	**Low**
Seafood and Shellfish Industrial Facilities	Grovers Creek Hatchery is expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability. **(Exposure = Low)**	Adaptive Capacity of hatcheries is dependent on whether critical facilities, buildings and electrical infrastructure can be raised. It also depends on the capacity to handle excess water. Relocation is not possible due to natal stream requirements of salmon populations. **(Adaptive Capacity = Low)**	**Medium**
Parks	Six (6) parks are expected to be inundated by coastal flooding	The adaptive capacity of parks is expected to vary by the type	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	(SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including: • Silverdale Waterfront • Arness Roadside Park • Anderson Point • Keyport County Park • Salsbury Point Park • Point No Point Park **(Exposure = High)**	of assets present. As park facilities are not expected to provide critical functions to the community, the adaptive capacity may include conversion of open spaces to coastal wetlands or a receded shoreline. The infrastructure that serves the park may need to be relocated, retrofitted, or abandoned as inundation occurs. **(Adaptive Capacity = Medium)**	
	Pat Carey Vista is expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability. **(Exposure = Medium)**	*See above.* **(Adaptive Capacity = Medium)**	**Medium**
	Three (3) parks are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability, including: • Kitsap Memorial State Park • Scenic Beach State Park • Manchester State Park	*See above.* **(Adaptive Capacity = Medium)**	**Low**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	(Exposure = Low)		
Agricultural Land	Properties mapped as having exposure likelihood do not have fields or orchards that are within inundation areas. **(Exposure = Low)**	Inundation of agricultural land significantly limits the amount of area that can be utilized for harvest. Additionally, seawater intrusion has the potential to impact irrigation water, which prevents harvest during periods of intrusion. Mitigation measures are limited, but could include deeper wells or relocation of crops, where possible. However, these are cost limited. **(Adaptive Capacity = Low)**	**Medium**
Brownfield/Landfill	Four (4) sites are expected to be impacted by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 90% or 50% probability, including: • Hansville General Store • Captains Landing, Hansville • Seabeck Marina and Moorage • U.S.C.G. Point No Point Light Station **(Exposure = High)**	Landfills or brownfield sites are expected to contain contaminated soils, which could cause significant impacts if inundated. These facilities would require relocation, significant protection strategies and/or remediation to mitigate impacts. Operational impacts would be significant if active sites were to have interrupted functions. **(Adaptive Capacity = Low)**	**High**

Type of Asset	Exposure	Adaptive Capacity	Vulnerability
	Two (2) sites are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2050 with a 1% probability, or by 2100 with a 90% probability including: • Pioneer Landfill • Sinclair Inlet **(Exposure = Medium)**	*See above.* **(Adaptive Capacity = Low)**	**High**
	Two (2) sites are expected to be inundated by coastal flooding (SLR or 50-year return extreme flood) by 2100 with a 50% or 1% probability, including: • Port Gamble Bay and Mill Site • Welding and Supply, Gorst **(Exposure = Low)**	*See above.* **(Adaptive Capacity = Low)**	**Medium**

SECTION 8

Next Steps

FACET

8. Next Steps

Coastal flooding mitigation priorities include protecting low lying infrastructure from erosion, elevating structures above potential flood or inundation levels, and ensuring that floodwaters are able to drain back to the sea as tides recede. Through this report, Kitsap County is working to develop targeted strategies that address both the physical and social dimensions of climate vulnerability, ensuring a more resilient future for all its residents. By identifying and addressing the specific needs of vulnerable populations, Kitsap County could enhance its resilience to climate change impacts. The following next steps could be taken to expand on the findings of these reports and begin implementing resiliency strategies to protect assets and infrastructure in the future. The County should consider seeking grant opportunities for financial support to replace the aging infrastructure, particularly in areas most vulnerable. Prioritization should be made to implement mitigation measures for infrastructure in areas most at risk and to identify a list of roadway segments that should be evaluated to preserve emergency access for the community.

In order to quantify exposure of forage fish beaches, a dataset that identifies beaches on possible spawn substrate, along with hard armored shore mapping, would be needed to see where possible beaches could get squeezed out. Quantification of exposure of eelgrass habitat would require bathymetry and cross sectionals to evaluate elevations and see where appropriate habitat might be. Given this lack of data, the vulnerability of these areas was not included in this assessment.

Future revisions to plans or development regulations, such as those recommended in Section 6.0, could be incorporated to improve the resilience of new or redeveloped properties and reduce the risk of damage or loss. The County could benefit identifying areas where channel migration is a concern and applying a detailed CMZ delineation methodology to inform future hazards, integrated flood management, and restoration efforts. As flood events are expected to increase in extent and frequency from a changing climate, it is important to plan for development to be located outside of CMZs.

Since the Hansville community is likely at the greatest risk from sea level rise and extreme flood events, a community plan should be developed to identify the most beneficial resilience strategies along with their associated costs. This plan should be reviewed with residents and include clear steps for implementation with potential funding sources. Measures should be taken to ensure new, or redevelopment is adequately protected from rising sea levels and future flood events. A second phase of this assessment could include a more detailed evaluation of projected impacts on infrastructure, including compound flooding, in this area to develop a community plan and identify specific mitigation strategies.

Modeling of future groundwater changes from sea level rise, including impacts of saltwater intrusion, was not included in this report. Measurements of coastal groundwater quality should be utilized to evaluate the impact of rising sea levels on groundwater levels over time and monitor saltwater intrusion in vulnerable areas. A future study could be conducted to identify areas most at risk of saltwater intrusion and evaluate the interactions of existing conditions with future sea level rise projections for targeted areas. For areas identified to be most at risk, saltwater intrusion hazard areas could be designated to require additional standards or reports to be prepared to prevent adverse impacts and protect public health and safety.

For Group B water systems that have been identified as highly vulnerable in this assessment, it is recommended that individual contact with the systems managers be made to bring awareness of potential exposure hazards and plan for mitigation measures.

It is also recommended to develop an informational tool that allows residents to conduct a high-level self-assessment of their vulnerability through a series of guided questions and prompts. The tool could link to the County's ArcGIS StoryMap to help users identify their level of exposure. Using criteria similar to those in this report, residents could then evaluate their own infrastructure based on site-specific conditions and make informed decisions about mitigation and resilience strategies. Additional resources and informational links could also be included.

The County is encouraged to work with Washington State Department of Ecology to identify ways to streamline permitting for certain resiliency strategies and update codes respectively to allow for improved implementation. This effort could include developing new shoreline environment designations or sea level rise hazard areas that could be overlayed for locations that are most vulnerable to sea level rise or coastal flooding and creating specific allowances or requirements to protect assets and increase resilience. Efforts should be made to streamline permitting requests that improve resilience in areas most affected by sea level rise, including raising structures.

SECTION 9

References

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APPENDIX A: Maps

A web map was created that shows the different mapping scenarios. Assets are included, symbolized by exposure. The map can be found on the County's website by using the search term "Kitsap County Sea Level Rise Vulnerability Assessment" or visiting: https://www.kitsap.gov/dcd/Pages/SeaLevelRise_Assessment.aspx.

APPENDIX B: Memorandum

BLUE COAST ENGINEERING

MEMORANDUM

Date:	March 19, 2025
To:	Dawn Spilsbury and Alexandra Plumb, Facet
From:	Greg Curtiss, PE, Carter Howe, and Jessica M. Côté, PE
Project:	Kitsap County Sea Level Rise Study
Subject:	Coastal Engineering Evaluation

1 Overview

This technical memorandum summarizes coastal engineering support provided by Blue Coast Engineering LLC (Blue Coast) for the Facet team on the Kitsap County Sea Level Rise (SLR) study. The project team is currently completing a SLR Vulnerability and Risk Assessment for the County to aggregate data, identify and map potential climate change-related SLR impacts throughout the County shoreline. Blue Coast's scope of work was to provide input on two primary tasks for the study:

1. Coastal flooding evaluation (wind-wave and wave run-up) analysis for selected shoreline reaches within the study area.
2. Bluff recession SLR evaluation.

Task 1 consisted of a coastal flooding evaluation to evaluate the potential flooding risk for selected low-lying shoreline reaches throughout the County determined to be susceptible to coastal flooding during a storm event coupled with SLR. The task involved the completion of a 1-D wind-wave hindcast and wave run-up analysis to determine the potential total water level at a selected shoreline reach.

Task 2 consisted of an evaluation of potential impacts of SLR on bluff recession. The evaluation did not involve calculation of bluff recession rates and is limited to a discussion of the most recent science of predicting the impacts of SLR on coastal bluff recession rates (a limited literature review), the anticipated impacts from SLR on bluff erosion in Kitsap County, and potential planning recommendations to reduce risk from bluff erosion.

2 Background

Coincidence of high water levels and storm-induced wind-waves can result in flooding along the shoreline. Wave run-up is the landward and vertical extent to which waves reach on a slope which can result in flooding and a zone of high velocity. Flooding and high velocities can cause erosion of the beach or bluff or damage to structures. The total water level (TWL) reached along the shoreline or bluff is the combination of still water level (SWL) and dynamic water level (wave run-up) as shown in Figure 1 for a coastal bluff and low bank shoreline. Wave run-up is typically reported as $R_{2\%}$ which is a statistical measure of the wave run-up exceeded by 2% of the waves. The SWL used in this evaluation is the sum of the Mean Higher High Water (MHHW) tidal datum, storm surge (which includes wind set-up[1] and atmospheric effects, and predicted sea level rise (SLR).

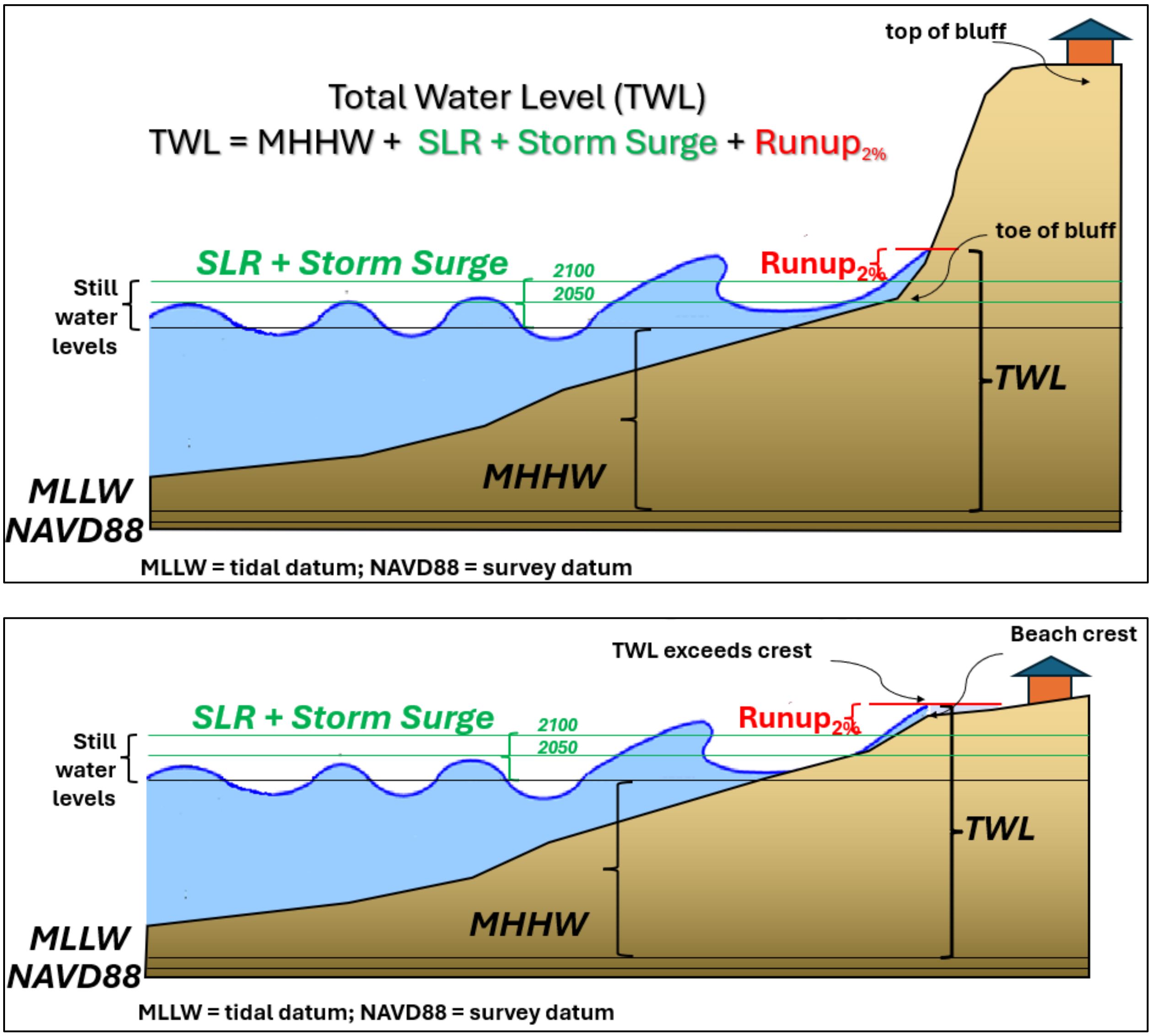

Figure 1. Conceptual diagram of total water levels for a coastal bluff (top) and low bank shoreline (bottom).

[1] The change in water level attributed to high winds.

3 Wind-wave and wave run-up analysis

The coastal flooding evaluation consisted of a wind-wave analysis to determine wave parameters and wave run-up at selected sites for planning purposes to estimate flood inundation susceptibility under SLR. The analysis relied on SLR change scenarios provided by Facet.

3.1 Site Selection

Seven sites were selected for analysis of susceptibility to coastal flooding for potential sea level rise scenarios. Several criteria, which were reviewed by the technical advisory committee, were used for selecting the sites, however the primary focus was placed on short (less than 1,000 foot) shoreline reaches with moderate or greater wind-wave exposure and thus most susceptible to coastal flooding. The full list of criteria is provided below:

- Areas which are non-military, unincorporated shoreline.
- Moderate or greater wind-wave energy as determined by a fetch length of at least 1 mile or greater. Sites with higher mapped erosion potential[2] value in Beach Strategies (CGS 2017) were also prioritized for selection.
- Low-bank (less than 5 feet in height) shoreline consisting of either accretion shoreform, transport zone, or no appreciable drift shoretypes (non-feeder bluff) as defined by Beach Strategies (CGS 2017) mapping.
- Consideration was also given to selecting sites which were representative of shorelines throughout the county.

An overview map of selected sites is provided in Figure 2. High level maps of each site including fetch measurements and critical assets as well as detailed plan and section views of wave run-up transects are found in Attachment A. Table 1 includes a description of fetch, shoretype, and types of critical assets in the immediate area of each site.

[2] Erosion potential is a combined score of shoreline erosive tendency based on shoretype and fetch exposure.

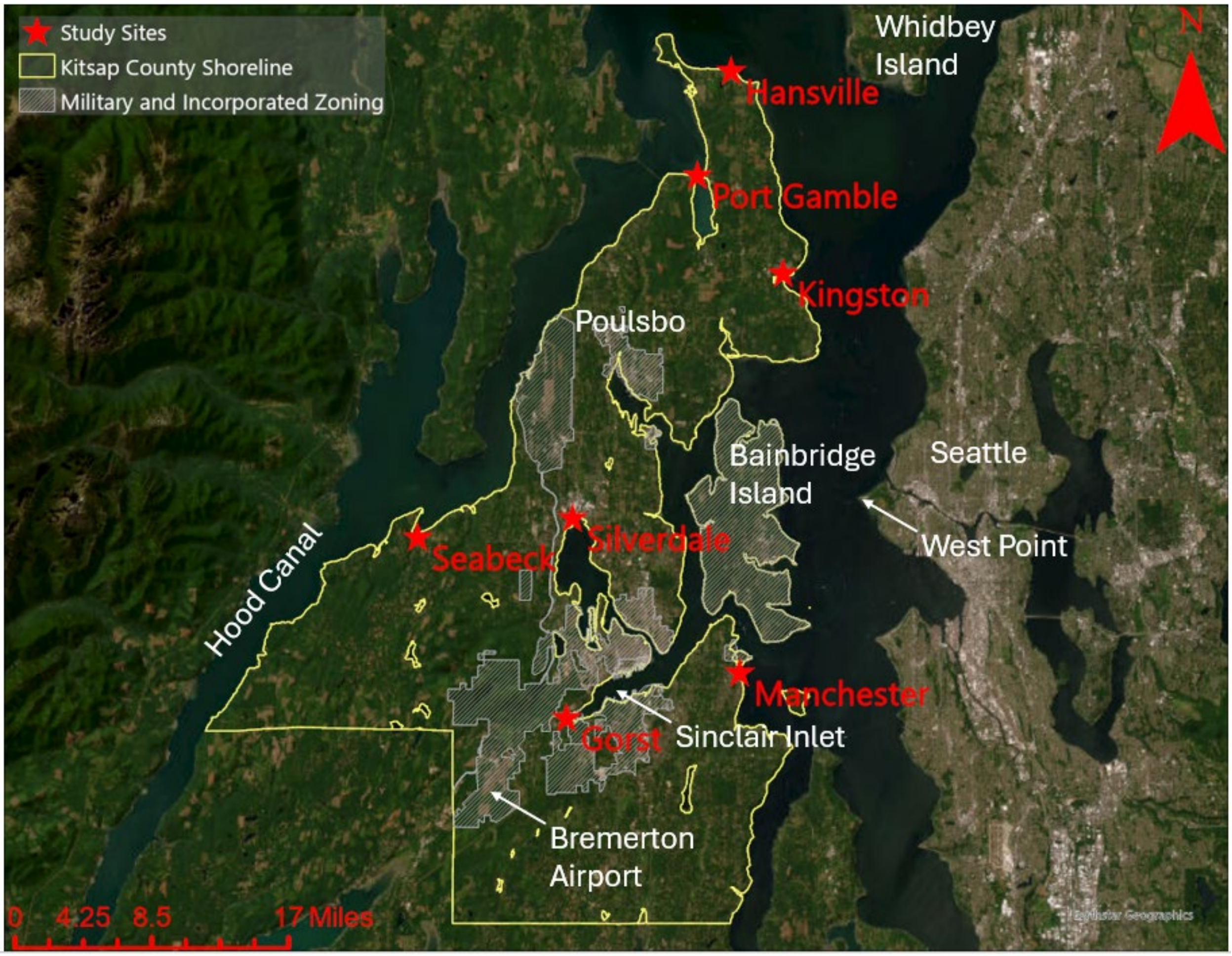

Figure 2. Map of selected sites for wind-wave evaluation.

Table 1. Characteristics of selected sites for coastal flooding evaluation.

Site	Fetch length (miles)	Fetch direction (degrees)	Shoretype[1]	Critical assets[2]
Hansville	42.7	333	Accretion shoreform, Transport zone	Roadways
Port Gamble	12.2	341	No appreciable drift, transport zone	Roadway, community facility
Kingston	8.1	132	No appreciable drift	Roadway, sewer facilities, law enforcement, community facilities, parks
Seabeck	6.5	38	Accretion shoreform, No appreciable drift	Roadway, fire station
Silverdale	4.8	171	Accretion shoreform, transport zone, No appreciable drift	Roadway, sewer facilities, schools, parks, law enforcement
Manchester	4.5	135	Accretion shoreform	Roadway, sewer facilities, community facilities
Gorst	8.6	56	No appreciable drift	Roadways, fire station

Notes:

1. Shoretype as mapped by Beach Strategies (CGS 2017).
2. Critical assets from Kitsap County Open Data portal, https://kitsap-od-kitcowa.hub.arcgis.com/ .

3.2 Wind Climate

To characterize the wind climate, wind data was obtained from the historical record for the National Data Buoy Center (NDBC) WPOW1 station at West Point in Seattle, WA and the National Climate Data Center (NCDC) Bremerton Airport station. Hourly wind records are available from 1945 to present at West Point and from 1973 to present at Bremerton. The meteorological sites were chosen because they have long records suitable for estimation of extreme wind speeds, are located on or near the water, and are located in general proximity to the sites of interest. The West Point station is located on the water along the central basin of Puget Sound is therefore expected to be representative of the Manchester and Kingston sites located on the eastern shoreline of Kitsap County along the central basin of Puget Sound. The Bremerton station is longitudinally central to Kitsap County, and its proximity to Seabeck, Silverdale, Gorst, Manchester, and Port Gamble makes it a suitable representation of the winds for those stations. The wind record at the NCDC Whidbey Naval Air Station (NAS) was used for the Hansville site as this was deemed representative of the wind climate for the shoreline in the vicinity of Hansville as part of a previous study completed by Blue Coast (Blue Coast 2024).

Figures 3 and 4 show wind roses for the WPOW1 station in West Point, Seattle, WA and the Bremerton Airport. The prevailing wind direction in the Puget Sound region (including Kitsap County) is from the South and Southwest in the winter and West and Northwest during the summer (Overland and Walter 1983). The strongest winds are from the south during winter storm events. The wind roses for each station differ from these prevailing directions and from each other due to topographic steering unique to each station. At the Bremerton station, as it is positioned between Sinclair Inlet and Hood Canal, incoming winds funnel into these bodies of water between higher elevations and this funneling effect presents itself in the wind rose as more frequent wind blowing from the Northeast and Southwest. The West Point station is on land that protrudes out into the central basin of Puget Sound and the winds are primarily North and South aligned at this location. The average wind speeds for Bremerton Airport and West Point station are 8.2 and 10.6 mph respectively, with both stations recording wind speeds in excess of 60 mph.

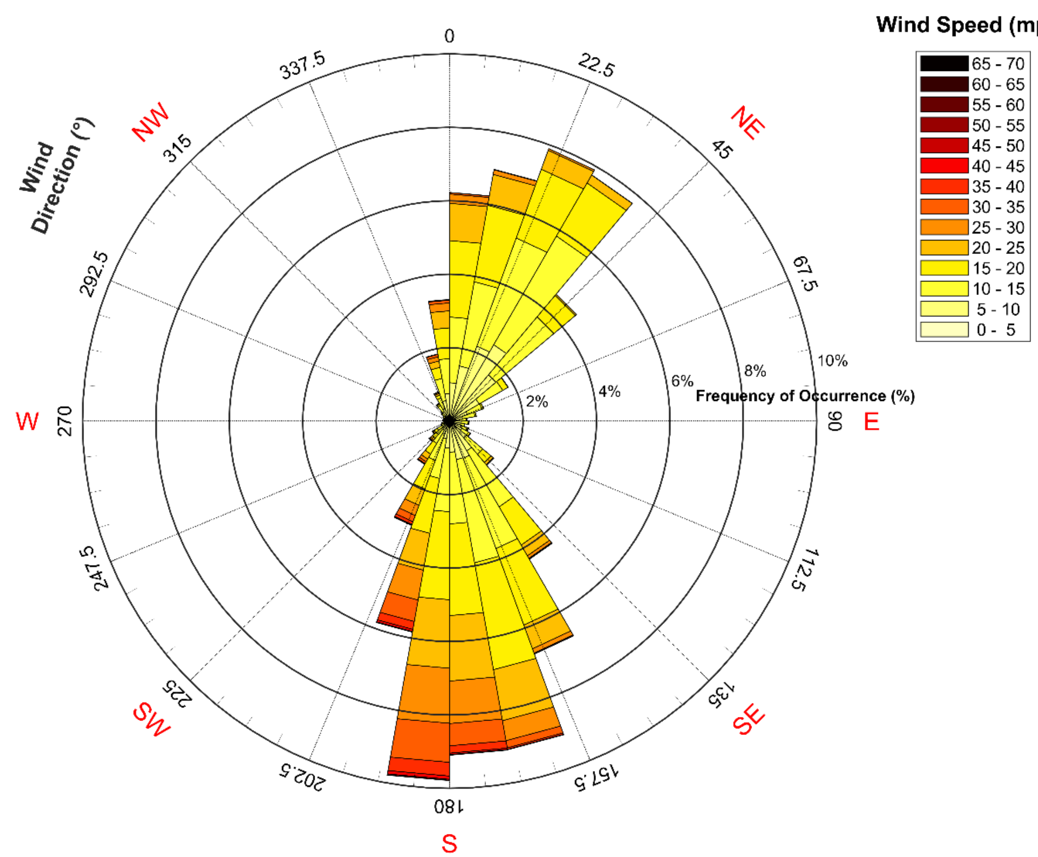

Figure 3. Wind rose of hourly observations from 1973 to 2023 at the NCDC WPOW1 station in West Point.

BLUE COAST ENGINEERING

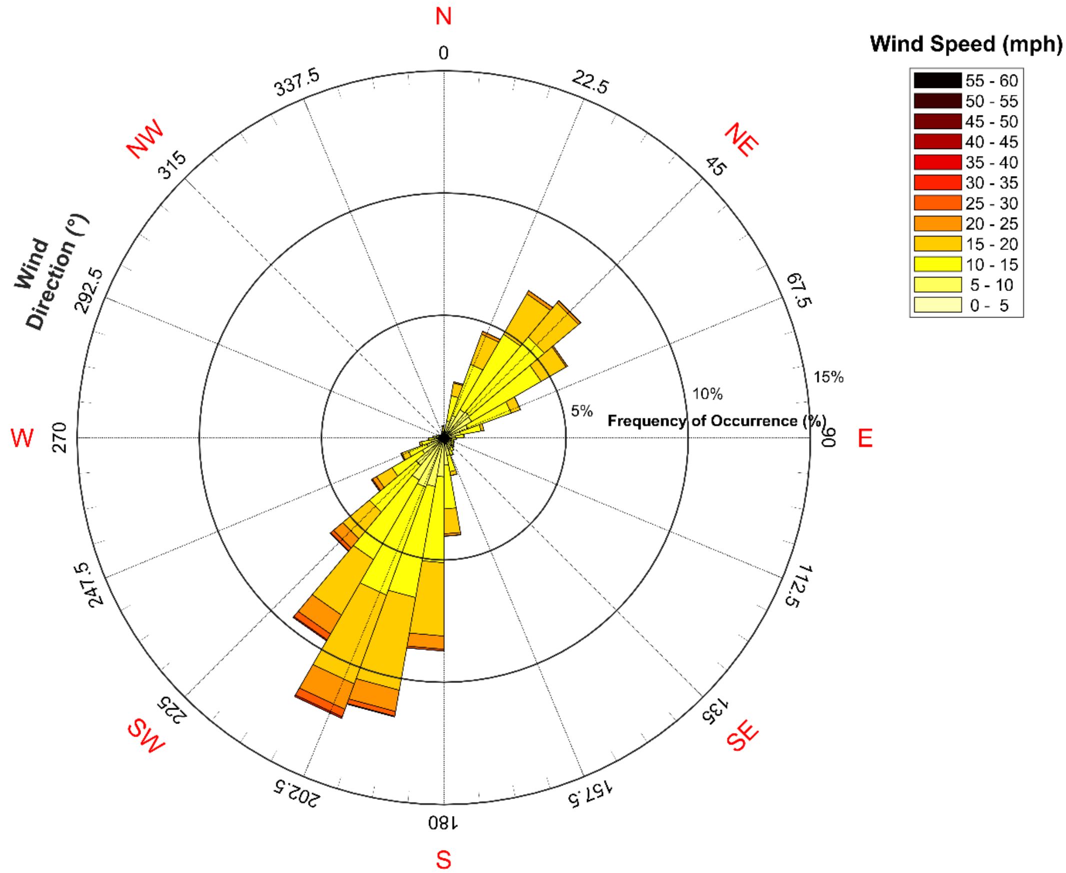

Figure 4. Wind rose of hourly observations from 1973 through 2023 at the NCDC station in Bremerton.

To characterize the extreme winds (and wind-waves) at each site, an extremal analysis of the wind records for each station was completed. An extreme value analysis of the wind record was completed following the methods of Goda (1988) to identify peak wind events and fit them to a Weibull extreme value probability distribution for relevant fetch directions. A wide direction range was used for characterizing the extreme winds at each site to account for the range of potential fetches each shoreline length is exposed to. Table 2 details the extreme value analysis inputs and results for each site. The 100-year return interval wind speed will be used for wind-wave analysis to evaluate coastal flooding during a storm.

Table 2. Extreme value analysis wind results.

Site	Meteorological Station	Wind Direction Range[1] (degrees)	1-Year Return Interval[2] Wind Speed (mph)	100-Year Return Interval[2] Wind Speed (mph)
Hansville	Whidbey NAS	300-40	34	51
Port Gamble	Bremerton	270-90	20	30
Kingston	West Point	0-180	36	57
Seabeck	Bremerton	270-90	20	30
Silverdale	Bremerton	90-270	28	38
Manchester	Bremerton	0-180	35	57
Gorst	West Point	0-180	20	32

Notes:

1. The direction range was chosen based on the range of fetches at a given site.
2. The 1-year wind speed is anticipated to be equaled or exceeded at least once a year, while the 100-year wind speed is a more extreme event that has a 1% chance of being equaled or exceeded in any given year.

3.3 Wind-wave hindcast

Fetch is the open water distance over which wind can blow unimpeded and form waves. Waves in Puget Sound are usually fetch-limited, meaning even during the strongest windstorms the wave heights are limited in growth by the fetch distance. A typical storm event in the inland channels of Puget Sound reaches up to a maximum of 3 feet (significant wave height) with wave periods less than 4 seconds (Finlayson 2006), although extreme events can exceed these values.

Attachment A includes figures of each site and with their maximum fetch distance labeled. The Automated Coastal Engineering Software (ACES) (Leenknecht et al. 1992) was used to calculate the corresponding wave parameters for the 100-year wind event. Table 3 details each site’s wind speed and fetch length as well as the corresponding wave parameters calculated. Seabeck and Port Gamble provide an example of how fetch length can impact wave heights, in that they both have the same 100-year wind speed, Seabeck but the longer fetch length exposure at Port Gamble results in a wave height 50% higher than that of Seabeck. In contrast, Port Gamble (northerly fetch) has a lower 100-year wind speed than Silverdale (southerly fetch), and it has a higher predicted wind-wave height due to its longer fetch.

Table 3. Wind-wave hindcast results.

Site	Wind speed (mph)	Fetch Length (miles)	Wave Height (ft)	Wave Period (s)
Hansville	51.0	42.7	5.1	4.5
Port Gamble	29.8	12.2	2.6	3.6
Kingston	57.3	8.1	5.3	4.4
Seabeck	29.8	6.5	1.7	2.9
Silverdale	37.7	4.8	2.0	2.9
Manchester	57.4	4.5	4.1	3.7
Gorst	32.0	8.6	1.9	3.2

3.4 Total Water levels

Total water levels were evaluated at the selected sites for one of several SWL scenarios identified in the Kitsap County Sea Level Rise and Coastal Flooding Risk Assessment (Facet; in progress 2025). The SWL scenarios identified in the Risk Assessment are the sum of the Mean Higher High Water (MHHW) tidal datum, storm surge (which includes wind set-up and atmospheric effects, and predicted sea level rise (SLR). Total water levels are calculated by adding the predicted wave run-up to the SWL. The selected scenario provides a conservative upper limit for planning purposes as it combines a high likelihood (50% probability) SLR scenario combined with a lower likelihood extreme storm surge (50-year event) and 100-yr wave event (1% probability). The particular SWL scenario used in this evaluation is described in more detail in Section 3.4.1 and the wave run-up analysis is described in Section 3.4.2.

3.4.1 Still water level

The input SWL scenario for the coastal flooding evaluation is the sum of three components: the MHHW tidal datum, storm surge, and predicted sea level rise which are described below. The input values used for each site are provided in Table 4 along with wave run-up results. MHHW was determined for each site using the NOAA Vdatum tool (Office of Coast Survey 2025). Predictions of sea level rise are from Miller et al. (2018) which are provided in localized coastal areas in Washington. These predictions incorporate low and high greenhouse gas scenarios (RCP 4.5 ["Low"] and RCP 8.5 ["High"]) as well as local estimates of vertical land motion. Facet (2025) provided a single rounded value of SLR (RCP 8.5 in year 2050, 50% probability) to use for all shorelines within Kitsap County which was combined with a 50-year storm surge. The combined SLR projection and 50-year return interval storm surge is 3.9 feet above MHHW everywhere except in embayments. Model results discussed in Miller (2019) suggest that certain embayments in Puget Sound may experience higher magnitude storm surge than the rest of Puget Sound. In Sinclair Inlet (Gorst) the combined value is 4.3 feet above MHHW and in Dyes Inlet (Silverdale) the combined value is 4.0 feet above MHHW. The non-embayment value was used for Port Gamble because the shoreline reach evaluated is outside of the embayment.

3.4.2 Wave Run-up

Wave run-up is the landward and vertical extent that waves can travel after breaking. Wave run-up has the potential to substantially increase water levels and can drive coastal erosion and overtopping. While a certain coastline's crest elevation may be higher than future SLR projections and flood events, run-up from waves on top of heightened water levels may be able to overtop and cause flooding. Wave run-up is dependent on a number of factors: wave height, beach slope, beach armoring, and Iribarren number[3] (also known as surf similarity parameter that describes breaking waves). For each site previously identified, wave run-up was calculated on a beach profile chosen to be typical of the shoreline reach based on a limited desktop assessment of the reach. The beach profile (shore normal transect) was extracted from the Washington Department of Natural Resources (DNR) digital terrain model (Washington Geological Survey 2023). The 100-year wind-wave (see Section 3.3) parameters were input into the wave run-up evaluation.

The wave run-up estimates presented in this memorandum should be interpreted within the range of uncertainty and caveats associated with climate change-induced sea level rise projections as well as the approximation of the input parameters (slope, elevations, and wind-wave estimates). The slopes and elevations of the existing ground and elevations in the shoreline areas are based on publicly available LiDAR data and not on a detailed topographic or bathymetric survey (which is not currently available). Wind-wave estimates are based on non-site specific wind measurements and one-dimension wave hindcast methodology does not account for bathymetric effects on wave development (refraction and diffraction). The calculations of wave run-up were developed only for planning purposes and should not be used for engineering design without further refinement.

For sites without armoring, the modified Mase method as reported in Melby (2012) was used to estimate wave run-up and total water level elevation. For the Silverdale and Port Gamble sites, which are armored with rock, the Eurotop (2018) method for wave runup on an embankment was used to calculate wave run-up. Table 4 details the wave run-up parameters and calculation for each site. In one case (Gorst), the SWL exceeds the shoreline crest elevation, resulting in still water inundation landward of the shoreline crest. In this case, the larger calculated waves break on the beach face and wave run-up was calculated on the slope inland of the shoreline crest using a depth-limited wave height. Depth-limited waves are assumed to have a wave height proportional to the water depth using the wave height to water depth ratio of 0.78 (USACE 2018). When this ratio is exceeded, the water column is no longer able to sustain higher wave heights and wave breaking begins.

[3] Irribarren number is a ratio of beach slope and wave steepness that can be used to classify wave breaker type, wave run-up and reflection.

The wave run-up values suggest approximately 1 to 3 feet (vertical extent) of additional flood inundation above the SWL can be expected in Kitsap County under the 100-year wind-wave event. The landward extent of this inundation varies depending on the shoreline slope, surface roughness, and crest elevation. At all of the sites except Manchester[4] the total water level elevation exceeds the shoreline crest elevation which indicates a zone of potentially high wave velocity inland of the shoreline crest. In all cases the total water level exceeds the current Base Flood Elevation of 13 feet NAVD88 as mapped by the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM) for Kitsap County (FEMA 2017). The coastal BFE is calculated as the total still water elevation for a 1% annual chance flood plus the additional flood hazard from overland wave effects (storm-induced erosion, wave run-up, and overtopping) and does not account for SLR so this is the expected result.

[4] In the case of Gorst, the still water elevation exceeds the shoreline crest and wave runup is calculated across the inland topography.

Table 4. Wave run-up and TWL calculation results and inputs for each site.

Site	Armored Shoreline?	Site MHHW tidal datum (feet NAVD88)	Combined Storm Surge and SLR value (feet)[1]	Still water level (feet NAVD88)	Shoreline Crest Elevation (feet NAVD88	Shoreline slope (H:V)	Wave Run-up $R_{2\%}$ (feet)	Total Water Level (feet NAVD88)
Hansville		8.4	3.9	12.3	13.8	7.2	4.0	16.3
Port Gamble	Y	8.2	3.9	12.1	13.8	4.1	3.3	15.4
Kingston		8.4	3.9	12.3	13.4	29.5	1.3	13.6
Seabeck		8.6	3.9	12.5	14.6	3.0	3.2	15.7
Silverdale	Y	9.3	4.0	13.3	13.8	5.5	1.9	15.2
Manchester		8.9	3.9	12.8	20.9	4.1	4.5	17.3
Gorst		9.0	4.3	13.3	14.2 (inland crest elevation)	29.5	0.1[2]	13.4

Notes:

1. Combined storm surge and SLR value (RCP 8.5, 50% probability for year 2050) provided by Facet (2025).
2. Depth limited waves height used for run-up calculation because thestill water elevation exceeds the shoreline crest. Wave run-up calculated on inland slope across the parking lot.

4 Bluff Recession

The following section provides an evaluation of the potential impacts of SLR on coastal bluff erosion in Kitsap County. The evaluation first provides a limited literature review of the most recent science of predicting the impacts of SLR on coastal bluff recession rates followed by the anticipated impacts from SLR to Kitsap County shorelines and recommendations to reduce the potential risk from bluff erosion.

4.1 Literature review

Puget Sound bluff geology and erosional processes related to bluff recession are described in several technical papers (Shipman 2004; Johannsen and MacLennan 2007; and MacLennan et al. 2018). The erosion mechanisms for bluffs are categorized as those related to wave action and toe erosion and those related to upland processes (raveling, soil creep, block failure, and hydrology – surface runoff and seepage). These processes result in landsliding, both shallow and deep-seated. The occurrence of these is dependent on site-specific conditions such as bluff height, geology, hydrology, shoreform, and hydrodynamics (wind-wave energy and water levels), and land-use management. Bluff recession can be the result of a cyclical process in which wave action removes material at the toe of a slope, creating an unstable bluff through oversteepening the slope that eventually leads to mass wasting and delivery of new material to the base of the bluff slope (Shipman 2004). This material delivered to the base of the bluff is a primary source of sediment for Puget Sound beaches. Climatic conditions and stratigraphy (geology) are cited by Johannesen and MacLennan (2007) as having a greater influence on erosion than wave-induced toe erosion.

All of the factors cited above and illustrated in Figure 5 result in spatial and temporal variability in bluff erosion. Bluff recession is usually not a linear process and is more typically the result of one larger scale “change event” every 15-25 years (MacLennan et al. 2018). Although smaller scale sloughing of bluff material may also occur more frequently causing bluff recession of a couple of inches per year. Long-term bluff recession rates are documented at nine locations throughout Kitsap County by MacLennan (et al. 2018). A list of these sites and the erosion rates is provided in Table 5. The recession rates were measured using a combination of aerial photograph analysis and field-based methods. The average long-term erosion rate throughout Puget Sound was approximately 0.3 feet per year and in Kitsap County the average was slightly higher at approximately 0.4 feet per year and a median of 0.1 feet per year (MacLennan et al. 2018). The highest long term recession rate in Kitsap County is documented as approximately 1.6 feet per year at a bluff near Eglon, along the east facing shoreline of the Peninsula which is exposed to large wind-waves generated across the central basin in Puget Sound. The erosion rates provided by MacLennan et al (2018) can typically be applied to the bluffs within the same littoral drift cell[5].

[5] The stretch of shoreline in which sediment moves in one dominant direction and bounded by a change in geology and landscape.

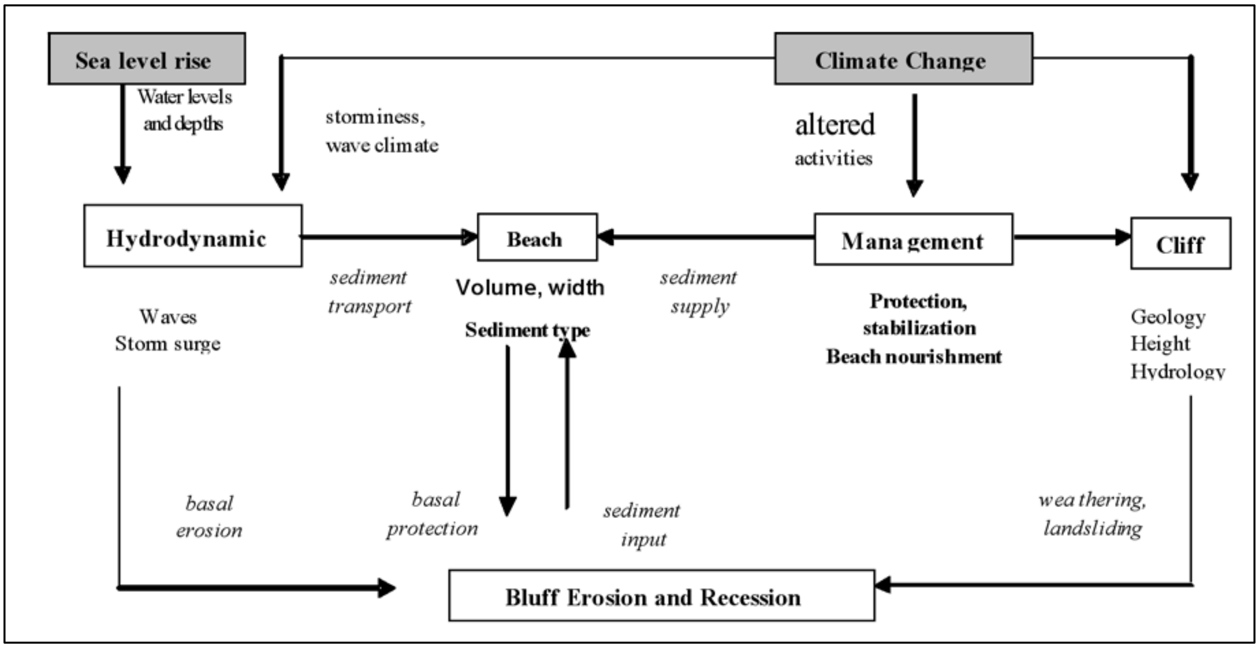

Figure 5. Summary of factors influencing bluff erosion, adapted from Bray and Hooke (1997).

Table 5. Long term bluff recession rates measured in Kitsap County (MacLennan et al. 2018)

Site # and Location	Description	Erosion Rate (feet per year)[1]
8	Port Madison (Bainbridge Island)	-0.07
9	South Sinclair Inlet	-0.08
10	North Bremerton	-0.08
11	Keyport	-0.10
12	Liberty Bay (west of Poulsbo)	-0.11
13	Point Jefferson (near Indianola)	-0.22
138	Hood Canal (south of Coon Bay)	-0.36
143	Eglon	-1.63
149	Hood Canal (near Bangor)	-0.49
Median		-0.11
Average		-0.38

Notes:

1. The erosion rates are taken directly from the cited report, but should be used as an approximation since the uncertainty of the methods ranges between 0.08 to 0.84 feet per year depending on the length of available data and the data sources.

Projected sea level rise will add a new factor affecting and potentially accelerating the long-term rates of bluff recession. Previous research into the relationship between sea level rise and shoreline recession follows the concepts of equilibrium profile geometry and sediment conservation, as introduced by Bruun (1962) and typically applied to low-lying coastlines (known as the Bruun rule). More recent research by Ashton et al. (2011) and Lee (2005) which build on the Bruun rule have been applied to bluffs in the Puget Sound region (and Kitsap County) on a site-specific basis. Both methods rely on historical recession rates to predict anticipated future bluff recession for a given change in the rate of SLR. The application of each approach requires making assumptions about the feedback process between SLR and the erosion process, although the method by Ashton et al. (2011) attempts to more systematically present these judgements in their model. An additional method for projecting recession rates developed by Limber et al. (2018) has been tested in Puget Sound at four sites by Little (2024). The method relies on an empirically derived site-specific calibration constant.

In addition to increased SLR, climate change is predicted to result in changes to the local climate in Puget Sound. Mauger et al. (2015) summarizes the state of knowledge with regard to climate change impacts in the Puget Sound region. The research predicts changes to seasonal precipitation such as a decline in the summer and an increase in winter, spring, and fall precipitation. The research also predicts changes to annual precipitation amount and heavy rainfall events ("atmospheric river") events are predicted to become more severe. Increased heavy precipitation events, like increased SLR, are likely to have implications for bluff recession in Kitsap County, however we are not aware of quantitative predictions of changes to bluff recession related to these events.

The application of methods for calculating future bluff recession is dependent on the precision of historical estimates, the assumptions about future SLR, and assumption about physical forcing mechanisms interaction with the bluff. Kaminsky et al. (2014) completed an assessment of bluff recession rates and applied the method for predicting future recession rates by Lee (2005) on bluffs near Port Angeles, WA. Their report recommended that further studies are needed to evaluate the importance of event forcings (wave energy, water levels, and precipitation patterns), key factors in forecasts of bluff erosion under climate change, and their link to bluff erosion patterns. Site-specific studies of forcing mechanisms are, however, expensive and time consuming to complete, particularly at a county-wide level. Little (2024) suggests that modeling of future recession rates could be improved with increased and more frequent measurements of bluff recession to provide insight into how SLR is already influencing bluff recession. The study also stressed the importance of planners to consider the upper and lower confidence bounds in any estimates of modeled recession rates when using them for shoreline management.

4.2 Impacts and recommendations

Increased bluff recession rates resulting from SLR (and other climate change impacts) in Kitsap County have the potential to accelerate changes to the shoreline than if sea levels were not rising. This will increase the potential vulnerability resulting from shoreline erosion of both public infrastructure and private property throughout the County.

As sea levels rise, the face of the bluff will become saturated at higher levels and can weaken the sediments and increase the rate of erosion. The increased intensity of heavy precipitation events is expected to increase the flow of surface water across the face of the bluffs which can result in more episodes of shallow and deep-seated landslides depending on the geology. Initially, the sediment eroded from the face of the bluff, will be deposited on the shoreline and protect the toe of the bluff. Overtime, the deposited sediment will be mobilized and transported alongshore, exposing the toe of the bluff and the cycle will repeat.

It is important to recognize that bluff recession, landslides, and discharge of sediment to the beach are important natural processes required to sustain beach widths and shoreline habitats both at the toe of the bluff and further alongshore. However, as bluffs gradually recede landward encroaching on land use there will be a continued desire from infrastructure managers and property owners to protect their property and assets.

Land use planning for coastal hazards typically falls in three categories: reduce, retreat, relocate. Potential planning recommendations to reduce risk from bluff erosion in these three areas are discussed in the bullets below.

Reduce:

- Since bluff recession can be accelerated by increased surface water runoff, controlling the surface water is one of the primary ways to reduce the potential for increases in bluff recession.
    - Controlling surface waters can be done through drainage management techniques for residential properties and roads. Managing surface waters on shoreline properties typically involves collecting surface water from impervious surfaces into a drainage pipe and running the pipe as a tightline down the face of the bluff and to the toe of the slope with a T-diffuser on the end.
    - Adding vegetation in the upland, particularly large trees, can reduce the potential for bluff recession by both stabilizing sediments within the root structure, up taking water through the roots, and diffusing precipitation across the land as it hits the tree canopy.

- Reducing the amount of infrastructure for access to the shoreline on the face of bluffs can also decrease recession rates. Shoreline access structures add weight to the bluff face, create holes and destabilize sediments where they are anchored and reduce the vegetation on the bluff face. In addition, these structures require maintenance which will cause a regular disruption of the bluff. One way to reduce shoreline access infrastructure is through having communal access points rather than individual parcel access.

- Traditional shoreline protection structures such as bulkheads, seawalls, and revetements can reduce wave erosion at the toe of the bluffs, but they will not prevent landslides as the result of upland forces. In addition, these structures prevent sediment from being deposited on the beach and therefore starve the shoreline of sediment at the toe and within the drift cell. This loss of sediment at the bluff toe (also called colluvium) exacerbates erosion rates at the base of the bluff and affects shoreline habitats (shellfish, eelgrass, forage fish etc. [Shipman 2018]). These types of structures are not typically recommended for bluffs for these reasons, and they will provide limited protection against SLR.

- Nature based solutions such as beach nourishment and placement of large wood can reduce shoreline erosion in some cases, but have limited applications. The toe of a bluff is typically in a dynamic location within a littoral drift cell and the toe of the bluff typically interacts with wind-waves at tidal elevations equal to mean higher high water and higher. Therefore, placing beach nourishment could provide a short term solution, but would need to be repeated on a maintenance cycle of perhaps every 4 to 5 years to reduce recession rates. While large wood (not anchored) has proven to be efficacious in low bank beach shorelines, placing large wood at the toe of a bluff has not been particularly effective. This is because the beach at the toe of the bluff is a narrower swath than on beaches and buoyant wood moves under wind-waves and high water levels.

Retreat:

- Proactively planning to move infrastructure and residences landward on the same parcel to increase the setback distance from the bluff crest and allow bluff recession to continue (sometimes known as shoreline retreat) can reduce the hazard of bluff recession. This approach requires there to be sufficient space in the upland which is owned or can be acquired in which to move the primary infrastructure as well as supporting infrastructure such as utilities.

- For roads, this reduction strategy could result in a two lane road being reduced to a one-way road, for example.

Relocate:

- One of the best long term measures to reduce the risk of infrastructure to the effects of bluff recession is to plan to remove the infrastructure from the top of the bluff and rebuild it in another location. This is the most complex option as it involves abandoning the current land use and new land acquisition. However, there are organizations such as Greater Peninsula Land Trust who focus on conservation of natural areas and are interested in purchasing properties which will provide long term protection to feeder bluffs.

5 Limitations

The wave run-up estimates presented in this memorandum should be interpreted within the range of uncertainty and caveats associated with climate-change induced sea level rise projections as well as the approximation of the input parameters (slope, elevations, and wind-wave estimates). The slopes and elevations of the existing ground and elevations in the shoreline areas are based on publicly available LiDAR data and not on a detailed topographic or bathymetric survey (which is not currently available). Wind-wave estimates are based on non-site specific wind measurements and one-dimension wave hindcast methodology does not account for bathymetric effects on wave development (refraction and diffraction). The calculations of wave run-up were developed only for planning purposes and are not to be used for engineering design.

6 Closure

This document has been prepared by Blue Coast Engineering LLC. in accordance with generally accepted engineering practices and is intended for specific application to the Kitsap County Sea Level Rise (SLR) study in Kitsap County, WA. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization from Blue Coast Engineering LLC. No other warranty, expressed or implied, is made. Blue Coast Engineering LLC. and its officers, directors, employees, and agents assume no responsibility for the reliance upon this document or any of its contents by any parties other than the Facet and Kitsap County, WA. The information in this document is to be used for planning purposes and is not intended for design or construction.

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Attachment A – Additional Figures

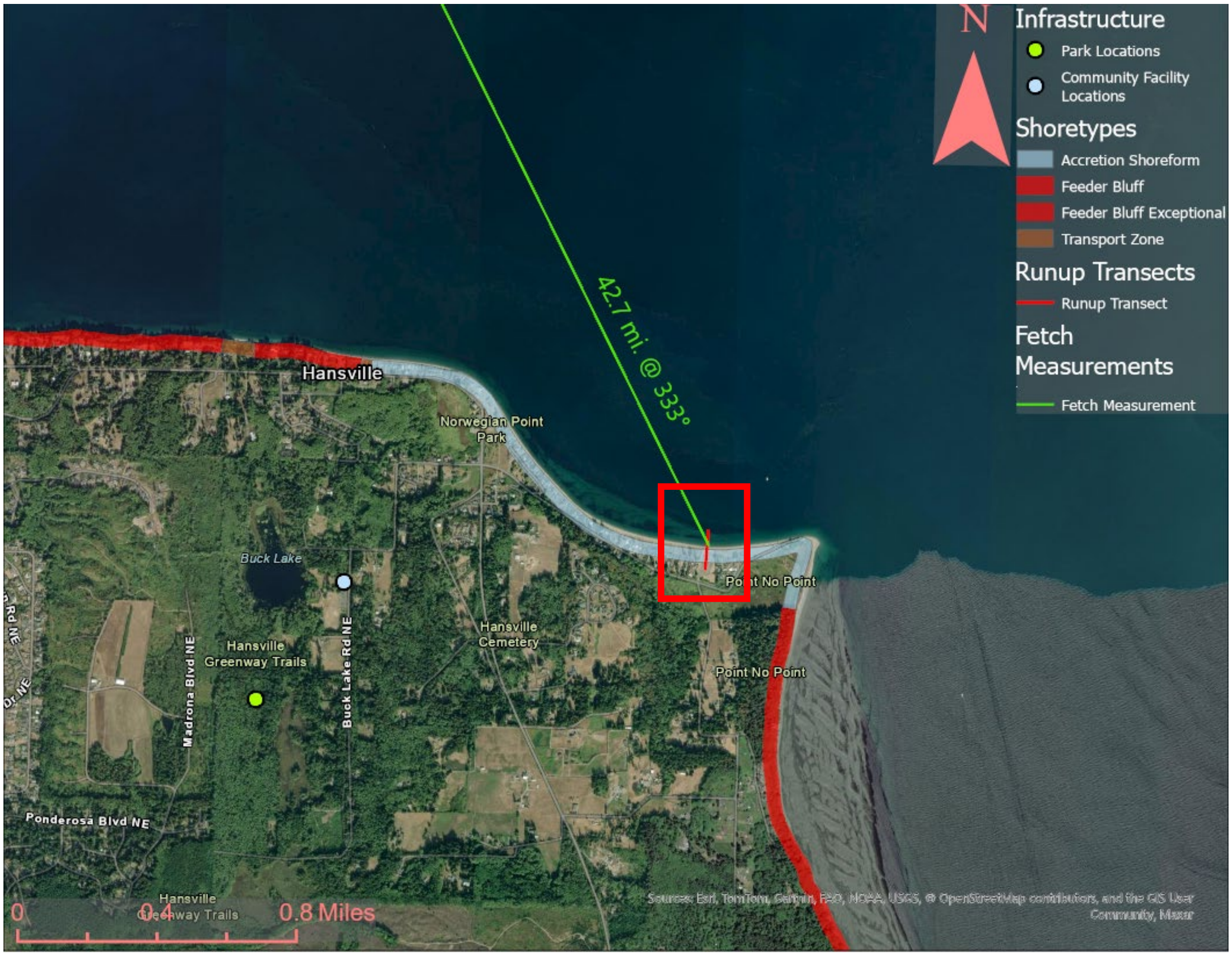

Figure A-1. Overview map of Hansville coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

Figure A-2. Plan view of the Hansville coastal flood evaluation site.

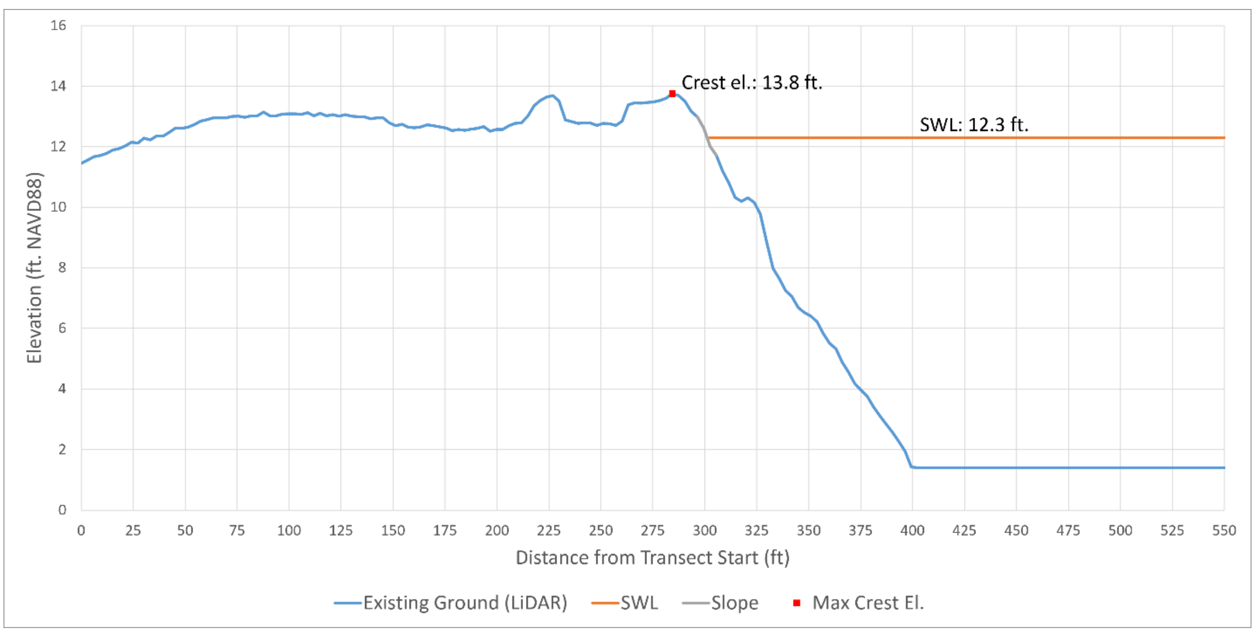

Figure A-3. Cross-section evaluated at Hansville site.

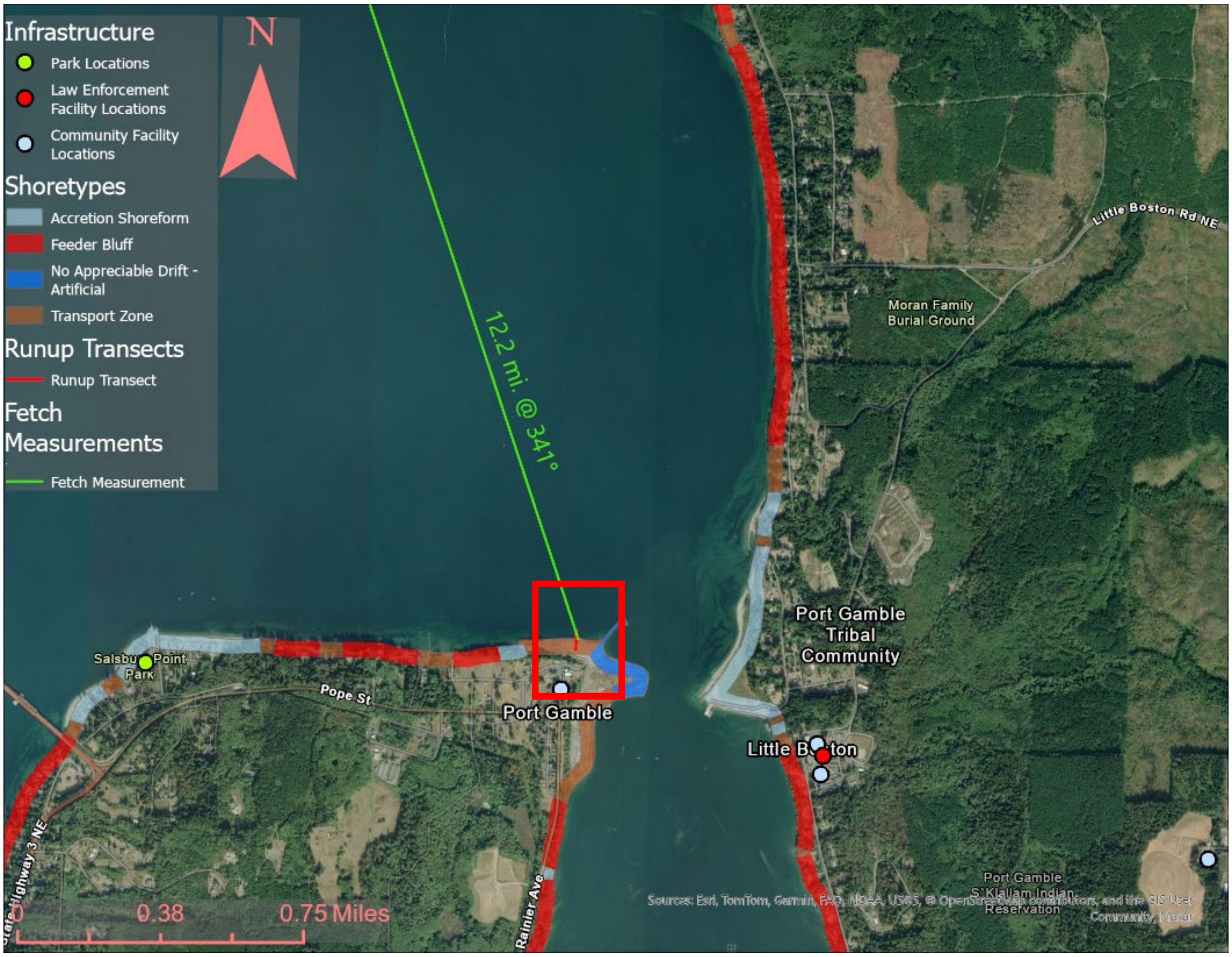

Figure A-4. Overview map of Port Gamble coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

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Figure A-5. Plan view of the Port Gamble coastal flood evaluation site.

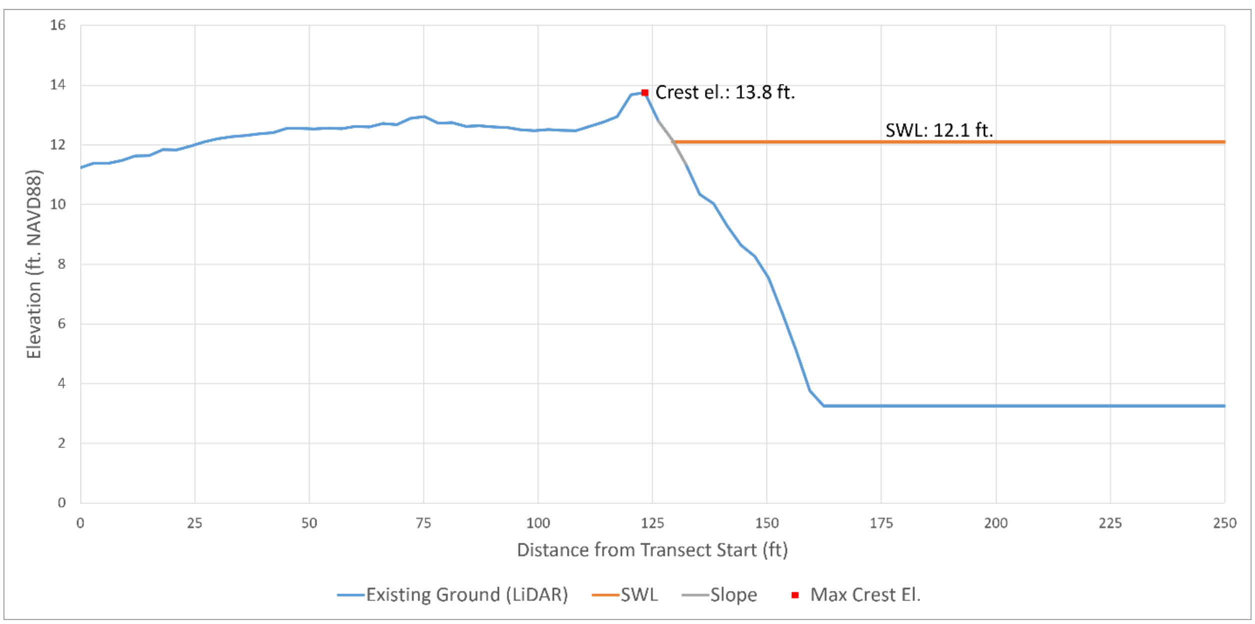

Figure A-6. Cross-section evaluated at Port Gamble site.

Figure A-7. Overview map of Kingston coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

Figure A-8. Plan view of the Kingston coastal flood evaluation site.

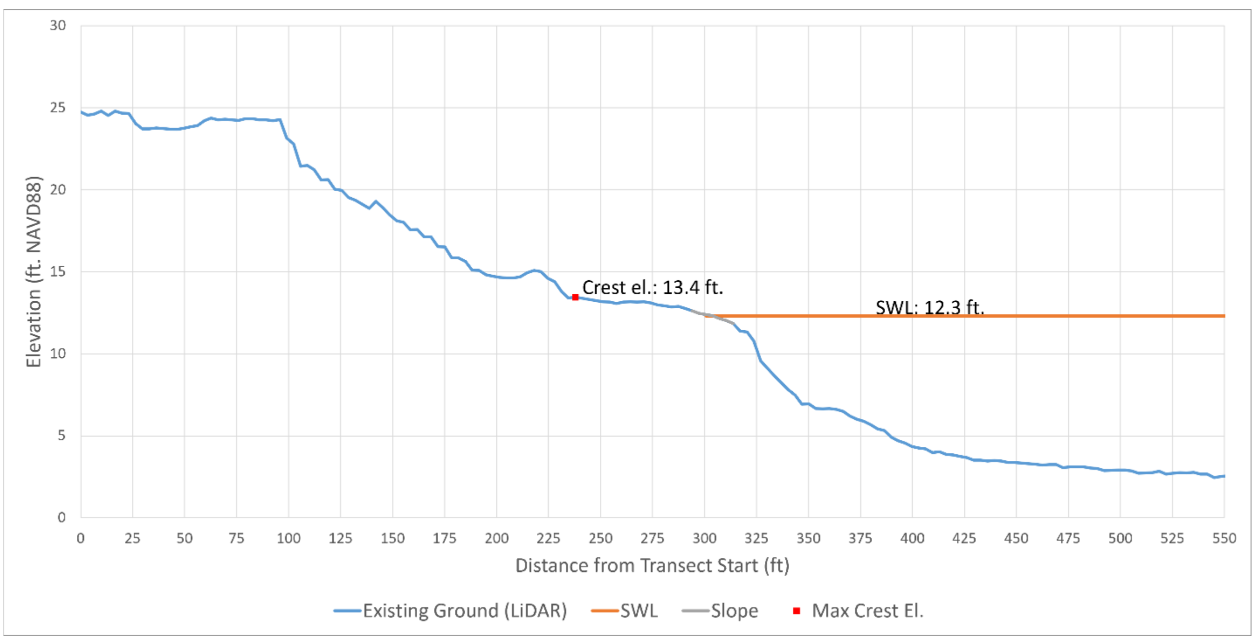

Figure A-9. Cross-section evaluated at Kingston site.

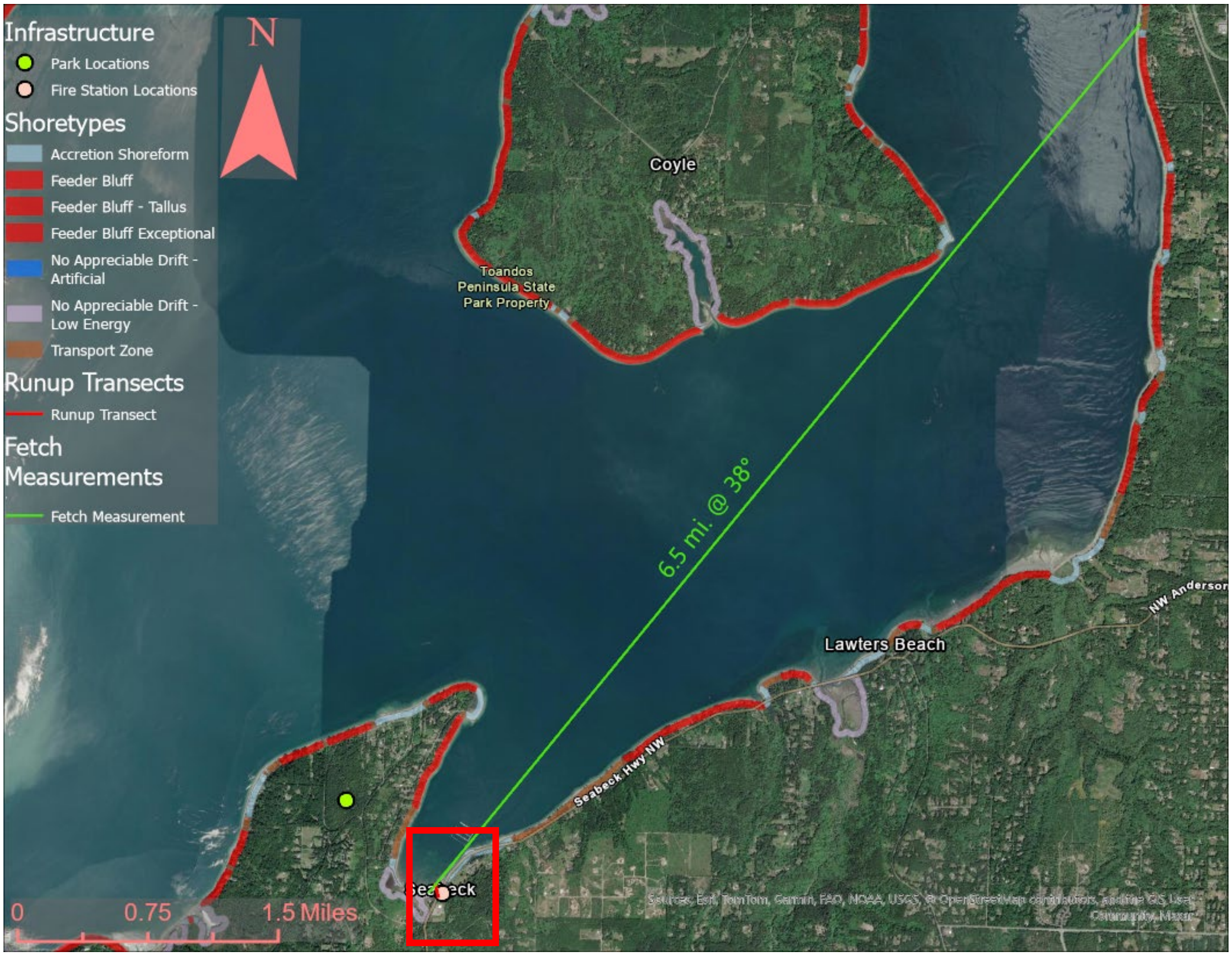

Figure A-10. Overview map of Seabeck coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

Figure A-11. Plan view of the Seabeck coastal flood evaluation site.

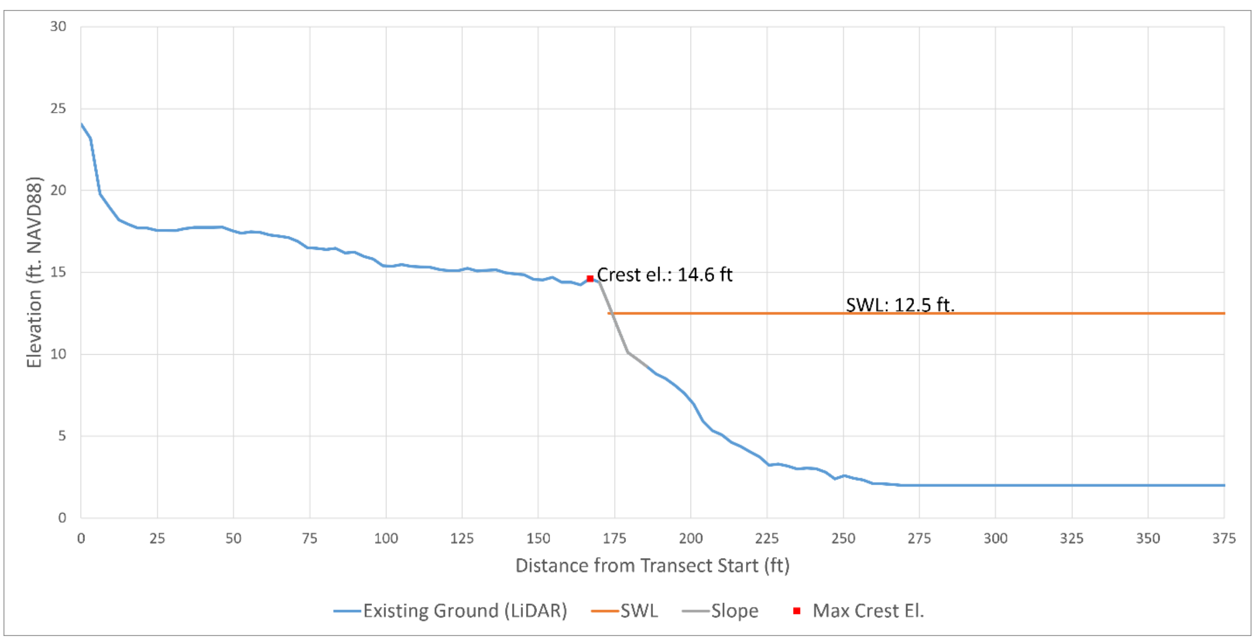

Figure A-12. Cross-section evaluated at Seabeck site.

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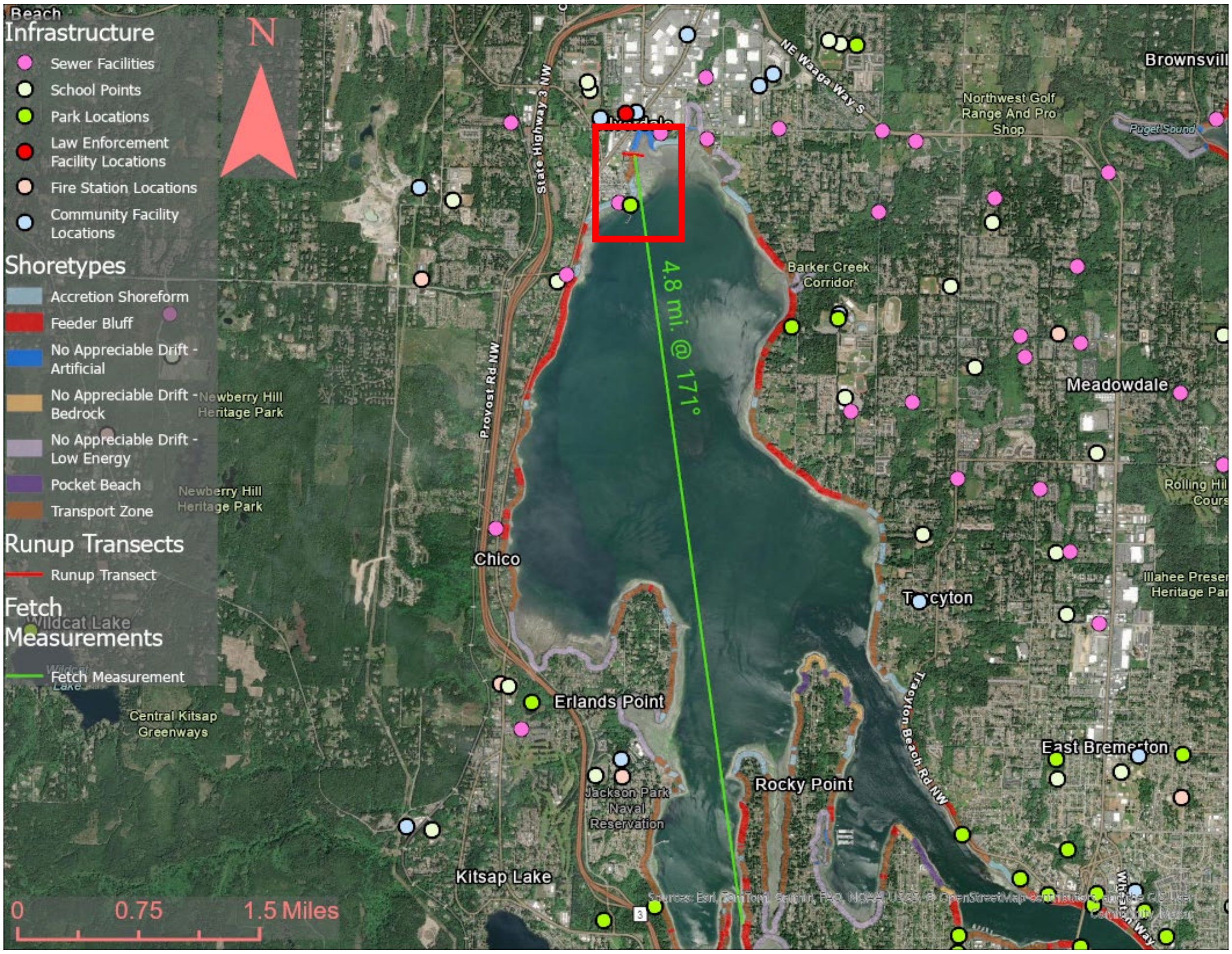

Figure A-13. Overview map of Silverdale coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

Figure A-14. Plan view of the Silverdale coastal flood evaluation site.

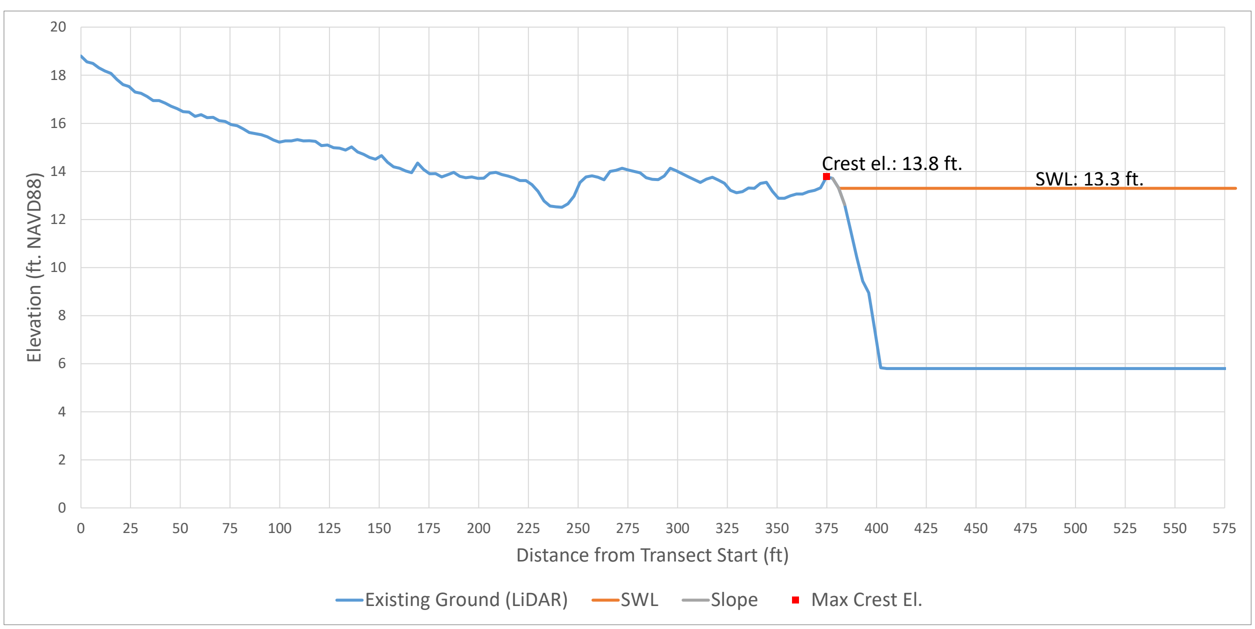

Figure A-15. Cross-section evaluated at Silverdale site.

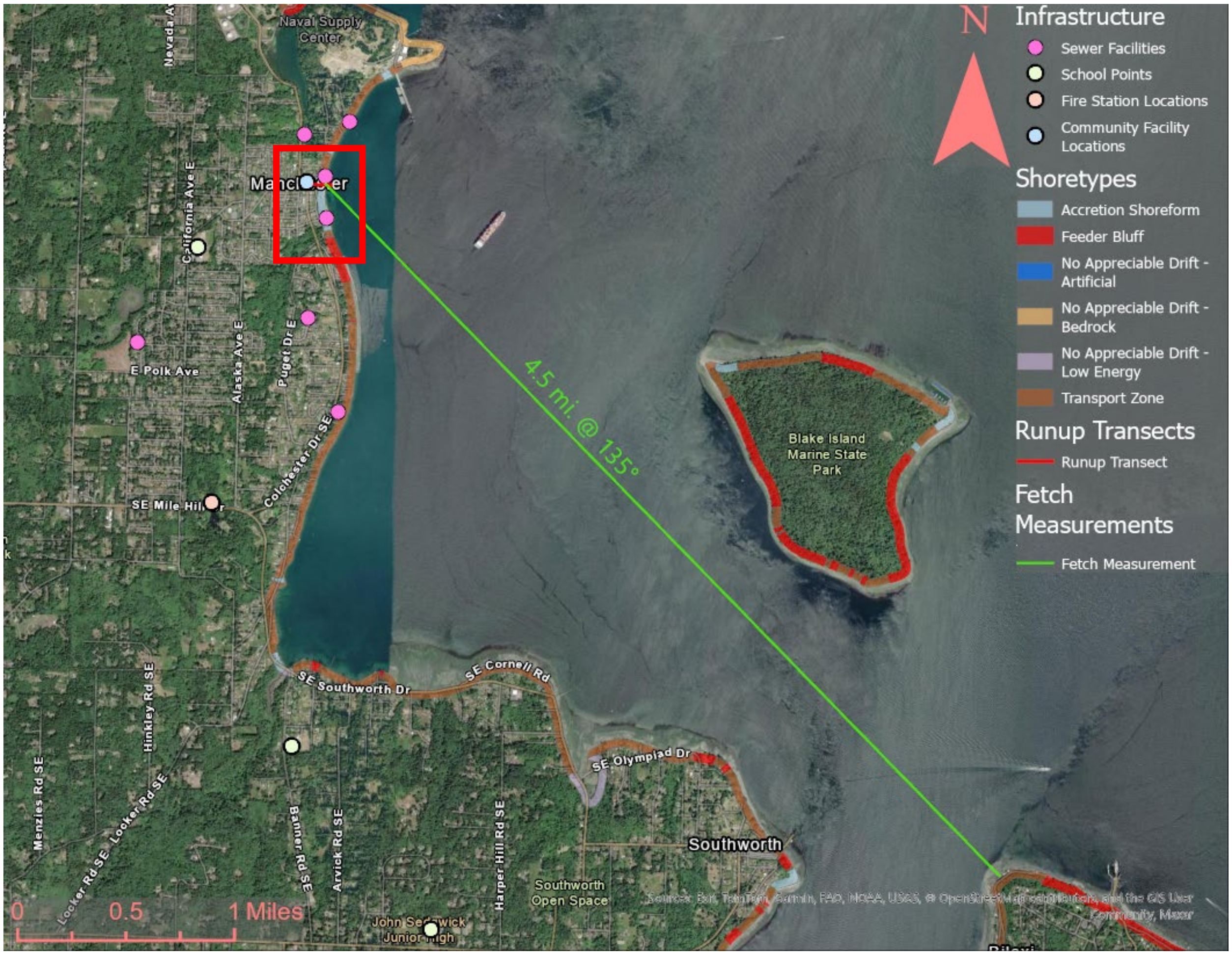

Figure A-16. Overview map of Manchester coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

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Figure A-17. Plan view of the Manchester coastal flood evaluation site.

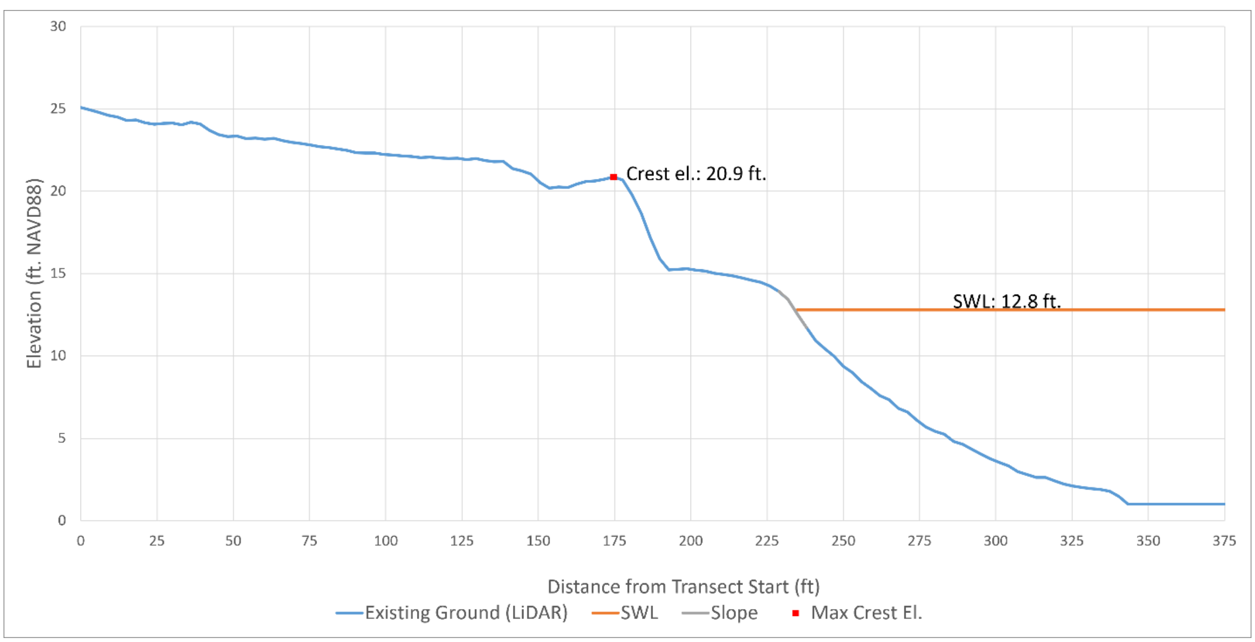

Figure A-18. Cross-section evaluated at Manchester site.

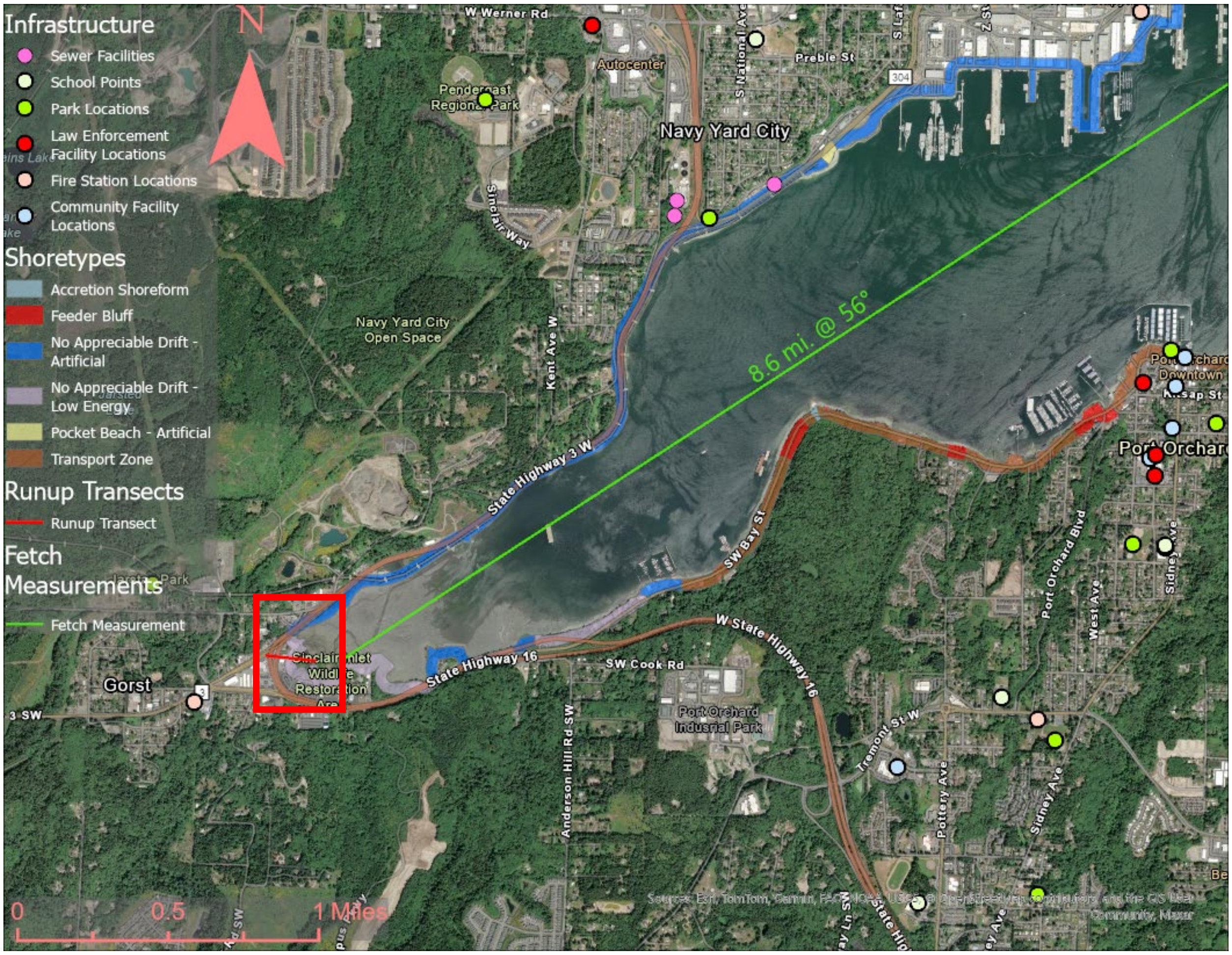

Figure A-19. Overview map of Gorst coastal flood evaluation site showing maximum fetch measurement. Red box indicates approximate shoreline reach focus area.

Figure A-20. Plan view of the Gorst coastal flood evaluation site.

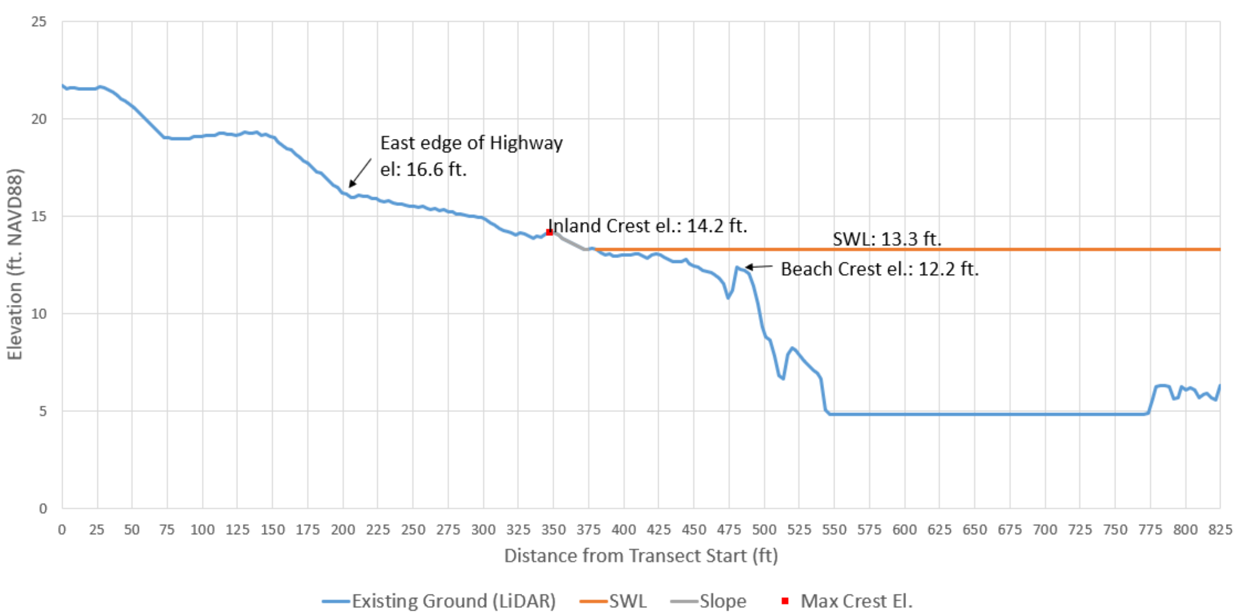

Figure A-21. Cross-section evaluated at Gorst site.