Port of Bellingham Coastal Vulnerability Assessment

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

BFE	Base Flood Elevation
CAS	Climate Action Strategy
CORS	Continuously Operating Reference System
CoSMoS	Coastal Storm Modeling System
EA	EA Engineering, Science, and Technology, Inc., PBC
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Studies
FRM	Flood Risk Management
ft	Foot (feet)
GCMs	Global Climate Models
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
in.	Inch(es)
NAVD88	North American Vertical Datum 1988
NFHL	National Flood Hazard Layer
NGS	National Geodetic Survey
NNBF	Natural and Nature Based Features for Flood Risk Management
Port	Port of Bellingham
RCP	Representative Concentration Pathway
RSLR	Relative Sea Level Rise
SLR	Sea Level Rise
USACE	U.S. Army Corps of Engineers
USGS	United States Geologic Survey
UW	University of Washington
WSRN	Washington State Reference Network

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EXECUTIVE SUMMARY

The Port of Bellingham (Port) is a special purpose municipal corporation engaged in a variety of business operations including marine and aviation, community and economy, administration, and land management. The Port operates approximately 300 acres of tideland and 1,600 acres of land in Blaine, Sumas, Bellingham, and unincorporated Whatcom County. The Port's marina operations support private and public boats, commercial fishing operations, and serve as a main passageway between the U.S. and Canada.

Sea Level Rise (SLR) associated with climate change is putting coastal operations such as the Port's at increased risk. These risks include flooding, and an increase in the frequency of intense storms and associated storm surge. Without proper planning and implementation of mitigation/adaptation efforts the Port could see direct impacts to the marine economy (resulting in loss of jobs), built and natural infrastructure, and various other assets.

This high-level coastal vulnerability assessment (Vulnerability Assessment) identifies Port assets that are at the greatest risk to adverse flooding and storm impacts resulting from SLR. This Assessment is an essential tool for future resilience and planning by the Port. It will help the Port take steps to protect its most vulnerable assets, develop measures to improve coastal resilience, and reduce greenhouse gas emissions.

This Vulnerability Assessment is a component of the Port's Climate Action Strategy, a broader effort that includes inventorying the Port's Greenhouse Gas emissions and identifying short, medium and long-term actions to reduce them. **The goal of the Vulnerability Assessment is to identify the Port's most vulnerable properties and to begin to develop adaptation strategies to address the impacts of future SLR, storm events, and river flooding.**

Approach

Data and mapping information of Port infrastructure were compiled into a GIS framework, along with inputs from the "Topobathymetric Model of Puget Sound, Washington, 1887 to 2017". This was done to map the Port's physical infrastructure and the surrounding natural shoreline. The next step was to overlay Port properties with output from the U.S. Geological Survey's (USGS) Coastal Storm Modeling System (CoSMoS), which integrates global, regional, and local scale numerical models to identify areas of the Port vulnerable to flooding under various scenarios. From this effort, two types of maps were developed:

- Estimated flood extent for a given storm event with varying levels of SLR.
- Estimated vulnerability for the Port, on a scale from low (unshaded) to high (red).

The vulnerable areas are ranked as “Low”, “Medium”, “Medium High”, and “High” to help the Port further investigate and prioritize vulnerable infrastructure. This ranking utilized the University of Washington’s (UW) Climate Impacts Group relative SLR projections and focused on two scenarios. The first scenario represents a 17% likelihood of occurrence; the second a 1% likelihood of occurrence. As shown in Figure ES-1, the CoSMoS model outputs, together with the 17% and 1% UW local SLR scenarios, predict the Bellingham shoreline could see one meter of relative SLR between 2083 and 2119.

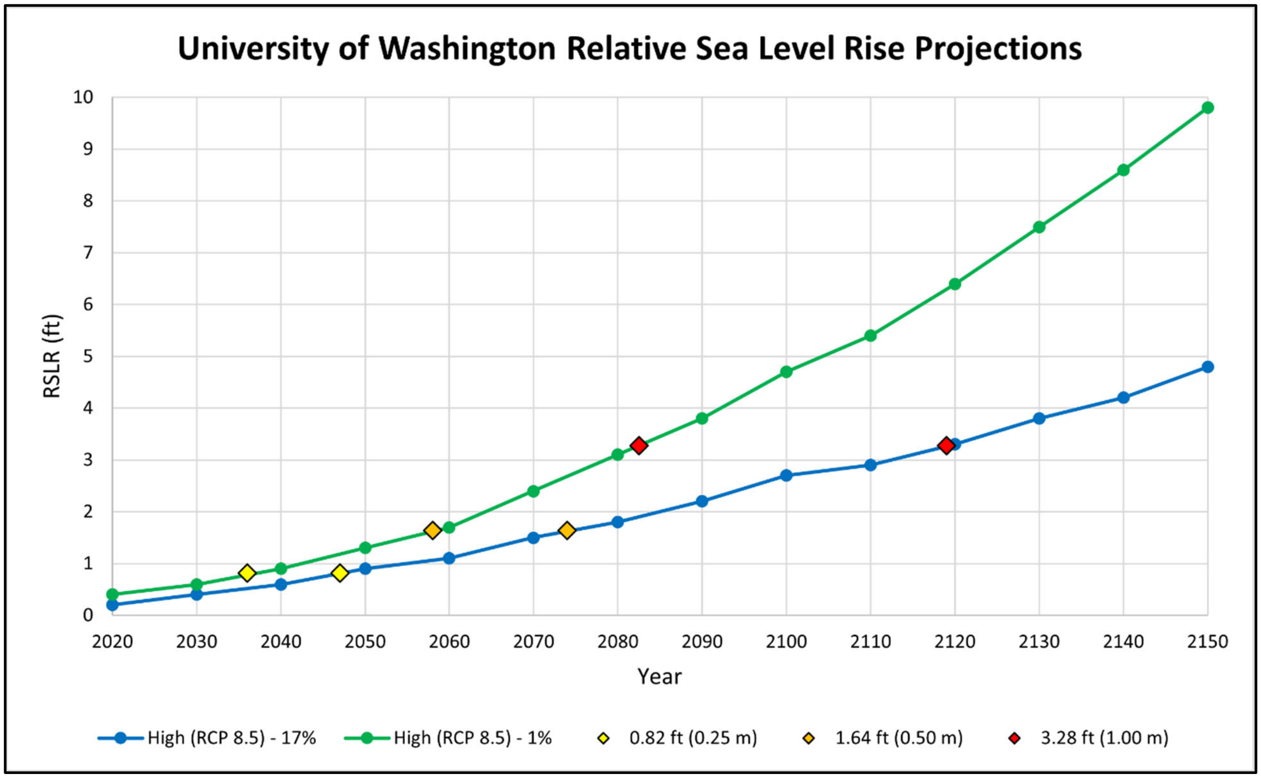

Figure ES-1. Relative Sea Level Rise Projections Port of Bellingham (Miller et al. 2018)

Through this Vulnerability Assessment, it is clear the Port is at risk of flooding under current conditions (no SLR) scenarios during king tides and/or intense rain events. Relative SLR resulting from climate change will exacerbate its vulnerability.

The Vulnerability Assessment identified the low-lying areas of the Port that are most at risk of flooding and therefore the most vulnerable. These highly vulnerable areas include regions around:

- Squalicum Parkway Industrial Area
- Bellingham Shipping Terminal Area

- Marine Trades Area by the I & J Waterway
- The Fairhaven Marine Industrial Park

These locations, which could be impacted by the flooding, include several parking lots, offices, local businesses, boat yards, public recreation areas, railroads, roadways, and utilities. Figures ES-1 and ES-2 show the king tide and 100-year storm event (1% chance of occurring in any given year) scenarios for the Squalicum Parkway Industrial Area as examples of the potential flooding impacts of rising sea levels and increasing storm intensity.

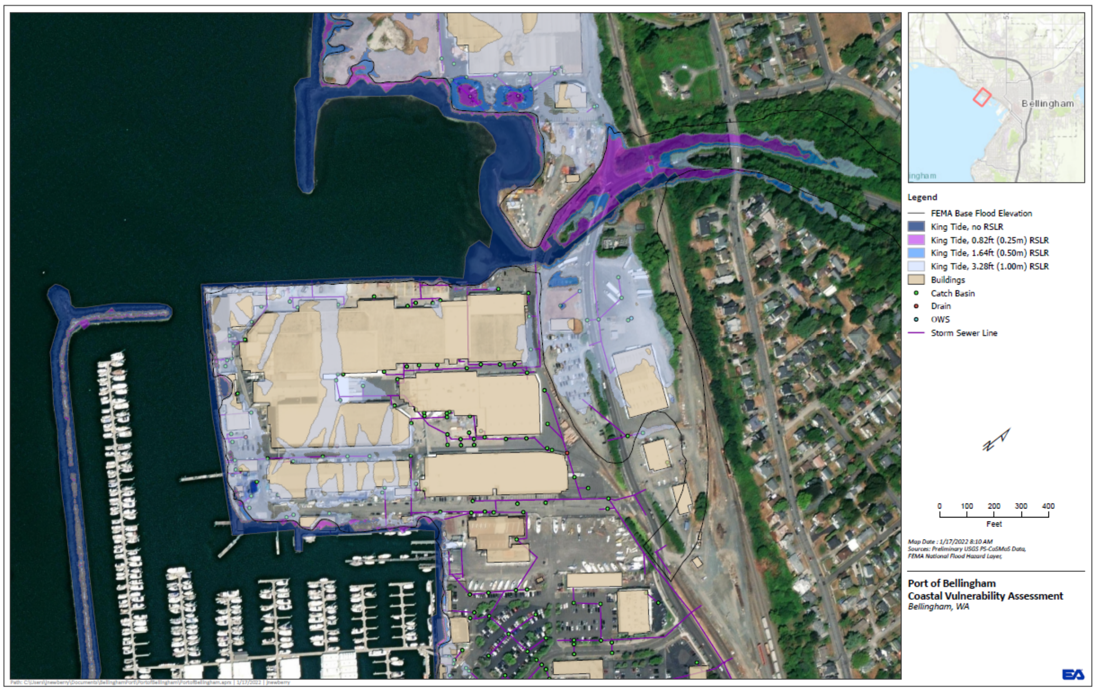

Figure ES-1. King Tide Scenarios— Squalicum Parkway Industrial Area

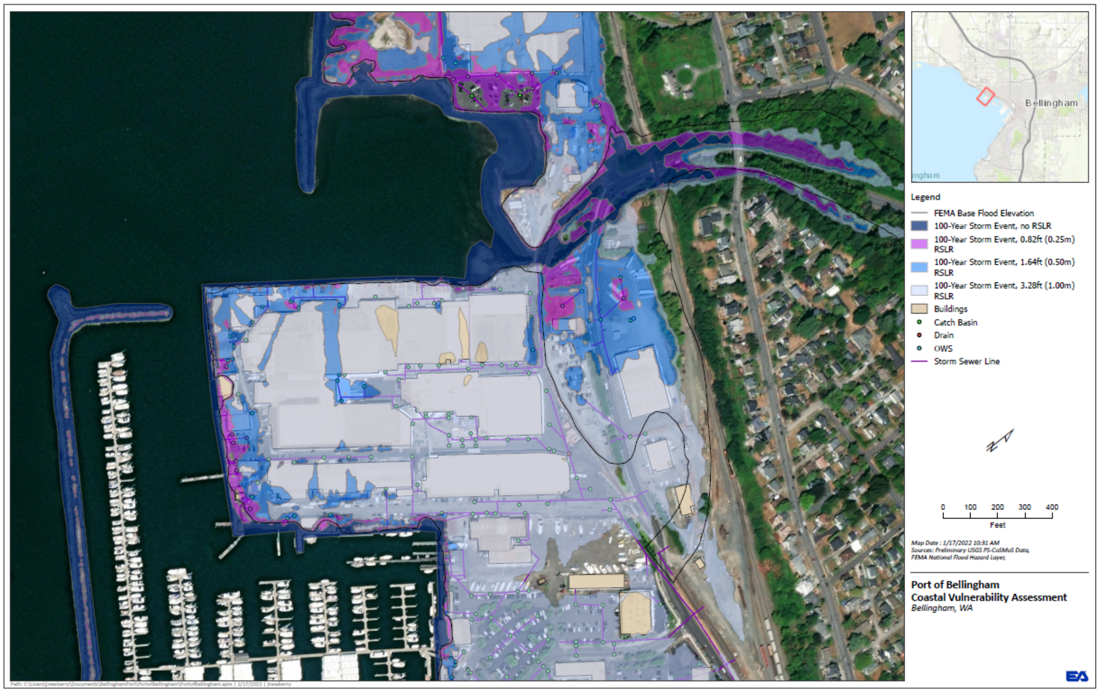

Figure ES-2. 100-Year Storm Event Scenarios— Squalicum Parkway Industrial Area

Completing an exposure, sensitivity, and adaptive capacity analyses of the vulnerable areas identified in this Vulnerability Assessment is the next step in identifying specific mitigation/adaptation measures that could lessen the damage from flooding. Altering current infrastructure, building new infrastructure, or employing nature-based solutions could help curb the effects of flooding. Building or altering infrastructure using this information could allow for a direct mitigation of flood effects. Nature-based solutions could provide increased protections while minimizing the impact on coastlines, leading to the creation of additional habitat.

1. INTRODUCTION

1.1 THE PORT OF BELLINGHAM

The Port of Bellingham (the Port), located in Whatcom County, Washington, is a special purpose municipal corporation that supports more than 240 businesses. The Bellingham International Airport, multiple harbors, and real estate ventures account for the largest portion of the Port's business operations. The Port's main mission is to fulfill the essential transportation and economic development needs of the region, while providing leadership in maintaining Whatcom County's overall economic vitality through the development of comprehensive facilities, programs, and services. The Port contributes approximately 10% of Whatcom County's economic activity through its various businesses. The Port's marinas support private and public boats, commercial fishing operations and serve as a main passageway between the U.S. and Canada. (Port of Bellingham 2022).

The Port is divided into eight planning areas: Blaine Harbor, Sumas International Cargo Terminal, Bellingham International Airport, Little Squalicum Beach, Squalicum Harbor, Bellwether on the Bay, The Waterfront District, and Fairhaven. There are approximately 2,000 boat slips, three boat launches, four industrial parks, a multi-modal transportation center, and a network of other entities in place for public use. Blaine Harbor serves as the main entry port between the Northwestern United States and Southwestern Canada, while the other harbor locations serve various other economically important needs by attracting a variety of tenants. The traffic generated by the various functions of the Port of Bellingham allows the Port to contribute to the economy of the county (Port of Bellingham 2022). For example, the Port is well located for commercial fishing vessels to reach southeastern Alaskan waters, the Puget Sound and other Pacific Northwest waters. Commercial fishing vessels contribute to the economy both directly by paying for services in the Port, and indirectly by creating job opportunities, paying taxes, and spending money in the area (Port of Bellingham 2014). The same can be said for other commercial and private operations out of the Port. Any operation that brings an influx of people also brings an influx of money spent in the local area.

Sea Level Rise (SLR) associated with climate change is putting coastal operations at increased risk of flooding. Climate change is also driving higher frequency of more intense storms and associated storm surge that could negatively affect the Port (ECONorthwest 2019). Without proper contingency planning and implementation of mitigation/adaptation efforts the Port could see impacts to the marine economy (resulting in loss of jobs), built and natural infrastructure, and various other vital assets (ECONorthwest 2019). A coastal vulnerability assessment is essential to the future planning of the Port as it provides identification of the most at-risk areas and informs the discussion of possible measures that could be implemented.

It is especially important in the face of impacts from climate change, including the anticipated increase in storms, to protect the operations conducted at the Port and to preserve its economic vitality. Mitigation/adaptation efforts can be made both by improving coastal resilience and by decreasing the fossil fuel emissions of the Port to help reduce greenhouse gas emissions which will curb increases in global temperatures (ECONorthwest 2019).

1.2 CONTEXT FOR THE COASTAL VULNERABILITY ASSESSMENT

EA Engineering, Science, and Technology, Inc., PBC (EA) prepared this Vulnerability Assessment as part of the Port's overall goal of developing a comprehensive Climate Action Strategy (CAS). The CAS is being developed to address the physical and economic effects of climate change on the Port's operations and will include a range of adaption strategies appropriate for the Port. This report focuses on the potential impacts to the Port resulting from the effects of climate change including present-day and future coastal storms. For this report, the climate change effects that were primarily considered were 1) increased frequency and intensity of storm events and 2) localized sea level increase due to Relative Sea Level Rise (RSLR). Under the current understanding of climate change, models project that there will be significant increases in sea level, which will increase the vulnerability of coastal areas. The Vulnerability Assessment can be viewed as an initial step in identifying the areas around the Port for which to conduct a more detailed Exposure, Sensitivity, and Adaptive Capacity (ESA) Analysis.. In this assessment, the vulnerability primarily correlates to exposure by showing which assets face impacts associated with climate change. Chapter 4 then provides the methodology for conducting an ESA analysis a provides the results of a pilot ESA conducted for the area around the Central Maintenance facility.

For additional understanding of the vulnerability of the Port region, EA reviewed publicly available reports developed for local, regional, or state entities concerning protection from and response to natural hazards. These reports are summarized below and were used in conjunction with EA knowledge to develop a draft CAS Vulnerability Matrix. This CAS Vulnerability Matrix is included in Appendix B and highlights the Port's vulnerabilities, assets and strengths, data gaps, and recommendations related to specific climate change issues. EA drafted the matrix to inform the development of the overall CAS. Note that this matrix is provided as a reference starting point on items to be considered for the CAS, this Vulnerability Assessment does not cover all the items listed in the matrix. For this assessment, EA relied on draft outputs from the CoSMoS effort carried out by the United States Geological Survey (USGS).

Roadmap to a Climate Action Plan: Port of Bellingham (EconNorthwest, December 2019)

> A 2019 Report commissioned by the Port of Bellingham laid out a "roadmap" to developing a Climate Action Plan for the Port that would identify actions the Port could

take to mitigate its climate change contributions and to adapt to the impacts of climate change. The report initially identifies some vulnerabilities and assets of the Port but recommends a vulnerability assessment to inform the goals and strategies appropriate to adapting the Port to climate change. Recommended steps for the vulnerability assessment include identifying a list of assets including physical or built, natural, human, and social assets, identifying potential impacts of climate change to the asset, assessing the adaptive capacity of the asset (strengths), and using this information to determine an adaptation strategy. EA followed this process in the development of the Vulnerability Assessment Matrix (Section 2.2.2 and Appendix B). The Roadmap provided some information about potential vulnerabilities as well as references to additional resources on these topics which were reviewed and included in EA's report as appropriate.

City of Bellingham Greenhouse Gas Inventory and Climate Protection Action Plan, May 2007)

The City of Bellingham 2007 Greenhouse Gas Inventory and Climate Protection Action Plan laid the framework for the City's commitment to combat climate change. This plan included five Climate Protection milestones and emissions reduction targets for 2012 and 2020. The City has completed the initial five Climate Protection milestones.

City of Bellingham Climate Protection Action Plan 2018 Update

In 2018, the City of Bellingham updated its 2007 Climate Protection Action Plan to include new emissions reduction measures to meet emissions targets for 2020 and beyond. The City aimed to reduce municipal greenhouse gas emissions to 85% below 2000 levels by 2030 and 100% below 2000 levels by 2050 – making the city government carbon neutral. The new emissions targets are 70% below 2000 levels by 2030 and 85% by 2050.

Whatcom County Natural Hazards Mitigation Plan (Whatcom County Sheriff's Division of Emergency Management, June 2021)

The Whatcom County Natural Hazards Mitigation Plan summarizes various hazards that may impact the County to promote public awareness of these hazards, document resources for risk reduction and loss prevention, and identify actions that will increase the safety, resiliency, and sustainability of the community within the County. By doing so, the plan is intended to, "promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards." The plan is updated every five (5) years and maintained on an annual basis. The Port of Bellingham has contributed to the plan, which provided some information on existing infrastructure at the port and on the existing hazards. This information was integrated into the CAS Vulnerability Matrix, which may serve as a baseline for the CAS.

City of Bellingham, Washington, Comprehensive Emergency Management Plan (City of Bellingham, WA, January 2018)

The Comprehensive Emergency Management Plan identifies emergency management concepts, assigns responsibilities for disaster response, and describes how local, state, and federal agencies are anticipated to coordinate responses during an emergency. The plan does not identify any emergency management response specific to climate change or to the Port or identify a specific role for the Port. However, it is helpful in identifying local partners that may assist the Port in the event of an emergency and from there inferring how that response may be impacted by climate change.

1.3 GOALS OF THE COASTAL VULNERABILITY ASSESSMENT

Although climate change will have numerous impacts on the Port, this Vulnerability Assessment will focus specifically on the impacts of RSLR, coastal storm-induced flooding, and other coastal hazards on the built infrastructure and natural features of the Port's property and the surrounding Bellingham Bay shoreline. The goal of this assessment is to provide the Port with detailed maps and data that convey the expected flood extents and the associated vulnerabilities that result from RSLR and coastal storm events. This Vulnerability Assessment and associated maps will help Port divisions assess areas and assets at highest risk. This will help the Port prioritize projects aimed at increasing overall resilience through site-specific mitigation and/or adaptation strategies. An additional benefit of this Vulnerability Assessment is the possible identification of data gaps.

This Vulnerability Assessment will benefit the Port by:

- Supporting the development of a scalable CAS to respond to new scientific information and Port business needs that is easily transferable to policy.
- Ensuring that RSLR and coastal storm event flooding can be incorporated into future design specifications.
- Providing a framework to begin the process of mitigating the impacts of RSLR and coastal storm events on the Port through climate resilient means including spatial planning, identifying areas where infrastructural upgrades are needed, and targeting investment in technology and equipment.
- Providing a pathway for enhancing the resiliency of Port infrastructure to support future shipping needs and economic development.
- Identifying and prioritizing risk to Port infrastructure specific to Sea Level Rise and other climate impacts not previously included in regional planning (e.g., Whatcom County Sheriff Office's Division of Emergency Management's Natural Hazards Mitigation Plan)

2. VULNERABILITY ASSESSMENT METHODS

The Vulnerability Assessment that EA performed for the Port involved field investigations leveraged with work completed by others, primarily the ongoing state-of-the-art modeling effort performed by the United States Geological Survey (USGS). This assessment aimed to investigate the vulnerability of built and natural infrastructure of the Port to impacts resulting from climate change, including coastal storm events. The subsequent sections describe the methods implemented by EA to perform the assessment.

2.1 COMPONENTS OF THE VULNERABILITY ASSESSMENT

EA pulled together several key components to perform this assessment. These components can be broken down into input data categories, which are described below. Information from each data category was integrated into the assessment process to perform a comprehensive investigation of the overall risk the Port infrastructure is projected to face moving forward. The data that was incorporated into this assessment came from the Port and its partners, a desktop review of publicly available data sources, and two separate EA field efforts to record elevation data around the Port. The relevant data from the various sources described below was combined to generate the vulnerability figures included in Appendix A.

2.1.1 Port Infrastructure

The Port provided facility and engineering data relating to infrastructure on its property. A brief description with bullets of the key information provided in relevant file formats is listed below.

The Port provided EA with the following Geographic Information System (GIS) data:

- Catch Basin Locations
- Manhole Locations
- Oil Separator Locations
- Surface Drain Locations
- Outfall Locations
- Storm Sewer Line Locations.

EA used this information by including the relevant locations on the final figures of the report.

The Port provided EA with several AutoCAD files that covered the main Port (including Fairhaven and Blaine) areas in detail. The files included the following information:

- Building Footprints
- Pier Locations
- Topographic Survey

- Tank Locations
- Road Centerlines
- Manhole Locations
- Storm Sewer Line Locations
- Asset Numbers (incomplete list)
- Other Miscellaneous Items (i.e., fence lines).

From this dataset EA extracted the building footprints. The asset numbers dataset associated with the Port infrastructure was not complete for all areas, therefore EA did not use this dataset. EA recommends that the Port compile a complete list of all building names, associated asset numbers, and finished floor elevations to improve the quality and usefulness for any future work. This information would be key in advancing the overall goals of the CAS and would help with future vulnerability assessments and other Port-studies. EA also excluded AutoCAD data (the fence lines, road centerlines, pier locations, etc.) from the final figures to prevent repetition and overcrowding.

2.1.2 Onsite Field Data Collection Process

EA carried out field events in July and August of 2021 to collect elevation data around the Port's facilities including the Fairhaven and Blaine locations. The primary objective was to collect site-specific data for built infrastructure and vulnerable areas to compare against estimated storm levels, allowing for the characterization of risk across Port assets. In total EA collected 592 elevation points. These were incorporated into the assessment. The elevation point distribution range from the water's edge to building floor elevations, including utilities and other at-risk infrastructure found in between these areas.

To complete the elevation survey for the Port, EA utilized a Leica GS16 Global Navigation Satellite System (GNSS) Antenna and CS20 Field Controller as a rover unit connected to the Washington State Reference Network (WSRN). The WSRN provides real-time GNSS correction data to the rover from a network of Continuously Operating Reference Stations (CORS). The nearest CORS station is located in Sedro Woolley, Washington; however, the WSRN and equipment setup allows the rover to communicate with any CORS station in the region allowing for adjustments due to degradation in signal quality to a specific station. The horizontal data was referenced to the North American Datum of 1983 – 2011 adjustment (NAD83[2011]) Washington State Plane North in U.S. Survey Feet. Vertical data was referenced to the North American Vertical Datum of 1988 (NAVD88).

Utilizing the WSRN CORS network eliminates the need for setting up a separate GNSS base station, relying on the CORS stations instead. Typically, to evaluate the accuracy of the survey effort, the position of physical National Geodetic Survey (NGS) benchmarks with known horizontal and vertical coordinates would be measured before and after data collection. A reliable NGS benchmark was not located for the Port area; however, the Port provided EA with information for a survey grade, temporary benchmark that was recently installed near the Aeration Stabilization Basin (ASB). EA compared the data collected on the temporary benchmark with the known surveyed horizontal and vertical values. The results indicated errors of less than 2.0 inches vertically and 3 inches horizontally. Note that the temporary benchmark was not measured every field day due to the original plan of using an NGS benchmark. The temporary benchmark was an in-field solution that was implemented on the second field day. Therefore, errors associated with data collected on the first field day vary from the aforementioned values, but significant errors are not anticipated and would fall within the overall uncertainty associated with this assessment.

EA also performed a secondary check of the field-recorded Real Time Kinetics Global Positioning System (RTK) elevation data by performing a comparison against the most recent publicly available elevation dataset that covers the Port (USGS, 2020) This elevation data combines several elevation data resources that the USGS identified as the newest/best for the coverage area and implemented this final dataset in its Puget Sound modeling effort, which is discussed in Section 2.1.3. EA extracted elevation values from this USGS dataset at the same location as all the field recorded RTK elevation points. EA performed a comparison check to investigate the overall agreement between the two sources. The results generally showed the anticipated trend; that the field collected RTK data matched the USGS elevation dataset very well in open areas where Lidar achieves its highest level of accuracy. The agreement between the two elevation sources decreases in more densely developed areas and at bathymetric points, where the elevation dataset would be less accurate than the RTK data. Additional differences can be attributed to the higher accuracy achieved by the RTK system when compared to flown Lidar, such as field recording of curb/slab levels versus adjacent grade that the Lidar resolution would not be able to capture. Overall, it was determined that the field collected RTK data fell within acceptable error tolerances.

2.1.3 Coastal Storm Modeling System (CoSMoS)

One of the primary sources of data used to identify highest risk areas of the Port was the USGS' Coastal Storm Modeling System (CoSMoS). CoSMoS integrates global, regional, and local scale physics-based numerical models to provide predictions of coastal flooding resulting from future SLR, storm events, and river flooding driven by climate change. The primary goal of CoSMoS is to use oceanographic and geomorphic models to investigate potential current and future flood impacts at coastal management-relevant scales (Barnard et al. 2019). CoSMoS incorporates projections of global climate patterns throughout the 21st century from Global Climate Models (GCMs) that were developed for the Intergovernmental Panel on Climate Change's 5th Assessment Report to estimate possible future oceanographic conditions. These GCMs outputs are then dynamically downscaled to the regional and local level and utilized as wind forcing for the coupled numerical models to predict coastal waves, water levels, and flooding for a range of storm and SLR scenarios through the year 2100 (Barnard et al. 2019). An overview flowchart of this tightly coupled modeling system is shown in Figure 2-1.

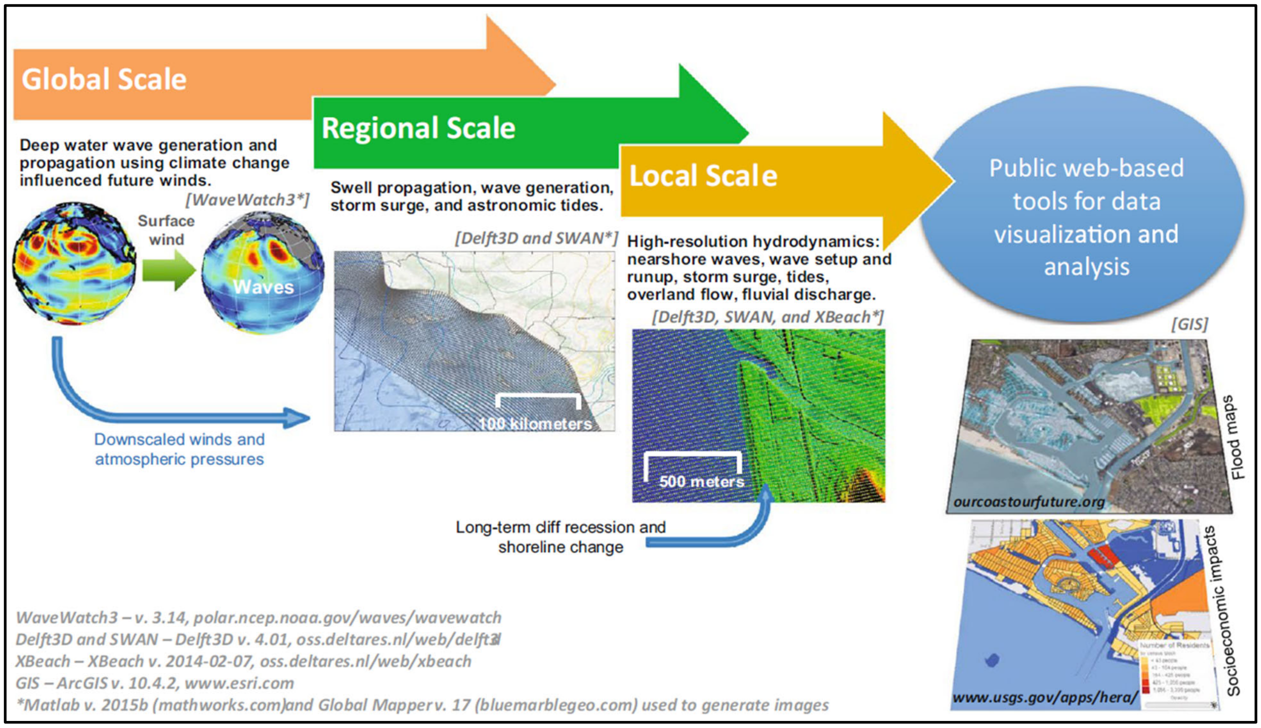

Figure 2-1. CoSMoS Modeling Flowchart (Barnard et al. 2019)

CoSMoS was initially developed and applied to locations in California, but work has been underway to expand the model to Puget Sound. This Puget Sound version, named PS-CoSMoS, is being developed to support a variety of planning for the 2,600 miles of vulnerable coastline in this region. The effort will allow decision-makers to plan, prioritize, and implement adaptive-management techniques to protect coastal and floodplain communities, ports, harbors, and infrastructure.

The CoSMoS modeling outputs are available for most of California and are publicly available as GIS shapefiles or can be easily viewed on an online mapper (https://ourcoastourfuture.org/). PS-CoSMoS modeling outputs were not publicly available at the time this report was developed. EA obtained preliminary results through the Port of Bellingham's partnership with the USGS. The data provided to EA included water level, water depth, and duration associated with a range of return periods and SLR scenarios. The water level output provided by USGS was used for this report, and 16 total scenarios categorized by storm event and SLR were selected for further evaluation from the dataset. Table 2-1 shows the breakdown of the 16 scenarios, which included events ranging from a king tide up to the 100-year storm event with SLR projections varying from 0 to 3.28 ft (1.00 m). The king tide event correlates to the average of the highest tidal water levels reached by exceptionally high tides in the area over the period of a year. King tide events typically occur seasonally or as a result of new/full moons. The 0 ft SLR scenarios represent present-day sea level conditions as defined by the aforementioned USGS topobathy elevation dataset.

Table 2-1. Port of Bellingham Vulnerability Assessment Scenarios

Scenario	SLR (ft [m])	Event
1	0	King Tide
2	0.82 [0.25]	
3	1.64 [0.50]	
4	3.28 [1.00]	
5	0	10-Year Storm
6	0.82 [0.25]	
7	1.64 [0.50]	
8	3.28 [1.00]	
9	0	50-Year Storm
10	0.82 [0.25]	
11	1.64 [0.50]	
12	3.28 [1.00]	
13	0	100-Year Storm
14	0.82 [0.25]	
15	1.64 [0.50]	
16	3.28 [1.00]	
Sources: USGS PS-CoSMoS		

It is important to clarify the definition of return period storms as it is often misinterpreted. For example, flood risk is typically conveyed through the 100-year storm event. The 100-year storm event does not refer to a flood that will occur 100 years in the future, nor does it mean that a flood of this magnitude will occur in a 100-year timeframe. It is based on probability, meaning that the 100-year flood has a 1% chance of occurring in any given year. It could happen tomorrow, in a couple years, in 150 years, or even multiple times in a single year. However, the probability of the flood occurring does increase when time periods greater than 1-year are considered. As an example, if a period or planning horizon of 50 years is considered, statistically there is a 39.5% chance the 100-year storm event would occur within the timeframe. This concept is important to understand since EA utilized these USGS return period flood events to investigate the vulnerability of the Port. EA identified the 10-, 50-, and 100-year flood events as the most important flooding scenarios to review. The storms selected have a 10%, 2%, and 1% probability of occurrence, respectively, for any given year.

Additionally, it should be noted that due to the potential for more frequent intense storms because of climate change, the 100-year storm event today based on historical data may not represent the 100-year storm under future (or even present) conditions. For example, the 100-

year storm event that occurs today may only represent a 50-year storm event in 2050 depending on the intensity increases that have happened over that period. The PS-CoSMoS outputs do attempt to account for this potential increase in future return period conditions through downscaling of GCM projections; however, there is much uncertainty associated with this process. To the extent practical, return period estimates should be reviewed whenever possible to account for new data and science.

2.1.4 Federal Emergency Management Agency Data

The Federal Emergency Management Agency (FEMA) has performed Flood Insurance Studies (FIS) all over the United States to quantify the risk associated with potential flood events. The resulting FIS reports and National Flood Hazard Layer (NFHL) information is made publicly available in effective and preliminary formats. Preliminary format is a label applied to data that has been revised but not officially integrated into flood insurance determinations. EA reviewed the FIS and NFHL data available for the Port, which was revised in January 2019, and pulled the most useful data for this assessment. The NFHL data is provided in a user-friendly GIS Geodatabase that can be downloaded directly from FEMA's website. EA utilized the Base Flood Elevation (BFE) GIS layer, which FEMA uses to define its 100-year storm event, inclusive of water level and wave effects. This BFE GIS layer was included in the vulnerability assessment as it provides a reference point to compare against the PS-CoSMoS data. It is important to include this comparison as FEMA does not consider impacts from climate change when performing its analyses and therefore the BFE flood scenarios often underpredict the associated future and current risk.

2.1.5 Tidal Data

The tidal boundary condition information used in the USGS PS-CoSMoS model is derived from TOPEX/Poseidon satellite altimetry data. A tidal harmonic analysis was performed to pull the tidal constituents for the area to force the water levels within the numerical modeling system. This same tidal data was used by USGS to identify the magnitude of the king tide event, which was discussed earlier. Unfortunately, a report detailing these methods and information is not yet available from the USGS as they are still finishing work associated with PS-CoSMoS. EA included additional information on NOAA tidal data for the Puget Sound area as the differences are not expected to be large between the datasets, and the NOAA data would be more site-specific as it was pulled from nearby tidal stations, one in Bellingham and one in Blaine.

Information related to water level and tidal datums for the project area were pulled from the nearest NOAA Center for Operational Oceanographic Products (CO-OPS), which were the Bellingham, Washington, tidal station (Station ID: 9449211) and the Blaine, Drayton Harbor, Washington, tidal station (Station ID: 9449679). These tidal stations were established in March of 1973 and October of 1973, respectively. Both were removed after a short time in 1975; however, each recorded enough data for an analysis to be performed to determine the tidal datums for the locations. Additionally, nearby control stations were used by NOAA's for each station to improve the tidal datum analyses. Note that the Blaine tidal station was reestablished for a couple months in 2011 as well, but again was removed. The water level data from the tidal stations show that the project areas experience relatively large amplitude, mixed semidiurnal tides (two high/low tides per day of different sizes) from the Pacific Ocean transmitted through the Strait of Juan de Fuca into Bellingham Bay and Drayton Harbor. The mean tidal range at the Bellingham tidal station is 5.44 ft and at the Blaine tidal station the mean range is 6.01 ft. This slight difference in tidal magnitude can be associated to localized factors, such as coastal configuration and bathymetry. The main tidal datum elevations referenced to the North American Vertical Datum of 1988 (NAVD88) are shown in Table 2-2.

Table 2-2. Tidal Datums and Range at NOAA's Bellingham and Blaine, Washington, Stations

Tidal Datum	Bellingham Elevation (ft; NAVD 88)	Blaine Elevation (ft; NAVD 88)
Mean Higher High Water (MHHW)	8.03	8.51
Mean High Water (MHW)	7.31	7.65
Mean Tide Level (MTL)	4.59	4.65
Mean Sea Level (MSL)	4.47	4.46
Mean Low Water (MLW)	1.87	1.64
North American Vertical Datum of 1988 (NAVD 88)	0.00	0.00
Mean Lower Low Water (MLLW)	-0.48	-1.02

NOTES:
ft = feet
NAVD 88 = North Atlantic Vertical Datum of 1988

Sources:
NOAA CO-OPS Bellingham, Washington, Tidal Station 9449211
Main Page: https://tidesandcurrents.noaa.gov/stationhome.html?id=9449211
Benchmark Sheet: https://tidesandcurrents.noaa.gov/benchmarks.html?id=9449211

NOAA CO-OPS Blaine, Drayton Harbor, Washington, Tidal Station 9449679
Main Page: https://tidesandcurrents.noaa.gov/stationhome.html?id=9449679
Benchmark Sheet: https://tidesandcurrents.noaa.gov/benchmarks.html?id=9449679&type=BenchMarkSheets

Tidal Datum Analysis Period: 1974-1975
National Tidal Datum Epoch: 1983-2001

These datums are based on a tidal datum analysis period of 1974 to 1975 and tied to the current National Tidal Datum Epoch (NTDE) through control stations. The NTDE covers a 19-year period to ensure that an 18.6-year astronomical cycle that includes all significant variations in the distances to the moon and sun, which produce slowly varying changes in the tidal range, is accounted for in the epoch (NOAA et al. 2017). The current NTDE is 20+ years old and it is NOAA's policy to consider revising the NTDE every 20-25 years. The NTDE needs to be revised to account for changes in tidal constituents, RSLR, and vertical land movement. This means the tidal datums presented are inherently already outdate. However, the tidal datums should still provide a reasonable representation of the tidal levels, excluding any increases that have occurred as a result of the aforementioned factors.

NOAA is working on revising the NTDE to cover the period of 2002 to 2020, with an anticipated release of 2025. It will be important to revisit the tidal datum numbers in Table 2-2 when the new epoch is released. It should be noted that an analysis could be performed to update to a new epoch, but it would involve effort beyond the scope of this work. However, for refence the changes since 2001 at the nearest currently active NOAA tidal station, Friday Harbor (Station ID: 9449880), appear to be on the order of 2 inches or less.

2.1.6 Relative Sea Level Rise

Future water level as a result of SLR is an important factor in determining the long-term resiliency of the Port. Global SLR is driven by climate change, which is causing sea level to increase primarily because of thermal expansion as oceans warm and the melting of ice sheets/glaciers. The global MSL has historically increased at a rate of approximately 3 millimeters per year since the mid-1980s. This rate is expected to accelerate with the ongoing effects of climate change (NOAA et al. 2017). However, sea levels do not increase uniformly around the globe. They are spatially variable and can vary by region. This more locally focused increase is referred to as RSLR. RSLR is water level increase specific to certain locations, which can be more or less than the global average (NOAA et al. 2017). Local variation in RSLR is a function of vertical land movement (subsidence/uplift) and changes in regional ocean currents.

For this project, the University of Washington’s (UW) Climate Impacts Group RSLR projections for the Port area were used. Note the RSLR for Blaine were not differentiated in this report as there is not a significant difference in values; however, site-specific estimates for Blaine are available online. These UW RSLR projections were published in 2018 and provide estimates of potential RSLR on a decadal interval through the year 2150 for different Representative Concentration Pathways (RCP) and various exceedance probabilities (Raymond et al. 2020).

RCPs refer to the greenhouse-gas emission pathways that the climate may be subjected to in the future. Two RCPs were used in the UW study, and each represents possible socioeconomic conditions and technological considerations. These included a lower-end member with moderate mitigation (RCP 4.5) and high-end member (RCP 8.5). RCP 4.5 involves stabilizing greenhouse-gas emissions through 2050 and then decreasing emissions thereafter. RCP 8.5 is considered the ‘business-as-usual’ greenhouse-gas emission scenario and involves significant use of fossil fuels (NOAA et al. 2017). Depending on which RCP scenario the global climate ends up following the potential RSLR fluctuates greatly.

UW provides 10 RSLR projections in terms of likelihood of exceedance that range from 0.1% to 99% for each RCP. The 99% scenario means there is a 99% probability RSLR would exceed the corresponding estimates. The UW RSLR projections for the two RCPs begin to diverge after 2050 so the selection of which RCP scenario to use becomes important for long-term planning horizons. EA selected to use RCP 8.5 as it offers a more conservative approach. The likelihood scenarios of 17% and 1% were selected for this analysis to provide different risk levels for RSLR consideration and because they correlated well with projections published by NOAA in 2017. The two UW RLSR scenarios are shown in Figure 2-2 and Table 2-3, denoted “High (RCP 8.5) – 17%” and “High (RCP 8.5) – 1%”, respectively. The scenario to follow for planning horizons is ultimately up to the Port and would involve a balance of risk tolerance and project cost reduction. EA recommends that the Port reviews its risk tolerance into the future to set a Port-wide RSLR scenario design standard. This standard would depend on the asset in question.

As part of this effort, the PS-CoSMoS 0.82 ft (0.25 m), 1.6 ft (0.5 m) and 3.3 ft (1.0 m) RSLR increments were used and where they fell on the UW “High (RCP 8.5) – 17%” and “High (RCP 8.5) – 1%” scenarios were extracted to tie the USGS RSLR values to an estimated occurrence year. Using this process, on the UW 17% curve it is projected that the 0.82 ft (0.25 m), 1.6 ft (0.5 m), and 3.3 ft (1.0 m) RSLR scenarios would occur by 2047, 2074, and 2119, respectively. Following the UW 1% curve it is projected that the 0.82 ft (0.25 m), 1.6 ft (0.5 m), and 3.3 ft (1.0 m) RSLR scenarios would occur by 2036, 2058, and 2083, respectively. These values are identified and bolded in Table 2-3.

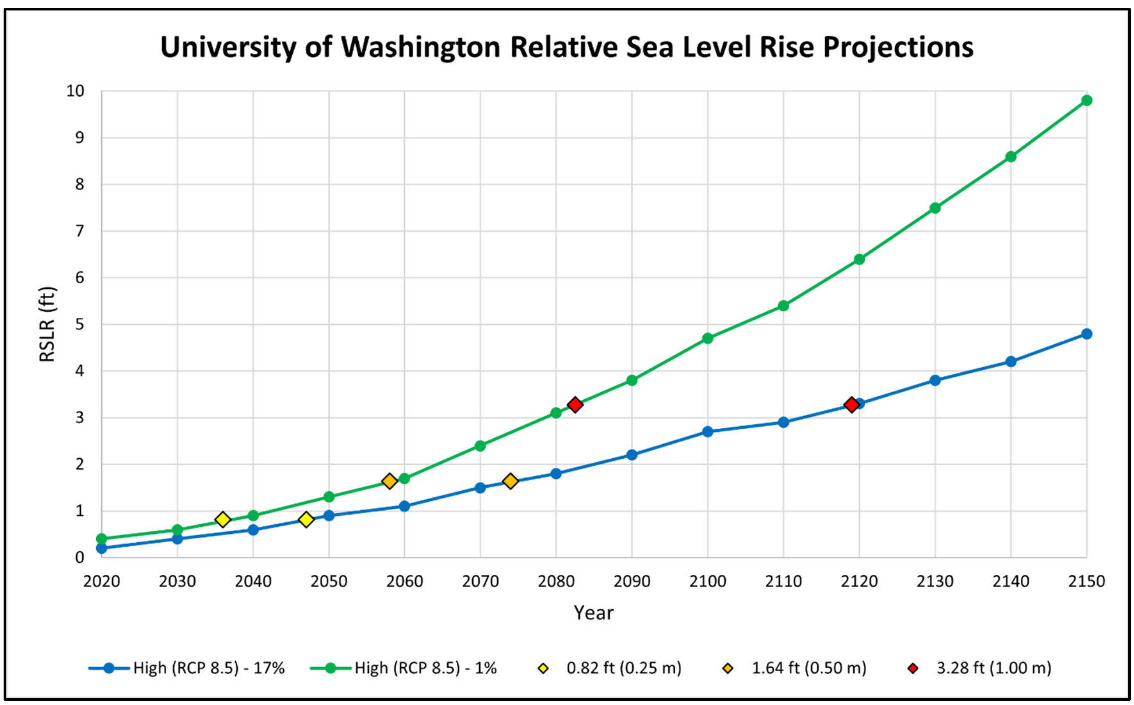

Figure 2-2. Relative Sea Level Rise Projections Port of Bellingham (Lavin et al. 2019)

Table 2-3. Relative Sea Level Rise Projections Port of Bellingham

Year	UW High (RCP 8.5) – 17% Relative Sea Level Rise (ft [m])	UW High (RCP 8.5) – 1% Relative Sea Level Rise (ft [m])
2020	0.20 [0.06]	0.40 [0.12]
2030	0.40 [0.12]	0.60 [0.18]
2036	0.51 [0.16]	**0.82 [0.25]**
2040	0.60 [0.18]	0.90 [0.27]
2047	**0.82 [0.25]**	1.20 [0.37]
2050	0.90 [0.27]	1.30 [0.40]
2058	1.07 [0.33]	**1.64 [0.50]**
2060	1.10 [0.34]	1.70 [0.52]
2070	1.50 [0.46]	2.40 [0.73]
2074	**1.64 [0.50]**	2.65 [0.81]
2080	1.80 [0.55]	3.10 [0.94]
2083	1.95 [0.59]	**3.28 [1.00]**
2090	2.20 [0.67]	3.80 [1.16]
2100	2.70 [0.88]	4.70 [1.43]
2110	2.90 [1.01]	5.40 [1.65]
2119	**3.28 [1.00]**	6.35 [1.94]
2120	3.30 [1.01]	6.40 [1.95]
2130	3.80 [1.16]	7.50 [2.29]
2140	4.20 [1.28]	8.60 [2.62]
2150	4.80 [1.46]	9.80 [2.99]

ft = feet; m = meters

Notes: Non-decadal interval years were estimated using the curves.

Source: Lavin, P., Roop, H.A., Neff, P.D., Morgan, H., Cory, D., Correll, M., Kosara, R., and Norheim, R., 2019. *Interactive Washington State Sea Level Rise Data Visualizations*. Prepared by the Climate Impacts Group, University of Washington, Seattle.

2.1.7 Geographic Information System Analysis Framework

To perform the Vulnerability Assessment for the Port, EA pulled together the components into a GIS based analysis framework. This GIS framework reads in the discussed components as inputs, analyses/processes said inputs, and generates output maps that show the estimated flood extent and the risk overview for the Port. A flowchart depicting how the vulnerability assessment components come together to produce the final output maps is shown in Figure 2-3. In this GIS framework the PS-CoSMoS outputs, including climate change impacts, were the primary input to identify the vulnerability of areas around the Port. The PS-CoSMoS scenarios incorporated in the analysis were previously shown in Table 2-1 and initial planning horizons for the scenarios were identified through correlation with the NOAA RSLR projection curves for the region. The built and natural infrastructure information was derived from the GIS and AutoCAD files obtained from the Port and from aerial imagery. The field recorded RTK elevation points were used in this analysis to further assess the vulnerability of specific areas in conjunction with the PS-CoSMoS outputs.

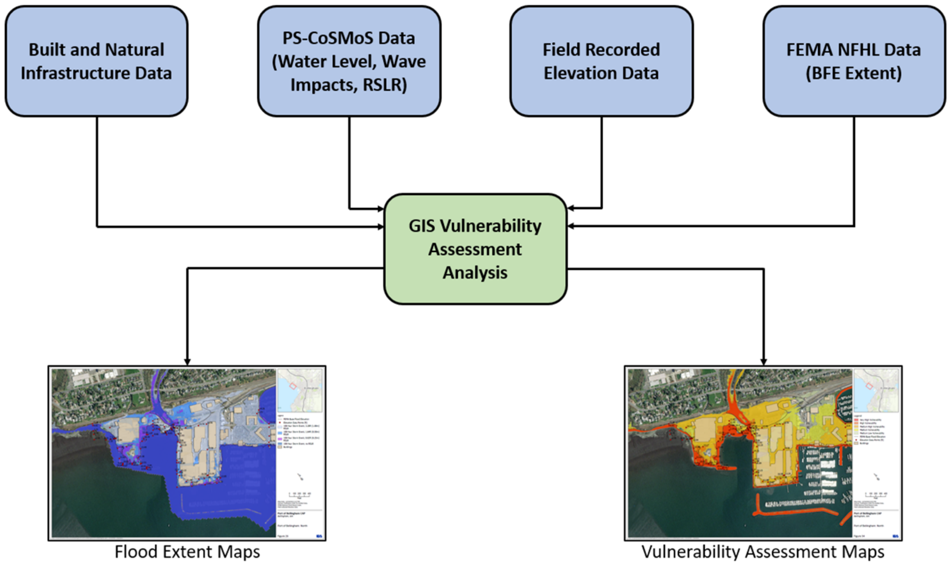

Figure 2-3. GIS Vulnerability Assessment Analysis Flowchart, Light Blue Denotes Inputs and Green Denotes Analysis

Two main types of mapping products are generated through the GIS analysis framework to convey the vulnerability of the Port. The first mapping product, presented in Appendix A, shows the estimated flood extent for a given storm event with varying levels of RSLR all superimposed on top of each other. The goal of these maps is to show how the estimated extent of flooding increases throughout the Port as a result of climate change, namely the water level increases associated with RSLR and coastal storm events. These maps convey the possible future conditions and flooding that the Port may encounter. The second mapping product, again found in Appendix A, shows the estimated vulnerability for the Port, on a scale from medium (yellow) to high (red), derived from an assessment of the various flood extents/elevations estimated by the PS-CoSMoS outputs. Table 2-4 shows how the storm events and RSLR scenarios were binned to determine the associated vulnerability levels. The storms were binned on the likelihood that the storm event could impact the Port in the near future and the severity of the corresponding storm event:

- High—Areas inundated by:
  - 10 yr, 50 yr, and 100 yr storms with no RSLR,
  - 10 yr and 50 yr storms with 0.25 m RSLR, and,
  - 10 yr storm with 0.5 m RSLR.

- Medium High—Areas inundated by:
  - 100 yr storm with 0.25 m RSLR,

- 50 yr storms with 0.5 m RSLR, and,
- 10 yr storm with 1.0 m RSLR.

- Medium—Areas inundated by:
  - 100 yr storms with 0.5 m RSLR, and,
  - 10 yr and 50 yr storms with 1.0 m RSLR.

For example, areas of the Port vulnerable to a 10-year storm event are considered to have high vulnerability because a relatively small storm leads to impacts. This current 10-year storm event is the most likely of all storm scenarios. Conversely, the 100-year storm event with 3.28 ft (1.00 m) of RSLR is the least likely of all storm events and therefore areas impacted by this event are considered to have medium vulnerability. **Essentially, the vulnerability of areas around the Port is a function of storm severity and timeframe**. **The more probable an event is to occur in a shorter timeframe the higher the vulnerability.**

The goal of these vulnerability maps is to identify the areas around the Port that are the most susceptible to impacts from climate change, including present-day and future coastal storms. With these highly vulnerable areas identified it becomes easier to prioritize projects to improve the resiliency of the Port. Combining these maps with knowledge from the Port's staff on the most valuable assets, the areas with the highest priority can be filtered further. Additionally, an exposure, sensitivity, and adaptive capacity analysis could be performed to inform these decisions. Note on all overview map products the building footprints and FEMA BFE are displayed. Additionally, on all zoomed map products focusing on high-risk areas stormwater lines and manholes are shown as well.

Table 2-4. Vulnerability Assessment Categories

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

Notes:
1) Vulnerability categories are broken up into three levels from medium (yellow) to high (red).
2) Vulnerability is ranked relative to storm levels. It is important to note medium still represents significant potential for damage to some areas.
3) Unshaded areas of the Port, while considered "low" vulnerability. They may be impacted by specific extraordinary scenarios.

ft = feet
m = meters

2.2 ASSESSMENT OF CLIMATE CHANGE HAZARDS, PORT ASSETS, VULNERABILITES, AND DATA GAPS

2.2.1 Coastal Hazards Matrix

A Coastal Hazard Matrix brings together all of the potential coastal hazards climate change can cause on the built and natural environment. Table 2-5 lays out the most common coastal hazards anticipated to worsen at the Port of Bellingham facilities because of climate change. Although this report focuses on RSLR and coastal storm event flooding, these hazards will not occur or change independently of other coastal hazards, and therefore coastal erosion/sedimentation, changes in weather patterns, and ocean acidification will need to be considered in any long term planning and project development resulting from this Vulnerability Assessment. Some potential interactions between RSLR, coastal storm events, and these hazards include the following:

- As RLSR increases, the rates and locations of coastal erosion and sedimentation are likely to change, though these impacts may be difficult to predict.
- Changes in RLSR in combination with increasing temperatures due to climate change may impact local weather patterns, potentially increasing the severity of local storms.
- RLSR is likely to worsen flooding due to both coastal and inland storms, as river mouths and storm drainage systems will be backwatered.
- The impacts of ocean acidification on Port infrastructure and on environmental resources may be aggravated by the fact that additional infrastructure will be inundated due to sea level rise.

Table 2-5 also lays out some of the assets the Port may bring to bear for adapting to these impacts, data gaps that currently limit adaptive capacity, and general recommendations to improve resiliency.

2.2.2 Climate Action Strategy Planning Matrix

As described in EcoNorthwest (2019), the completion of a vulnerability assessment requires identification of assets and the assessment of their exposure, sensitivity, and adaptive capacity (i.e., strengths) in the face of climate change. EA developed a similar draft Climate Action Strategy Planning matrix for the Port, shown in Appendix B, which is intended as a tool to guide the Climate Action Strategy to be developed, in part, based on the result of this Vulnerability Assessment. The matrix qualitatively lays out the Port's assets and describes the known strengths and vulnerabilities associated with each (incorporating the analyses described in Section 2.1), as well as asset-specific data gaps and recommendations for adaptation and resiliency. The draft Climate Action Strategy Planning matrix is provided in Appendix B.

Table 2-5: Coastal Climate Change Hazards

Hazard	Description of Hazard	Port Assets	Data Gaps	Recommendations
Relative Sea Level Rise	• Increases in sea level are occurring as a result of climate change. • Changes in sea level will impact the rate and severity of the occurrence of the other hazards listed in this table. • Increases in sea level will increase the rate of corrosion of any partially-submerged infrastructure (e.g. docks, piles, pile caps, and beams). • Increases in sea level will reduce the rate at which stormwater is able to drain from Port facilities, causing increase flooding due to precipitation events. This is known as compound flooding. • Storm surge damage to Ports will increase due to RSLR. • Some Port facilities may be subject to permanent inundation, depending on the degree of RSLR. • Port facilities subject to more frequent or permanent inundation may be more vulnerable to corrosion due to increased ocean acidification.	• Extensive studies have been carried out nationwide due to the severity of the hazard. This results in readily available data for the Port to use.	• Long-term water level record specifically located within the Port. • Not a major gap as nearby locations can be used to provide reasonable estimates.	• Continue to monitor RSLR guidance as the science evolves. • Consider installing a water level sensor to collect long-term trends at the Port.
Changes in Weather Patterns	• Transportation and shipping services may be interrupted by more intense and more frequent storms. • Future coastal and inland flooding may increase due to climate change. • Increased wind speeds may threaten infrastructure.	• The Port is has contributed to the PS-CoSMoS work that models coastal storms, taking into account potential changes in weather patterns.	• No gap, final PS-CoSMoS outputs should account for this.	• Continue to revise analyses and port planning strategies as new results become available.
Coastal Erosion/Sedimentation	• RSLR and changes in weather patterns are expected to lead to changes in coastal erosion and sedimentation, potentially threatening port infrastructure and/or shipping channels. • More frequent intense precipitation events in combination with development in coastal watersheds may increase sediment loads entering Bellingham Bay and other areas of Puget Sound.	• Limited erosion hazards have thus far been identified on Port properties (at Squalicum and Blaine), and Port Engineering and Facilities leads are aware of this hazard. The Whatcom County NHMP considers this concern not applicable to the Port under current conditions.	• Historical shoreline change rates. • Sediment transport rates in coastal watersheds. • Estimates on RSLR and storm-induced shoreline change will be incorporated in the final PS-CoSMoS results. • Port currently relies on others to raise awareness of any erosion issues.	• Analyze shoreline change trends using historic aerial imagery. • Analyze sediment transport rates in the watershed under both current and projected climate change conditions to determine how sediment transport rates to the Bay of Bellingham and other Port harbors will change. • Use sediment transport analysis.
Flooding	• Climate change may lead to a greater frequency of intense precipitation events, increasing the risk of flooding. • Increases in sea level will reduce the rate at which stormwater is able to drain from Port facilities, causing increased flooding due to precipitation events. This is known as compound flooding. • Port facilities subject to more frequent or permanent inundation may be more vulnerable to corrosion due to increased ocean acidification.	• The Port has contributed to the PS-CoSMoS work that models coastal storms, considering the impacts of climate change.	• Impacts of erosion combined with flooding, will be available once final PS-CoSMoS results are ready. • Impacts of combined inland and coastal flooding across the Port, will be available once final PS-CoSMoS results are ready. • While flood mitigation actions on a 2-5 year timescale are identified in the Whatcom County NHMP[5], progress on these actions is unknown. •	• Continue to update analysis as new model results become available. • Use results to begin planning mitigation/adaptation strategies for the most at risk areas.
Ocean Acidification	• It is possible that increased ocean acidification may increase corrosion of submerged port assets. • Ocean acidification results from the absorption of carbon dioxide, and has been accelerated by human-produced carbon emissions. • Ocean acidification is detrimental to many marine shellfish species and will impact >30% of Puget Sound's marine species. Based on 2013 data, approximately 2,000 jobs rely directly on commercial fishing activities at the Squalicum and Blaine marinas alone. These jobs are vulnerable to changes in commercial fisheries populations. Additional jobs depend on recreational fisheries, which may also be impacted by climate change.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Inventory of infrastructural assets that will be vulnerable to ocean acidification. • Assessment of impacts of ocean acidification on marine wildlife and the economic impacts on commercial and recreational fisheries.	• Evaluate the impacts of ocean acidification on marine wildlife and Port infrastructure.

3. RESULTS OF THE VULNERABILITY ASSESSMENT

Following implementation of the methods described in Section 2, EA generated a series of maps that show an overview of the vulnerability of the Port. The figures show all Port properties divided into five maps:

- Port of Bellingham: North
- Port of Bellingham: Central
- Port of Bellingham: South
- Fairhaven
- Blaine

And then provide three zoomed extent figures focus on the most vulnerable areas identified, specifically the areas around:

- Squalicum Parkway Industrial Area
- Bellingham Shipping Terminal Area
- Marine Trades Area

There are four figures for each of the locations above representing four storm scenarios: King Tide alone, and then King Tide plus 10-year, 50-year, and 100-year storm scenarios. These figures each illustrate inundation for the different RSLR scenarios examined using color shading.

For example, Figure 3-1 shows the king tide and 100-year storm event (1% chance of occurring in any given year) scenarios for the Squalicum Parkway Industrial Area as examples of the potential flooding impacts of rising sea levels and increasing storm intensity.

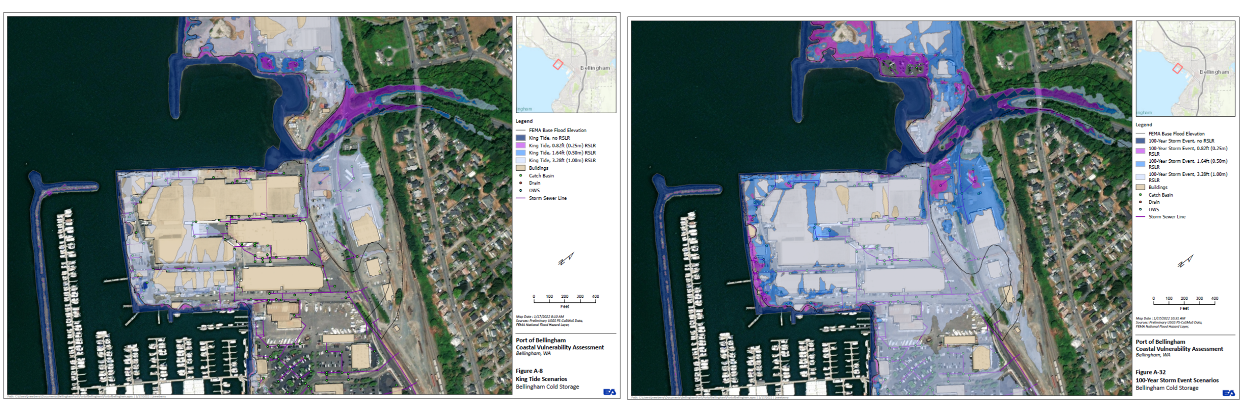

Figure 3-1. King Tide and 100-year Storm Scenarios— Squalicum Parkway Industrial Area

A set of vulnerability assessment figures were also created based on the vulnerability category breakdown shown in Table 2-4 (Appendix A figures A34-A41). The following sections present the figures that were generated through this analysis and discuss observations that can be derived from each. More flood extent and vulnerability assessment figures are in Appendix A.

3.1 KING TIDE EVENT SCENARIOS

Scenarios 1 through 4 in Table 2-1 depict the king tide events and are presented in Figures A-2 to A-9. These figures were generated for all eight views described above. The king tide event scenarios should be viewed as the nuisance flooding that could begin occurring several times a year at the Port due to water level increases resulting from RSLR during the highest tides. Nuisance flooding is typically defined as flooding that results from tidal influences and does not occur as a result of coastal storms. This type of flooding involves the temporary inundation of low-lying areas due to extreme high tide events. The figures show that as RSLR increases it no longer takes a strong coastal storm to cause flooding at the Port. This non-storm induced flooding would result in inconveniences such as frequent road closures, overwhelmed storm drains, and compromised built and natural infrastructure.

Figure A-2 shows the area of the Port that is currently most susceptible to this nuisance flooding. The primary flooding path for this area of the Port is around the Squalicum Creek connection with Bellingham Bay. Large areas begin to flood under the smallest RSLR scenario and several buildings/infrastructure, such as the Roeder Avenue Bridge, are impacted under the 3.28 ft (1.00 m) RSLR scenario. This area of the Port currently experiences flooding with rainfall events occurring at high tides. Also, note that the outer Squalicum Harbor Marina breakwater is overtopped in several places in the king tide event. This will allow significant wave action into the marina in the later storm event scenarios. The remainder of the main areas of the Port, shown in Figures A-5 and A-6, fare a bit better when just the increased water level due to RSLR is considered. Some low-lying areas still show flooding under all RSLR scenarios, but significant nuisance flooding does not begin until the 3.28 ft (1.00 m) RSLR scenario.

This analysis also shows that the areas in Fairhaven (Figure A-5) adjacent to Padden Creek are prone to nuisance flooding resulting from RSLR. The creek begins to encroach on the nearby infrastructure under the lowest RSLR scenario and could lead to potentially significant impacts to operations in this area with the 3.28 ft (1.00 m) RSLR scenario. The results for Blaine, shown in Figure A-6, show that there are few major nuisance flooding issues associated with RSLR. Only the 3.28 ft (1.00 m) RSLR scenario results in flooding. While more protected than Squalicum Harbor, the Blaine Marina breakwater shows significant overtopping in the king tide event. Depending on storm/wind direction, this may allow significant wave action into the marina in the later storm event scenarios. However, it’s important to note that these figures only show the flood extent related to king tides. The RSLR increase associated with each scenario may not produce flooding under king tide conditions, but the scenarios do significantly increase the vulnerability of the Port to coastal storms.

3.2 10-YEAR STORM EVENT SCENARIOS

The 10-year storm event scenarios, 5 through 8 as shown in Table 2-1, are presented in Figures A-10 to A-17. These figures were generated for all eight view extents that were described above. The 10-year storm event scenarios display how the vulnerability of the Port to small storm events increases significantly with sea level increases due to RSLR. Under present day conditions the 10-year storm event does not result in much flooding to the Port; however, the area by Squalicum Creek does begin to show some flooding. As mentioned before, this area experiences flooding during rain events at high tide, so flooding from a smaller scale storm event is to be expected. With the increasing water level conditions, the buildings/infrastructure of the Port begin to be substantially impacted starting at the 1.64 ft (0.50 m) RSLR scenario. Similar to before, the worst flooding begins to occur in the low-lying areas around the connection of Squalicum Creek to Bellingham Bay and in Fairhaven in the areas adjacent to Padden Creek. Under the 3.28 ft (1.00 m) RSLR scenario the 10-year event results in extensive flooding and impacts numerous buildings/infrastructure. The Squalicum Parkway Industrial Area, the Fairhaven Marine Industrial Park, and parking/loading areas of the Bellingham Cruise Terminal locations of the Port are the most flooded areas. In these locations a large number of the buildings would experience some level of flooding.

3.3 50-YEAR STORM EVENT SCENARIOS

The 50-year storm event scenarios, 9 through 12 as shown in Table 2-1, are presented in Figures A-18 to A-25. These figures were generated for all eight view extents that were described above. The 50-year storm event figures display how the vulnerability of the Port to fairly large storm events increases significantly with sea level increases due to RSLR. Under present day conditions the 50-year event does not result in much flooding for most of the Port. In this scenario the low-lying areas near the Squalicum Creek connection with Bellingham and the Fairhaven areas near Padden Creek begin to flood without any added impacts associated with RSLR. This estimated flooding does not begin to impact the buildings in these locations but does lead to flooding on the roadways. Next, looking at the 0.82 ft (0.25 m) RSLR scenario the Port begins to experience flooding that impacts some of the infrastructure in the low elevation areas. This flooding does not appear to be significant but could lead to issues for some of the Port's buildings. Moving to the next RSLR scenario, the 1.64 ft (0.5 m), is when the extent of flooding becomes severe for the Port during a 50-year storm event. The flooding associated with this event impacts several of the buildings over in the Squalicum Parkway Industrial Area. It also begins to impact the Marine Trades Area by the I & J Waterway and floods down Hilton Ave to the building between Hilton Ave and G Street. The flooding near the Whatcom Creek Waterway also encroaches on several of the buildings located in the lower elevated regions. Up in Blaine the flooding would begin to impact Shipyard Industrial Park to the east of McMillan Ave and the Dakota Commons eastern building. Under the highest RSLR scenario, 3.28 ft (1.00 m), the flooding around all areas of the Port is significant. Numerous buildings/infrastructure would be flooded and the expected damage would be extensive.

3.4 100-YEAR STORM EVENT SCENARIOS

The 100-year storm event scenarios, 13 through 16 as shown in Table 2-1, are presented in Figures A-26 to A-33. These figures were generated for all eight view extents that were described above. The 100-year storm event figures display how the vulnerability of the Port to extreme storm events increases significantly with sea level increases due to RSLR. Under present-day conditions, the 100-year storm event is estimated to begin flooding the low-lying areas of the Port. The flood water would begin to reach buildings that are immediately situated on the shoreline in these areas. As with the 50-year storm event, the low-lying area near the Squalicum Creek connection with Bellingham Bay and the Fairhaven areas near Padden Creek experience the most significant flooding. The 100-year storm event with the lowest level of RSLR, 0.82 ft (0.25 m), is when the flooding begins to impact several buildings and other infrastructure around the Port, again following a similar trend to the 50-year storm event. The 1.64 ft (0.50 m) RSLR scenario would cause flooding to occur in numerous buildings around the Port, especially in the Squalicum Parkway Industrial Area. Additionally, this area would experience flooding that impacts Roeder Avenue and could impact Squalicum Way, which runs northeast away from the Port and is one of the evacuation routes for this area. The 3.28 ft (1.00m) RSLR scenario would overwhelm the Port and cause substantial flooding to a significant number of buildings and other infrastructure, such as utilities and roads. Most buildings are estimated to experience flooding, and entire parking lots could be submerged. As with the other storm event scenarios, the flooding is the worst over in Squalicum Creek area. In this location the results show that almost all of the area would be underwater, and the roadways would also experience significant flooding.

3.5 VULNERABILITY ASSESSMENT CATEGORIES

The storm event scenarios that were discussed in previous sections help to convey the vulnerability the Port faces from climate change induced increases in coastal storm event severity. To further investigate the vulnerability of the Port, EA developed maps to show a relative ranking of the most susceptible areas of the Port based on the categories shown in Table 2-5. It's important to understand that all areas identified are vulnerable, but the maps help to highlight the locations where the most vulnerability exists, which mainly was a result of low-lying elevations. **There is a high level of uncertainty associated with many components of this analysis, namely the PS-CoSMoS outputs and the RSLR projections. This means the results should be viewed as a vulnerability indicator rather than an exact picture of what may occur during a significant coastal storm event. The goal is to develop maps that assist Port personnel in identifying the locations around the Port that require additional study, and to begin the conversations around the areas that mitigation/adaptation projects should be prioritized. These vulnerability maps should be combined with knowledge from personnel in various Port divisions to correlate coastal vulnerability with asset importance/value.**

The maps in Figures A-34 to A-41 incorporate the vulnerability of the Port to RSLR and coastal storms together with the timing of that vulnerability. Essentially, the higher the vulnerability rating on the maps the more probable it is that these areas will experience significant impacts and damage from a coastal storm event in the near term. These vulnerability maps follow a similar trend as the previously discussed flood extent maps, meaning the areas defined as most at risk are the low-lying areas that were prone to flooding under lesser storms and RSLR combinations. The vulnerability maps identified the areas surrounding the connection of Squalicum Creek to Bellingham Bay as some of the most at-risk land at the Port. In this location the road is extremely vulnerable to impacts associated with climate change driven RSLR and coastal storms.

This vulnerability was made evident during the November 15, 2021, flooding that resulted from heavy rainfall that inundated the road leading to it becoming impassible. Even though this was mainly a rainfall event, the Squalicum Parkway Industrial Area experienced significant flooding. The area of the Squalicum Parkway Industrial Area north of Squalicum Creek experienced over a foot of flooding in most of its main manufacturing and storage area, and the area south of Squalicum Creek had flood water blocking access to its entrance and parking areas. If this flooding was caused by a coastal storm event in conjunction with the heavy rain rather than just heavy rain it is likely the Squalicum Parkway Industrial Area would have experienced substantially more flooding. This is due to the combined flooding impacts (coastal squeeze) that would occur starting at the connection point of Squalicum Creek and Bellingham Bay and spreading outwards following the low elevations.

These vulnerability maps also show that the adjacent areas around Padden Creek in Fairhaven, such as the Bellingham Cruise Terminal parking/loading areas and the Fairhaven Marine Industrial Park are highly vulnerable to the increase in coastal storm effects resulting from RSLR. These locations are shown to be highly vulnerable due to the flooding the spreads in the low-lying creek. This would result in flooding to the bus station, the train tracks, and potentially lead to Harris Avenue becoming impassible. The Marine Park beach area in Fairhaven is also shown to be at a high vulnerability, leading to possible damage.

Moving up to Blaine, Figure A-38 shows that the buildings/infrastructure immediately adjacent to the inner harbor area is most vulnerable to flooding impacts. The most vulnerable locations in Blaine are the areas around Shipyard Industrial Park to the east of McMillan Ave, Dakota Commons eastern building, and the warehouse/storage lot below Milhollin Drive (Plover Plot and Mariner Village). This vulnerability assessment found that the evacuation route (Marine Drive) out of the Blaine Harbor area is fairly resilient to the higher risk associated with RSLR, only becoming vulnerable under the most extreme storm conditions.

Additionally, EA generated three zoomed extent maps to focus in on areas of high interest that were identified by Port personnel. These are shown in Figures A-39 to A-41, which focus on the

Bellingham Shipping Terminal Area, the Squalicum Parkway Industrial Area, and the Marine Trades Area, respectively. The ability to create these high-resolution maps displays the usefulness of this vulnerability assessment framework as it allows the Port to focus in on locations its personnel believe to be the most important. The results show that the majority of the Bellingham Shipping Terminal Area falls into the Medium High vulnerability category. This means that under current conditions a major storm event would likely lead to damage and under projected future conditions the same storm would result in extensive damage. A similar story is true for the region around the Squalicum Parkway Industrial Area, with most of the area falling into the Medium High vulnerability category, including a large segment of Roeder Avenue. This zoomed extent map also highlights the High vulnerability associated with the areas immediately adjacent to Squalicum Creek around the connection to Bellingham Bay. The last zoomed extent focused on the Marine Trades Area, which again follows a similar trend with much of the region falling into the Medium High vulnerability category.

4. EXPOSURE, SENSITIVITY, AND ADAPTIVE CAPACITY ANALYSIS

This Exposure, Sensitivity, and Adaptive Capacity (ESA) Analysis examines the exposure, sensitivity, and adaptive capacity of assets to climate change and coastal hazards to understand the vulnerability of the asset. The following definitions are used in the analysis:

- **Exposure** – The presence of people, infrastructure, natural systems, and economic, cultural, and social resources (i.e., assets) in areas that are at risk from climate change and coastal hazards.
- **Sensitivity** – The degree to which an asset is impacted from climate change and coastal hazards.
- **Adaptive Capacity** – The ability of an asset to respond or adjust to external risks associated with climate change and coastal hazards.
- **Vulnerability** – The result of combining exposure, sensitivity, and adaptive capacity.

The climate change factors considered in the ESA Analysis are Relative Sea Level Rise (RSLR) and increased storm intensity through modeled water levels. Analysis of additional climate change hazards, such as precipitation changes, coastal erosion, and ocean acidification under current and future climate conditions, will be carried out under a separate report.

Section 4.1 outlines the methods used for the ESA Analysis, and Section 4.2 is a pilot ESA Analysis for the Central Maintenance facility and surrounding area at the Bellingham Shipping Terminal. This area was selected as it was identified as one of the most vulnerable areas in the Vulnerability Assessment. Section 4.1 can be used as a template for future ESA Analyses at other areas of the Port.

4.1 METHODS

The methods for the ESA Analysis outlined in this section include data collection; how exposure, sensitivity, adaptive capacity, and vulnerability are defined and scored; and an overview of vulnerability mitigation and resiliency measures. While developing this ESA Analysis, scoring methods and definitions were reviewed from a variety of sources (Arcadis 2021, EA 2021, IPCC 2012, and ICF 2019).

Numerical values are assigned to score the assets in exposure, sensitivity, and adaptive capacity, and then used to calculate a vulnerability ranking of low, medium, or high. T**The numerical values are subjective, with the purpose of showing a relative range of vulnerabilities, and providing the Port with a high, medium, low ranking of assets**. A high vulnerability ranking indicated assets that should be addressed first to lower their exposure or sensitivity to exposure, or adapted to avoid the risk of exposure.

4.1.1 Data Collection

The asset types of interest for the Port include the following:

- Buildings
- Parking lots
- Utility infrastructure
  - Energy infrastructure
  - Sanitary sewer
  - Storm sewer
  - Water supply
- Equipment / vehicles
- Coastal infrastructure (breakwaters, bulkheads, etc.)

For the assets of interest, the following information were gathered:

- Name/nameplate where possible
- Brief description
- Location (latitude and longitude)
- Elevation offset relative to floor/ground elevation
- Photos

Assets were grouped by subareas as needed. Note that if there are multiple similar assets (e.g., multiple outlets or light switches) at the same or similar height from the finished floor elevation, these are treated as one asset type for the ESA Analysis.

4.1.2 Exposure

The exposure of each asset/asset group will be scored similarly to the general vulnerability scoring methodology presented in Table 2-1. Water depth above ground surface derived from the CoSMoS modeling will be compared to each asset's elevation above the ground to determine inundation exposure. For this analysis the highest scoring exposure scenario was used when an asset had multiple exposure scenarios as a conservative assumption.

The scores assigned to each asset range from High (3) being the highest score, Medium (2), and Low (1) having the lowest score. The scoring represents the likelihood of exposure of the asset during a specific storm event at a given relative sea level rise. An asset with a "High" rating is at a more imminent risk of exposure. As the rating moves lower the likelihood of exposure decreases.

Table 4-1. Exposure Scoring Categories

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High (3)	High (3)	High (3)	Medium (2)
50-Year	High (3)	High (3)	Medium (2)	Low (1)
100-Year	High (3)	Medium (2)	Low (1)	Low (1)

Notes:

4) Exposure categories are broken up into three risk levels from low (yellow) to high (red) reflecting timing and frequency.
5) Exposure is ranked relative to storm levels. It is important to note low still represents significant potential for damage to some areas.
6) Scores for vulnerability calculations are in parentheses: high (3), medium (2), and low (1).

ft = feet
m = meters

4.1.3 Sensitivity

Sensitivity is the degree of damage the asset experiences if exposed to climate change and coastal hazards. Increased water levels from RSLR and/or storms can physically damage the asset through impact as well as through saltwater immersion. The sensitivity scoring is presented in Table 4-2.

The scores assigned to each asset range from High (3) being the highest score, Medium (2), and Low (1) having the lowest score. As the scoring moves from a high score to a low score, the degree of damage to the asset decreases. An asset assigned a “High” rating will experience damage beyond the ability of repair or normal function. As for an asset with a “Low” rating, exposure may only result in minor damages that don’t impair functionality.

Table 4-2. Sensitivity Scoring Categories

Score	Sensitivity Scoring
High (3)	If exposed, could become damaged beyond repair or destroyed to the point that normal function cannot resume until replaced.
Medium (2)	If exposed, could become damaged such that repairs are necessary before functionality can resume.
Low (1)	If exposed, could only suffer minor damage but still maintains functionality.

Notes:

1) In this analysis potential damage was estimated based on modeled water levels resulting from coastal storms.
2) Impacts from climate change are incorporated through RSLR and increased storm intensity.
3) Scores for vulnerability calculations are in parentheses: high (3), medium (2), and low (1).

4.1.4 Adaptive Capacity

Adaptive capacity is the ability of the asset to respond or adjust to climate change and coastal hazard impacts. Factors include the ability to protect, modify, or move the asset, which are affected by cost, location, and other engineering and administrative considerations. The scoring for adaptive capacity is presented in Table 4-3.

Adaptative Capacity Scoring addresses the ability of the asset to respond or adjust to climate change and coastal hazard impacts. The scores assigned to each asset range from Low (3) being the highest score, Medium (2), and High (1) having the lowest score. An asset with a “Low” adaptive capacity has lower ability to adapt,respond or adjust, meaning it is a higher risk asset for the Port. Whereas, an asset with a “High” adaptive capacity is more easily adapted to address the impacts of potential exposure.

Table 4-3. Adaptive Capacity Scoring Categories

Score	Adaptive Capacity Scoring
Low (3)	The asset cannot be protected from climate change and coastal hazards. Engineering methods would be inadequate or cost prohibitive and no further administrative methods can be implemented.
Medium (2)	The asset can be protected with some additional effort, whether through engineering or administrative methods.
High (1)	The asset can easily be protected or modified to mitigate exposure to climate change and coastal hazards through a variety of means. Most common are simple engineering or administrative methods.
Notes: 1) Impacts from climate change are incorporated through RSLR and increased storm intensity. 2) Scores for vulnerability calculations are in parentheses: low (3), medium (2), and high (1).	

4.1.5 Vulnerability

Vulnerability is a function of exposure, sensitivity, and adaptive capacity. Exposure and sensitivity represent the components that contribute to the potential impact to the assets. Adaptative Capacity represents the ability for the asset to negate the impact posed from exposure and sensitivity. The ESA Analysis uses the product of exposure, sensitivity, and adaptive capacity scores to calculate vulnerability. This provides a range of vulnerability values, which are ranked as high, medium, and low per Table 4-4 below.

Table 4-4. Vulnerability Scoring Categories

Score	Vulnerability Scoring
High	Product of exposure, sensitivity, and adaptive capacity is 9 or greater.
Medium	Product of exposure, sensitivity, and adaptive capacity is between 4 and 8.
Low	Product of exposure, sensitivity, and adaptive capacity is 3 or less.
Notes: 1) Impacts from climate change are incorporated through RSLR and increased storm intensity.	

4.1.6 Vulnerability Adaptation / Resiliency Measures

For assets identified as being at risk, each of the vulnerability adaptation and resiliency measures identified in Section 4.2 can be evaluated using a cost benefit analysis to select a response measure. Often this analysis and response will be a phased approach.

For example, a parking area susceptible to inundation on king tide and/or large storm events might go through 3 phases:

- **Administrative Measures,** such as identifying king and highest tide dates for the coming year and not parking there on those dates. Also tracking weather and not parking there when strong storms are forecast.
- **Temporary Build Measures,** such as installing tide gates on stormwater outfalls and sand bagging or building curbing to dry-proof.
- **Permanent Built Measures,** that may include filling and raising the entire area and reconstructing utilities and stormwater infrastructure or building a new parking area elsewhere.

4.2 PILOT AREA IMPLEMENTATION

Based on the CoSMoS outputs presented in Section 2, three low-lying areas were identified highly vulnerable to inundation:

- Squalicum Parkway Industrial Area
- Bellingham Shipping Terminal Area
- Marine Trades Area

After discussions with Port staff, the Central Maintenance Facility and surrounding maintenance storage areas that are part of the Bellingham Shipping Terminal Area were selected for a pilot implementation of the ESA Analysis approach developed. The goal of this pilot is to apply the ESA Analysis methodology developed with the CoSMoS outputs to evaluate the resulting vulnerability of specific infrastructure assets and provide the opportunity to fine tune the process prior to application to Port-wide infrastructure assets. The Port may choose to implement the full ESA Analysis in phases using the CoSMoS outputs provided in this vulnerability assessment to guide the prioritization of ESA Analysis to the most vulnerable assets. The ESA Analysis pilot area boundaries are shown in Figure 4-1.

Figure 5-1. ESA Analysis Pilot Boundary - Central Maintenance Facility and Surrounding Area

4.2.1 Site Overview

The Central Maintenance Facility and surrounding area selected for the ESA Analysis pilot implementation includes six subareas (demarcated with numbers) and their corresponding asset groups (demarcated with letters):

1. Central Maintenance Building
    a. Office Area
    b. Portable/Non-Fixed Equipment
    c. Fixed Equipment

    d. Electrical Panels/Switches/Receptacles
    e. Hazardous Material Storage
2. Fuel Island
    a. Fuel Tanks
    b. Electrical Assets and Pumps
    c. Stormwater Catch Basins and Trench Drains
3. Outdoor Parking: Front Parking Lot
    a. Vehicle Parking
4. Outdoor Parking: Back Parking Lot
    a. Vehicle Parking
    b. Oil-Water Separator
    c. Outdoor Storage Containers/Sheds
    d. Outdoor Storage Materials/Equipment
5. Locker Building
    a. Electrical Panels/Switches/Receptacles
    b. Hazardous Material Storage
    c. Portable/Non-Fixed Equipment
6. Shoreline Assets and Infiltration Galleries
    a. Rock/Rubble Shore Armoring
    b. Infiltration Galleries

4.2.2 Asset Analysis

EA conducted site visits on May 19 and June 13, 2022 to identify specific assets and collect asset details needed for the ESA Analysis. Appendix C includes figures identifying assets by number in the Central Maintenance Building, Locker Building and exterior parking, storage, fuel island, and shoreline areas. Also included in Appendix C is a detailed asset data table. Appendix D includes a photo log of selected assets.

Assets within each subarea were grouped according to elevation (exposure) and similar sensitivity and adaptive capacity. For example, the Central Maintenance Building has numerous electrical receptacles and light switches at the same/similar elevations. These are treated as one asset type for the ESA Analysis.

An exposure analysis was conducted for each RSLR/storm scenario presented based on the inundation depth extracted from the CoSMoS outputs at seven reference points within the pilot area. Figure 4-2 provides the location of the seven reference points. Reference point 3 was calculated as an average inundation depth of three points along the centerline of the Maintenance Building to reflect variations in the CoSMoS output over the area of the building.

Sensitivity and adaptive capacity for each asset group were assigned according to the definitions presented in Sections 4.1.3, and 4.1.4, respectively. Finally, the vulnerability score of each asset group was calculated from the exposure, sensitivity, and adaptive capacity scores, as defined in Section 4.1.5. The ESA Analysis results for the pilot area are summarized in Section 4.2.3.

Figure 5-2. CoSMoS Inundation Depth Reference Points

4.2.2.1 Central Maintenance Building (Subarea #1)

For the ESA Analysis of the Central Maintenance Building each of the asset groups identified in Section 4.2.1 were evaluated.

Asset groups identified within the Central Maintenance Building (Subarea #1) include:

a. Office Area
b. Portable/Non-Fixed Equipment

c. Fixed Equipment
d. Electrical Panels/Switches/Receptacles
e. Hazardous Material Storage

Asset groups #1.b through #1.e are located within the three maintenance bays, a fabrication shop, a wood working shop, and the office area. The Central Maintenance Building also includes a second story storage area but it was not evaluated because the elevation of the second story storage area is significantly above the RSLR and storm event scenarios examined. Also note that the ESA analysis of the trench drains in the Central Maintenance Building is included with the analysis of the catch basins in the fuel island area that are connected to the same Oil—Water Separator (OWS) in the front parking lot (see Section 2.2.2.2). Exposure inundation depths output from CoSMoS for the Central Maintenance Building are presented in Table 4-5. These exposure scenarios apply to all assets within the Central Maintenance Building. The 7 in inundation depth for the 10-yr storm/3.28 ft RSLR scenario would classify any assets less than 7 in above the floor as "Medium" exposure. Assets between 7 in and 20 in above the floor would be classified as "Low" exposure.

Table 4-5. Maintenance Building Inundation Depths for Exposure

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	-	-
10-Year Water Depth	-	-	-	7 in
50-Year Water Depth	-	-	-	16 in
100-Year Water Depth	-	-	-	20 in

Notes:
1) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
2) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
3) Unshaded areas while considered "below low" exposure may still be impacted by significant events.

ft = feet
in = inches

Office Area (#1.a)

Vulnerability Score: High

The office area consists of approximately 2,500 square feet of office space finished with drywall and carpet. There are eight office/meeting/training rooms as well as restrooms and locker space, a kitchen area and common areas.

- **Exposure: Medium/Low—**The 10-yr storm/3.28 ft RSLR scenario would produce a “Medium” risk of inundation of the floor. 50 and 100-yr storm/3.28 ft RSLR scenarios produce a “low” risk of inundation of electrical assets.
- **Sensitivity: High—**Inundation of the maintenance office space would be disruptive of operations and require removal/replacement of drywall and insulation and replacement or drying/cleaning of carpet throughout, resulting in significant time and resources to retore to full operation.
- **Adaptive Capacity: Low—**The construction of the Central Maintenance Building (slab-on-grade) does not lend itself to easy adaptation strategies.

Portable/Non-Fixed Equipment (#1.b)

Vulnerability Score: Medium Equipment within 7 in of the floor is “Medium” vulnerability.	

The three maintenance bays with roll up doors on both sides, the fabrication shop, and the wood working shop have numerous non-fixed equipment on the floor including welders, saws, the computer controlling the Computer Numerical Control (CNC) milling machine, and numerous electrically powered hand tools stored at or near floor level.

- **Exposure: Medium/Low—**Equipment within 7 in of the floor is “Medium” risk of exposure. Equipment between 7 in and 20 in above the floor is “Low” exposure. For this analysis, the “Medium” exposure was used.
- **Sensitivity: High—**Inundation of electrical/mechanical equipment in salt water is typically not repairable.
- **Adaptive Capacity: High—**The storage of the majority of equipment in the maintenance bays and shops can either be relocated/elevated with minimal effort. Alternatively, maintenance staff can perform a sweep of the shop prior to expected storms and relocate equipment temporarily.

Fixed Equipment (#1.c)

Vulnerability Score: High Equipment within 20 in of the floor is “High” vulnerability.	

The three maintenance bays, the fabrication and wood shops, and the office have numerous fixed equipment including saws, a belt sander, a lathe, a drill press, a washer/dryer, and a photocopier.

- **Exposure: Medium/Low—**Equipment within 7 in of the floor is “Medium” risk of exposure. Equipment between 7 in and 20 in above the floor is “Low” exposure. For this analysis, the “Medium” exposure was used.
- **Sensitivity: High—**Inundation of electrical/mechanical equipment in salt water is typically not repairable.

- **Adaptive Capacity: Low—**The majority of fixed equipment is large, heavy, and therefore not easily temporarily relocated. Operation/use of equipment requires installation at specified height above the floor. Adaptation options are limited and cost prohibitive.

Electrical Panels/Switches/Receptacles (#1.d)

Vulnerability Score: High Electrical assets within 20 in of the floor is "High" vulnerability.	

The maintenance bays, fabrication and wood shops, and office area have numerous electrical panels, light and equipment switches and receptacles.

- **Exposure: Medium/Low—**Electrical assets within 7 in of the floor are "Medium" risk of exposure. Electrical assets between 7 in and 20 in above the floor is "Low" exposure. For this analysis, the "Medium" exposure was used.
- **Sensitivity: High—**Inundation of electrical equipment in salt water would require inspection/cleaning of connections at a minimum and potentially replacement.
- **Adaptive Capacity: Low—**The relocation of electrical panels, light Electrical assets within 20 in of the floor is "High" vulnerability and equipment switches and receptacles is possible, but cost prohibitive.

Hazardous Material Storage (#1.e)

Vulnerability Score: Medium Hazardous material storage including the Oil Room, Battery Room, and flammables cabinets within 7 in of the floor are "Medium" vulnerability.	

The maintenance bays and fabrication and wood shops have numerous hazardous material storage rooms and cabinets including the oil storage room, battery room, flammable cabinet in the wood shop and portable oil/fluid containers around the shop. Inundation of these storage areas would result in the potential release of hazardous materials from spills/drips within the storage area and/or leaks/spills from material drums/cans/containers.

- **Exposure: Medium—**The majority of hazardous material storage in the Maintenance Building is within 7 in of the floor, and therefore, is "Medium" risk of exposure. There were no hazardous material storage areas identified as "Low" exposure, that is, between 7 in and 20 in above the floor.
- **Sensitivity: Medium—**Inundation of hazardous material storage Has the immediate concern of release of any drips/spills/residue in the cabinet and/or secondary containment and work be a "medium" risk. Deeper inundation could result in larger releases from spilled/over toped storage containers.
- **Adaptive Capacity: High—**The storage of the majority of equipment in the maintenance bays and shops can either be relocated/elevated with minimal effort. Alternatively,

maintenance staff can perform a sweep of the shop prior to expected storms and relocate equipment temporarily.

4.2.2.2 Fuel Island (Subarea #2)

Exposure inundation depths output from CoSMoS for the Fuel Island are presented in Table 4-6. These exposure scenarios apply to assets at the fuel island and adjacent hydraulic lift. The 7 in inundation depth for the King Tide/3.28 ft RSLR scenario would classify any assets less than 7 in above the ground surface as "High" exposure. Assets between 7 in and 15 in above the ground would be classified as "Medium" exposure (for the 10-year storm event). Assets between 15 in and 28 in above the ground would be classified as "Low" exposure. For the 100-year storm/1.64 ft RSLR scenario, assets within 5 in of the ground surface are classified as "Low" exposure. For this analysis the 3.28 ft RSLR is used to be more conservative.

Table 4-6. Fuel Island Inundation Depths

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	-	7 in
10-Year Water Depth	-	-	-	15 in
50-Year Water Depth	-	-	-	24 in
100-Year Water Depth	-	-	5 in	28 in

Notes:
1) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
2) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
3) Unshaded areas while considered "below low" exposure may still be impacted by significant events.

ft = feet
in = inches

Asset groups identified within the fuel island area include:
- Fuel tanks (propane, gasoline, diesel, and used oil)
- Electrical assets and pumps for dispensing fuel
- Stormwater catch basins connected to sanitary sewer

Fuel Tanks (#2.a)

Vulnerability Score: High

There are four large storage tanks at the fuel island: propane, gasoline, diesel, and used oil. Minor inundation of the tanks is not a risk, but as water levels rise around the tanks, they may become buoyant depending on the volume of fuel/oil in the tank.

- **Exposure: High—**The gasoline, diesel, and used oil tanks are approximately 8” above ground surface are “High” risk based on the 3.28 ft RSLR/King Tide scenario that would see these assets submerged several times per year.
- **Sensitivity: High—**Buoyancy/wave action may compromise the tanks’ attachment to the ground potentially resulting in a significant release.
- **Adaptive Capacity: High—**If existing tank connections are determined to be inadequate, the installation of additional restraints to is easily accomplished.

Electrical Assets and Pumps (#2.b)

Vulnerability Score: Medium	

Electrical assets and pumps for dispensing fuel at the ground are “High” exposure risk. Other pump/electrical assets, including the fuel shutoff and hydraulic lift controller mounted on the outside of the maintenance building, are above the projected inundation depth, and at minimal risk.

- **Exposure: High—**The electrical junction box at ground level and the pump and controls for the propane tank are at “High” risk. Inundation of 24 to 28” would produce significant buoyancy on the tanks.
- **Sensitivity: Medium—**Cleaning connections/repair of these assets could be accomplished at minimal cost and effort.
- **Adaptive Capacity: High—**Waterproofing and/or relocating these assets can be accomplished at minimal cost and effort.

Stormwater Catch Basins and Trench Drains (#2.c)

Vulnerability Score: High	

There is a catch basin under the fuel island roof and another under the hydraulic lift roof that connect, along with the trench drains in the Maintenance Building, to the OWS in the front parking lot, and then to the sanitary sewer.

- **Exposure: High/Medium—**The two catch basins are “High” exposure based on the 3.28 ft RSLR/King Tide scenario. The trench drains are “Medium” exposure. For this analysis, the “High” exposure was used.
- **Sensitivity: High—**These assets drain to the sanitary sewer and ultimately to the City of Bellingham treatment plant. Any level of inundation of these assets would send large flows to the treatment plant, exceeding the Ports discharge permit limits, and potentially, overwhelming the treatment plant with excess flow.
- **Adaptive Capacity: Low—**While administrative measures such as covering the catch basins/trench drains to prevent inflow before expected storm events can be implemented at minimal cost and effort, these measures could violate other permit/regulatory requirements like secondary containment/spill prevention.

4.2.2.3 Outdoor Parking: Front Parking Lot (Subarea #3)

Exposure inundation depths output from CoSMoS for the front parking lot are presented in Table 4-7. The 11 in inundation depth for the King Tide/3.28 ft RSLR scenario would classify any assets less than 11 in above the ground surface as "High" exposure. Assets between 11 in and 20 in above the ground would be classified as "Medium" exposure. Assets between 20 in and 32 in above the ground would be classified as "Low" exposure. For the 100-year storm/1.64 ft RSLR scenario, assets within 9 in of the ground surface are "Low" exposure. For this analysis, the 3.28 ft RSLR exposures are used to be more conservative.

Table 4-7. Front Parking Lot Inundation Depths

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	-	11 in
10-Year Water Depth	-	-	-	20 in
50-Year Water Depth	-	-	-	29 in
100-Year Water Depth	-	-	9 in	32 in

Notes:
1) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
2) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
3) Unshaded areas while considered "below low" exposure may still be impacted by significant events.

ft = feet
in = inches

Note that there is an OWS in the front parking lot but it is analyzed in Section 4.2.2.2 (#2.c). The OWS in the front parking lot receives drainage from the catch basins located at the fuel island and the hydraulic lift, as well as from the trench drains in the maintenance shop bays. The OWS separates and captures oil in the drainage before discharging to the City of Bellingham sanitary sewer system. Section 4.2.2.2 (#2.c) examined the impact of excess flow from the OWS to the sanitary sewer.

<u>**Vehicle Parking (#3.a)**</u>

Vulnerability Score: High

This area incorporates the publicly accessible parking area in front of the Central Maintenance building. There are approximately 20 marked parking spaces in the front parking lot plus additional area along the waterfront that may be used for parking. Vehicles begin to have mechanical components impacted at approximately 6 to 12 in of inundation (brakes, suspension). For this analysis the more conservative 6 in inundation depth was used.

- **Exposure: High/Medium/Low—**Vehicles parked in the front parking lot range from "High" to "Low" exposure based on the 3.28 ft RSLR scenarios. The 1.64 ft RSLR/100-year storm scenario results in a "Low" exposure. For this analysis, the "High" exposure was used.
- **Sensitivity: High—**Even minor inundation of vehicles can result in significant damage and increased maintenance/repair.
- **Adaptive Capacity: High—**Administrative measures like parking elsewhere before expected storm events can be implemented at minimal cost and effort.

4.2.2.4 Outdoor Parking: Back Parking Lot (Subarea #4)

Exposure inundation depths output from CoSMoS for the back parking lot are presented in Table 4-8. The 18 in inundation depth for the 3.28 ft RSLR scenario would classify any assets less than 18 in above the ground surface as "High" exposure. Assets between 18 in and 26 in above the ground would be classified as "Medium" exposure. Assets between 26 in and 39 in above the ground would be classified as "Low" exposure. For the 1.64 ft RSLR scenario assets are also classified from "High" to "Low" exposure pending the water depth. For the 0.82 RSLR scenario there is "Medium" exposure for assets less than 8 in above the ground surface.

Table 4-8. Back Parking Lot Inundation Depths

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	-	18 in
10-Year Water Depth	-	-	4 in	26 in
50-Year Water Depth	-	-	11 in	35in
100-Year Water Depth	-	8 in	16 in	39 in

Notes:

4) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
5) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
6) Unshaded areas while considered "below low" exposure may still be impacted by significant events.

ft = feet
in = inches

Vehicle Parking (#4.a) — **Vulnerability Score: High**

In the fenced parking and storage area behind the Central Maintenance building (back parking lot) there are approximately 30 marked parking spaces plus outdoor storage/additional parking. The outdoor storage is evaluated separately under asset groups #4.c and #4.d.

- **Exposure: High/Medium/Low—**Vehicles parked in the back parking lot range from "High" to "Low" exposure based on the 3.28 ft RSLR scenarios. The 1.64 ft MSLR storm scenarios result in "High" to "Low" exposure. The 0.82 ft RSLR storm scenario results in a "Medium" exposure. For this analysis, the "High" exposure was used.
- **Sensitivity: High—**Even minor inundation of vehicles can result in significant damage and increased maintenance/repair.
- **Adaptive Capacity: High—**Administrative measures like parking elsewhere before expected storm events can be implemented at minimal cost and effort.

Oil-Water Separator (#4.b)

Vulnerability Score: Medium	

There is an OWS in the back parking lot that treats stormwater discharges from the parking lot to separate and retain oil prior discharge to the bay. Inundation of this OWS could result in the release of retained oil to the environment

- **Exposure: High/Medium/Low—**The OWS in the back parking lot ranges from "High" to "Low" exposure based on the 3.28 ft MSLR scenarios. The 1.64 ft RSLR storm scenarios also result in "Medium" to "Low" exposure. The 0.82 ft RSLR storm scenario results in a "Medium" exposure. For this analysis, the "High" exposure was used.
- **Sensitivity: Medium—**Even minor inundation of vehicles can result in significant damage and increased maintenance/repair.
- **Adaptive Capacity: High—**Administrative measures like more frequent cleaning of the OWS can minimize the volume of oil potential at risk. Engineering measures such as installing water tight, bolt-down access lids on the OWS can minimize the potential release of oil form the OWS during inundation.

Outdoor Storage Containers/Sheds (#4.c)

Vulnerability Score: High	

There are four shipping containers/sheds elevated 8 to 12 in above ground surface in the back parking lot as well as outdoor storage of materials and equipment. The containers/sheds include storage of oil and other hazardous liquids in drums, and crushed, used oil filters.

- **Exposure: High/Medium/Low—**The storage containers/sheds in the back parking lot ranges from "High" to "Low" exposure based on the 3.28 ft MSLR scenarios. The 1.64 ft RSLR storm scenarios also result in "Medium" to "Low" exposure. For this analysis, the "High" exposure was used.
- **Sensitivity: High—**Even minor inundation of the storage areas could result in the release of residual drips/spills in the secondary containment. Higher level inundation could result in more significant releases from unsealed containers.

- **Adaptive Capacity: High—**Administrative measures like more frequent cleaning of the secondary containment can minimize the volume of oil potential at risk. Engineering measures such as raising/relocating the storage containers/shed could reduce the risk.

Outdoor Storage Materials/Equipment (#4.d)

Vulnerability Score: Medium	

There is a variety of material and equipment stored outdoors in the back parking lot, including part of the bulk material laydown area for the Bellingham Shipping Terminal currently used for large rock storage. Much of the materials currently on site would not be impacted by inundation, but this should be taken into consideration when storing additional material/equipment. There is also an electric gate opener located at each access gate that are approximately 4 in above ground surface.

- **Exposure: High/Medium/Low—**The outdoor storage in the back parking lot ranges from “High” to “Low” exposure based on the 3.28 ft RSLR scenarios. The 1.64 ft RSLR storm scenarios result in “Medium” to “Low” exposure. The 0.82 ft RSLR storm scenario results in a “Medium” exposure. For this analysis, the “High” exposure was used.
- **Sensitivity: Medium—**Even minor inundation of the gate openers and/or mechanical equipment stored outdoors could result in damage to the equipment.
- **Adaptive Capacity: High—**Administrative measures like more frequent cleaning of the secondary containment can minimize the volume of oil potential at risk. Engineering measures such as raising/relocating the storage containers/shed could reduce the risk.

4.2.2.5 Locker Building (Subarea #5)

The Locker Building consists of four storage areas for equipment and materials. Exposure inundation depths output from CoSMoS for the Locker Building are presented in Table 4-9. The 18 in inundation depth for the 3.28 ft RSLR scenario would classify any assets less than 18 in above the ground surface as “High” exposure. Assets between 18 in and 26 in above the ground would be classified as “Medium” exposure. Assets between 26 in and 39 in above the ground would be classified as “Low” exposure. For the 1.64 ft RSLR scenario assets are also classified from “High” to “Low” exposure pending the water depth. For the 0.82 RSLR scenario there is “Medium” exposure for assets less than 8 in above the ground surface.

Table 4-9. Locker Building Inundation Depths

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	-	-
10-Year Water Depth	-	-	-	6 in
50-Year Water Depth	-	-	-	16in
100-Year Water Depth	-	-	-	19 in

Notes:
7) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
8) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
9) Unshaded areas while considered “below low” exposure may still be impacted by significant events.

ft = feet
in = inches

Electrical Panels/Switches/Receptacles (#5.a)

Vulnerability Score: Medium

The four lockers in the Locker Building have numerous electrical panels, light and equipment switches and receptacles, and a heater in the gym room.

- **Exposure: Medium/Low—**Electrical assets within 7 in of the floor are “Medium” risk of exposure. Electrical assets between 7 in and 20 in above the floor is “Low” exposure. For this analysis, the “Medium” exposure was used.
- **Sensitivity: High—**Inundation of electrical equipment in salt water would require inspection/cleaning of connections at a minimum and potentially replacement.
- **Adaptive Capacity: High—**There were only 5 electrical assets identified less than 38 in above the floor. Relocation of these assets is possible at minimal cost and effort.

Hazardous Material Storage (#5.b)

Vulnerability Score: Medium

Four paint and hazardous material storage cabinets were identified in the Locker Building. Inundation of these storage areas would result in the potential release of hazardous materials from spills/drips within the storage area and/or leaks/spills from material drums/cans/containers.

- **Exposure: Medium—**The majority of hazardous material storage in the Locker Building is within 4 in of the floor, and therefore, is “Medium” risk of exposure. There were no hazardous material storage areas identified as “Low” exposure, that is, between 7 in and 20 in above the floor.

- **Sensitivity: Medium—**Inundation of hazardous material storage Has the immediate concern of release of any drips/spills/residue in the cabinet and/or secondary containment and work be a "medium" risk. Deeper inundation could result in larger releases from spilled/over toped storage containers.
- **Adaptive Capacity: High—**The storage of the majority of equipment in the Locker Building can either be relocated/elevated with minimal effort.

<u>Portable/Non-Fixed Equipment (#5.c)</u>

Vulnerability Score: Medium	

The four lockers in the Locker Building have numerous non-fixed equipment on the floor including mowers, tractors, blowers and trimmers, and other gas/electrical powered hand tools stored at or near floor level.

- **Exposure: Medium/Low—**Equipment within 9 in of the floor is "Medium" risk of exposure. Equipment between 7 in and 20 in above the floor is "Low" exposure. For this analysis, the "Medium" exposure was used.
- **Sensitivity: High—**Inundation of electrical/mechanical equipment in salt water is typically not repairable.
- **Adaptive Capacity: High—**The storage of the majority of equipment in the maintenance bays and shops can either be relocated/elevated with minimal effort. Alternatively, maintenance staff can perform a sweep of the shop prior to expected storms and relocate equipment temporarily.

4.2.2.6 Shoreline Assets and Infiltration Galleries (Subarea #6)

Exposure inundation depths output from CoSMoS for the back parking lot are presented in Table 4-8. The 18 in inundation depth for the 3.28 ft RSLR scenario would classify any assets less than 18 in above the ground surface as "High" exposure. Assets between 18 in and 26 in above the ground would be classified as "Medium" exposure. Assets between 26 in and 39 in above the ground would be classified as "Low" exposure. For the 1.64 ft RSLR scenario assets are also classified from "High" to "Low" exposure pending the water depth. For the 0.82 RSLR scenario there is "Medium" exposure for assets less than 8 in above the ground surface.

Table 4-10. Shoreline and Infiltration Gallery Inundation Depths

Storm Event	RSLR (ft)			
	0	0.82	1.64	3.28
King Tide Water Depth	-	-	4 in	18 in
10-Year Water Depth	-	-	5 in	27 in
50-Year Water Depth	-	3 in	12 in	36in
100-Year Water Depth	-	9 in	17 in	40 in

Notes:

10) Exposure categories are broken up into three levels from low (yellow) to medium (orange) to high (red).
11) Exposure categories from Table 4-1 are only shown if there is a corresponding inundation water depth.
12) Unshaded areas while considered "below low" exposure may still be impacted by significant events.

ft = feet
in = inches

Rock/Rubble Shore Armoring and Beach Area(#6.a)

Vulnerability Score: High

The shoreline along the Maintenance Building down to the Shipping Terminal is armored with rip rap and broken concrete of various sizes. It does not appear to be an engineered design, but rather was constructed over time on materials that were available. A more detailed engineering analysis should be included as part of any restoration/raising of the shoreline armoring.

- **Exposure: High—**The top of the armoring is approximately 12 in below the control point presented in Table 4-10 and is regularly overtopped by king tides and storm wave action.
- **Sensitivity: Medium—**Currently, the armoring appears to be stable. However, RSLR will subject the armoring and ground surface behind the armoring to additional wave action that may result in erosion and degradation of the armoring.
- **Adaptive Capacity: Low—**Any effort to raise/improve the shoreline armoring as a breakwater to RSLR and wave action will require engineering design, and potentially removal/replacement of existing armoring materials.

Infiltration Galleries (#6.b)

Vulnerability Score: Medium

There are three infiltration galleries along the shoreline of the bulk material laydown area between the Maintenance Building and the Shipping Terminal. One of the infiltration galleries and part of another fall within the boundaries of this study area as shown in Figure 4-1. The infiltration galleries were constructed to treat stormwater from the break bulk laydown area currently being utilized to store large stone rip rap prior to shipping. Inundation of this OWS could result in the release of retained oil to the environment. The paving of the break bulk area is on hold pending the completion of the large rip rap storage, and the infiltration galleries are not currently in use.

- **Exposure: High—**Based on the CoSMoS output, the infiltration galleries are subject to inundation during the King Tide/1.64 ft RSLR scenario and the 50-year/0.82 ft RSLR Scenario.
- **Sensitivity: Low—**Inundation of the infiltration galleries present little potential damage.
- **Adaptive Capacity: Low—**The infiltration galleries are not easily redesigned to accommodate RSLR.

4.2.3 ESA Analysis Summary

The ESA analysis scoring for each asset group is summarized in Table 4-11. The ESA analysis results identified 10 of 19 asset groups as "High" risk. They include:

- 1. Central Maintenance Building:
    - a. Office Area
    - c. Fixed Equipment
    - Electrical Panels/Switches/Receptacles
- 2. Fuel Island
    - a. Fuel Tanks
    - c. Stormwater Catch Basins and Catch Drains
- 3. Outdoor Park – Front Parking Lot
    - a. Vehicle Parking
- 4. Outdoor Parking – Back Parking Lot
    - a. Vehicle Parking
    - c. Outdoor Storage Containers/Sheds
- 6. Shoreline Assets and Infiltration Galleries
    - a. Rock/Rubble Shore armoring
    - b. Infiltration Galleries

Subarea / Asset Group	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1. Central Maintenance Building				
1.a Office Area	Medium	High	High	High
1.b Portable/Non-Fixed Equipment – within 7 in of the floor	Medium	High	Low	Medium
1.b Portable/Non-Fixed Equipment – between 7 in and 20 in above the floor	Low	High	Low	Low
1.c Fixed Equipment	Medium Low	High	High	High
1.d Electrical Panels/ Switches/Receptacles	Medium Low	High	High	High
1.e Hazardous Material Storage	Medium	Medium	Low	Medium
2. Fuel Island				
2.a Fuel Tanks	High	High	Low	High
2.b Electrical Assets and Pumps	High	Medium	Low	Medium
2.c Stormwater Catch Basins and Trench Drains	High Medium	High	High	High
3. Outdoor Parking: Front Parking Lot				
3.a Vehicle Parking	High	High	Low	High
4. Outdoor Parking: Back Parking Lot				
4.a Vehicle Parking	High	High	Low	High
4.b Oil-Water Separator	High	Medium	Low	Medium
4.c Outdoor Storage Containers/Sheds	High	High	Low	High
4.d Outdoor Storage Materials/Equipment	High	Medium	Low	Medium
5. Locker Building				
5.a Eletrical Panels/ Switches/ Receptacles	Medium	High	Low	Medium
5.b Hazardous Material Storage	Medium	Medium	Low	Medium
5.c Portable/Non-Fixed Equipment	Medium	High	Low	Medium
6. Shoreline Assets and Infiltration Galleries				
6.a Rock/Rubble Shore Armoring	High	Medium	High	High
6.b Infiltration Galleries	High	Low	High	High
Notes:				
1) In this analysis potential damage was estimated based on modeled water levels resulting from coastal storms.				
2) Impacts from climate change are incorporated through RSLR and increased storm intensity.				

Table 4-11 ESA Scoring Summary

4.3 ESA ANALYSIS NEXT STEPS

The pilot area ESA analysis in Section 4.2 is an example of how the methods outlined in Section 4.1 can be deployed. The ESA Analysis methodology can be scaled up for other Port areas / assets. The recommended next steps for continuation of the vulnerability assessment process in the following:

- Set up an ESA analysis process in a geospatial database compatible with the format of the Port's Asset Management System (AMS) to allow continued revision and update of the Port's ESA analysis as new/updated RSLR projections become available.
- Establish two to three exposure scenarios to represent the Port's selected scenarios for projected future timeframes (e.g., 2030, 2050, 2100). This would simplify the ESA analysis and allow development of concrete adaptability goals for each timeframe.
- Continue the ESA analyses of other highly vulnerable areas at the Port identified in Section 3.5, and eventually to all Port assets.
- For assets identified as being at risk, each of the vulnerability adaptation and resiliency measures identified in Section 4.2 can be evaluated using a cost benefit analysis to select a response measure. Often this analysis will be a phased approach.

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5. RECOMMENDATIONS TO IMPROVE RESILIENCE

Through this vulnerability assessment EA has demonstrated that the Port is at risk of flooding under current conditions, shown by the no RSLR scenarios, and that continuing RSLR and coastal storm events resulting from climate change will exacerbate the vulnerability of the Port. The assessment identified the low-lying areas of the Port that are most at risk of flooding and therefore the most vulnerable. These highly vulnerable areas included the regions around the Squalicum Parkway Industrial Area, the Bellingham Shipping Terminal Area, the Marine Trades Area by the I & J Waterway, and the Bellingham Cruise Terminal, as well as critical non-port assets such as Harris Avenue and Roeder Avenue that are essential transportation corridors for Port operations. In these locations several parking lots, offices, local businesses, boat yards, public recreation areas, railroads, roadways, and utilities could be flooded. As has been mentioned, an exposure, sensitivity, and adaptive capacity analysis would be a next step to assess the overall risk to the Port's assets.

EA has demonstrated that king tides under future conditions could lead to nuisance flooding, and that large storms may completely flood the aforementioned areas. Employing a variety of mitigation/adaptation measures could help ensure the Port experiences less damage when these floods occur. Altering current infrastructure, building new infrastructure, or turning to nature-based solutions are all approaches to curb the effects of flooding. Building or altering infrastructure could allow for a direct mitigation of flood effects while using nature-based solutions could provide increased protections while also minimizing the impact on coastline, leading to the creation of additional natural environment for organisms.

The Vulnerability Assessment identified the low-lying areas of the Port that are most at risk of flooding and therefore the most vulnerable. These highly vulnerable areas include regions around:

- Squalicum Parkway Industrial Area
- Bellingham Shipping Terminal Area
- Marine Trades Area by the I & J Waterway
- The Fairhaven Marine Industrial Park and Cruise Terminal

These locations, which could be impacted by the flooding, include several parking lots, offices, local businesses, boat yards, public recreation areas, railroads, roadways, and utilities. The Port should prioritize these areas for a more detailed investigation of specific assets at risk and potential approaches to mitigating risk.

5.1 DATA GAP ELIMINATION

To begin improving resilience at the Port, EA recommends that a sensitivity analysis be conducted on existing assets. With the vulnerability assessment in mind, EA suggests the Port determine which of its assets are the most important and valuable, and then further assess which are most vulnerable to RSLR and coastal storm events. This can be aided by using the RTK elevation data collected by EA to perform asset specific elevation spot checks. These spot checks will lead to an understanding of what elevations around the Port are most at risk and therefore can be used to identify all vulnerable assets, including any future development. This is essentially what EA has done in this vulnerability assessment, but it would take it a step further by incorporating asset specific information. Including this data would allow the Port to further assess in which areas developing adaptation measures will be the most important.

As a next step to improve resilience at the Port, EA recommends the Port develop a complete inventory and database that includes all fixed Port assets and a corresponding ID. The database should include spatial data for each fixed asset and would allow detailed asset-specific analyses of climate vulnerabilities and development of appropriate resiliency measures. Recommended inventories include Port buildings (including finished floor elevations) and all utility infrastructure (including water supply, sanitary sewer, storm sewer, and energy infrastructure).

A complete inventory of Port assets would also permit the development of an asset management system that would facilitate coordination of adaptation measures, maintenance, and capital planning. Although such systems may take significant resources to implement, it would maintain the investment already put into the recommended inventory of assets and facilitate the appropriate allocation of additional resources. Asset management will become more crucial as climate change limits available resources and increases hazards to Port assets.

Further and more detailed analyses of climate change hazards should be carried out following inventory of Port assets. These include future analyses of coastal erosion and sedimentation rates and ocean acidification under current and future climate conditions, as well as additional detailed analyses of RSLR and coastal storm events on inventoried assets.

5.2 INFRASTRUCTURE PROTECTION MEASURES

Planning and adapting to RSLR and coastal storm events is relatively new. In many cases where an area is at risk of increased flooding, short- and long-term strategies have yet to be implemented. However, some coastal dwellings have developed or have been recommended various strategies for implementation. For example, Port-Penn in Delaware has developed a document on mitigation strategies based on its own vulnerability assessment, many of which are discussed below (Michael Baker, Int 2019).

5.2.1 Temporary Built Measures

Dry floodproofing is an option that can work to prevent flooding in buildings or areas minimally affected by nuisance floods. Dry floodproofing works by creating a watertight seal in the area to be affected by a flood. It prevents water from entering the area or building. Dry floodproofing is a relatively inexpensive option and can hold for an extended period of approximately 25 or more years. However, if sea levels were to continue to rise at arapid rate, then a building treated with only dry floodproofing would be at considerable risk of flooding in a period shorter than the lifespan of the seal. A study conducted by Port Penn in Delaware indicated this technique would work on buildings estimated to experience less than one foot flood depth (Michael Baker, Int 2016).

5.2.2 Permanent Built Measures

Elevating structures and at-risk components could be implemented to curb the effects of RSLR and coastal storm events. When elevating structures, it is important to note what part of a structure is at risk. For example, if utilities or electronics in a building are at an elevation that puts them at risk to flooding, then elevating those items would be the most logical course of action. The downside to elevating these items above flood-prone elevations is that it is expensive. However, the expense would typically be lower than replacing flood damaged equipment.

Common structures built for the purpose of flood protection in flood prone areas include sea walls, groins, revetments, and breakwaters. Protecting lower elevations is especially important for the flooding that could be observed in the near future. Coastal structures are designed to minimize various coastal hazards, such as storm surge, wave attack, and erosion. These methods are generally made of rock deposits or armored rock. The Port has engineered structures that could be improved, and adding new structures could improve its resilience.

During the site visit, riprap revetments and bulkheads were observed throughout the Port. Additionally, breakwaters protecting the various harbors associated with the Port have been observed both during the site visit and through satellite imagery. The breakwaters surrounding the harbors are very important to ensure that wave action does not disturb moored boats or the buildings in the harbor areas. Protective measures such as these breakwaters should be inventoried, have structural integrity assessed, and have their resilience against upcoming climate change issues assessed to determine if retrofitting or improvements are needed.

5.2.3 Managed Retreat

Retreat and/or relocation can decrease risks of flooding due to RSLR and coastal storm events. Given the nature of the Port's functions, it might only be feasible to move assets that do not need to be on or near the water. Subsequent assessment is needed to determine the best approach due to the complexities associated with a managed retreat.

5.2.4 Climate Mitigation Measures

The Port of Bellingham is committed to reducing emissions to cut impacts on global warming, and thus RSLR and coastal storm events. The Port was presented with a road map in 2019 by ECONorthwest that led to the creation a climate action strategy to reduce emissions. By continuing to switch to renewable energy, increasing energy efficiency and the numerous other measures being considered and adopted, the Port is on a path towards mitigation of Greenhouse Gas emissions. Although not a direct adaptation to RSLR flooding and coastal storm events, it is an important step in the right direction.

5.2.5 Nature-Based Solutions

The United States Army Corp of Engineers (USACE) initiated and led a push for natural engineering solutions for flood prevention adaptation called the Natural and Nature Based Features (NNBF) for Flood Risk Management (FRM). Nature has long contributed to flood mitigation so the USACE, in conjunction with other partners, developed guidelines on how to engineer using landscape material (USACE 2021). NNBF guidelines were established to use natural processes to minimize impacts on coastlines while receiving maximum benefits. Nature-based approaches to flood prevention adaptation include implementing living shorelines, which involves the use of natural hard (oysters, reefs) and soft (vegetation) organisms or substances to help stabilize a shoreline. Additionally, beach nourishment is a way to use a naturally occurring substance (sand) to strengthen a beach or coast for added protection. The use of NNBF is site-specific and each solution is developed to provide the highest level of flood protection while maintaining and promoting the natural environment.

5.3 CAPITAL PROJECT PLANNING

Designs for future capital projects should incorporate projected RSLR and coastal storm events for the anticipated lifetime of the project. Frontloading projects with careful planning at the design and construction phases (including permitting, operating and maintenance costs) will result in more resilient infrastructure and overall lower total costs, if costs associated with repairs following storm events and king tides are considered.

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Appendix A

Flood Extent and Vulnerability Assessment Figures

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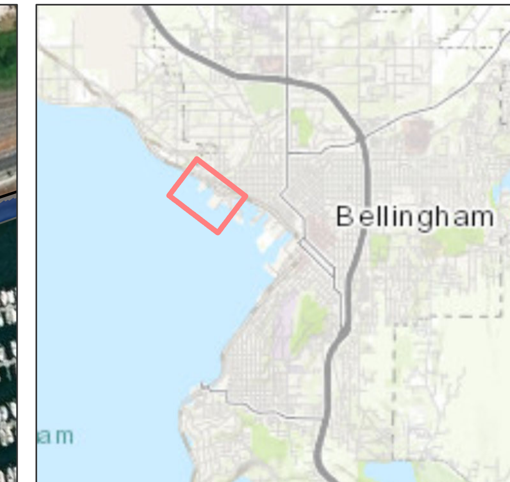
LIST OF FIGURES

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-1
Locator Map



Legend

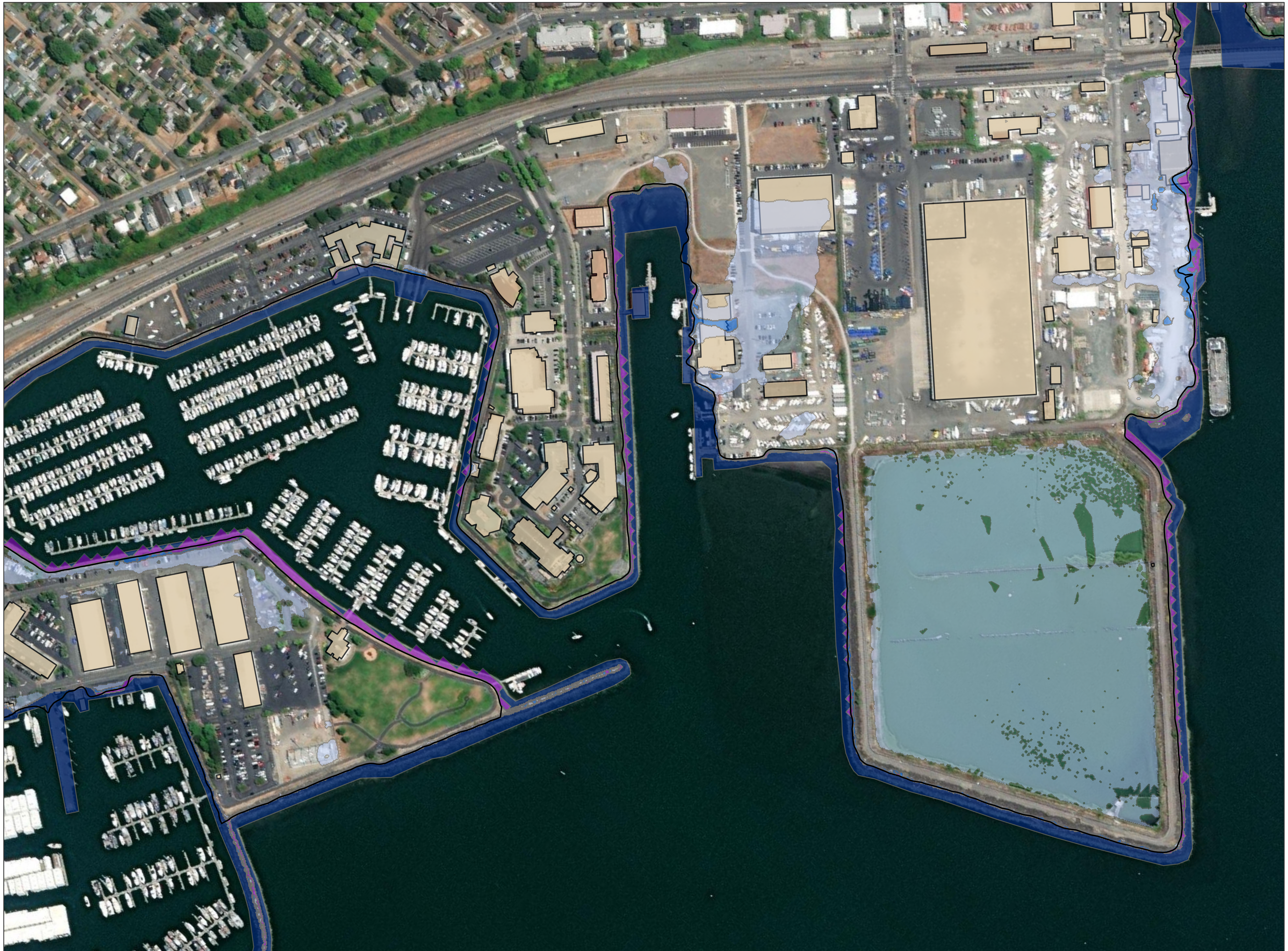
- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings

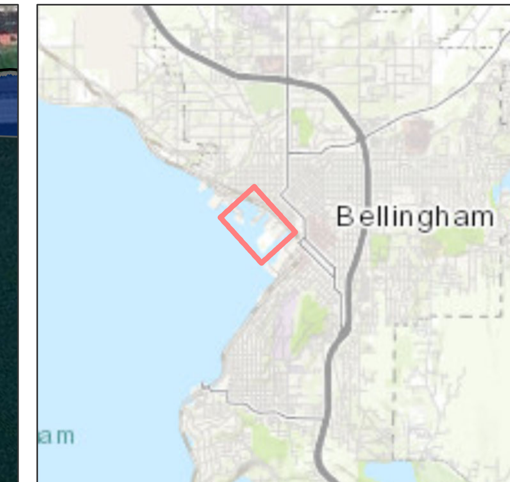
0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-2
King Tide Scenarios
Port of Bellingham: North





Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400

Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-3
King Tide Scenarios
Port of Bellingham: Central

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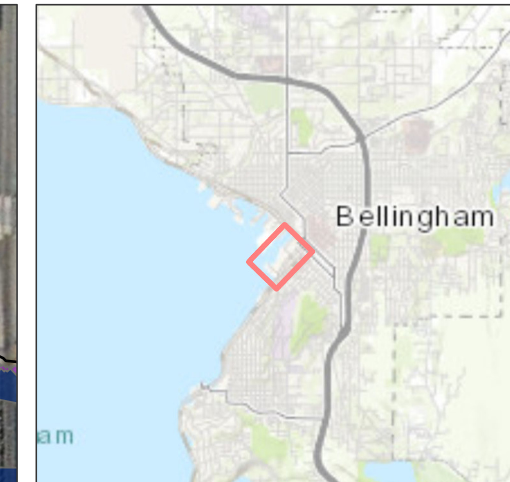

Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

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Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-4
King Tide Scenarios
Port of Bellingham: South

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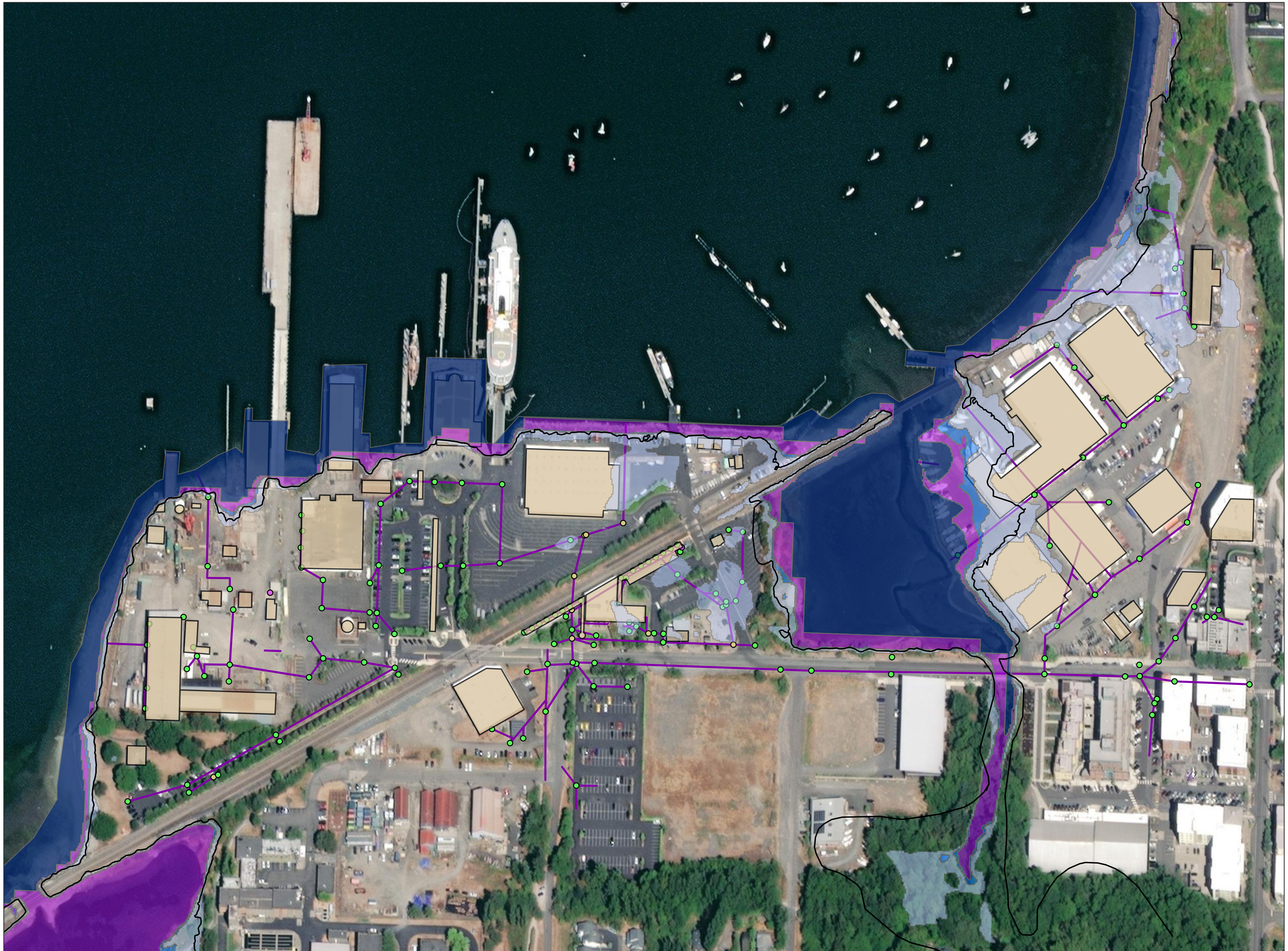

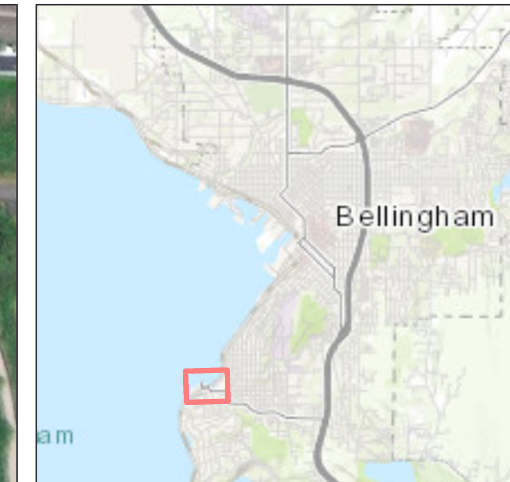

Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Cleanout
- Manhole
- Storm Sewer Line

N

0 100 200 300 400

Feet

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Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-5
King Tide Scenarios
Fairhaven

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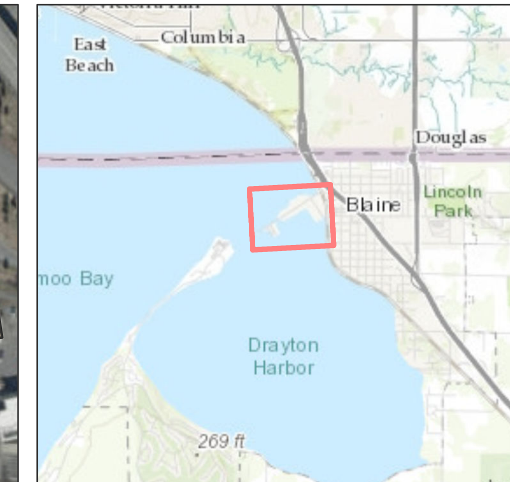

Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Storm Sewer Line

N

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

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Bellingham, WA

Figure A-6
King Tide Scenarios
Blaine Harbor

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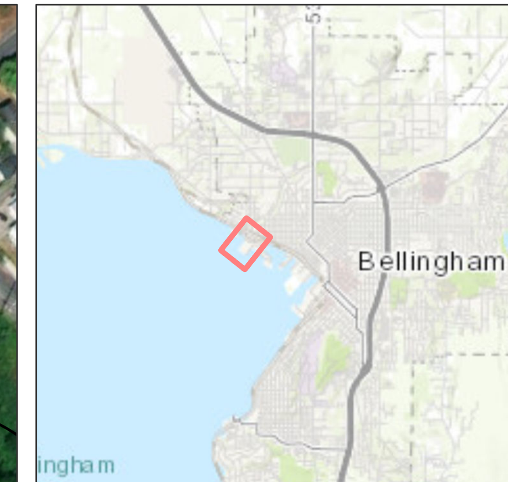
Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-7
King Tide Scenarios
Bellingham Shipping Terminal



Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Drain
- OWS
- Storm Sewer Line

0 100 200 300 400
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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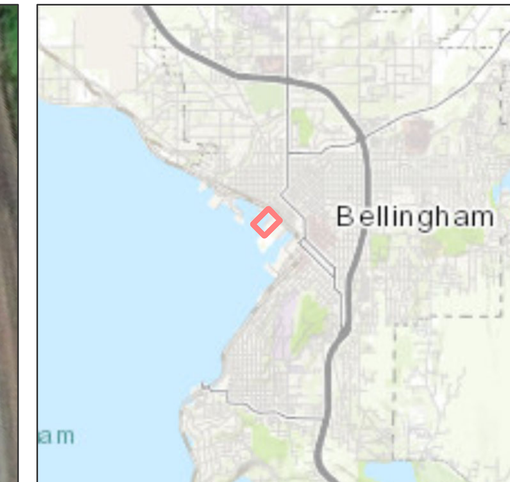
Bellingham, WA

Figure A-8
King Tide Scenarios
Squalicum Parkway Industrial Area

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- King Tide, no RSLR
- King Tide, 0.82ft (0.25m) RSLR
- King Tide, 1.64ft (0.50m) RSLR
- King Tide, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

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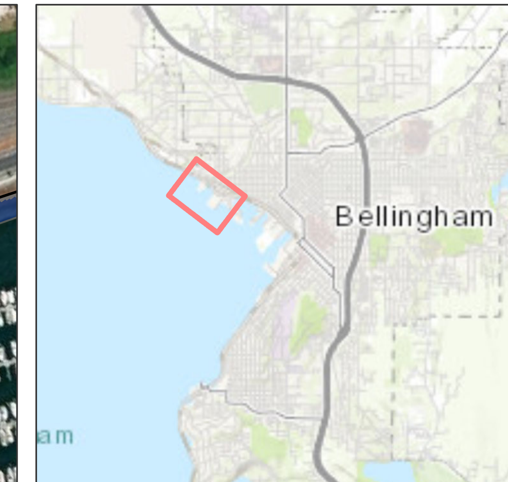
Figure A-9
King Tide Scenarios
Marine Trades Area

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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Bellingham, WA

Figure A-10
10-Year Storm Event Scenarios
Port of Bellingham: North

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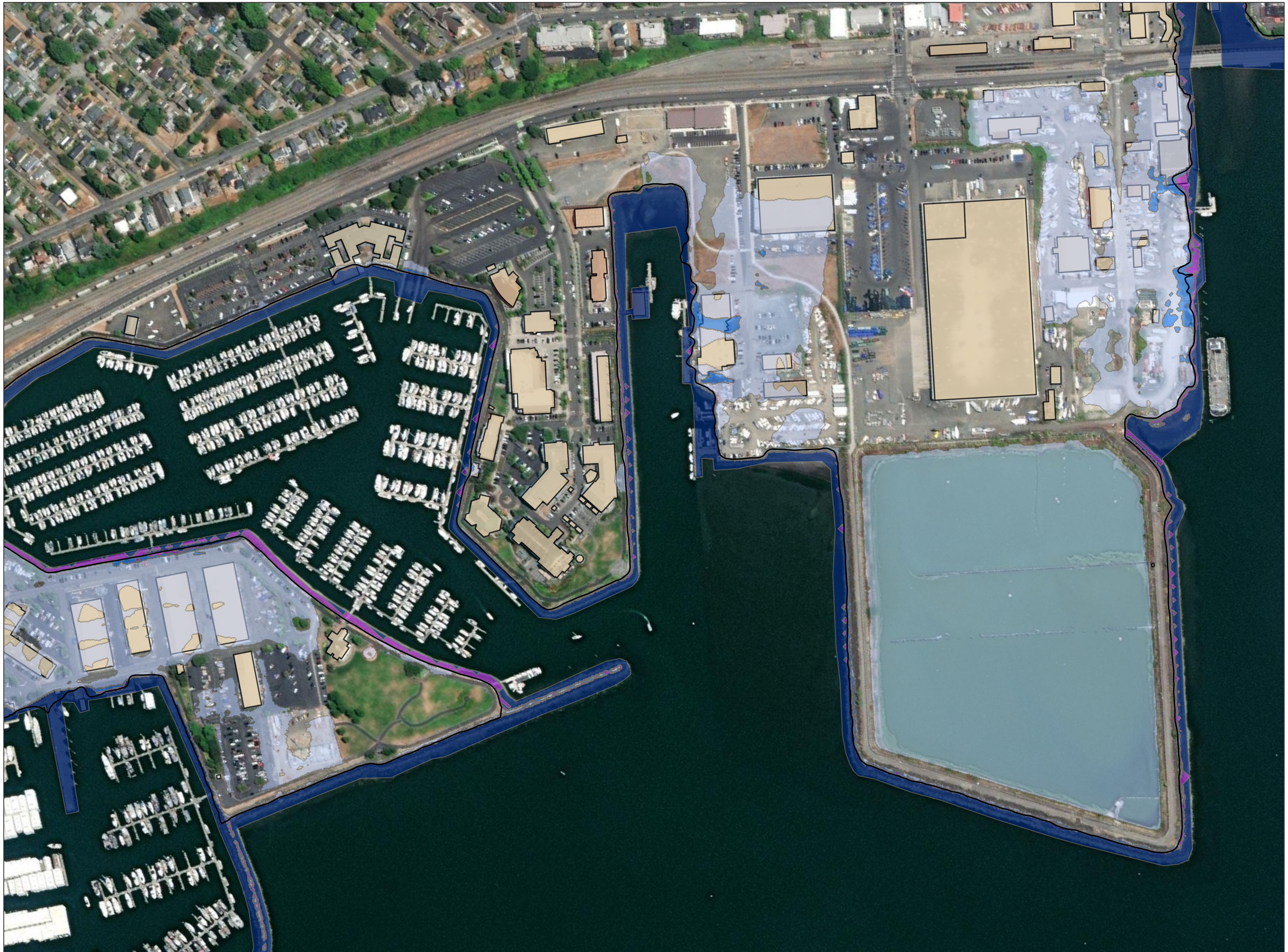

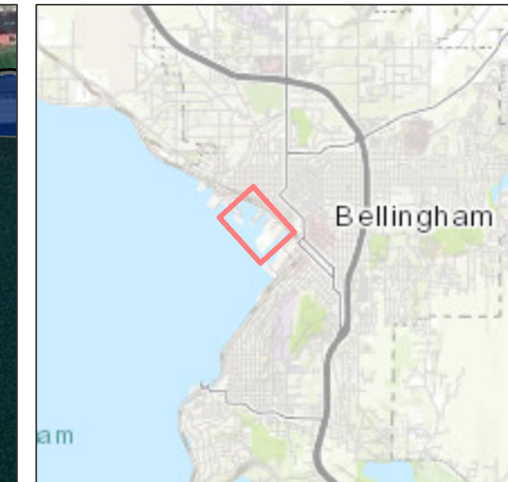

Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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Bellingham, WA

Figure A-11
10-Year Storm Event Scenarios
Port of Bellingham: Central

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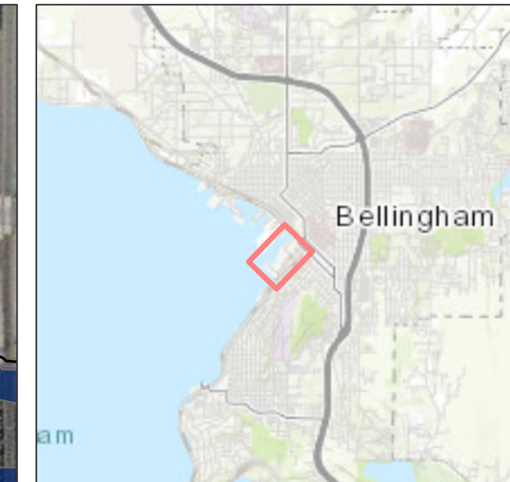

Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

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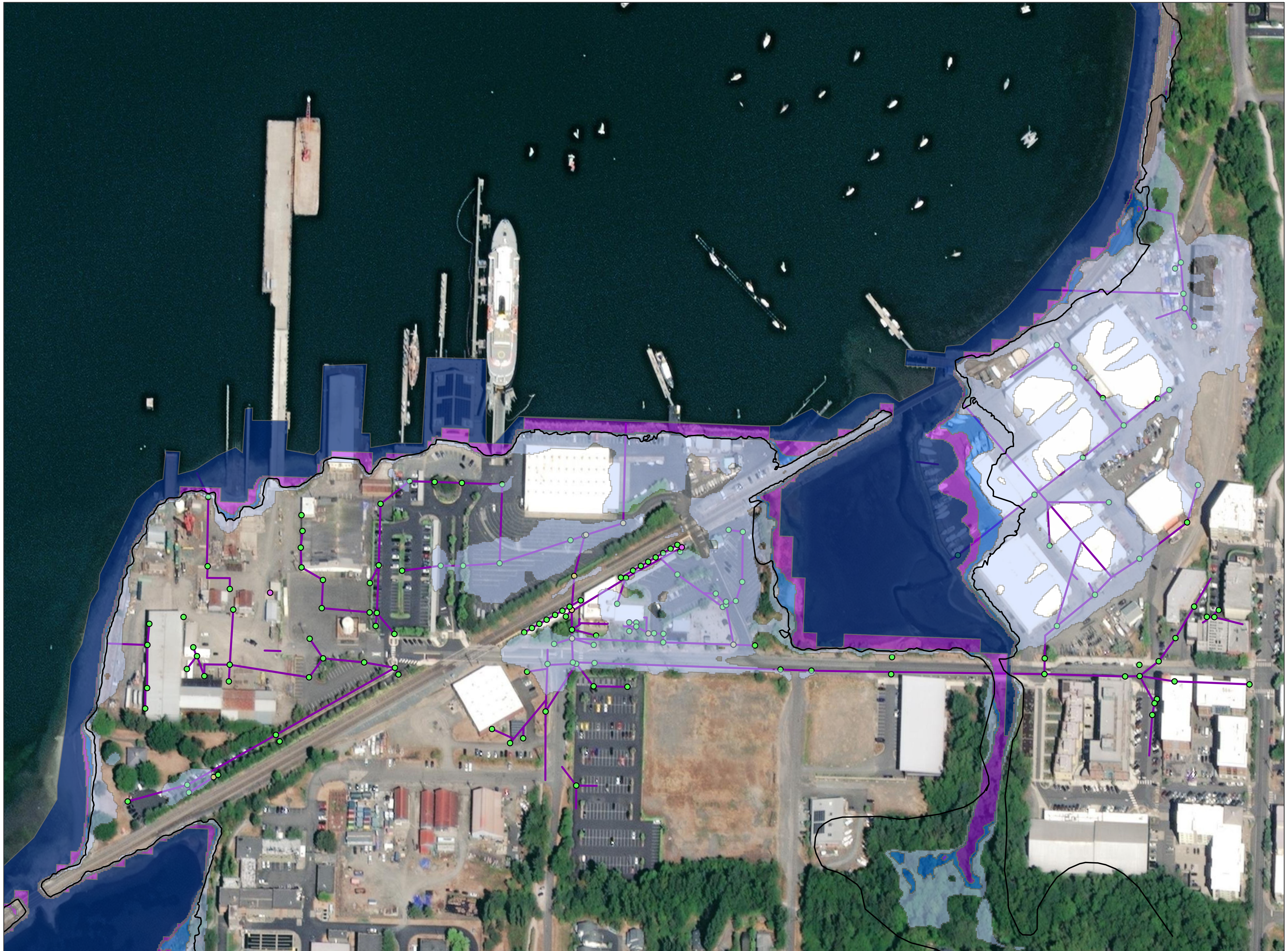
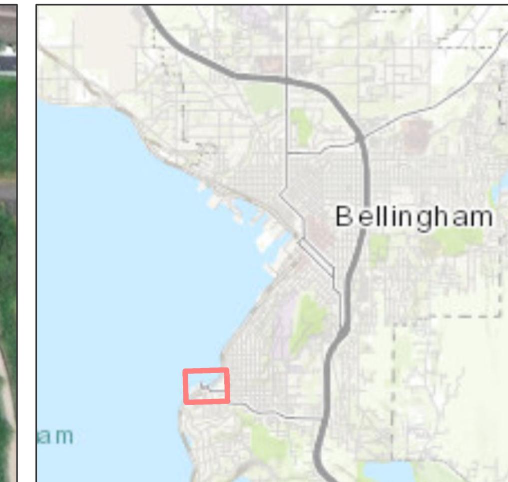
Bellingham, WA

Figure A-12
10-Year Storm Event Scenarios
Port of Bellingham: South

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry





Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Catch Basin
- Cleanout
- Manhole
- Storm Sewer Line

N

0 100 200 300 400

Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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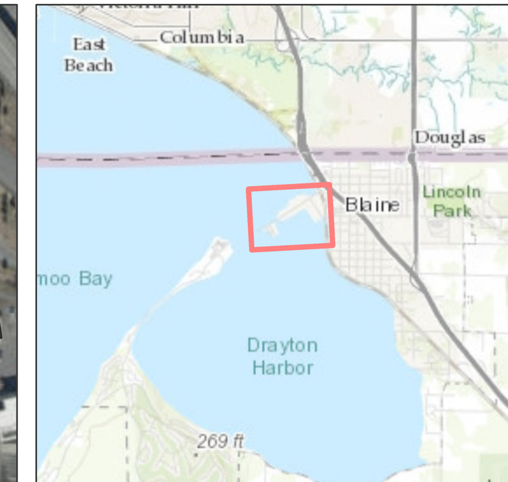
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-13
10-Year Storm Event Scenarios
Fairhaven

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Storm Sewer Line

N

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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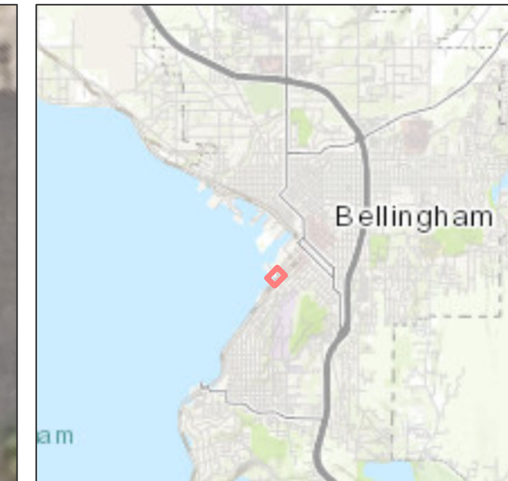
Bellingham, WA

Figure A-14
10-Year Storm Event Scenarios
Blaine Harbor

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend

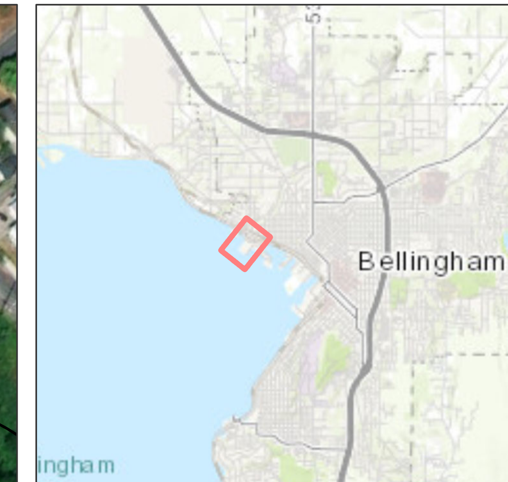
- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Manhole
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-15
10-Year Storm Event Scenarios
Bellingham Shipping Terminal



Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Drain
- OWS
- Storm Sewer Line

0 100 200 300 400
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

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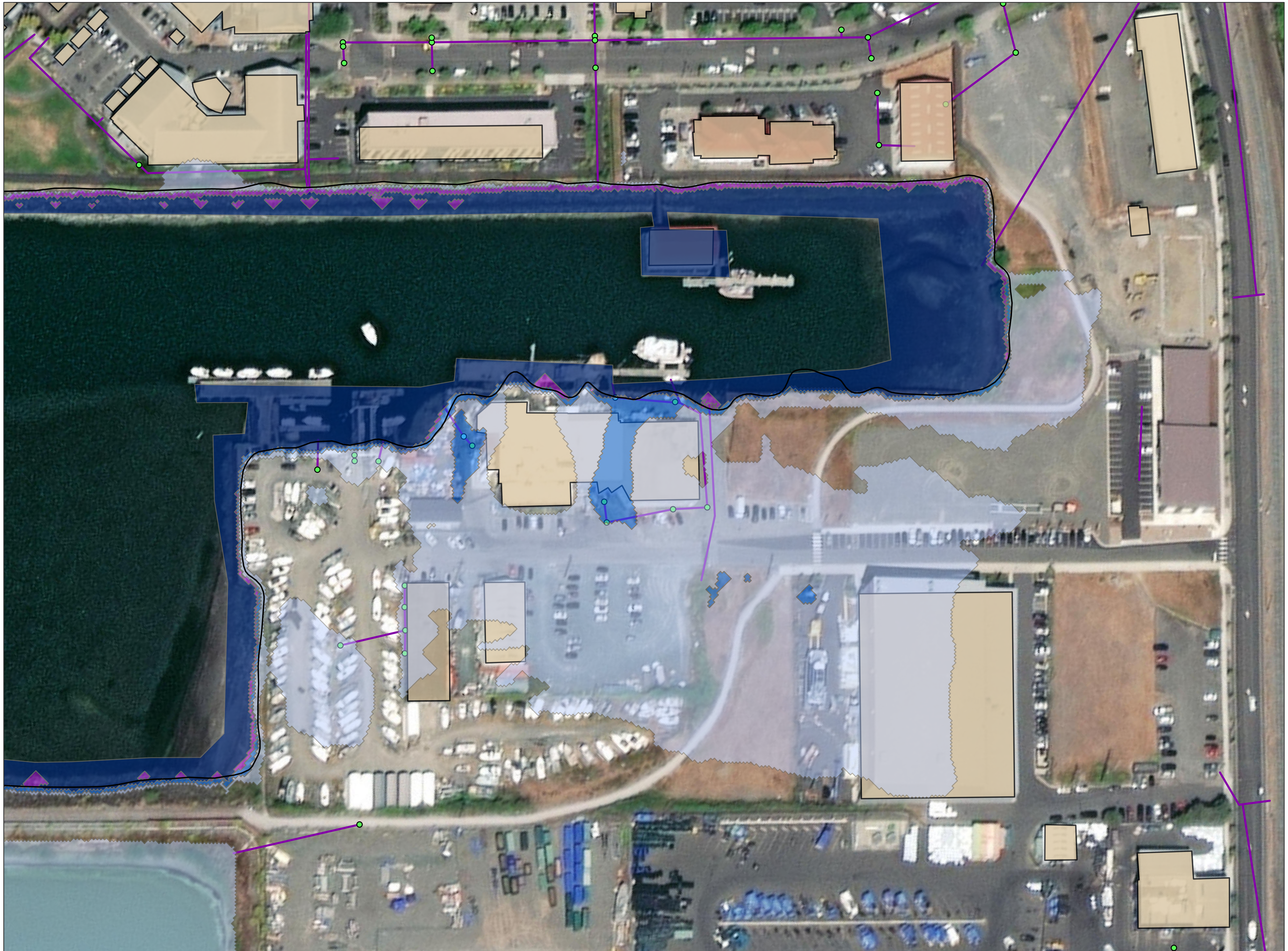
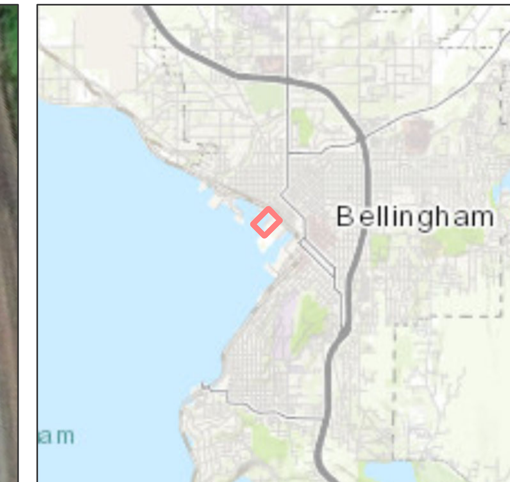
Bellingham, WA

Figure A-16
10-Year Storm Event Scenarios
Squalicum Parkway Industrial Area

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry





Legend

- FEMA Base Flood Elevation
- 10-Year Storm Event, no RSLR
- 10-Year Storm Event, 0.82ft (0.25m) RSLR
- 10-Year Storm Event, 1.64ft (0.50m) RSLR
- 10-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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Bellingham, WA

Figure A-17
10-Year Storm Event Scenarios
Marine Trades Area

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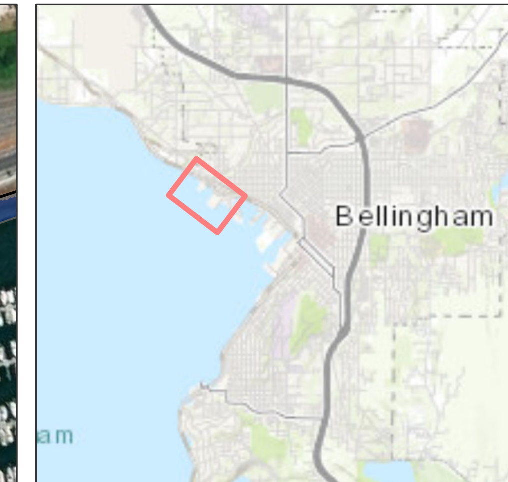
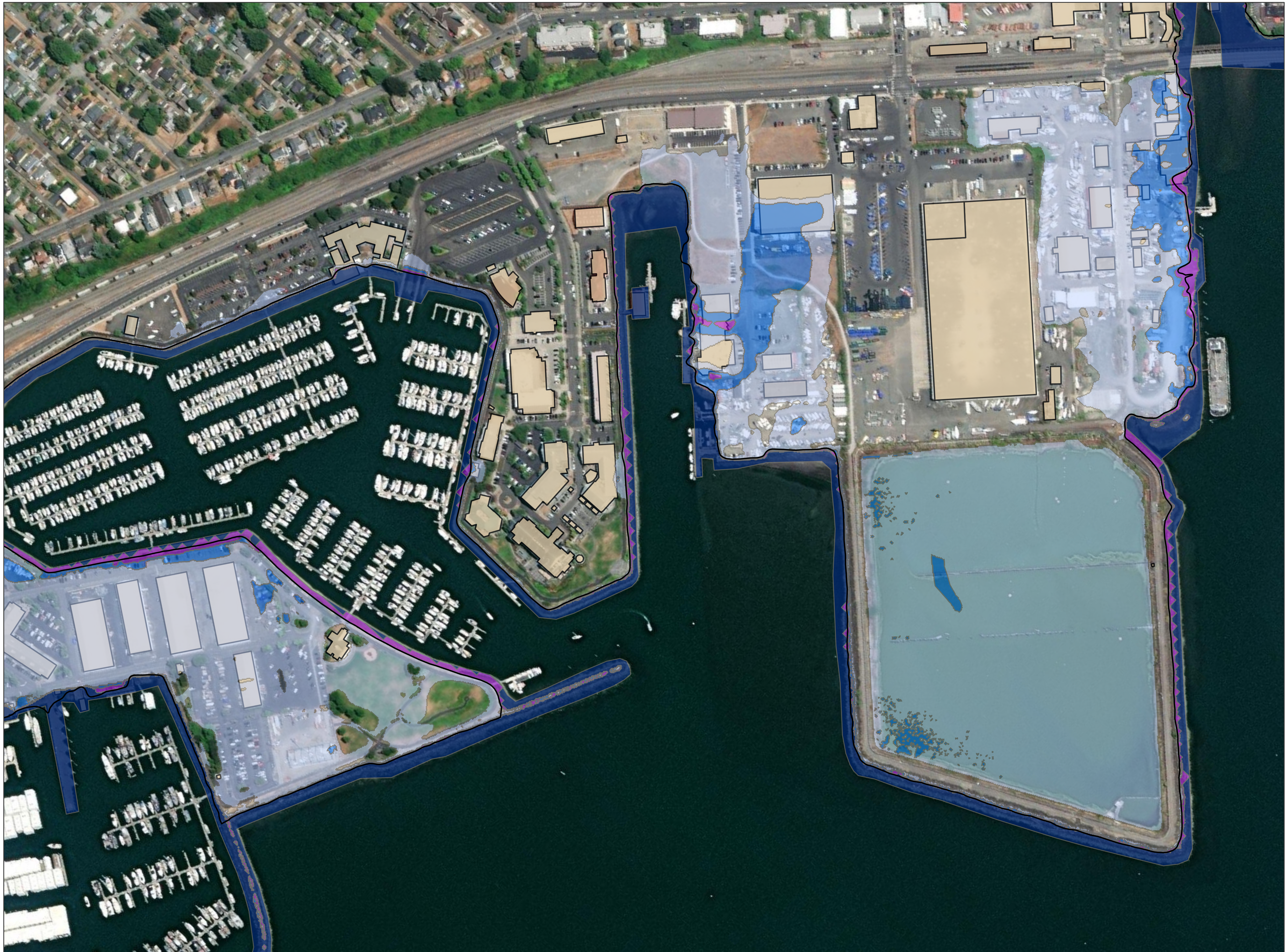


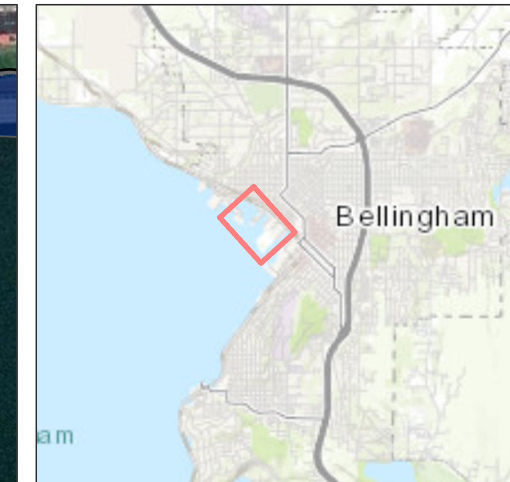
Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-18
50-Year Storm Event Scenarios
Port of Bellingham: North

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry





Legend

- FEMA Base Flood Elevation
- 50-Year Storm Event, no RSLR
- 50-Year Storm Event, 0.82ft (0.25m) RSLR
- 50-Year Storm Event, 1.64ft (0.50m) RSLR
- 50-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
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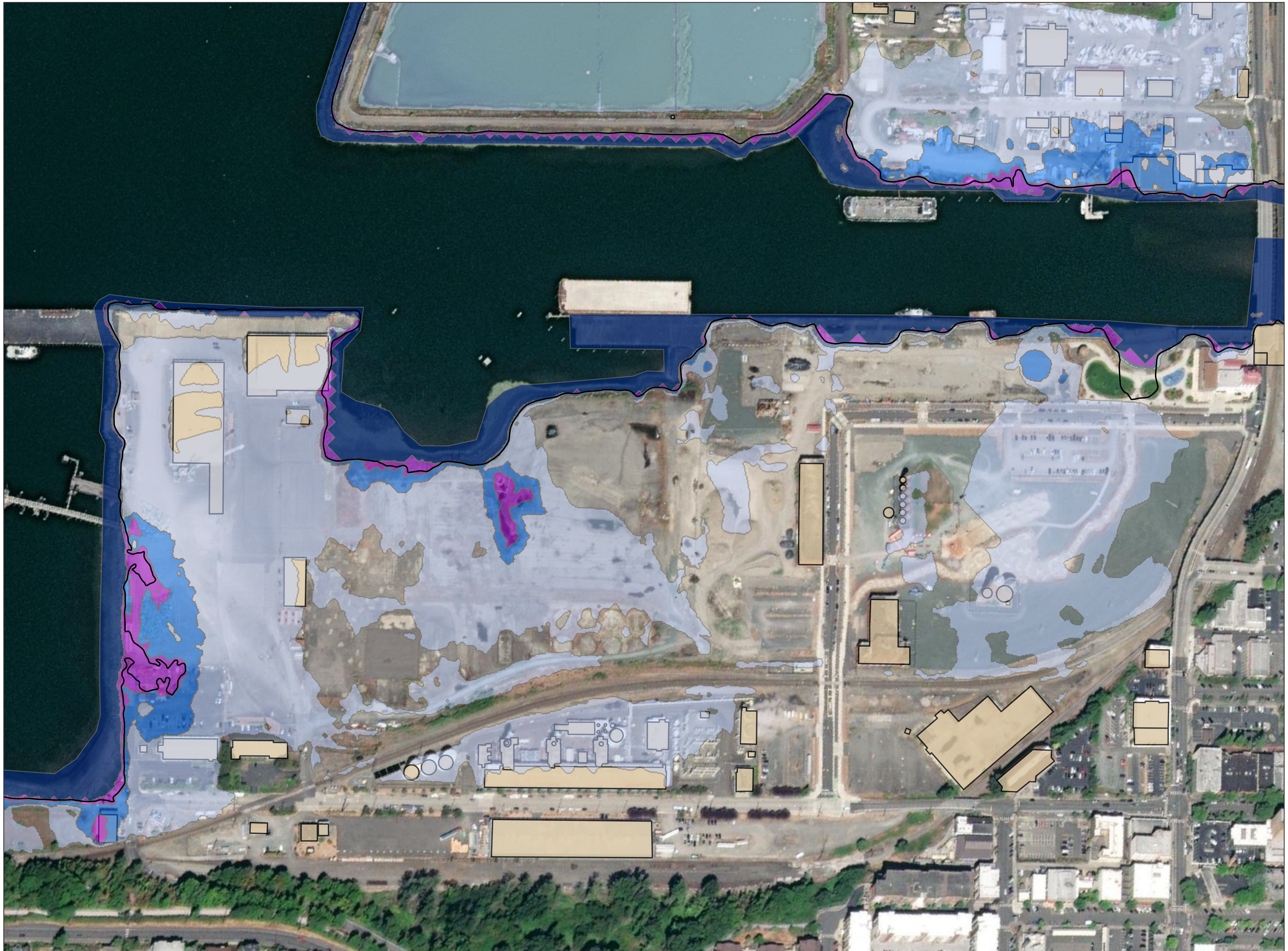
Bellingham, WA

Figure A-19
50-Year Storm Event Scenarios
Port of Bellingham: Central

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- 50-Year Storm Event, no RSLR
- 50-Year Storm Event, 0.82ft (0.25m) RSLR
- 50-Year Storm Event, 1.64ft (0.50m) RSLR
- 50-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

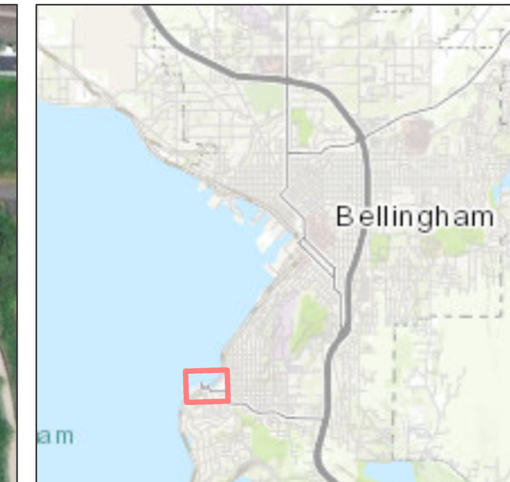
0 100 200 300 400
Feet

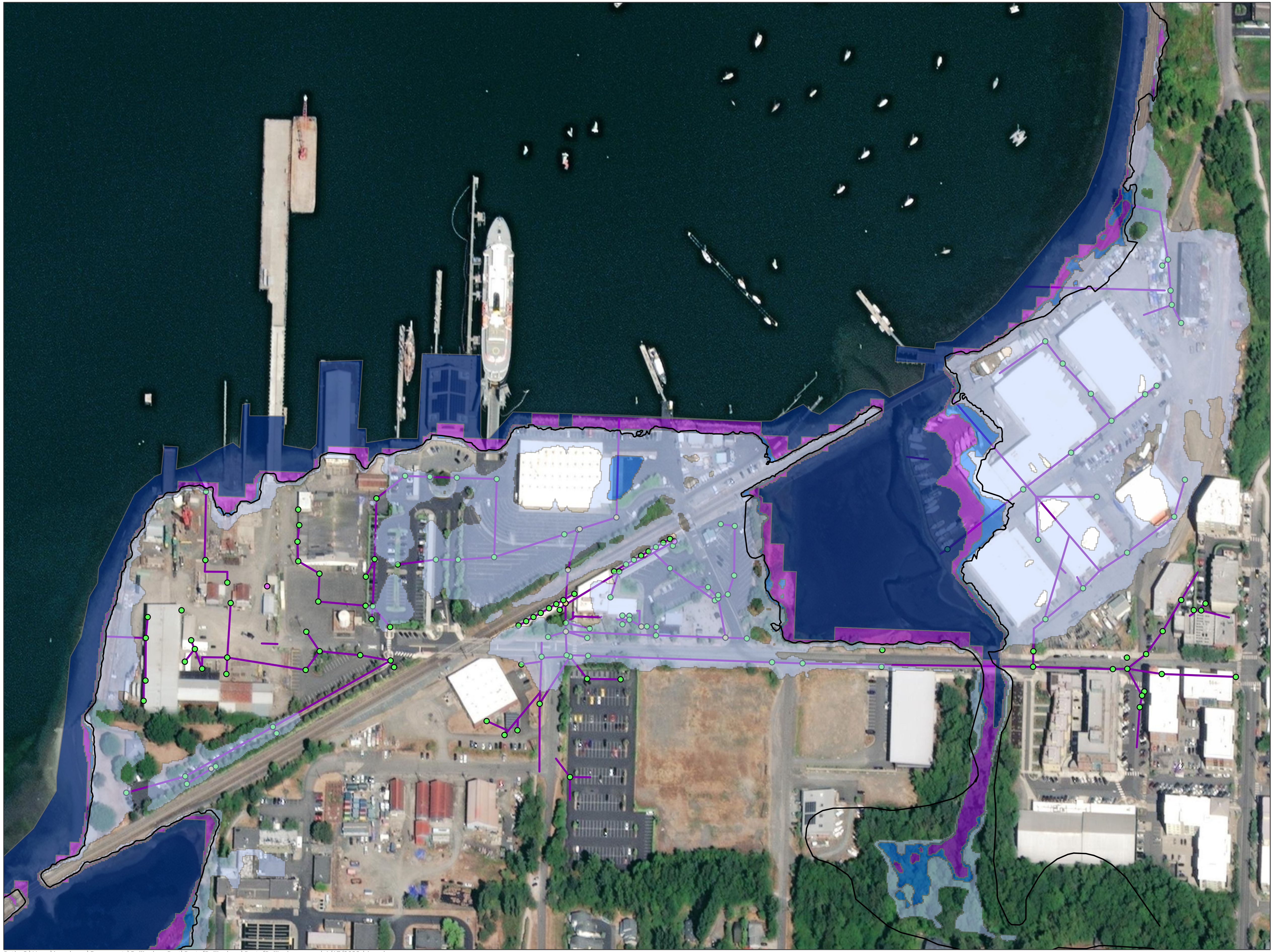
Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-20
50-Year Storm Event Scenarios
Port of Bellingham: South

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry





Legend

- FEMA Base Flood Elevation
- 50-Year Storm Event, no RSLR
- 50-Year Storm Event, 0.82ft (0.25m) RSLR
- 50-Year Storm Event, 1.64ft (0.50m) RSLR
- 50-Year Storm Event, 3.28ft (1.00m) RSLR
- Catch Basin
- Cleanout
- Manhole
- Storm Sewer Line

0 100 200 300 400
Feet

Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

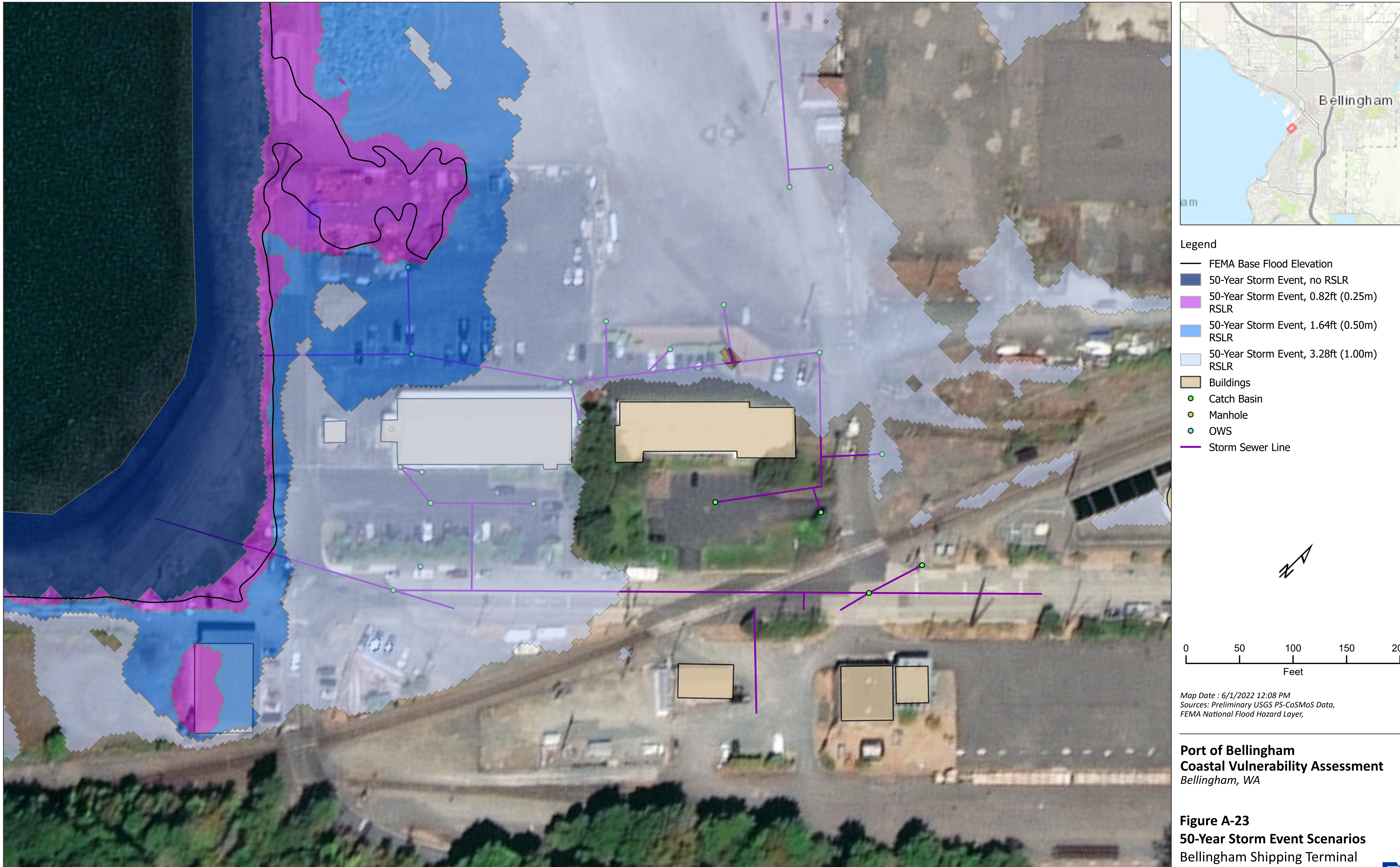
Figure A-21
50-Year Storm Event Scenarios
Fairhaven

Legend
- FEMA Base Flood Elevation
- 50-Year Storm Event, no RSLR
- 50-Year Storm Event, 0.82ft (0.25m) RSLR
- 50-Year Storm Event, 1.64ft (0.50m) RSLR
- 50-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Storm Sewer Line

Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-22
50-Year Storm Event Scenarios
Blaine Harbor



Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

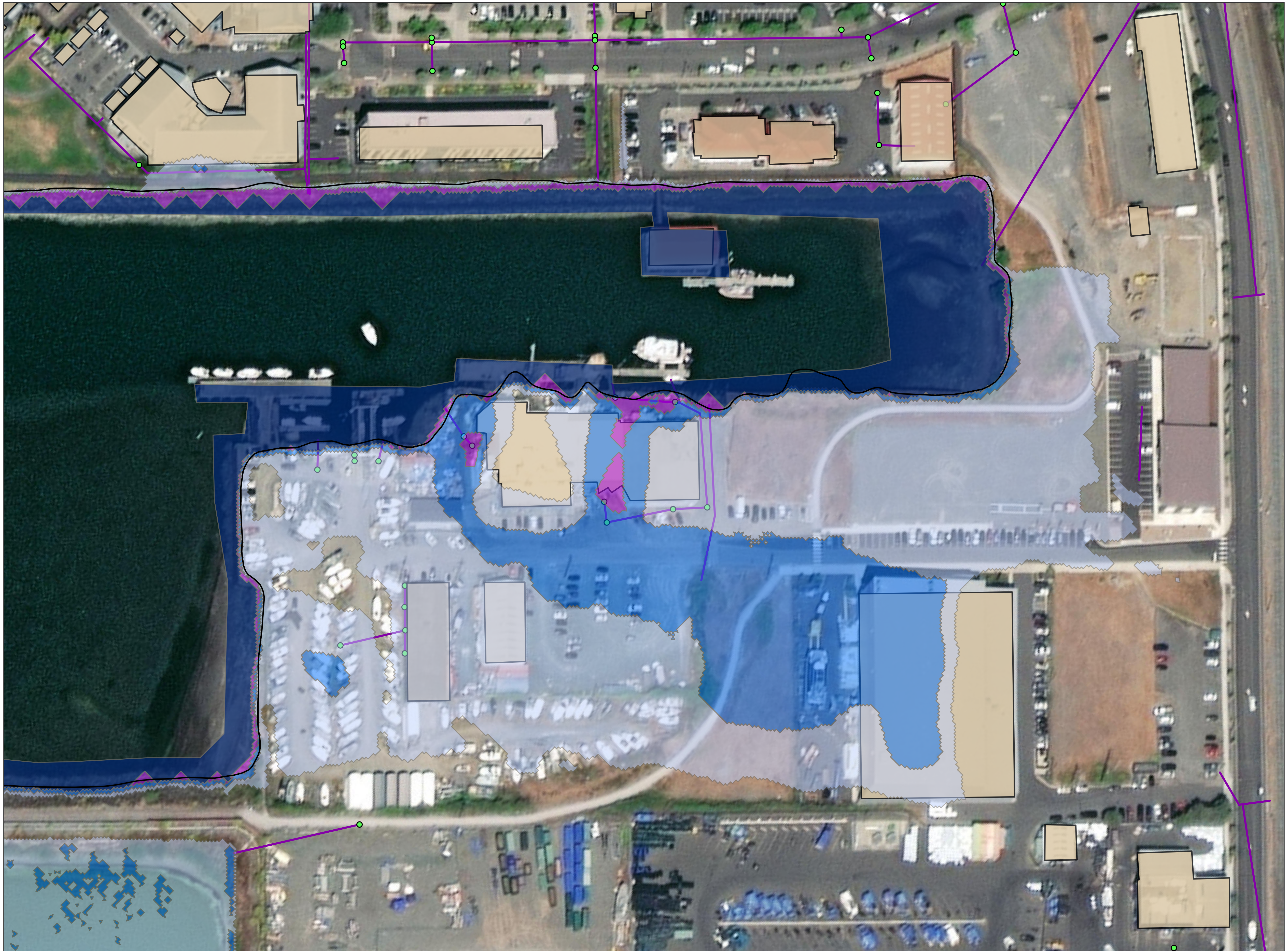
Figure A-23
50-Year Storm Event Scenarios
Bellingham Shipping Terminal

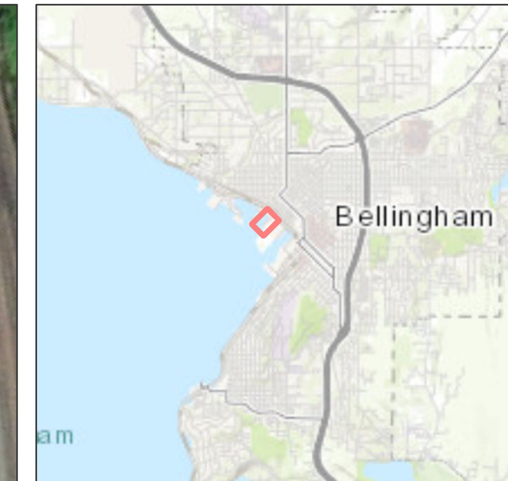
Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-24
50-Year Storm Event Scenarios
Squalicum Parkway Industrial Area

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry





Legend

- FEMA Base Flood Elevation
- 50-Year Storm Event, no RSLR
- 50-Year Storm Event, 0.82ft (0.25m) RSLR
- 50-Year Storm Event, 1.64ft (0.50m) RSLR
- 50-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

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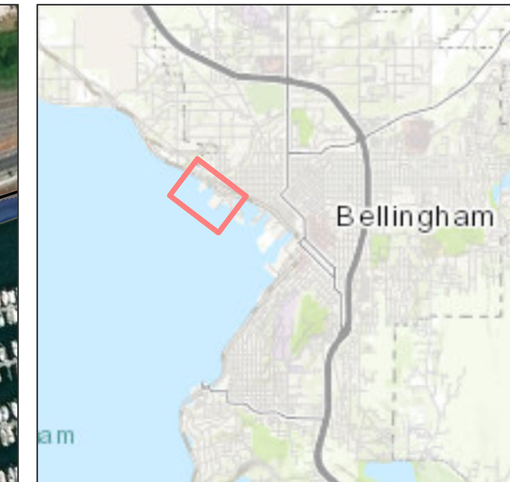
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-25
50-Year Storm Event Scenarios
Marine Trades Area



Legend

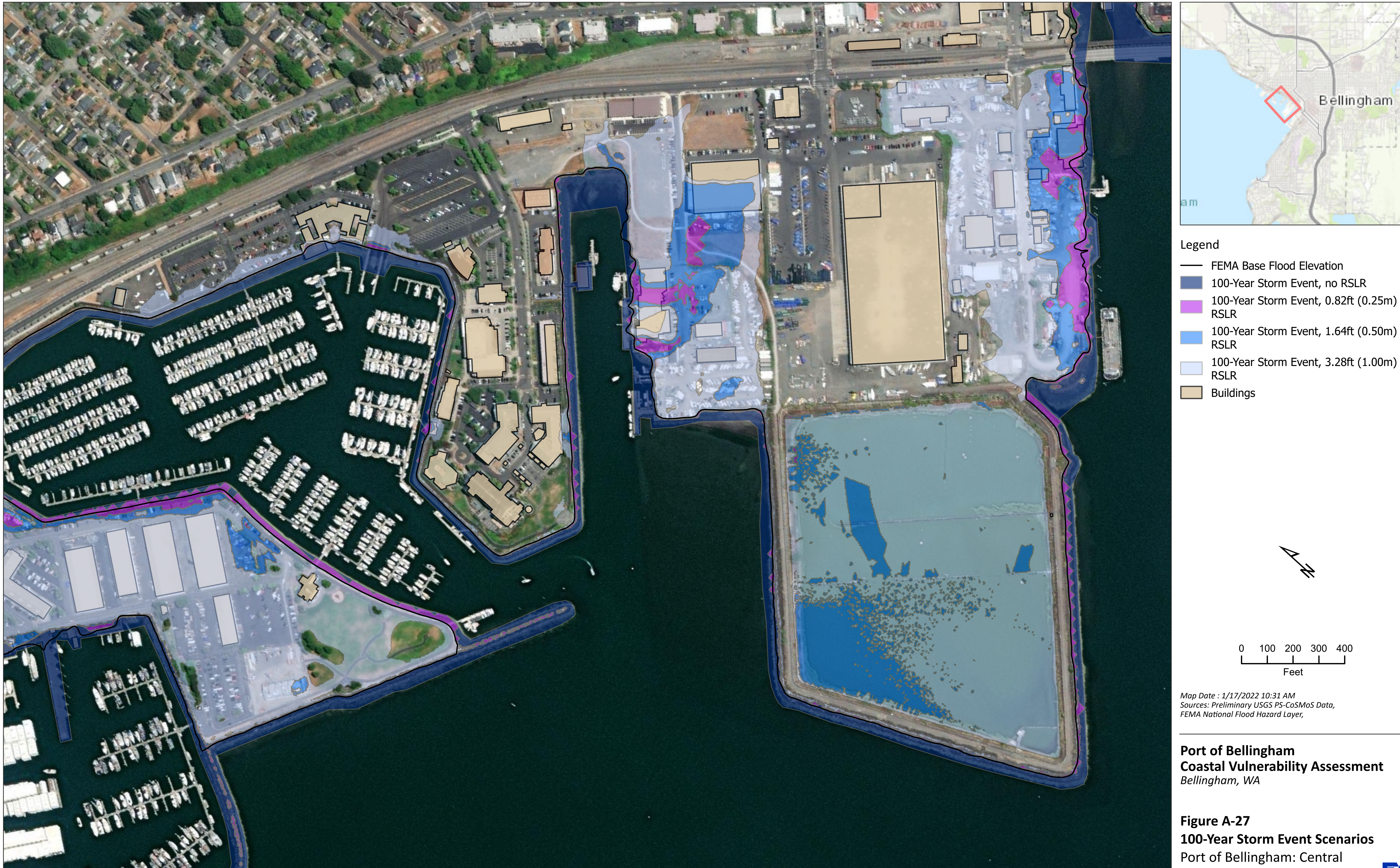
- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings

0 100 200 300 400
Feet

Map Date : 1/14/2022 11:43 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-26
100-Year Storm Event Scenarios
Port of Bellingham: North



Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
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Figure A-27
100-Year Storm Event Scenarios
Port of Bellingham: Central

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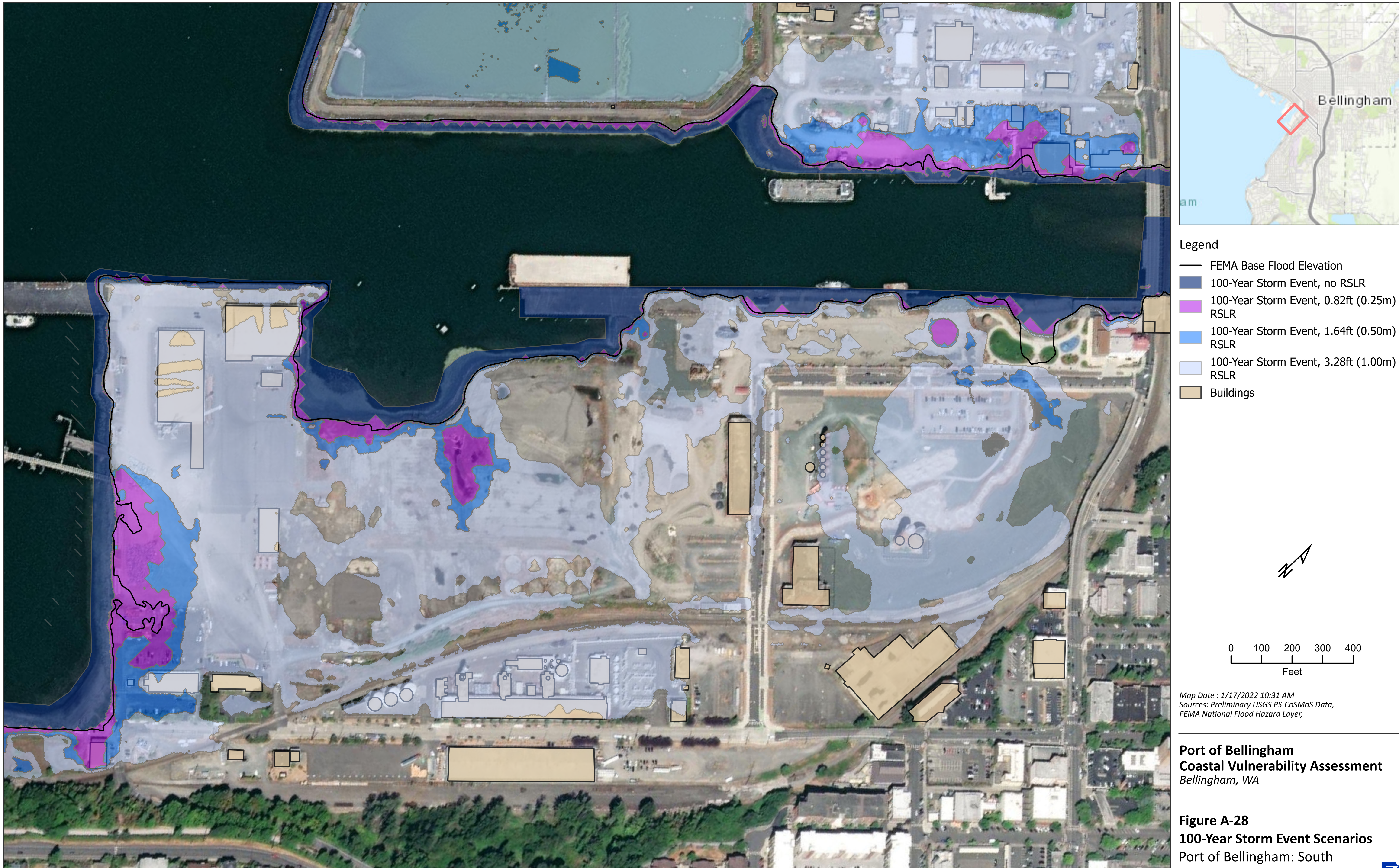
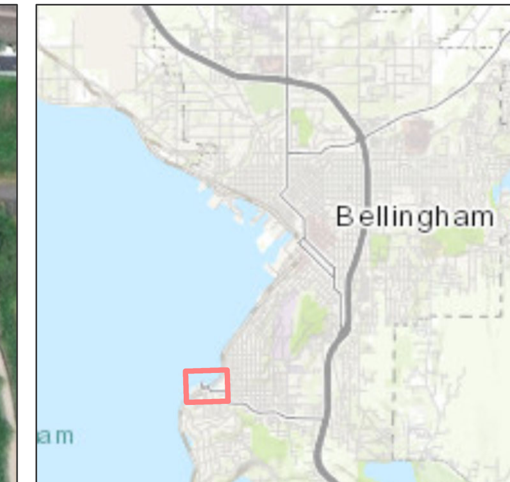


Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-28
100-Year Storm Event Scenarios
Port of Bellingham: South

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend
- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Catch Basin
- Cleanout
- Manhole
- Storm Sewer Line

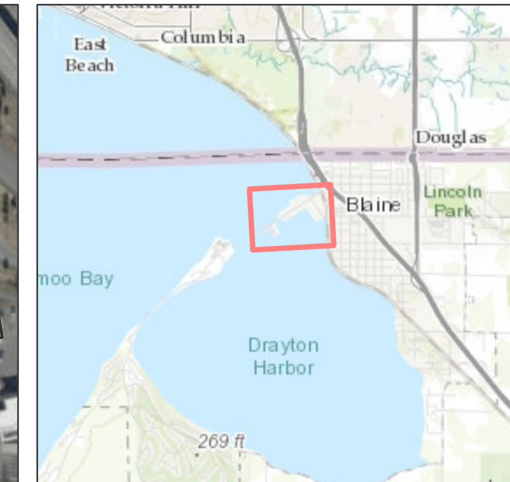
N

0 100 200 300 400
Feet

Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-29
100-Year Storm Event Scenarios
Fairhaven



Legend

- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Storm Sewer Line

N

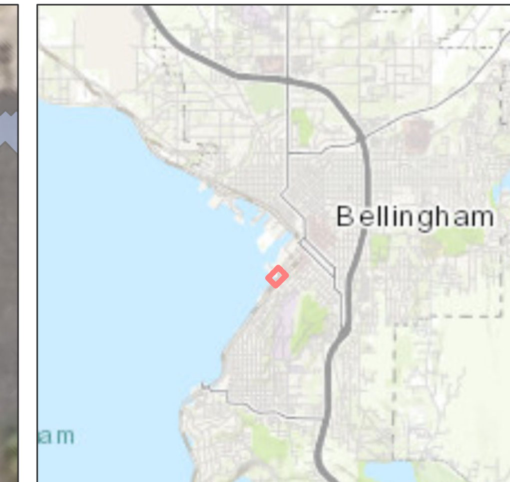
0 100 200 300 400
Feet

Map Date : 1/17/2022 10:31 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-30
100-Year Storm Event Scenarios
Blaine Harbor

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Manhole
- OWS
- Storm Sewer Line

0 50 100 150 200

Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
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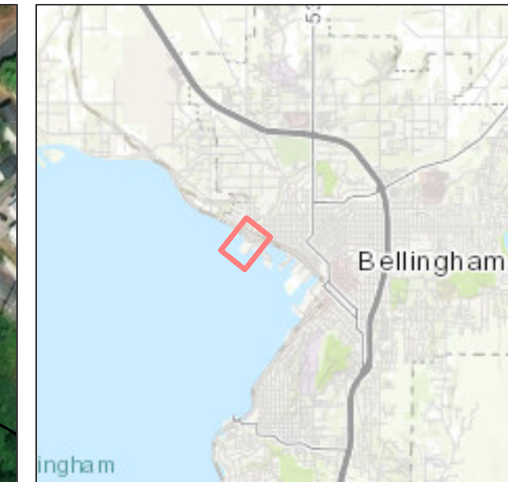
Figure A-31
100-Year Storm Event Scenarios
Bellingham Shipping Terminal

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- Drain
- OWS
- Storm Sewer Line

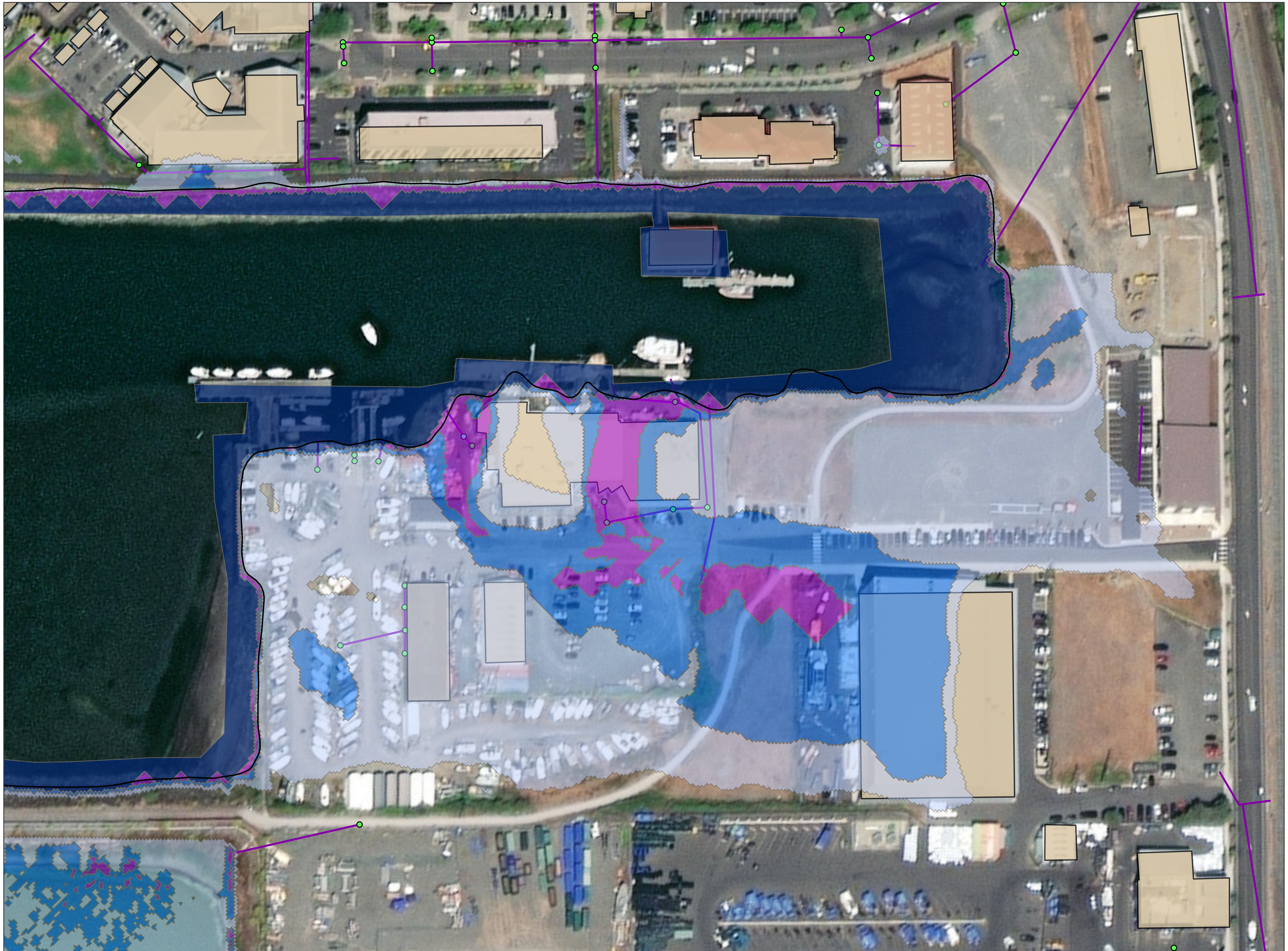
0 100 200 300 400
Feet

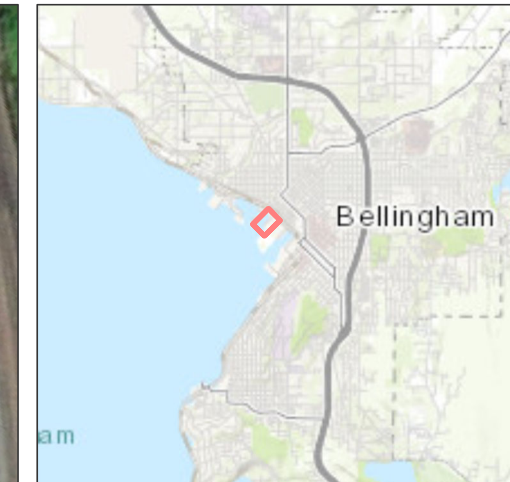
Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-32
100-Year Storm Event Scenarios
Squalicum Parkway Industrial Area

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 6/1/2022 | jnewberry





Legend

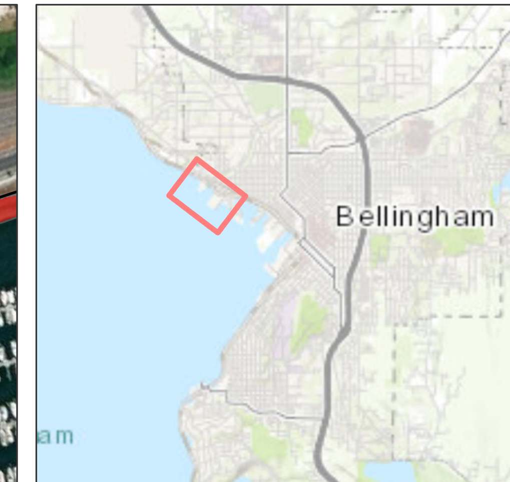
- FEMA Base Flood Elevation
- 100-Year Storm Event, no RSLR
- 100-Year Storm Event, 0.82ft (0.25m) RSLR
- 100-Year Storm Event, 1.64ft (0.50m) RSLR
- 100-Year Storm Event, 3.28ft (1.00m) RSLR
- Buildings
- Catch Basin
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 12:08 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-33
100-Year Storm Event Scenarios
Marine Trades Area



Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

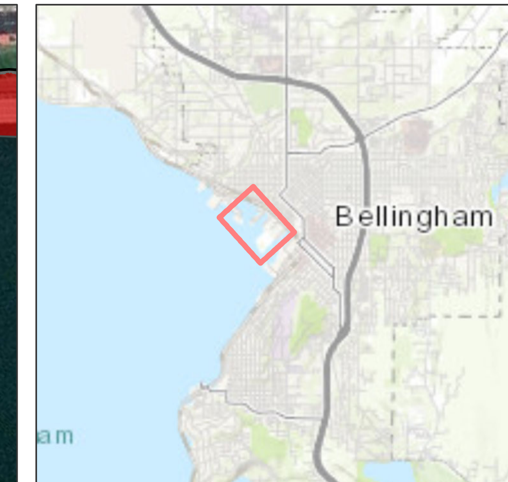
0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-34
Vulnerability Assessment Categories
Port of Bellingham: North

Path: C:\Users\jnewberry\Documents\BellinghamPort\PortofBellingham\PortofBellingham.aprx | 1/17/2022 | jnewberry



Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-35
Vulnerability Assessment Categories
Port of Bellingham: Central

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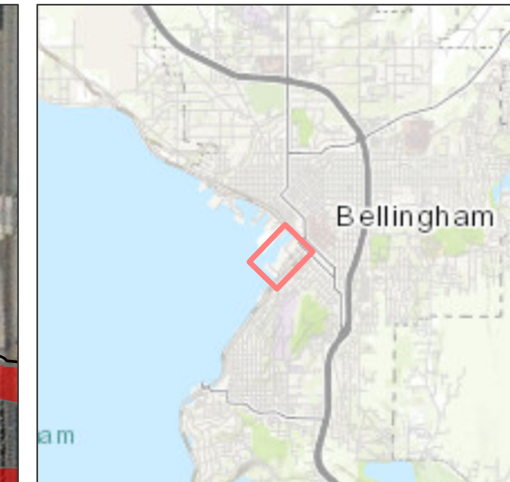

Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings

Storm Event	RSLR (ft [m]) 0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-36
Vulnerability Assessment Categories
Port of Bellingham: South

EA

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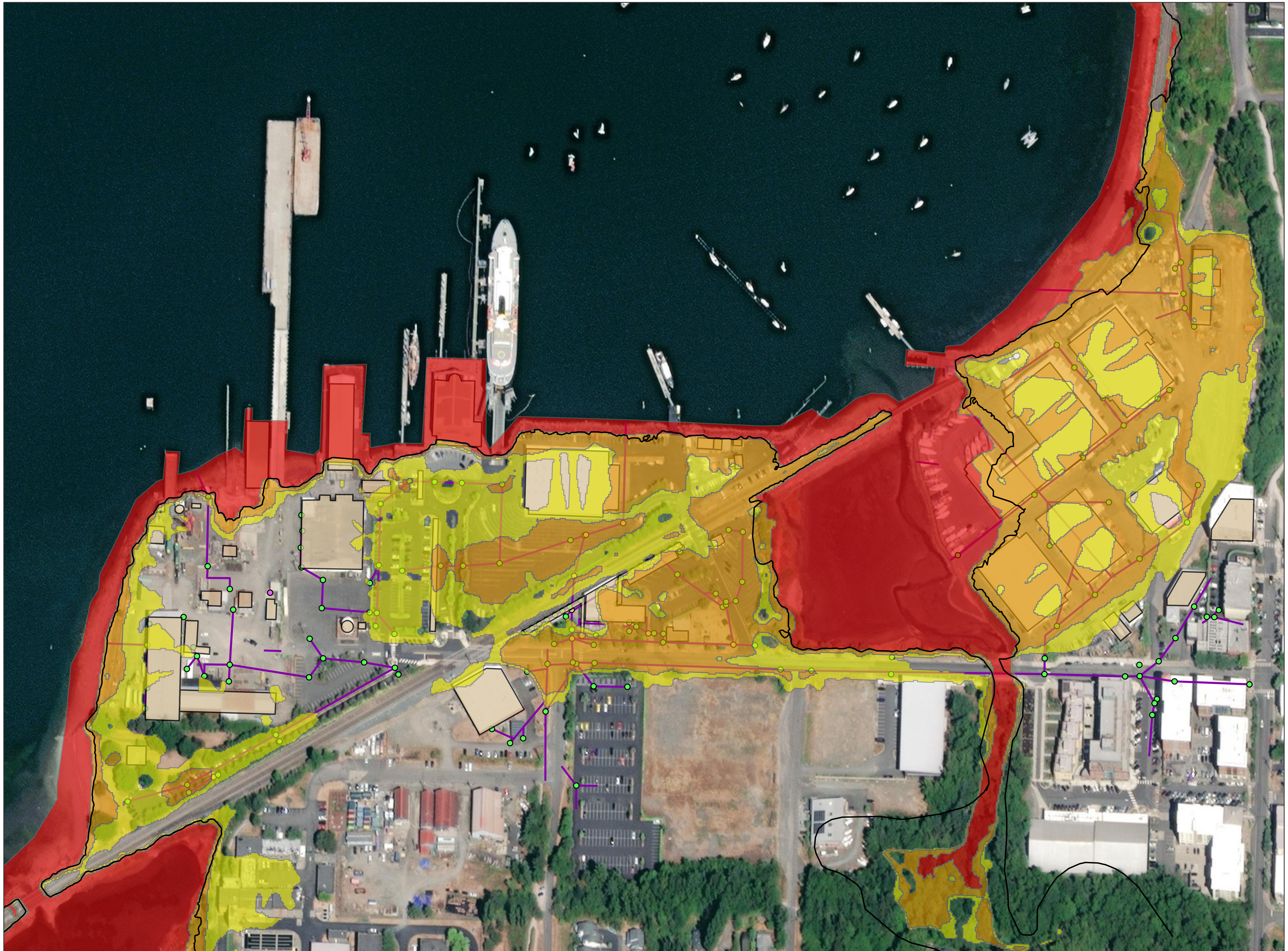

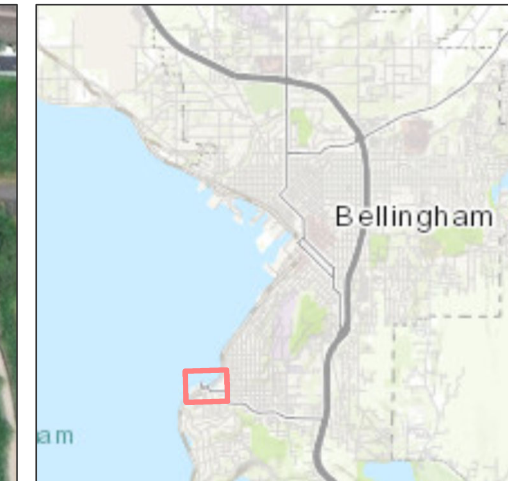

Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings
- Catch Basin
- Cleanout
- Manhole
- Storm Sewer Line

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

N

0 100 200 300 400

Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-37
Vulnerability Assessment Categories
Fairhaven

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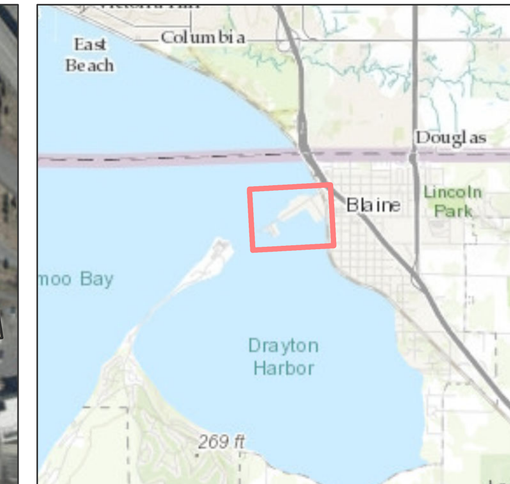

Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings
- Catch Basin
- Storm Sewer Line

Storm Event	RSLR (ft [m])			
	0	0.82 [0.25]	1.64 [0.50]	3.28 [1.00]
10-Year	High	High	High	Medium High
50-Year	High	High	Medium High	Medium
100-Year	High	Medium High	Medium	Medium

0 100 200 300 400
Feet

Map Date : 1/17/2022 8:10 AM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-38
Vulnerability Assessment Categories
Blaine Harbor

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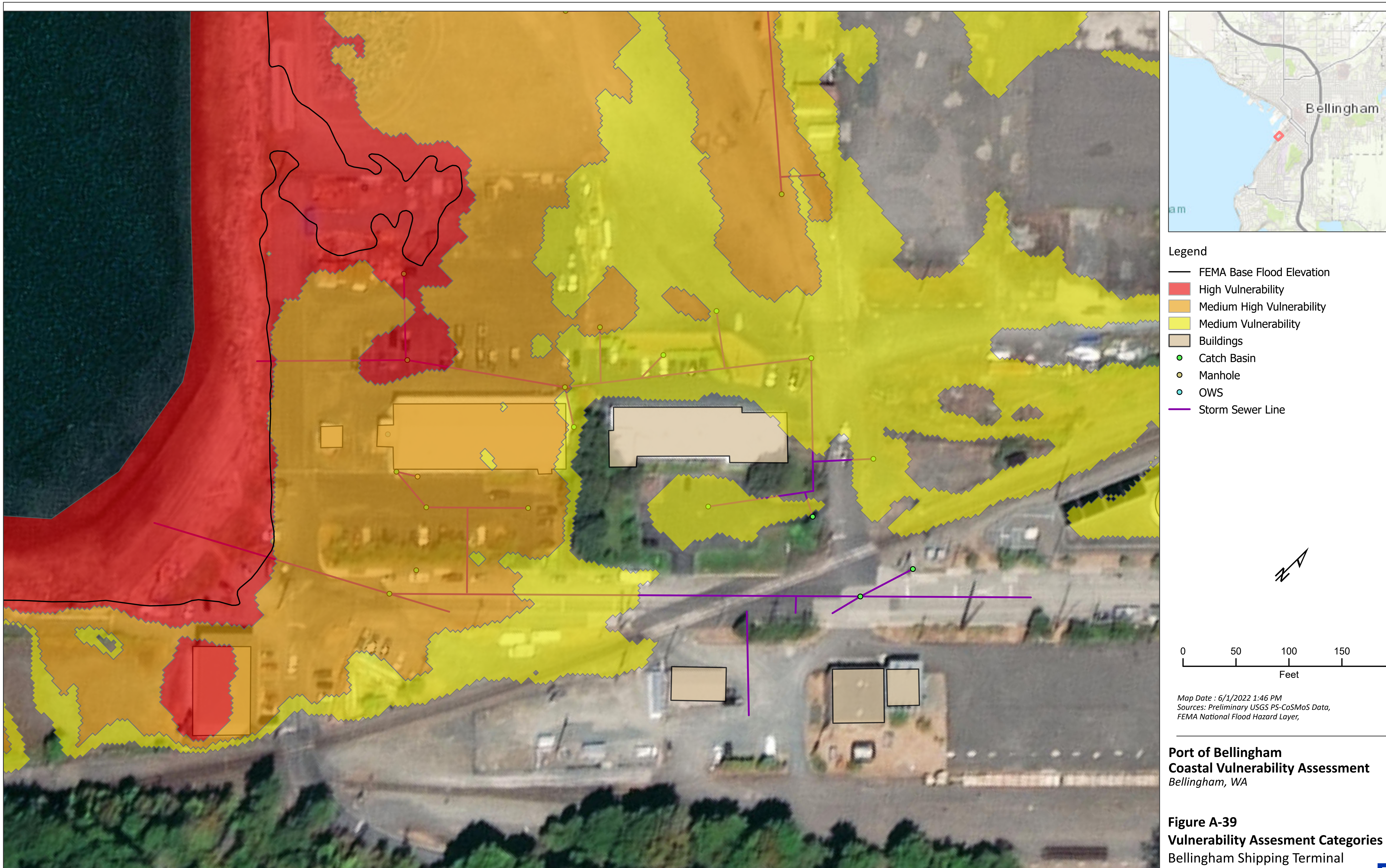

Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings
- Catch Basin
- Manhole
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 1:46 PM
Sources: Preliminary USGS PS-CoSMoS Data, FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-39
Vulnerability Assesment Categories
Bellingham Shipping Terminal

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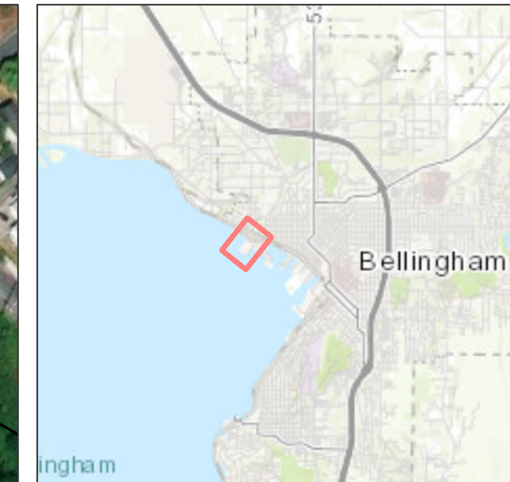


Legend

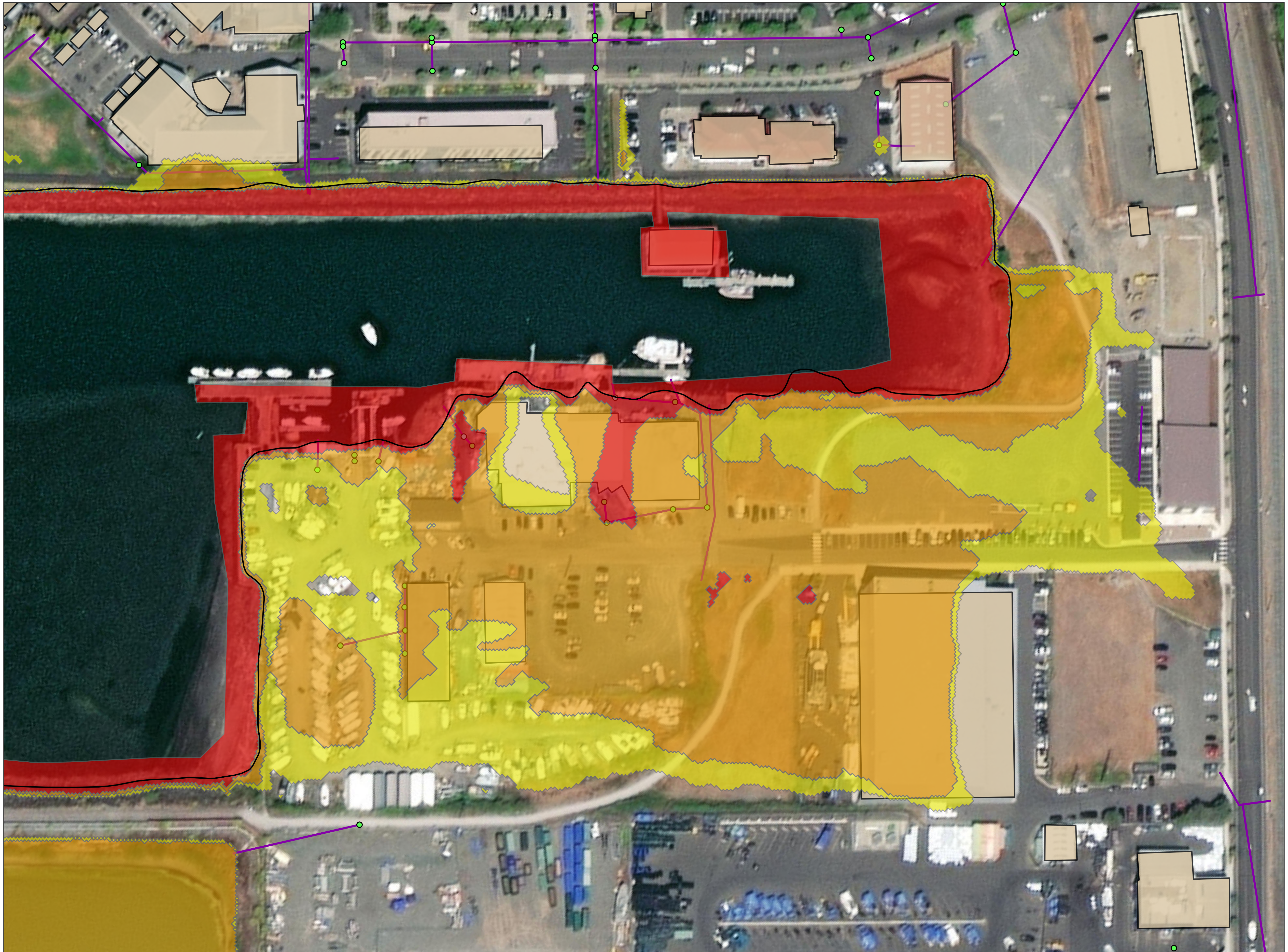
- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings
- Catch Basin
- Drain
- OWS
- Storm Sewer Line

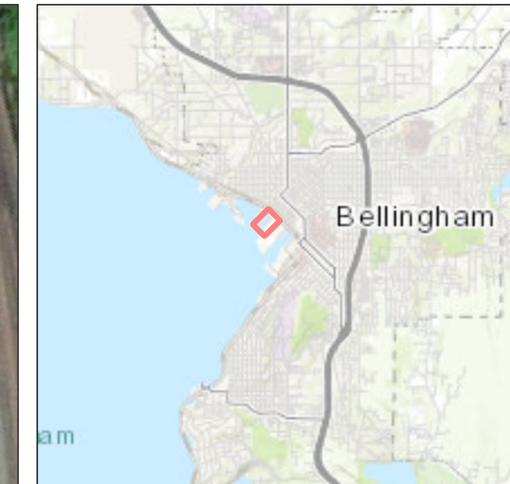
0 100 200 300 400
Feet

Map Date : 6/1/2022 1:46 PM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-40
Vulnerability Assessment Categories
Squalicum Parkway Industrial Area





Legend

- FEMA Base Flood Elevation
- High Vulnerability
- Medium High Vulnerability
- Medium Vulnerability
- Buildings
- Catch Basin
- OWS
- Storm Sewer Line

0 50 100 150 200
Feet

Map Date : 6/1/2022 1:46 PM
Sources: Preliminary USGS PS-CoSMoS Data,
FEMA National Flood Hazard Layer,

Port of Bellingham
Coastal Vulnerability Assessment
Bellingham, WA

Figure A-41
Vulnerability Assessment Categories
Marine Trades Area

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Appendix B

Vulnerability Assessment Matrix

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COASTAL HAZARD AND VULNERABILITY ASSESSMENT MATRICES

The completion of a vulnerability assessment requires identification of assets and the assessment of their vulnerabilities and adaptive capacity (i.e. strengths) in the face of climate change. The Vulnerability Assessment matrix provided in this Appendix lays out Port assets and describes the known strengths and vulnerabilities associated with each, as well as asset-specific data gaps and recommendations for adaptation and resiliency. The assets are grouped into categories as described below, and details provided in the Vulnerability Assessment Matrix, Table B-1.

Port Sector

Ports are impacted directly and indirectly by the ability of other ports to operate, and RSLR will directly impact ports across the globe. Impacts will vary by port, and little information is available at this point about the scope and magnitude of these impacts. Information about direct impacts of RSLR at each port may help inform analysis of impacts to the sector as a whole.

Infrastructure

Digital Infrastructure
Digital infrastructure includes all computers and software upon which the Port relies. This may include any asset management systems in use by the Port for tracking of physical infrastructure and for decision-making, as well as digital systems for equipment operation and stabilization of any hazardous materials.

Physical Infrastructure
Physical infrastructure includes all of the built structures at the Port, including all buildings, equipment for loading and unloading ships, and utilities upon which the Port and its tenants rely. These utilities include energy/electricity, sanitary sewers, storm sewers, and water.

Social, Human, and Societal Assets

The analysis considered the skills, knowledge, and abilities of Port staff and the community that support the Port and the local community. Although less tangible than physical or digital infrastructure, these are important resources that face unique vulnerabilities to climate change but ultimately will be required to reduce overall climate change risk.

The Natural Environment

Elements of the natural environment may also be impacted by climate change and that will impact the Port. These include potential vulnerabilities as well as any capacity for the natural systems in and around the port to buffer the impacts of climate change. The CAS matrix assesses risks to marine wildlife and undeveloped public land.

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Table B-1: Draft Vulnerability Assessment Matrix

	Vulnerabilities	Assets/Strengths	Data Gaps	Recommendations
Port Sector				
Global Supply Chain	• RSLR may impact the availability and demand for the Port's main imports and exports by impacting terminals and goods at other ports.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Information is limited regarding the specific impacts of RSLR on the port sector, including other port terminals.	• Monitor RSLR impacts and responses at other ports. • Share information on impacts and collaborate with other ports and decision-makers on solutions.
Infrastructure - Digital				
Asset Management System	• The port does not appear to have an asset management system for buildings or other key infrastructure. • RSLR will result in higher rates of infrastructure degradation due to inundation, increased rates of corrosion, and saturation of materials at higher elevations.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Incomplete inventory of Buildings and Structures, including finished floor elevations. • Incomplete inventory of shipping terminal and cruise terminal infrastructure.	• Complete building inventory. • Implement asset management system that allows for continuous updates and frequent reviews. • Complete assessment of assets that are most at risk from RSLR, coastal erosion, and other climate change hazards. • Determine what assets are mobile and the speed at which they can be moved to respond to increased climate risk, including intense storm events or RSLR.
Automated Risk Management Systems	• No known automated risk management systems in place at the Port. *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• No known automated risk management systems in place at the Port.	• Consider whether automated risk management systems may reduce the vulnerability of Port assets to RSLR and other climate change impacts by reducing the potential for human error in responding to climate change impacts and to speed response.
Infrastructure - Physical				
Roads and Bridges	• Access to the Port is via roads owned/maintained by others. • Some areas of the Port (e.g. Squalicum Harbor) are accessible by only one land route.	• Roeder Ave bridge is elevated to a level that is currently resilient against most storms, ensuring that one evacuation route remains viable.	• As-built engineering drawings and/or other elevation data for roads and bridges.	• Perform an assessment on all nearby bridges to further investigate if they will become flooded during storm events. • Review current evacuation routes against estimated flooding; consider projects to increase their resilience.
Utilities – Energy	• Incomplete inventory of transformers and other energy infrastructure.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Incomplete inventory of transformers and other energy infrastructure, including backup energy infrastructure.	• Complete inventory of energy infrastructure, including assessment of critical sites where power must be maintained at all times or with minimal gaps. • Assess risk to energy infrastructure and backup energy sources posed by RSLR. Determine if additional or planned energy sources can be sited where RSLR, coastal erosion, and more intense storms will pose less of a threat.
Utilities – Water	• Incomplete inventory of water supply infrastructure.	• No known wells on site that would be impacted by RSLR. • The City of Bellingham's Water Shortage Contingency Plan includes recognition of drought risk as established by an assessment of regional climate conditions. However, drought mitigation actions are considered Low or Medium priority according to the plan.	• Unknown elevations for lines and manholes.	• Complete inventory of water supply infrastructure. • Assess necessary repairs and upgrades to prevent intrusion of salt water into water supply infrastructure, incorporating RSLR projections. • Assess whether water mains are located in proximity to hazardous materials or contaminated sites that may be impacted by RSLR.
Utilities – Sanitary Sewer	• Incomplete inventory of sanitary sewer infrastructure.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Unknown impact of RSLR on operation of sanitary sewers. • Unknown elevations for lines and manholes.	• Analyze sanitary sewer system to determine impacts of RSLR on operations and maintenance. • Maintain sanitary sewers, pumps, and valves in good condition to limit negative backwater impacts of RSLR.

Table B-1: Draft Vulnerability Assessment Matrix

	Vulnerabilities	Assets/Strengths	Data Gaps	Recommendations
				• Encourage Port employees and tenants to properly maintain sewers by ONLY flushing or draining items appropriate for sanitary sewers. Sewer impacts may become more likely with RSLR.
Utilities – Storm Sewer	• Incomplete inventory of storm sewer infrastructure.	• Storm sewers are not combined with sanitary sewers, eliminating a source of contamination that would be worsened by climate change.	• Incomplete vertical elevation data for stormwater infrastructure.	• Collect vertical elevation data (pipe inverts/Catch basin rim) for stormwater infrastructure and incorporate into stormwater GIS. • Maintain stormwater backwater valves. • Model the existing stormwater system to determine its capacity relative to projected more frequent and intense precipitation events combined with RSLR.
Hazardous Materials and Hazardous Waste	• Possible lack of widely-applicable or easily available plans for addressing the spill.	• Environmental cleanup sites at the Port and in the Bay of Bellingham are listed on the Port website and the Washington Department of Ecology website, respectively. Environmental cleanup sites are also documented in Port planning documents. • The Port has developed a Port-wide spill response plan, "Petroleum / Hazardous Materials Spill Response Plan", which is posted at all Port operating sites and includes a list of qualified spill responders.	• RSLR risk to individual environmental cleanup sites is unknown. • The following Port documents could not be located: Comprehensive Hazardous Waste Inventory; Comprehensive Hazardous Waste Management Plan. • Without accessing a Hazardous Waste Inventory, EA staff were unable to determine if hazardous materials maintained in a stable condition by mechanical means are located on site. Such materials may pose an increased risk if related power systems are threatened by RSLR.	• Compare data on environmental cleanup sites (where contamination may remain to be cleaned up or is capped in place) to RSLR projections to determine risk of further contamination or disturbance. • Develop comprehensive (Port-wide) or site-specific documents that are easily accessible by Port staff. If these documents already exist, make sure they are updated to include any relevant information on RSLR and other climate change impacts and place them in a location where they can easily be accessed by appropriate Port staff.
Shipping Terminal(s) – Docks, Gantries, etc.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• According to a 2019 report, the Bellingham cruise and shipping terminals provide the only facilities in Whatcom County capable of accommodating large vessels.	• Incomplete inventory of shipping terminal infrastructure.	• Assess potential coastal climate change impacts to the shipping terminal(s). Assessment should include physical impacts to infrastructure as well as economic impacts. •
Bellingham Cruise Terminal (BCT)	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• According to a 2019 report, the Bellingham cruise and shipping terminals provide the only facilities in Whatcom County capable of accommodating large vessels.	• Incomplete inventory of cruise terminal infrastructure	• Assess potential coastal climate change impacts to the cruise terminal. Assessment should include physical impacts to infrastructure as well as economic impacts. • Integrate the cruise terminal into Hazard Mitigation and Emergency Response plans as appropriate to build climate resilience, including resiliency to more frequent and intense storms and to known hazards that will be worsened by climate change.
Ferries, Boats	• More frequent severe storms may result in greater frequency of damage to fishing fleets, ferries, and other watercraft.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Incomplete inventory of boats, ferries, and related infrastructure.	• Assess potential coastal climate change impacts on watercraft over time, including economic impacts.
Public Lands and Public Recreational Areas on Port property	• RSLR may inundate public lands and recreational areas along the waterfront. • Coastal climate change impacts may lead to increased maintenance in public areas or more severe damage to public areas during storm events.	• Open areas may serve as buffer areas that may absorb RSLR and/or increased runoff and flooding during storm events.	• Impact of coastal climate change impacts on public lands and public recreation areas. • Projected public use or need for public lands and public recreational areas.	• Assess potential coastal climate change impact on public lands and public recreational areas to determine need for retreat. • Assess potential future demand for public recreation areas, especially in response to rising temperatures.
Social, Human, and Societal Assets				
Emergency Response Procedures	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Port operation departments include an Emergency Management and Security Department.	• Port website does not clarify if the Port has its own Emergency Response or Hazard Mitigation Plan, or if that is entirely covered in plans by others.	• Perform detailed analysis of which evacuation routes, resources, and procedures might be impacted by RSLR (e.g. inundated evacuation routes).

Table B-1: Draft Vulnerability Assessment Matrix

	Vulnerabilities	Assets/Strengths	Data Gaps	Recommendations
		emergency response needs may be built on existing plans and operations. • The Port can draw from local emergency response and climate change planning efforts. • The Whatcom Unified Emergency Operations Center is identified in the Whatcom County NHMP as a shared City/County/Port facility[5].		• Indicate clearly what Emergency Response or Hazard Mitigation plan takes precedence at the Port. • Ensure that emergency responders are aware of Port access points and possible bottlenecks, as well as any available equipment onsite that may be useful in an emergency response.
Partnerships with local, state, and federal agencies	• RSLR and other climate change impacts will place increasing strain on individual entities and existing relationships as climate change impacts become more frequent and severe and as resources become more limited. • Any building codes or other regulations that are more or less stringent than Port policies may complicate capital projects.	• The Port lists established planning partnerships with the following groups: • Army Corps of Engineers • City of Bellingham • Lummi Nation • Nooksack Tribe • Nooksack Salmon Enhancement Association • National Oceanic and Atmospheric Administration • Puget Sound Partnership • U.S. Fish and Wildlife Service • Washington State Department of Ecology • Washington Department of Fish and Wildlife • Washington Department of Natural Resources • Washington Department of Transportation • Whatcom County.	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Maintain existing partnerships and foster additional partnerships to coordinate planning and sharing of resiliency resources. • Partnership with the City of Bellingham is a high priority due to the need for road access and the City's jurisdiction over land holdings by the Port. City building codes (e.g. required foundation height above sea level) will have major impacts on required capital improvements and growth or loss of business at the port.
Institutional Knowledge of Port Employees	• Experienced employees may move or retire, causing a potential loss of valuable knowledge of Port operations and infrastructure.	• Port staff, especially those experienced in Port operations and resources, can provide knowledge and capacity to help with climate change adaptation planning. • A 2019 report describes openminded leadership and flexibility as an institute as a strength in the face of climate change impacts.	• Lack of information about what institutional knowledge is available that should be documented and integrated into resiliency and adaptation planning.	• Determine what institutional knowledge should be documented and integrated into resiliency planning. • Maintain openminded leadership and flexibility in resiliency planning, partnership development, and other responses to climate change.
Human Health	• RSLR and associated climate impacts on coastal conditions are expected to worsen hazards to human health. The nature of these potential hazards is not fully understood.	• Climate change impacts on human health may reduce available labor at the Port or expose the Port to liability for the health of employees and visitors to public areas on Port property.	• The range and severity of potential risks to human health arising from climate change.	• Assess potential risks to human health arising from coastal climate change impacts and develop appropriate safety measures.
Cultural Resources	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Lack of information about cultural resource located at or associated with the Port.	• Assess what cultural resources may be impacted by RSLR, coastal erosion, changes in marine wildlife populations, or other.
The Natural Environment				
Marine Wildlife Populations	• RSLR and coastal erosion may cause inundation and destruction of marine and intertidal habitats faster than they can naturally adapt. • Changes in marine wildlife populations may results in increases in marine biofouling or other negative interactions between wildlife and Port infrastructure.	• The Port is a co-manager of the Bellingham Bay Demonstration Pilot, a partnership of federal, state, local, and tribal agencies working cooperatively to improve the environmental health of Bellingham Bay. • The Port completed a habitat restoration project in 2005, reconnecting tideflats and eelgrass beds.	• Lack of complete information about potential impacts of climate change on marine wildlife populations. • Lack of information about how climate change will impact the interactions between wildlife and Port infrastructure (e.g. biofouling, boat-wildlife collisions, etc.).	• Evaluate existing projects for potential coastal climate change impacts. • Incorporate findings from climate change analyses into future habitat restoration project planning. • Evaluate potential negative interactions between infrastructure and wildlife that may occur due to or be worsened by climate change.

Table B-1: Draft Vulnerability Assessment Matrix

	Vulnerabilities	Assets/Strengths	Data Gaps	Recommendations
	• Ocean acidification is detrimental to many marine shellfish species and will impact >30% of Puget Sound's marine species. • Based on 2013 data, approximately 2000 jobs rely directly on commercial fishing activities at the Squalicum and Blaine marinas alone. These jobs are vulnerable to changes in commercial fisheries populations, which may be impacted by climate change.			• Assess the magnitude of potential impacts of ocean acidification on commercial and recreational fishing.
Undeveloped Public Land	• *Requires further investigation in future stages of the development of the Climate Action Strategy.*	• Open areas may serve as buffer areas that may absorb RSLR and/or increased runoff and flooding during storm events.	• Locations and elevations of undeveloped public lands adjacent to or near Port property.	• Assess potential RSLR and coastal storm impacts on undeveloped public land.

Appendix C

Maintenance Area and Lockers ESA Analysis

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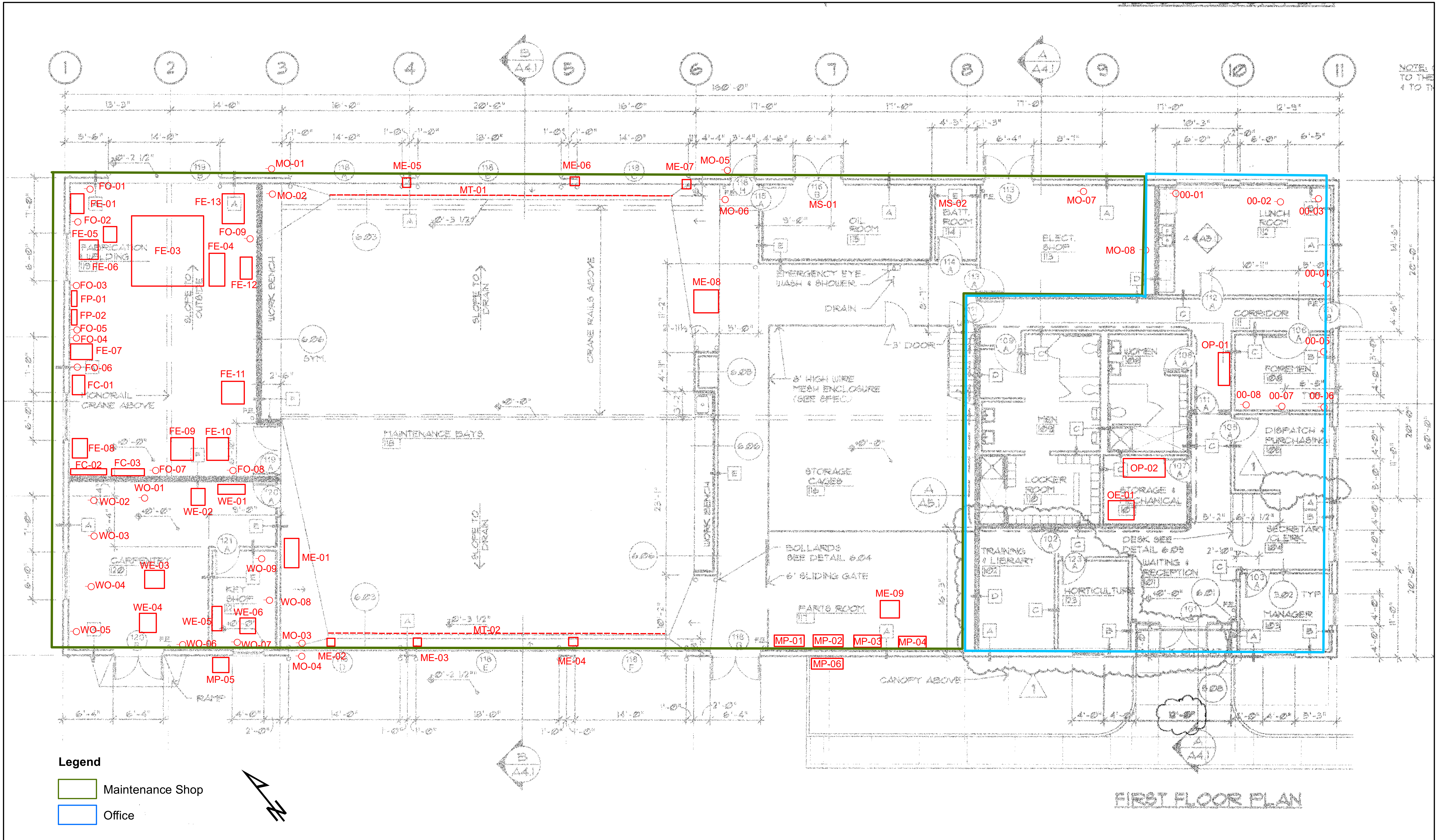
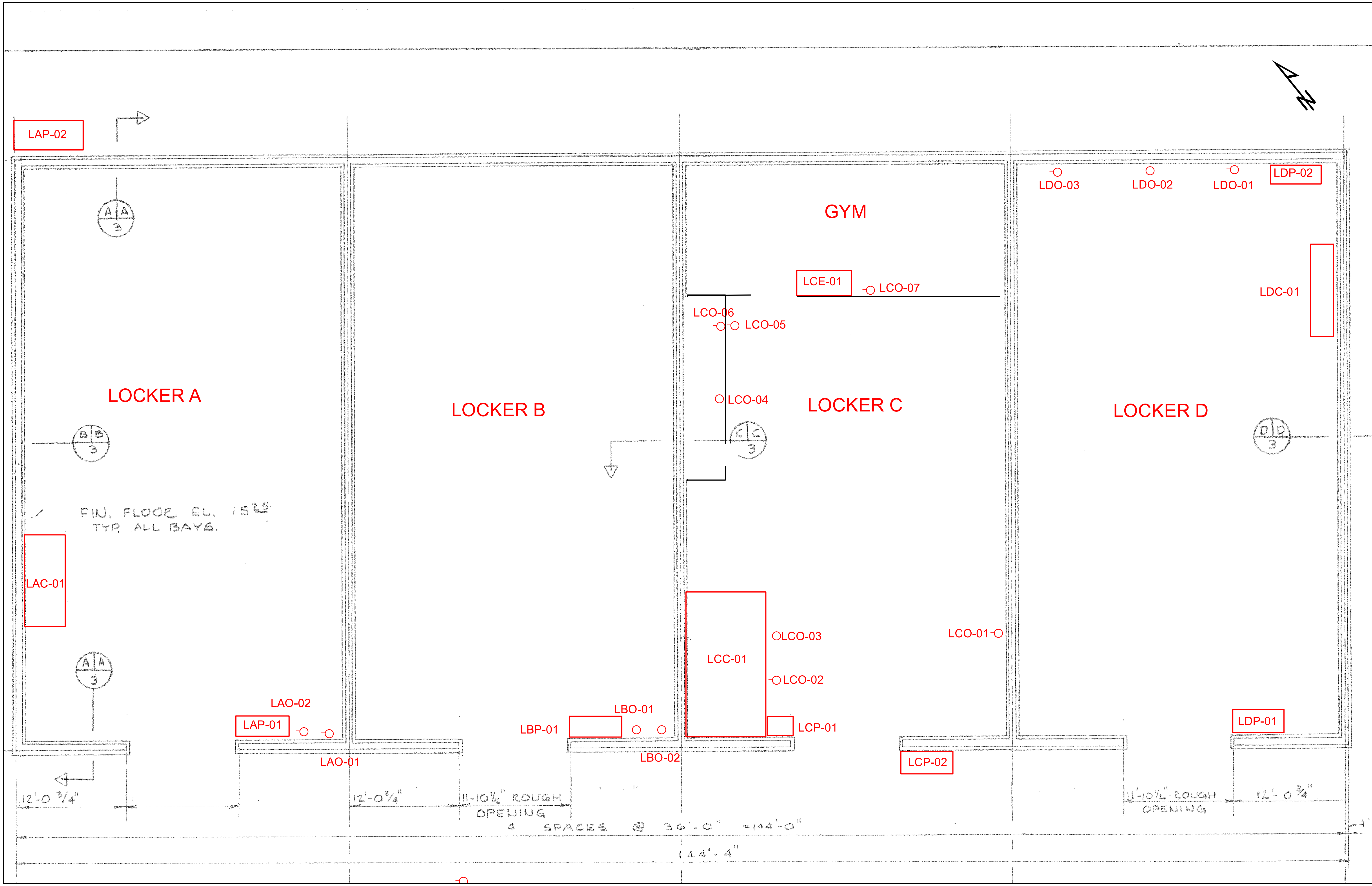


FIRST FLOOR PLAN
MAINTENANCE BAYS
FABRICATION & WELDING
CARPENTRY
KEY SHOP
OIL ROOM
BATT. ROOM
ELECT. SHOP
LUNCH ROOM
CORRIDOR
WOMEN
MEN
LOCKER ROOM
STORAGE & MECHANICAL
FOREMEN
DISPATCH & PURCHASING
SECRETARY / CLERK
TRAINING & LIBRARY
HORTICULTURE
WAITING & RECEPTION
MANAGER
STORAGE CAGES
PARTS ROOM
CANOPY ABOVE
RAMP
EMERGENCY EYE-WASH & SHOWER
DRAIN
8' HIGH WIRE MESH ENCLOSURE (SEE SPEC.)
BOLLARDS SEE DETAIL 6.04
6' SLIDING GATE
CRANE RAILS ABOVE
MONORAIL CRANE ABOVE
WORK BENCH
SLOPE TO DRAIN
SLOPE TO OUTSIDE
MO-01 MO-02 MO-03 MO-04 MO-05 MO-06 MO-07 MO-08
ME-01 ME-02 ME-03 ME-04 ME-05 ME-06 ME-07 ME-08 ME-09
MT-01 MT-02
MS-01 MS-02
MP-01 MP-02 MP-03 MP-04 MP-05 MP-06
FO-01 FO-02 FO-03 FO-04 FO-05 FO-06 FO-07 FO-08 FO-09
FE-01 FE-03 FE-04 FE-05 FE-06 FE-07 FE-08 FE-09 FE-10 FE-11 FE-12 FE-13
FP-01 FP-02
FC-01 FC-02 FC-03
WO-01 WO-02 WO-03 WO-04 WO-05 WO-06 WO-07 WO-08 WO-09
WE-01 WE-02 WE-03 WE-04 WE-05 WE-06
00-01 00-02 00-03 00-04 00-05 00-06 00-07 00-08
OP-01 OP-02
OE-01
Legend
Maintenance Shop
Office


LAP-02
LDO-03
LDO-02
LDO-01
LDP-02
GYM
LCE-01
LCO-07
LCO-06
LCO-05
LDC-01
LOCKER A
LOCKER B
LCO-04
LOCKER C
LOCKER D
FIN. FLOOR EL. 15 25
TYP. ALL BAYS.
LAC-01
LCO-03
LCC-01
LCO-01
LCO-02
LAO-02
LBO-01
LAP-01
LBP-01
LCP-01
LDP-01
LAO-01
LBO-02
LCP-02
12'-0 3/4"
12'-0 3/4"
11'-10 1/4" ROUGH OPENING
4 SPACES @ 36'-0" =144'-0"
11'-10 1/2" ROUGH OPENING
12'-0 3/4"
144'-4"