Draft

SEA LEVEL RISE, TSUNAMI HAZARDS, AND EROSION RESILIENCE STRATEGY FOR NOYO HARBOR

Vulnerability and Risk Assessment

Prepared for
City of Fort Bragg
416 North Franklin Street
Fort Bragg, CA 95437

May 2025

ARUP ESA

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City of Fort Bragg
416 North Franklin Street
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775 Baywood Drive
Suite 100
Petaluma, CA 94954
707.795.0900
esassoc.com

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560 Mission Street
Suite 700
San Francisco, CA 94105
415.946.0214
arup.com

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1. INTRODUCTION

The Vulnerability and Risk Assessment for the Noyo Harbor Sea Level Rise, Tsunami Hazards, and Erosion Resilience Strategy (SLRRS) is a comprehensive evaluation aimed at understanding and mitigating the impacts of coastal hazards on Noyo Harbor and adjacent areas. This assessment is part of a broader initiative funded by the California Coastal Commission and conducted in collaboration with the City of Fort Bragg, Noyo Harbor District, and various consulting partners. The Vulnerability and Risk Assessment serves as a foundational document for the development of a robust resilience strategy that will guide future planning and investment in Noyo Harbor, ensuring its continued functionality and sustainability in the face of climate change and coastal hazards.

The primary objectives of the Vulnerability and Risk Assessment are to:

- Identify and assess the vulnerabilities of Noyo Harbor's assets and uses to sea level rise, tsunami hazards, and erosion.
- Develop a comprehensive understanding of the potential impacts of these hazards on the harbor's operations and community.

The Vulnerability and Risk Assessment will be folded into the forthcoming SLRRS. The SLRRS will incorporate these additional objectives:

- Engage with stakeholders and the public to gather input and ensure that the resilience strategy reflects the needs and priorities of the community.
- Propose mitigation and adaptation strategies to enhance the harbor's resilience to future coastal hazards.

Ultimately, the SLRRS will become part of the Noyo Harbor Blue Economy Visioning, Resiliency, and Implementation (BEVRI) Plan. The BEVRI Plan is a collaborative effort between the City of Fort Bragg, Noyo Harbor District, and California Sea Grant to develop a roadmap for coastal resiliency in Noyo Harbor.

The Vulnerability and Risk Assessment is organized as follows:

- **Section 1** – Introduction
- **Section 2** – Project Setting
- **Section 3** – Existing and Future Coastal Hazard Zones
- **Section 4 –** Noyo Harbor – Key Assets and Operational Goals
- **Section 5** – Analysis of Hazard Exposure by Scenario
- **Section 6 –** Noyo Harbor Asset-Specific Vulnerability and Risk Assessment
- **Section 7** – Opportunity Zones in Noyo Harbor

- **Section 8** – Conclusions
- **Section 9** – References

1.1 Key Terms and Definitions

The following terms are used throughout the document based on the definitions included in this section:

- **Riverine flooding** refers to flooding originating from rainfall and high creek water levels.
- **Coastal flooding** refers to flooding due to waves and high water levels originating from the ocean.
- **Coastal storms** impact the shoreline through higher water levels and waves from the ocean and are commonly associated with low-pressure weather systems. Planning and analysis often occurs for the "100-year storm," which is the storm estimated to have a 1% chance of occurring each year.
- **Coastal storm flooding** refers to coastal flooding that occurs during coastal storm events.
- **Tidal inundation** refers to coastal flooding during regular high tides under non-storm conditions.
- **Coastal erosion** refers to loss of sandy beaches, dunes, and the low-lying backshore along the shoreline through natural processes such as waves, wind, or tides.
- **Coastal bluff erosion** refers to loss of coastal bluffs as material falls or collapses onto the beach or into the ocean below.

1.2 Disclaimer and Use Restrictions

1.2.1 Funding Agencies

These data and this report were prepared for the City of Fort Bragg and is partially funded by the California Coastal Commission (CCC) through the Local Coastal Program Local Assistance Grant Program. The data and report do not necessarily represent the views of the funding agencies, their respective officers, agents and employees, subcontractors, or the State of California. The funding agencies, the State of California, and their respective officers, employees, agents, contractors, and subcontractors make no warranty, express or implied, and assume no responsibility or liability, for the results of any actions taken or other information developed based on this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. These study results are being made available for informational purposes only and have not been approved or disapproved by the funding agencies, nor have the funding agencies passed upon the accuracy, currency, completeness, or adequacy of the information in this report. Users of this information agree by their use to hold blameless each of the funding agencies, study participants and authors for any liability associated with its use in any form.

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The entire risk associated with use of the study results is assumed by the user. The City of Fort Bragg, the Noyo Harbor District, ESA, and the California Coastal Commission shall not be responsible or liable for any loss or damage of any sort incurred in connection with the use of the report or data.

2. PROJECT SETTING

2.1 Study Area

This Vulnerability and Risk Assessment is focused on Noyo Harbor and its supporting assets, and the study area includes harbor developments upstream to Dolphin Isle Marina (**Figure 1**, *Study Area*). The project site is within the traditional territory of the Northern Pomo people, and new construction projects in the area have consulted with the Sherwood Valley Band of Pomo Indians in cultural resources investigation (Roscoe and Associates, 2016). A related assessment in Mendocino County will include most of the open-coast portions of the City of Fort Bragg, except for the dredge containment cell portion of Noyo Bay, which will be included in this study.

2.2 Noyo Harbor Background

Information on the harbor area's history, current uses, and future plans is summarized below. Additional detail is provided in **Appendix A**, *Existing Conditions and Data Inventory Memorandum*.

Harbor functions: Originally a seasonal settlement for the Pomo people, the harbor supported the logging industry in the early 20th century before transitioning focus to commercial fishing. In 2023, Noyo Harbor ranked sixth highest in the state in terms of ex-vessel revenues, bringing in $7.7 million. The harbor supports a variety of businesses. It also caters to recreational activities, including boating and sport fishing, with several thousand recreational fishing passengers each year. The marina consists of 8 docks with 256 berths, and slightly less than half of the berths contain commercial vessels.

Harbor dredging and Noyo Beach: Harbor maintenance includes periodic dredging to ensure boats can navigate and moor during all tide levels. Sediment from the riverbed is transported to a containment cell where material dries before being further transported to a landfill. The containment cell is located adjacent to Noyo Beach, a popular beach providing a variety of recreational activities. Storm-caused erosion has compromised the structural integrity of the containment cell. The cell's contents, which include hazardous materials, are at risk of spilling onto Noyo Beach (Storm Damage Inventory Narrative, 2023).

Community Sustainability and Blue Economy Initiatives: The Community Sustainability Plan (CSP) and BEVRI Plan are initiatives aimed at preserving and enhancing Noyo Harbor's functionality, balancing economic development with environmental stewardship. California's blue economy has seen annual revenues increase by 18 percent and jobs increase by 163 percent over the past decade, even in the face of pandemic-related and other economic challenges. In addition to the assessment of sea level rise, tsunami hazards, and erosion resilience conducted for this project, it also includes an Aquaculture Feasibility Study, envisioning a future where sustainable seafood production thrives alongside traditional fisheries.

Figure 1. Study Area

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Demographics and social vulnerability: Fort Bragg is a small city with a population just under 7,000. One quarter of the city's population is 65 years or older, which is significantly higher than the state's average. Median household income in the city ($53,580) is much lower than the median statewide ($96,334). However, employment rates are similarly lower in Fort Bragg than in California as a whole. Additionally, 21 percent of residents identify as having a disability, a figure substantially higher than the state's 12 percent (US Census Bureau 2020-2023).

The two census tracts in the City of Fort Bragg have a moderate environmental justice burden, with CalEnviroScreen percentiles in the 47th and 49th percentiles. These two tracts, as well as the tract bordering the city on the north and the east, all have higher incidences of asthma—in the 79th percentile. Low birth weight is in the 80th percentile for the southern tract within the city. Both census tracts have 45th percentile burden for diesel exposure and a 41st percentile burden for traffic, both of which are much higher than anywhere else in the county, which has exposures in these areas in the single digits. Environmental effects from cleanup sites, groundwater threats, and hazardous waste and in the 50th – 70th percentiles for the city and its surrounding area. One tract in the City of Fort Bragg is 54% white and 41% Hispanic or Latino, while all other tracts on the Mendocino coast are over 70% white (CalEnviroScreen, 2021).

Historic Storm/Tsunami Events and Damages: The harbor area has experienced extensive damage from severe storm and tsunami events throughout the past century. The severe winter storms from December 27, 2022, through January 31, 2023, brought heavy rains, flooding, upriver landslides, and ocean storm surges, causing extensive damage to the harbor's facilities. Wave heights reached over 33 feet, and still water levels exceeded 8.5 feet NAVD, far surpassing typical winter conditions. The storm impacted the marina floor, dredge soils containment cell, public parking lot, and a piling in the marina. Additionally, the 1997 New Year's Flood resulted from a series of intense storms, leading to severe flooding across Northern California and damaging harbor facilities. Other significant events include the March 1964 tsunami triggered by an Alaskan earthquake, which caused substantial damage along the California coastline, and the 1982-83 El Niño storms, which brought high winds, heavy rain, and significant flooding throughout California.

Significant storm events observed at the Arena Cove NOAA tide gauge for December 17-18, 2018; January 17-18, 2019; and January 5-8, 2023, along with tsunami events on March 11, 2011, and January 15, 2022, had non-tidal residuals ranging from 1 to 6 feet. The January 5, 2023, storm brought closures to Noyo Beach and boating activities at the Harbor, with receding waters bringing logs and other upstream debris through the Harbor and surrounding parking areas. These historic events underscore the importance of improving the harbor's resilience to future storms and tsunamis through comprehensive planning and mitigation strategies (Storm Damage Inventory Narrative, 2023).

3. EXISTING AND FUTURE COASTAL HAZARDS

This section describes coastal hazard zones under existing and future conditions. The sea level rise (SLR) scenarios used as a basis for the vulnerability analysis are 1 foot, 3 feet, and 6 feet. These are discussed in detail in **Appendix B**, *Sea Level Rise Scenarios Memorandum*. Coastal hazard zone mapping for this vulnerability assessment addresses high tide (non-storm) flooding, extreme (100-year) events, shoreline and cliff erosion, and tsunami risks.

3.1 Existing Flooding

This section describes the existing conditions for the three main flood sources – tides, extreme high water, waves, and the Noyo River – within Fort Bragg. Existing flood conditions form the foundation for projected changes with sea level rise.

3.1.1 Tides and Non-Storm Water Levels

Noyo Harbor experiences mixed semidiurnal tides, or two daily high tides and two daily low tides of differing elevations. These daily tides also vary with the spring-neap tidal cycles, which occur approximately twice a month.

Coastal engineers use vertical datums, or defined reference surfaces, to estimate the relative elevation of the tides and water levels to the land around it. For this study, ESA used the closest NOAA tide gauge, Arena Cove (Station #9416841), located approximately 36 miles south of the project area. Tidal datums for the Arena Cove gauge are shown in **Table 1**.

TABLE 1. TIDAL DATUMS AT ARENA COVE (#9416841), APPLICABLE TO NOYO HARBOR

Tidal Datum	Abbreviation	Feet (ft) NAVD
Maximum Observed Tide (observed on February 6, 1998)	MOT	8.53
Highest Astronomical Tide	HAT	7.48
Mean Higher High Water	MHHW	5.73
Mean High Water	MHW	5.06
Mean Tide Level	MTL	3.04
Mean Sea Level	MSL	3.00
Mean Low Water	MLW	1.01
Mean Lower Low Water	MLLW	-0.14

SOURCE: NOAA Tides and Currents 2020

NOTES: The tidal datums listed above are from the most recent tidal epoch: 1983-2001.

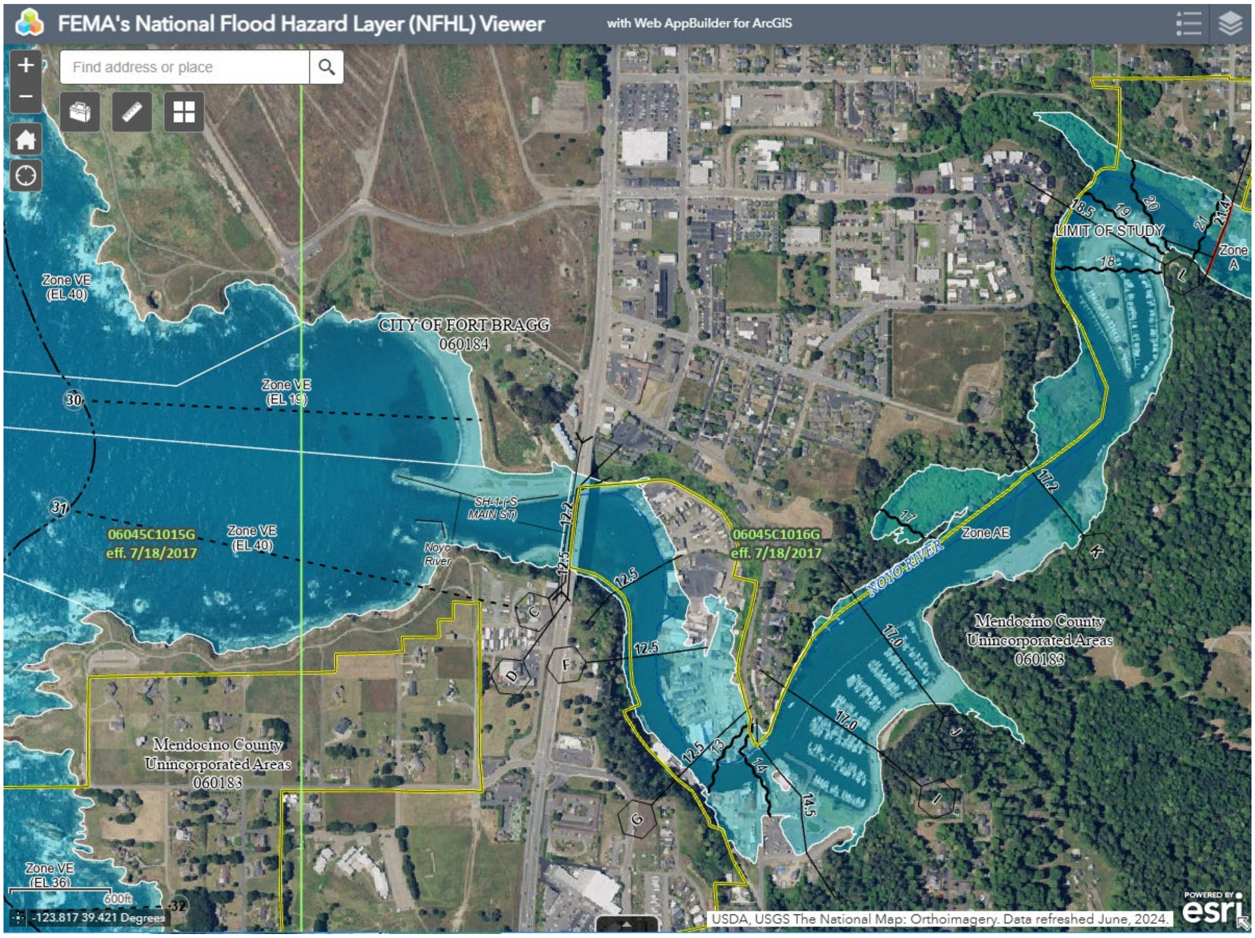
While the inside of the harbor is not directly exposed to large wave events, this area is exposed to wave-induced oscillations around the still water level, or infragravity waves. The resulting water levels are called dynamic water levels (DWLs). ESA analyzed measured water levels at Arena Cove (2008 to present) to calculate a maximum DWL at the site of 12.3 feet (ESA, 2023).

3.1.2 Extreme Event Flooding

FEMA develops Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs) for the purpose of informing the public of flood risks. FEMA maps typically show water levels (Base Flood Elevations) for the 1% (100-year) event and the extents of the 1% and 0.2% (500-year) annual chance flood events. These events can happen as a result of flooding from coastal flood sources (ocean water levels and waves), precipitation flood sources (high freshwater runoff), or a combination of both (as is the case for Noyo Harbor).

Within the flood hazard zone (also known as the 100-year floodplain), FEMA further categorizes Coastal High Hazard Areas, or VE zones. VE zones indicate areas where waves and high water velocities can intensify damages associated with flooding. Within the study area, the VE zone extends from offshore to the Highway 1 Bridge. Coastal areas denoted Zone AE, east of the Highway 1 bridge, indicate that while waves may be present, they are significantly lower in height. Fluvial flooding dominates the upstream reaches of the river. **Figure 2** shows the FEMA special flood hazard areas for the project area, including the coast and upstream along the Noyo River. The majority of Noyo Harbor and the Dolphin Island Marina are mapped in the 100-year floodplain.

FEMA estimates flood risks based on Total Water Levels (TWLs) which include the effects of high water and wave runup. In 2009, FEMA completed detailed modeling and analyses of coastal hazards along the open coast of California based on data available from 1960 to 2009 (FEMA, 2014). The FEMA modeling and analysis is based on a one-dimensional transect-based analysis. Transects 30 and 31 are the two that cover central Noyo Bay, as shown in Figure 2. Transects 29 and 32 are north and south of the bay along the cliff edges. The results of FEMA's 2009 analysis were used in mapping of the FEMA Base Flood Elevation (BFE), Figure 2. For this study, ESA calculated updated TWLs using FEMA methods and an extended period of record (1960 to 2024), an additional 15 years of record. Mapping of the extended period of record compared well with the FEMA mapping, with small differences in limited locations.



Source: FEMA, 2025

Figure 2.
FEMA Special Flood Hazard Areas

TWLs from the FEMA Open Pacific Coast Flood Study, FEMA BFE map and FEMA extended period of record are provided in **Table 2** along with the TWL selected for use in this study. For transects 29 and 32, the statistical approach provided results that appeared to be outliers. In these instances, the non-updated values were used.

TABLE 2. EXISTING EXTREME (100-YEAR) TOTAL WATER LEVELS

Transect (North to South)	FEMA IDS3	FEMA BFE	FEMA Extended	TWL Used for this Study
29	39.8	40	56	40
30	19.2	19	24.5	24.5
31	40.5	40	45.5	45.5
32	35.9	36	35.2	36

SOURCE: FEMA IDS3 2009, FEMA BFE 2024, ESA analysis.

3.1.3 Waves

The study area is exposed to large swell and large storm seas. **Figure 3** below shows an example from storms in 2021. Typical (non-storm) wave exposure comes from waves generated in the north Pacific with predominant swell directions from the west and northwest (ESA 2023). Storm-generated waves can vary in direction depending on the season with spring and summer winds (March through July) typically generating wind swells from the northwest and winter storms typically generating swell from the southwest. Based on input from local community members, the most damaging storms are winter storms from the west-southwesterly direction (Jason Island, pers. comm.).

In typical conditions, the study area is subject to a strong wave climate, with waves of 3 to 5+ feet high and periods of 10-15 seconds. In storms, swells from distant storms can result in very large waves exceeding 20 feet high and periods of 15-20+ seconds. Local storm waves also can be quite large, on the order of 15- to 20 feet with periods in the range of 10-15 seconds. ESA 2023 provides additional analysis of water levels and waves based on NOAA water level observations.

Source: Fort Bragg Resident Valadao, published on Mendo Fever—Mendocino County News

Figure 3.
Submerged Jetties at Noyo Harbor During High Swells of January 2021

3.1.4 River Flooding

Noyo River flood levels are detailed by FEMA and presented as BFEs on the FEMA flood map (Figure 2).

3.2 Future Coastal Hazards

3.2.1 Sea Level Rise

Relative sea level rise from 1978 to the present, as recorded for the Arena Cove tide gage, is 0.9 mm/year, or 0.3 feet over 100 years. Looking forward, sea level rise is projected to accelerate. The City of Fort

Bragg SLR, Tsunami Hazard, and Erosion Resilience Strategy (this study) considers three plausible scenarios of future sea level rise: 1 foot of SLR occurring by 2050 (near term), 3 feet of SLR by 2070-2100 (intermediate term), and 6 feet of SLR by 2100+ (long term). **Table 3** presents a summary of the SLR scenarios. See SLR scenarios for City of Fort Bragg Memorandum (ESA 2025) for detail on SLR guidance and projections.

TABLE 3. RECOMMENDED SLR SCENARIOS TO APPLY TO CITY OF FORT BRAGG SLR, TSUNAMI HAZARD, AND EROSION RESILIENCE STRATEGY

Scenario	SLR Amount (feet)[a]	Time (High Scenario)[b]	Time (Intermediate Scenario)[c]
Near Term	1	2040	2050
Intermediate Term	3	2070	2100
Long Term	6	2100	2150

SOURCE: 2024 OPC Guidance

NOTES:

a. SLR amount is rounded to the nearest foot to simplify analysis and reporting.
b. This time corresponds to the approximate earliest time that a given amount of SLR is projected under the high scenario.
c. This time corresponds to the approximate latest time that a given amount of SLR is projected under the intermediate scenario.

3.2.2 Future Extreme Event Flooding

Extreme flood levels will increase as sea levels rise, though not necessarily in a one-to-one correlation with the amount of SLR. As SWLs increase with SLR, wave run up can be amplified because of an increase in breaking wave heights closer to shore. This is particularly true for erosion resistant back shores. For erosional shores, such as sandy beaches, wave runup doesn’t amplify because the beach maintains its shape, moving upward and landward with SLR.

To assess how extreme flood elevations will be affected by SLR, ESA calculated future 100-year event TWLs following methods described in the Coastal Hazards Technical Methods Manual (ESA 2016). The methods account for wave runup variation based on the morphology of the future coastline. ESA used transect data from FEMA (2009) to develop the required morphology factors. Future TWLs were then calculated for each SLR scenario. **Table 4** shows the future TWLs for each SLR scenario. It should be noted that future TWLs use a conservatively high morphology factor and thus the water levels are considered a conservatively high estimate of extreme total water levels.

TABLE 4. FUTURE EXTREME TOTAL WATER LEVELS

Transect	TWL with 1ft SLR	TWL with 3ft SLR	TWL with 6ft SLR
29	44	52	64
30	27.5	33.5	42.5
31	49.5	57.5	69.5
32	40	48	60

SOURCE: ESA analysis.

NOTE: Assumes high morphology factor.

Wave overtopping was investigated for each transect and SLR scenario. Overall, overtopping was found to occur only with 6 feet of SLR at transects 29, 31 and 32. When overtopping occurs, the landward extent of overtopping was calculated and used in the mapping.

3.3 Coastal Hazard Mapping

The hazard zones used in this analysis are:

- Tidal Inundation – Tidal inundation refers to areas that are below the typical high tide elevation under non-storm conditions.
- Storm Flooding and Waves – In this study, "storm flooding" refers to flooding caused by the combination of tides, the high-water levels that come with a storm and the effects of waves, including wave setup (i.e., dynamic water level) and runup. The coastal storm used to define the hazard zone is estimated to have a 1% chance of occurring each year (i.e., a "100-year storm"). Includes riverine flooding.
- Dune and Bluff Erosion – In this study, "dune erosion" refers to the permanent loss of sandy beaches, dunes, and the low-lying backshore and "bluff erosion" refers to the inland movement of coastal bluffs as material falls or collapses onto the beach (or into the ocean) below.
- Tsunami- Tsunami hazards refer to areas that are within flooding elevations based on the 200-yr, 975-yr and 3000-yr tsunami hazards.

Figure 4 maps coastal hazards for existing conditions. **Figure 5**, **Figure 6**, and **Figure 7** map coastal hazards for 1 foot, 3 feet, and 6 feet of SLR, respectively. Mapping of each hazard type is discussed in the sections below.

3.3.1 Tidal Inundation

The National Oceanic and Atmospheric Administration (NOAA) produces (non-storm) tidal inundation mapping for existing and future sea levels. ESA utilized this data for Fort Bragg as CoSMoS data (commonly used) is not yet available. NOAA tidal inundation mapping was utilized for sea level rise scenarios of 0 feet, 1 feet, 3 feet and 6 feet.

Tidal inundation hazards affect assets on the surface by inundation, and buried assets (like sewer lines) could be exposed to saltwater intrusion and corrosion as higher sea levels change groundwater depth and salinity. This hazard does not include changes to stormwater drainage and specific culverts and resulting changes to flooding. In this study, tidal flooding is considered a permanent loss hazard, since assets regularly beneath high tide will likely be effectively unusable. **Figure 8** shows the areas exposed to the existing and future estimates due to tidal inundation.

3.3.2 Extreme Event Flooding and Storm Waves

The extreme event hazard zones for existing and future SLR scenarios were mapped using TWLs (from Section 3.2.2) and are shown in **Figure 9**. The extreme event is defined as the 100-year event for this study. Storm flooding and storm waves are considered a temporary loss hazard.

Figure 4. Existing Coastal Hazards

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Figure 5. Coastal Hazards with 1 ft of Sea Level Rise

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Figure 6. Coastal Hazards with 3 ft of Sea Level Rise

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Figure 7. Coastal Hazards with 6 ft of SLR

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Figure 8. Tidal Inundation Hazards

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Figure 9. Storm Flooding Hazards

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Wave Hazards (VE zones) were mapped in low-lying areas with direct wave exposure. Wave runup is considered in this vulnerability assessment because it can cause significant damage. Impacts from storm waves are more severe than storm flooding hazards from standing water because wave momentum can, for example, cause structural damage, move vehicles, and knock people over. As noted in Section 3.3.2, the TWLs used here provide a conservatively high estimate of future wave hazards.

Extreme Noyo River water levels were estimated for each SLR scenario by adding the amount of SLR to the FEMA flood water level for existing conditions. This approach was used in the absence of hydraulic modeling and provides a conservatively high estimate of hazards, particularly in upstream areas further from the bay.

3.3.3 Long-Term Shoreline and Bluff Erosion

Over time, sandy beaches and dunes experience temporary erosion, with sand moving seasonally to and away from the beach, and permanent erosion, with sand moving away from the beach without returning. In this study, “dune erosion” refers to the permanent loss of sandy beaches, dunes, and the low-lying backshore that occurs with changing sea level or sand supply. Coastal bluffs are subject to permanent erosion at the leading edge of the bluff as material falls or collapses onto the beach (or into the ocean) below. The term "coastal bluff" refers to the entire slope between a marine terrace or upland area and the sea (CCC n.d.). The terms bluff erosion and cliff erosion are sometimes used interchangeably since a seacliff is the ocean-facing (and erosive) part of a coastal bluff. Sea cliffs are the lower, near vertical portion of a coastal bluff.

This study draws from two sources to map coastal dune and bluff erosion at Fort Bragg: Philip Williams and Associates (PWA) 2009 and Coastal Storm Modeling System (CoSMoS). Each source has relative benefits and limitations. PWA (now ESA) prepared coastal erosion hazard mapping for the California Ocean Protection Commission for much of the California coast. The PWA (2009) dataset maps coastal bluff and dune erosion at Fort Bragg. The PWA study provides dune erosion estimates (not yet available through CoSMoS) and a higher level of spatial resolution at Fort Bragg relative to CoSMoS. Since the time of the PWA study, however, there have been advances in assessing shoreline erosion hazards.

The CoSMoS dataset for Northern California uses more up-to-date data and methods (Version 3.2, Erikson et al. 2017, O’Neal et al 2018, Erikson et al, 2018). CoSMoS provides projections of bluff erosion under future conditions with 1.6 feet, 3.3 feet and 6.6 feet SLR. CoSMoS dune erosion estimates are expected in late 2025. CoSMoS incorporates cliff materials, changing water levels, and wave conditions to provide a line indicating the inland extent of bluff erosion for each SLR scenario. The assets between this line and the tidal inundation hazard zone were deemed exposed to erosion.

In this study, bluff erosion is considered a **permanent loss hazard**, since assets in eroded areas will be completely lost. **Figure 10** shows the areas exposed to future dune and cliff erosion. CoSMoS may underpredict erosion along the south shore of Noyo Bay, where there has already been erosion to the edge of the coastal trail.

3.3.4 Tsunami

The State of California Tsunami Hazard Area Maps, produced by California Geological Survey, reveal low-lying regions in the Noyo Harbor area as vulnerable to tsunamis. The Tsunami Hazard Area (**Figure 11**) represents the area exposed to tsunami hazards and is based on a suite of extreme (low probability), yet realistic, tsunami model results with estimated return periods of 200-years, 975-years and 3,000-years.

Tsunami hazard maps are not currently available for sea level rise scenarios. The California Geological Survey is conducting a pilot study for mapping tsunami hazards for sea level rise scenarios (Jay Patton, CGS, pers. comm). The American Society of Civil Engineers provides guidelines (ASCE 7-22) on how to incorporate sea level rise effects in the technical analysis of tsunamis. However, the guidelines recommend advanced numerical modeling in areas with complex topographies and three-dimensional effects such as the study area.

Figure 10. Bluff and Dune Erosion Hazards

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Figure 11. Tsunami Hazards

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4. NOYO HARBOR – KEY ASSETS AND OPERATIONAL GOALS

Assessing the flood exposure, vulnerability, and risk of assets in Noyo Harbor requires an understanding of which assets are exposed to flood and erosion hazards across different time horizons and the impacts of hazard exposure on the functionality of the harbor. This section details the character of Noyo Harbor and elaborates on the list of assets described in the Existing Conditions Memorandum (Appendix A). Later sections include an exposure, vulnerability, and risk analysis of the assets described herein.

4.1 Noyo Harbor Geographic Character Zones

The Noyo Harbor District is broken out into several geographic character zones, as shown in **Figure 12**. The character zones are critical operations, commercial fishing, mooring basin, recreational boat launch, beach, local retail and residential, commercial fishing, and Dolphin Isle Marina. Each of these zones encompasses multiple assets, which are discussed further in the following sections.

4.2 Inventory of Assets at Noyo Harbor

This assessment divides asset datasets into categories to better characterize the exposure of certain systems. Sources of data include the Noyo Community Sustainability Plan, damage inventories from the 2023 storms, and discussions with the Noyo Harbormaster and City staff. The resulting geospatial dataset of 75 assets was categorized into the 7 categories shown in **Figure 13**. Each category is discussed in more detail in the following section.

4.2.1 Beach & Shoreline Protection

Noyo Beach is a recreational shoreline area at the mouth of the Noyo River, popular for fishing, kayaking, and dog walking. It is supported by a dedicated public parking lot managed by the Noyo Harbor District. The beach experienced severe damage during the winter storms of 2022–2023, which led to flooding, wave overtopping, and debris deposition. The adjacent dredge soil containment cell, damaged during the same storm, poses an environmental hazard to Noyo Beach, as it holds sediment with potentially hazardous material. The North Harbor Entrance Jetty, South Harbor Entrance Jetty & Breakwater, and Harbor Revetment are critical to protecting the harbor from ocean energy and storm surges. During the January 2023 storm, the Harbor's jetties were overwhelmed, resulting in flooding and sediment displacement. Noyo Beach and existing shoreline protection infrastructure are shown in **Figure 14** and **Figure 15**. More information about the harbor's jetties and revetments is included after Figure 15.

Figure 12. Noyo Harbor - Character Zones

(8.5x11)

Figure 13. Noyo Harbor - Asset Categories Overview

(8.5x11)

Figure 14. Noyo Harbor - Beach and Shoreline Protection

(8.5 x 11)

Figure 15. Operation and Maintenance (O&M)

(8.5 x 11)

North Jetty (North Breakwater / Wall)

The North Jetty, approximately 345 feet in length, forms the northern boundary of the entrance channel to Noyo Harbor and is federally maintained. Constructed with a combination of riprap stone armor and concrete reinforcement, the jetty is connected to the 620-foot-long North Wall and plays a critical role in reducing wave energy and maintaining navigable conditions in the channel. Over the past decade, the North Jetty has experienced increasing levels of structural degradation, driven by storm wave overtopping, high swell energy, and ongoing sediment transport challenges. Severe shoaling at the harbor entrance, particularly during winter storm events, has repeatedly impaired Coast Guard search and rescue operations. In response, the U.S. Army Corps of Engineers (USACE) has begun to plan for repairs. In FY22, the project received $2.5 million through the Infrastructure Investment and Jobs Act specifically for North Jetty repair work. Subsequent activities in FY23 and FY24 have included condition surveys and preliminary engineering analysis, in coordination with the Noyo Harbor District.

South Jetty (South Wall / Breakwater)

The South Jetty, approximately 234 feet in length, forms the southern boundary of the entrance channel and pairs with the North Jetty to create a protected navigation corridor into Noyo Harbor. It also features a southern breakwater structure designed to protect the adjacent shoreline from wave erosion and sediment intrusion. Built with similar materials and structural design to its northern counterpart, the South Jetty has not been flagged for immediate repair in recent USACE documentation. Still, it is vulnerable to high-energy wave conditions, especially during major storm events such as those observed in January 2023. While no formal repair projects are currently scheduled, the South Jetty is included in USACE condition surveys and will continue to be monitored as sea level rise and repeated storms increase erosion pressures on the structure.

Harbor Revetments

Stone revetments line portions of the inner harbor, protecting much of the critical infrastructure discussed in this section. These revetments are non-federal structures maintained by the Noyo Harbor District and play a critical role in reducing wave energy and preserving shoreline stability within the harbor basin. Damage from the 2023 winter storms highlighted the vulnerability of these features. In several locations, wave overtopping and debris flows compromised revetment integrity, particularly along the western and southern edges of the basin.

4.2.2 Harbor Operations

This category includes any infrastructure relevant to harbor operations. **Figure 16** identifies harbor operation assets included within this study.

- Two highly critical pieces of infrastructure – the Noyo Harbor District's Marine Rail and Cradle System and the U.S. Coast Guard's Station at Noyo River – are included in this category and discussed in greater detail in the sub-sections below.
- Critical infrastructure like the 3 Ton Hoist, High Dock, marina docks (A through K) support loading, unloading, vessel access, and mooring for the harbor's 256-berth marina, approximately 43 percent of which house commercial vessels. The High Dock is a fixed dock critical for offloading and service operations, and the hoist is the largest working one in the harbor. The docks, particularly C Dock,

serve most commercial fishing vessels. These assets are sensitive to sediment buildup, storm damage, and structural wear. Many were impacted during the 2023 storms, when sediment deposition disrupted marina depth, impacting channel navigability.

- Other buildings relevant to non-mission critical harbor operations in this category include the Noyo Harbor District Main office, the Noyo Center Marine Field Station, and the California Department of Fish and Wildlife office. The Noyo Harbor District Building houses administrative staff and the Harbormaster and serves as the operational hub for harbor management, permitting, and coordination with tenants and agencies. The Noyo Center Marine Field Station supports education, marine research, and public outreach, and contributes to broader goals around environmental awareness and sustainable harbor use. The California Department of Fish and Wildlife (CDFW) office plays a regulatory and enforcement role in fisheries management and marine resource protection.
- Recreational and residential assets such as the Dolphin Isle Marina and the Noyo River boat launch area are also included.
- Lastly, Noyo Harbor’s dredge containment cell is in this category and discussed in greater detail in the sub-sections below.

Figure 16. Noyo Harbor – Harbor Operations

(8.5 x 11)

Station Noyo River (U.S. Coast Guard)

Station Noyo River is under the Coast Guard's District 11 in the Pacific Area. The station's primary missions include search and rescue (SAR), law enforcement, and environmental protection. The station's area of responsibility spans approximately 120 miles of Northern California coastline, from Punta Gorda to Gualala, and extends up to 50 miles offshore. This region is known for challenging sea conditions, making the station's role critical for maritime safety. To effectively carry out its missions, Station Noyo River operates two 47-foot Motor Lifeboats (MLBs), which are designed for heavy weather and surf conditions. The station is staffed by a 30-person crew, including command staff and surf-qualified boat operators. **Figure 17** shows the U.S. Station Noyo River as well as its two MLBs.

Source: Google Earth, 2025

Figure 17.
Station Noyo River

Dredge Containment Cell

The dredge containment cell at Noyo Harbor is a critical piece of infrastructure used to temporarily store dredged sediment removed from the harbor's navigation channels and marina basin. This material is typically deposited wet and is allowed to dry before being transported to a designated upland landfill for permanent disposal. The cell is physically located on City of Fort Bragg property, but under a lease agreement, it is the full responsibility of the Noyo Harbor District to maintain, operate, and manage the transport of dried sediment—even though it is also used by the U.S. Army Corps of Engineers (USACE) for federal channel maintenance dredging. The containment cell is vital to harbor operations, as it enables both federal and local dredging to proceed. The USACE dredges the entrance and river channels for safe Coast Guard and vessel access, while the Harbor District dredges the marina area where commercial and recreational vessels berth. Without the availability of this drying and disposal area, dredging cannot legally or logistically continue, making it a single point of failure for harbor navigation and resilience.

The January 2023 winter storms severely impacted the dredge containment cell. High surf—generated by 30+ foot waves and elevated sea levels—combined with saturated soils from prior rainfall, resulted in wave overtopping and erosion of the ocean-facing western embankment. Approximately 1,368 cubic yards of structural fill were lost, dramatically altering the western face of the cell from its original trapezoidal profile to a steeper, unstable slope. This erosion placed the structural integrity of the wall at risk and raised concerns about the potential release of potentially contaminated dredge material onto Noyo Beach below. As a result of this damage, neither the USACE nor the Noyo Harbor District can currently proceed with dredging operations until the containment cell is restored. The structural failure and regulatory requirements for environmental compliance have led to deferred maintenance dredging originally scheduled for FY23 and pushed into FY24, pending containment cell repair and permitting clearance.

In terms of permitting and regulatory oversight, repair of the containment cell requires coordination and approval from multiple regulatory agencies, including:

- California Coastal Commission – Coastal Development Permit and California Environmental Quality Act (CEQA) lead
- U.S. Army Corps of Engineers – Section 404 permit (Clean Water Act)
- North Coast Regional Water Quality Control Board – Section 401 permit
- City of Fort Bragg – Encroachment permit, and coordination as the landowner
- Mendocino County Air Quality Management District – Air permit for dried material handling

Additional studies may be required, including hazardous materials characterization, particularly given the potential for contaminants in dredged sediment.

Noyo Marine Rail and Cradle System

The Noyo Marine Rail and Cradle System is one of the most critical pieces of harbor infrastructure located on the south side of the harbor near the High Dock. It is used to launch, haul, and service vessels, particularly commercial fishing boats that require drydock for maintenance or inspection. This asset allows for vessels to safely enter and exit the harbor and ensures vessels can berth safely. The marine rail system is designed to interact with tidal water levels and is expected to flood during normal operations. Its cradle system is lowered into the water to lift vessels and bring them ashore via a tracked incline. However, this asset is not invulnerable to storm or flooding impacts, particularly when sediment transport or high wave surges interact with components of the cradle system on land.

Dolphin Isle Marina

Though not operated by the Harbor District, Dolphin Isle Marina is a private marina that provides residential moorage, services for recreational boaters, and access to upland recreational vehicle (RV) and housing units. It is a key component of the harbor's community-oriented infrastructure. There are a few residential moorages in the marina that house both permanent and seasonal residents, including members of the working waterfront community.

4.2.3 Commercial Fishing

The commercial fishing businesses form the economic backbone of Noyo Harbor. Commercial fishing operations are centered around facilities like the South Winds Fishing Building, Noyo Fish Company, Bob Jones Ocean Fresh Seafood, and Grader Park. The first three businesses rely heavily on access to docks, cold storage, and vehicle access for transporting fish. Storm events, sedimentation, and dredging delays have impacted their operations in the past. The Community Sustainability Plan highlighted the need for upgraded flake ice facilities, improved hoists, and more fish buyers to sustain the working waterfront. **Figure 18** shows assets identified within the commercial fishing category.

4.2.4 Local Retail and Restaurant

Local retail and restaurant assets within Noyo Harbor play a key role in supporting both the commercial fishing industry and regional tourism. These include seafood markets, waterfront dining, tackle shops, and visitor-serving establishments concentrated primarily on the north side of the harbor. Many businesses operate in close proximity to shoreline and harbor infrastructure, making them sensitive to tidal and storm flooding. While no individual businesses were singled out in the damage inventory from the 2023 storms, their dependence on reliable parking, safe pedestrian and vehicle access does make them vulnerable to storm-related impacts and sea level rise. Stakeholder input in the Community Sustainability Plan notes inadequate parking and sidewalk access are common barriers for visitors, directly affecting local businesses. **Figure 19** displays local retail and restaurant assets within the study area.

4.2.5 Residential

The Tiny Homes and RV Parks 1 and 2 provide low-density housing adjacent to harbor operations. These sites are susceptible to access constraints, flooding, and infrastructure disruption. While not directly damaged in recent storms, their proximity to vulnerable roadways still places them at indirect risk. In the future, flooding may further affect habitability and access if roads like North or South Harbor Drive are flooded to the extent that they are no longer navigable during high tide or storm events. **Figure 20** identifies residential assets within the study area.

4.2.6 Roads and Access

Several key roads and entrances, including North Harbor Drive (East and West Entrances), Coast Road, South Harbor Drive, and Basin Street, are included in the study area. These roads serve as essential access for vehicle, equipment, and emergency transportation to and from Noyo Harbor. During the 2022–2023 storm events, several roads experienced overtopping, flooding, or obstruction from debris flows; however, the roads were still noted to be navigable (per April 2025 discussion with the Harbormaster). The Community Sustainability Plan emphasized the need for secondary emergency access, especially for North Harbor, and cited access issues as a limiting factor for both safety and operational efficiency.

The Georgia-Pacific Haul Road is a scenic pathway. A portion of the road, further inland, near the channel is flood-prone. **Figure 21** shows roads and identified access points within the study area.

Figure 18. Noyo Harbor - Commercial Fishing

(8.5 x 11)

Figure 19. Noyo Harbor - Local Retail and Restaurant

(8.5 x 11)

Figure 20. Noyo Harbor - Residential

(8.5 x 11)

Figure 21. Noyo Harbor - Transportation

(8.5x11)

4.2.7 Parking

Harbor Parking and Noyo Beach Parking are public lots serving marina operations, beachgoers, and recreational users. The main parking assets include six Harbor parking lots and the South Harbor Parking lot. These facilities vary in elevation, use, and proximity to the river or shoreline. Some serve general commercial access, while others provide access to the boat launch, harbor offices, or fish processing areas. **Figure 22** shows parking lots within the study area.

4.2.8 Buildings (Generic)

A number of miscellaneous buildings were not highlighted in this study, and information on them was not available in existing documents or the public realm. These buildings have been marked as generic and are highlighted in black. Flood depths are still provided for each of these buildings in the tables in **Appendix C**, *Asset Flood Exposure Results* and the geospatial files provided as supplementals to this report.

4.3 Key Operational Goals of Noyo Harbor and Marina

Noyo Harbor's operational resilience is structured around six key functional goals that are essential to its day-to-day and emergency operations. These goals are summarized in **Table 5** below, with the assets supporting each goal noted.

TABLE 5. KEY OPERATIONAL GOALS OF NOYO HARBOR AND MARINA

Operational Goal	Description	Supporting Assets
1	U.S. Coast Guard must be able to operate all station and motor vehicles.	Noyo River U.S. Coast Guard Station
2	Vessels must be able to safely enter/exit the harbor.	Noyo Marine Rail and Cradle System, Shoreline protection infrastructure (jetties and revetment)
3	Vessels must be able to berth and load/unload fishing cargo.	3 Ton Hoist, High Dock, C Dock
4	Commercial fisheries must be operational to store fishing cargo and conduct transactions.	South Winds Fishing Building, Noyo Fish Company, Bob Jones Ocean Fresh Seafood, storage areas, access roads (North and South Harbor Drive)
5	Residences must be safe to house their occupants.	Tiny Homes and RV Parks, Dolphin Isle Marina
6	Local retail (shops, restaurants, tourist attractions) must remain open and recreational fishing must be safe.	Docks A–K, Noyo River Boat Launch, Basin St, Noyo Beach and Beach Parking, Harbor Parking, Bait and Tackle Fishing Center Store, Zephyr Seafoods, Sea Pal Cove Fish & Chips, Kayak Noyo, Pacific Rim Seafood, The Wharf – Fort Bragg, Smoke on the Water BBQ, Sportsman's Park Gallery and Gifts, Nautical Decor Home Goods Store, Casa Del Sol Seafood Restaurant, Sacred Woods Furniture Store, other miscellaneous shops
7	Business continuity for all non-emergency harbor operations (not already included in goals 1-6)	Noyo Harbor District, Grader Park, Dredge Containment Cell, Noyo Center Marine Field Station, California Department of Fish and Wildlife

SOURCE: Derived from discussion with Noyo Harbor District

Figure 22. Noyo Harbor - Parking

(8.5 x 11)

5. ANALYSIS OF HAZARD EXPOSURE BY SCENARIO

This vulnerability and risk assessment is based on the exposure of identified assets to projected future coastal flooding, erosion, and tsunami hazards. To assess asset exposure to hazards, the assets in the different categories discussed in the prior section were intersected in Geographical Information System (GIS) software with each potential future hazard zone. Where an asset intersects a hazard zone, it is identified as exposed. If the flood exposure is expected to impact the asset's function, the asset is identified as vulnerable. If the loss of the asset's function is of consequence to the harbor's operational goals, the asset is identified as having high risk and is highlighted in the subsequent sections.

This type of analysis does not precisely assess the cause of failure or an established threshold for each asset type but is an appropriate technique for a planning-level vulnerability analysis. This analysis is meant to inform the order of magnitude of potential impacts if no future interventions are put in place, also known as a "No Action" alternative. This "No Action" baseline can then inform the development of a resilience strategy and related Local Coastal Program policies. This vulnerability analysis should not be used for asset-specific programing or engineering without additional study and possible refinements.

Each hazard was assessed for multiple hazard impacts from tidal inundation, storm surge, and coastal erosion at four timelines: present-day, near-, intermediate-, and long-term, which correspond to existing conditions, at 0, 1, 3, and 6 feet of sea level rise. As discussed in the SLR Scenarios Memo (Appendix B), these selected levels of SLR encompass multiple future climate projections and timelines: for example, one foot of SLR represents the near-term (2050) projections for Intermediate-high and High scenarios; three feet of SLR covers projections between 2070 and 2100 for the High and Intermediate scenarios; and six feet of SLR covers projections between 2100 and 2150 for the High and Intermediate scenarios. The Intermediate, Intermediate-High, and High scenarios are defined in the California Ocean Protection Council's 2024 Sea Level Rise Guidance and the selection process of these scenarios for this project is discussed further in Appendix B.

The results of the exposure analysis are summarized in this section, and a more detailed vulnerability and risk discussion is presented in the next section, along with implications for resilience and adaptation strategy building. The complete exposure tables and charts including exposure results for existing conditions, and with 1, 3, and 6 feet of sea level rise, are provided Appendix C.

5.1 Tidal Flooding

Tidal flooding is a recurring condition, particularly when compounded by high wave conditions. These conditions have historically disrupted harbor operations and demonstrate the vulnerability of dock infrastructure to flooding and sedimentation. In January 2023, wave heights in Noyo Harbor exceeded 33 feet and still water levels reached over 8.5 feet NAVD, causing overtopping, sediment deposition in the marina, and damage to several assets accounted for in this study. Tidal flooding is quasi-permanent, as it is expected to occur multiple times per year. If high tide inundation at a particular asset or cluster of assets is significant enough for the asset to experience some damage or loss of function, any consequences of that damage (operational, financial, etc.) will flag an asset to be at high risk because of the high likelihood of occurrence of this type of flooding.

This section gives a scenario-by-scenario overview of exposed assets and harbor operational goals impacted in all tidal flooding scenarios assessed in this study. For detailed assessment of the exposure, vulnerability, and risk of each asset, please see the next chapter of this report.

5.1.1 Existing Condition

Figure 23 shows the harbor assets impacted by tidal flooding in the existing condition scenario, with assets colored by the first scenario that causes any inundation. At present, tidal flooding is expected to primarily inundate Noyo Harbor's docks.

Assets and Operational Goals Impacted

Noyo Harbor's docks and hoists are marina structures designed for water; however, if the docks impacted are compromised by excess flooding and sedimentation, they can inhibit both recreational and commercial vessels from being able to berth and load/unload fishing cargo. An asset-by-asset list is provided in **Table 6** below, including the operational goal(s) impacted and the first exposure of this asset to flooding in this scenario. Scenario names are abbreviated. The full table for all scenarios is provided in Appendix C.

TABLE 6. ASSETS AND OPERATIONAL GOALS IMPACTED DURING TIDAL FLOODING (PRESENT-DAY EXISTING CONDITIONS)

Asset Name	Functions Served	OG Impacted	First Exposure
3 Ton Hoist	Harbor Operations	3	Tidal (Present-day)
High Dock	Harbor Operations	3	Tidal (Present-day)
A Dock	Harbor Operations	6	Tidal (Present-day)
B Dock	Harbor Operations	6	Tidal (Present-day)
C Dock	Harbor Operations	3	Tidal (Present-day)
D Dock	Harbor Operations	6	Tidal (Present-day)
E Dock	Harbor Operations	6	Tidal (Present-day)
F Dock	Harbor Operations	6	Tidal (Present-day)
G Dock	Harbor Operations	6	Tidal (Present-day)
H Dock	Harbor Operations	6	Tidal (Present-day)
K Dock	Harbor Operations	6	Tidal (Present-day)

Figure 23. Noyo Harbor Assets Impacted in Tidal Scenario 1 – King Tide (Existing Conditions)

(8.5x11)

5.1.2 Future Conditions – Tidal Flooding with Sea Level Rise

Sea level rise can exacerbate current conditions. Assets that already experience flooding under present-day tidal conditions may see greater flood depths and more frequent inundation in future sea level rise scenarios, potentially increasing the impact to their functionality. At the same time, assets that are presently unaffected by tidal events under current conditions may begin to experience tidal flooding as baseline water levels rise. It is also possible that some assets that experience tidal flooding at high flood depths and great frequency today may become permanently inundated in the future.

Tidal Flooding in a Future with 1 foot Sea Level Rise

Even minimal sea level rise can increase the impacts of tidal flooding. At Noyo Harbor, while sea level rise of one foot does cause some additional flooding, no further key assets in the Harbor are inundated compared to tidal flooding in present day's existing conditions. Parts of the northernmost tip of Noyo Beach may see low-levels of tidal inundation as sea levels rise; however, majority of the beach remains available in the tidal flood scenarios up to 3 feet of sea level rise.

Tidal Flooding in a Future with 3 feet Sea Level Rise

High tide flooding on top of three feet of SLR can impact a number of assets that may not have previously been impacted by tidal flooding. A number of the assets impacted in this scenario, though not reported as inundated in past storms, are located in low-lying areas and were previously flagged as vulnerable. The 2023 storms showed how elevated water levels and surges can threaten Noyo Harbor's infrastructure beyond the low-lying docks. The damage report also showed that sedimentation and erosion, especially at shoreline protection structures like the Harbor Revetment, increase significantly with higher mean water levels. **Figure 24** below shows the harbor assets impacted by tidal flooding in this as well as previous scenario(s), with assets colored by the first scenario of impact.

Assets and Operational Goals Impacted

In addition to the docks and hoists inundated during tidal flooding in the present-day and at 1 feet of sea level rise, this scenario additionally impacts the Noyo Marine Rail and Cradle System, Makela Boat Works Marine Railway, Noyo Center Marine Field Station, and Bob Jones Ocean Fresh Seafood. The Noyo Marine Rail and Cradle System are critical to safe passage of vessels in and out of the harbor, which supports Operational Goal 2 of Noyo Harbor. Bob Jones supports Operational Goal 3, which is focused on ensuring commercial fish buyers and sellers can reliably store, process, and sell their cargo. These facilities are closely tied to dock access and are essential for maintaining economic continuity across the harbor's working waterfront. An asset-by-asset list is provided in **Table 7** below, including the operational goal(s) impacted and the first exposure of this asset to flooding in this scenario as well as any previous scenarios. Scenario names are abbreviated. The full table for all scenarios is provided in Appendix C.

TABLE 7. ASSETS AND OPERATIONAL GOALS IMPACTED DURING TIDAL FLOODING +3FT SLR

Asset Name	Functions Served	OG Impacted	First Exposure
Noyo Marine Rail and Cradle System	Harbor Operations	2	Tidal (3ft SLR)
Makela Boat Works Marine Railway	Harbor Operations		Tidal (3ft SLR)
Noyo Center Marine Field Station	Harbor Operations	7	Tidal (3ft SLR)
Bob Jones Ocean Fresh Seafood	Commercial Fishing	4	Tidal (3ft SLR)

Figure 24. Noyo Harbor Assets Impacted in Tidal Scenario 3 – King Tide (+3ft SLR)

(8.5x11)

Tidal Flooding in a Future with 6 feet Sea Level Rise

This sea level rise scenario expands tidal flood impacts to include more local retail and restaurant buildings as well as harbor parking. The Noyo Fish Company and the South Harbor Storage Area are also inundated in this scenario. However, as discussed further in Chapter 6, the flood depths these assets experience are shallow, below 1 foot in most cases. Noyo Beach also begins to see flooding across its entire shoreline in this scenario. **Figure 25** below shows the harbor assets impacted by tidal flooding in this as well as previous scenario(s), with assets colored by the first scenario of impact.

Table 8 below provides a list of these assets as well as the operational goals impacted if the asset in question is damaged.

TABLE 8. ASSETS AND OPERATIONAL GOALS ADDITIONALLY IMPACTED BY TIDAL FLOODING +6FT SLR

Asset Name	Functions Served	OG Impacted	First Exposure
Makela Boat Works	Harbor Operations		Tidal (6ft SLR)
Noyo Fish Company	Commercial Fishing	4	Tidal (6ft SLR)
Bait and Tackle Fishing Center Store	Local Retail and Restaurant	6	Tidal (6ft SLR)
Zephyr Seafoods	Local Retail and Restaurant	6	Tidal (6ft SLR)
Sea Pal Cove Fish & Chips	Local Retail and Restaurant	6	Tidal (6ft SLR)
Kayak Noyo	Local Retail and Restaurant	6	Tidal (6ft SLR)
The Wharf - Fort Bragg	Local Retail and Restaurant	6	Tidal (6ft SLR)
Harbor Parking 3	Parking	6	Tidal (6ft SLR)
Harbor Parking 4	Parking	6	Tidal (6ft SLR)
Harbor Parking 5	Parking	6	Tidal (6ft SLR)
Harbor Parking 6	Parking	6	Tidal (6ft SLR)
S Harbor Storage Area	Harbor Operations	4	Tidal (6ft SLR)
Noyo Beach	Beach	6	Tidal (6ft SLR)

Figure 25. Noyo Harbor Assets Impacted in Tidal Scenario 4 – King Tide (+6ft SLR)

(8.5x11)

5.2 Storm Flooding from the 100-Year Event

5.2.1 Storm Flooding from the 100-Year Event (Existing Conditions)

When extreme rainfall, ocean surges, and wave energy caused widespread damage throughout Noyo Harbor, a 100-year storm event has widespread impact. In 2023, the harbor marina facilities were submerged, roads overtopped, and debris carried throughout key operational areas. These events impacted nearly every functional category, from vessel berthing to harbor access to the residences in the marina. The dredge containment cell, already damaged in 2023, faces a high risk of failure under this storm scenario. **Figure 26** below shows the harbor assets impacted by the 100-year storm flooding in this scenario, with assets colored by the first scenario that causes any inundation.

An asset-by-asset list is provided in **Table 9** below, including the first four operational goal(s) impacted and the first exposure of this asset to flooding in this scenario. Scenario names are abbreviated. The full table for all scenarios is provided in the Asset Flood Exposure Results Appendix. The assets that impact goals 6 and 7 are also shown in this table.

TABLE 9. ASSETS AND OPERATIONAL GOALS IMPACTED DURING 100-YEAR STORM FLOODING (PRESENT-DAY EXISTING CONDITIONS)

Asset Name	Functions Served	OG Impacted	First Exposure
US Coast Guard Station Noyo River	Harbor Operations	1	100-year (Present-day)
Noyo Marine Rail and Cradle System	Harbor Operations	2	100-year (Present-day)
3 Ton Hoist	Harbor Operations	3	100-year (Present-day)
High Dock	Harbor Operations	3	100-year (Present-day)
C Dock	Harbor Operations	3	100-year (Present-day)
Noyo Fish Company	Commercial Fishing	4	100-year (Present-day)
Bob Jones Ocean Fresh Seafood	Commercial Fishing	4	100-year (Present-day)
Storage Area 1	Harbor Operations	4	100-year (Present-day)
N Harbor Dr	Transportation	4	100-year (Present-day)
N Harbor Dr W Entrance	Transportation	4	100-year (Present-day)
S Harbor Storage Area	Harbor Operations	4	100-year (Present-day)
Coast Rd	Transportation	4	100-year (Present-day)
S Harbor Dr	Transportation	4	100-year (Present-day)
Dolphin Isle Marina	Harbor Operations	5	100-year (Present-day)

Figure 26. Noyo Harbor Assets Impacted in Storm Scenario 1 – 100-year Event (Existing Conditions)

(8.5x11)

5.2.2 Future Conditions - Storm Flooding from the 100-Year Event

Storm Flooding from the 100-Year Event in a Future with 1 Foot Sea Level Rise

With 1 foot of sea level rise, the extent of storm-induced flooding expands slightly. Key asset impacts include new retail locations and parking facilities, along with the South Winds commercial fish processing building (noted by the Harbormaster as one of the most critical buildings for the commercial fishing industry in Noyo Harbor). **Figure 27** below shows the harbor assets impacted by storm flooding in this as well as previous scenario(s), with assets colored by the first scenario of impact.

Two additional local retail shops, harbor parking, and the South Winds Commercial fishing building are additionally impacted in this scenario. North Harbor Drive would also begin to see some levels of inundation that may impact harbor access.

Storm Flooding from the 100-Year Event in a Future with 3 Feet Sea Level Rise

This scenario reflects a major expansion of asset exposure due to combined storm surge and sea level rise. Impacts extend further inland to residential areas, additional retail and restaurant sites, and more key roadways providing access to the marina. **Figure 28** below shows the harbor assets impacted by storm flooding in this as well as previous scenario(s), with assets colored by the first scenario of impact.

It is notable that all assets catalogued in this study are inundated in this scenario, including access roads and entry points, as most of the harbor marina is inundated, as shown and discussed in Section 3. As discussed in the conclusions of this report, the potential for widespread inundation during high-intensity storm events in an intermediate- and long-term future scenario makes the case for investment in both local and harbor-wide resilience strategies.

Storm Flooding from the 100-Year Event in a Future with 6 Feet Sea Level Rise

This extreme scenario represents a high-end future projection for sea level rise layered onto a 100-year storm. In this scenario, most functions of the harbor marina would experience widespread inundation. Additional impacts to the residential areas in the marina and in Dolphin Isle signal full loss of residential functionality for harbor-adjacent housing. The scale of flooding would impact almost all the assets noted in this study and challenge critical harbor operations, economic continuity, and local residential functions. **Figure 29** below shows the harbor assets impacted by storm flooding in this as well as previous scenario(s), with assets colored by the first scenario of impact.

Similar to the previous scenario, all assets catalogued in this study are inundated in this scenario, including access roads and entry points, as most of the harbor marina would be inundated, as shown and discussed in Section 3. Chapter 6 will delve further into the differences in depth of inundation between the scenarios by asset, potential impacts, and implications for resilience strategy planning.

Figure 27. Noyo Harbor Assets Impacted in Storm Scenario 2 – 100-year Event (+1ft SLR)

(8.5x11)

Figure 28. Noyo Harbor Assets Impacted in Storm Scenario 3 – 100-year Event (+3ft SLR)

(8.5x11)

Figure 29. Noyo Harbor Assets Impacted in Storm Scenario 4 – 100-year Event (+6ft SLR)

(8.5x11)

6. NOYO HARBOR ASSET-SPECIFIC VULNERABILITY AND RISK ASSESSMENT

This section presents the results of the asset-by-asset vulnerability and risk assessment for Noyo Harbor, using flood depth data across present-day, 1-foot, 3-feet, and 6-feet sea level rise (SLR) scenarios, under both tidal inundation and 100-year storm conditions. The purpose of this section is to evaluate how individual assets perform under various flooding scenarios, discuss their vulnerabilities, and understand how those vulnerabilities could affect the Harbor District's ability to meet its operational goals.

Assets were grouped into functional categories—such as harbor operations, commercial fishing, administrative buildings, transportation, parking, and retail/residential services—and assessed for both first exposure to flooding and projected flood depths under each scenario. These assessments were then connected to the seven operational goals of the harbor to identify potential consequences of asset-level failure on broader harbor functionality.

This section demonstrates that flood risk at Noyo Harbor is not isolated to one geographic zone or asset category, but often clustered geographically and functionally, emphasizing the need for both large-scale resilience strategies (e.g., harbor-wide elevation or edge protection) and targeted asset-level interventions (e.g., floodproofing or retrofitting of specific facilities). These findings serve as the foundation for the resilience strategies proposed in subsequent phases of this project.

6.1 Shoreline Protection Structures

As sea levels rise and high intensity storms continue to occur (possibly more frequently), harbor revetments are identified to be at risk of increased erosion and flood impacts. Under future scenarios with 3 feet and 6 feet of sea level rise, the flood analysis conducted in this study shows that these structures will be increasingly exposed to deeper and longer-duration tidal and storm-driven flooding. Without adaptation, continued erosion and infrastructure loss are likely. With the exception of the North Jetty (already identified by the USACE and the Noyo Harbor District for improvements), while the South Jetty and the harbor revetments are not currently part of any federal repair project, they are flagged as a priority for local adaptation planning and may require reinforcement or additional off-shore structures to be built out (e.g., off-shore breakwater) in the coming decades as part of any large-scale resilience strategy for the harbor.

6.2 Dredge Containment Cell

Under future sea level rise scenarios, the western embankment of the containment cell will likely experience more frequent direct interaction with high tides and storm surge, compounding erosion pressures. The containment cell structure is at-risk under both tidal flooding and 100-year storm conditions, and particularly for 3-foot and 6-foot rise scenarios. Should the containment cell become unusable on a recurring basis at some point in the future, which is likely given the results of this study, alternative storage strategies will need to be pursued, such as the development of a new upland drying site or offsite hauling of dredge material to further containment locations, which could be an part of a long-term resilience and revitalization strategy for Noyo Harbor.

6.3 Noyo River U.S. Coast Guard Station

The Noyo River U.S. Coast Guard Station is recognized as a critical facility (Operational Goal 1) whose uninterrupted function is essential for Noyo Harbor and the surrounding region. While the station does not experience flooding under current or projected tidal conditions in this study, it is vulnerable to storm-driven flooding, with risk intensifying under future sea level rise scenarios. **Table 10** shows average flood depths (in feet) estimated to occur at the building under the 100-year storm event:

TABLE 10. AVERAGE FLOOD DEPTHS ACROSS NOYO RIVER STATION DURING 100-YEAR STORM SCENARIOS

100-year Storm Scenario	Flood Depth (ft)
Present-Day	1
+1ft Sea Level Rise	2
+3ft Sea Level Rise	4
+6ft Sea Level Rise	7

This progressive increase in flood exposure puts the station's ability to safely deploy vessels and maintain operational readiness at significant risk. It is possible that a present-day storm could incur flooding at the building which exceeds 1 foot—enough to impact access, electrical systems, or lower-elevation facilities. In an extreme future scenario, considering a 100-year storm with 6 feet of sea level rise, the facility is subject to deeper inundation levels, which can take longer to recede, impacting building interiors, communications infrastructure, and by proxy, the station's emergency response capabilities.

The station supports both Operational Goal 1 (U.S. Coast Guard operations) and Operational Goal 2 (safe vessel entry/exit from the harbor). It is central to ensuring harbor access remains open for emergency responders and maritime traffic during high-impact events. Given its high risk, local resilience upgrades — such as structural floodproofing, emergency egress enhancements, and elevation planning— may need to be considered in conjunction with any harbor-wide resilience strategies to ensure that this Tier 1 critical asset remains functional across future conditions.

6.4 Dolphin Isle Marina

While Dolphin Isle does not experience flooding under current or projected tidal conditions, portions of the Dolphin Isle Marina are vulnerable to coastal storm-driven flooding, even under present-day conditions. **Table 11** shows the approximate range of flood depths across the marina under the 100-year storm scenario:

TABLE 11. FLOOD DEPTHS ACROSS DOLPHIN ISLE MARINA DURING 100-YEAR STORM SCENARIOS

100-Year Storm Scenario	Flood Depth (ft)
Present-Day	4 - 7
+1ft Sea Level Rise	5 - 8
+3ft Sea Level Rise	7 - 10
+6ft Sea Level Rise	- 13

Even in today's storm conditions, the marina (particularly the northeastern portion) is susceptible to flooding. Sea level rise is likely to significantly increase flooding across the entirety of Dolphin Isle. Dolphin Isle Marina's flood exposure has implications for both the recreational and residential functions of the harbor, with 5 live-aboard vessels and 15 mobile homes. Planning for a more adaptable and resilient Dolphin Isle will be critical to ensuring the continued use of this marina.

6.5 Noyo Marine Rail and Cradle System

The Noyo Marine Rail and Cradle System allows for vessels to safely enter and exit the harbor (2nd Operational Goal) and ensures vessels can berth safely (3rd Operational Goal). Although the cradle system is meant to operate in water, high flood depths could incur damage or frequent clearing and maintenance from sediment accumulation. Additional damages may include potential erosion at the toe of the slope, electric or hydraulic system failure during flood surges, and access limitations during high water events, which may delay service and vessel retrieval. As shown in **Table 12,** while tidal flooding poses minimal impact under current and near-term scenarios, storm conditions result in substantial inundation at the rail and cradle system —exceeding 7 feet today and increasing up to 13 feet with 6 feet of sea level rise. This magnitude of flood depths could impact electrical systems, machinery, access platforms, and other pieces of equipment around the cradle rails.

TABLE 12. AVERAGE FLOOD DEPTHS ACROSS NOYO MARINE RAIL AND CRADLE SYSTEM DURING ALL SCENARIOS MODELLED

Scenario	Flood Depth (ft)
Tidal - Present-Day	0
+1ft Sea Level Rise	0
+3ft Sea Level Rise	1
+6ft Sea Level Rise	4
Storm - Present-Day	7
+1ft Sea Level Rise	8
+3ft Sea Level Rise	10
+6ft Sea Level Rise	13

It is important to note that the Noyo Marine Rail and Cradle System is resilient but not completely robust to flooding. Due to its essential functional role in harbor operations (right now, it is the only rail and cradle system owned by the Noyo Harbor district), future resilience strategies will need to consider how to ensure the longevity of this cradle system to prolonged flood exposure from high intensity storm events.

6.6 Noyo Harbor District – Administrative Buildings

Three key administrative buildings – the Noyo Harbor District Main office, the Noyo Center Marine Field Station, and the California Department of Fish and Wildlife office – currently remain outside of the tidal floodplain and for the most part do so as well in the future scenarios studied. Therefore, it is unlikely that daily high-water levels and king tides will not interfere with regular operations at these facilities in the near term. However, all three facilities are exposed and likely vulnerable and at risk under the present and future storm scenarios studied. **Table 13** shows average flood depths (in feet) estimated to occur at the building under the 100-year storm event:

TABLE 13. AVERAGE FLOOD DEPTHS ACROSS NOYO HARBOR DISTRICT ADMINISTRATIVE BUILDINGS DURING100-YEAR STORM SCENARIOS

100-Year Storm Flood Depth (ft)	Noyo Harbor District	Noyo Center Marine Field Station	CA Dept. of Fish & Wildlife
Present-Day	3	4	0
+1ft Sea Level Rise	4	5	1
+3ft Sea Level Rise	6	7	3
+6ft Sea Level Rise	9	10	6

Buildings are typically vulnerable to a few feet of flooding and flooding at the Noyo Harbor District main building could impair emergency coordination basic operational continuity. The Noyo Center Marine Field Station is the most exposed, and these levels of inundation are likely to affect any facility access, research activities, and public programming the station provides. The more inland CDFW Office is slightly less exposed overall but still sees some flooding in extreme storm events under the future sea level rise scenarios studied.

Though not first-line emergency responders, these buildings and the departments they house play roles in permitting, compliance, coordination, education, and research and are therefore critical to harbor resilience and function and will need to continue to function within Noyo Harbor. While building-specific flood adaptation measures can be taken, the flood risk posed to these buildings (and others) point to the need for a harbor-wide resilience strategy that would increase the resilience of Noyo Harbor as a whole.

6.7 Commercial Fish Processing Facilities

Together, the South Winds Fishing Building, Bob Jones Ocean Fresh Seafood, and Noyo Fish Company support Operational Goal 3, which is focused on ensuring commercial fish buyers and sellers can reliably store, process, and sell their cargo. These facilities are closely tied to dock access and are essential for maintaining economic continuity across the harbor's working waterfront.

For the present-day and near-term future scenarios, tidal flooding and the risk of permanent inundation to these facilities is minimal. However, Bob Jones and Noyo Fish Co., both facilities on the southside of the North Harbor, begin to see significant flood depths at their buildings in the third scenario (tidal flooding + 6 feet of sea level rise). The South Winds Fishing Building remains above tidal flood levels in all scenarios, as shown in **Table 14** below.

TABLE 14. AVERAGE FLOOD DEPTHS ACROSS COMMERCIAL FISH PROCESSING FACILITIES DURING TIDAL SCENARIOS

Tidal Flood Depth (ft)	South Winds Fishing Bldg	Bob Jones Ocean Fresh	Noyo Fish Company
Present-Day	0	0	0
+1ft Sea Level Rise	0	0	0
+3ft Sea Level Rise	0	1	0
+6ft Sea Level Rise	0	4	2

At present, both of the North Harbor commercial fisheries are expected to see inundation from an extreme storm event, such as the 100-year storm modelled in this study. All commercial fisheries are expected to see some flood inundation from an extreme storm event in all future sea level rise scenarios modelled, as shown in **Table 15** below.

TABLE 15. AVERAGE FLOOD DEPTHS ACROSS COMMERCIAL FISH PROCESSING FACILITIES DURING 100-YEAR STORM SCENARIOS

100-Year Storm Flood Depth (ft)	South Winds Fishing Bldg	Bob Jones Ocean Fresh	Noyo Fish Company
Present-Day	0	5	2
+1ft Sea Level Rise	0	6	3
+3ft Sea Level Rise	1	8	5
+6ft Sea Level Rise	4	11	8

While South Winds is relatively protected from both tidal and near-term storm flooding, the Noyo harbormaster noted this area is particularly vulnerable to increased debris flow in storm events. The fisheries in the north harbor are both exposed to storm risk today and tidal impacts or more "permanent inundation" emerging over the longer term.

As these facilities make up the backbone of Noyo Harbor's commercial fishing industry, any long-term resilience strategy should consider harbor-wide as well as facility-specific measures to ensure their operational continuity, such as relocation further inland, elevation or floodproofing of any electrical and refrigeration systems, and emergency continuity planning for short-term shutdowns.

6.8 Local Retail and Restaurants

Storm surge represents the most pressing hazard to this asset group. A number of buildings already face storm-driven flooding under present-day 100-year conditions. As shown in **Table 16** below, these impacts deepen substantially under the SLR scenarios, with some structures at the waterfront exposed to 8–9 feet of floodwaters in the long-term (6 feet of SLR) scenario. Businesses located at slightly higher elevations or farther inland are affected later, typically after 3 feet of sea level rise.

TABLE 16. AVERAGE FLOOD DEPTHS ACROSS NOYO HARBOR DISTRICT LOCAL RETAIL AND RESTAURANTS DURING 100-YEAR STORM SCENARIOS

100-year Storm Flood Depth (ft)	Sea Pal Cove	The Wharf	Kayak Noyo	Bait & Tackle	Zephyr Seafoods	Casa Del Sol	Princess Seafood	Other Shops
Present-Day	2	4	2	1	2	0	1	0–2
+1ft Sea Level Rise	3	4	3	2	3	1	1	1–3
+3ft Sea Level Rise	5	5	5	4	5	3	3	2–4
+6ft Sea Level Rise	8	8	8	7	8	6	6	4–9

While not considered critical infrastructure, these businesses are still a vital part of Noyo Harbor's working waterfront and important for commercial continuity and the maintenance of Noyo Harbor's unique identity and vibrancy. While building-specific flood adaptation measures can be taken, the flood risk posed to these buildings (and others) point to the need for a harbor-wide resilience strategy that would increase the resilience of Noyo Harbor as a whole.

6.9 Residential Areas – Mobile Homes RV Parks

These sites provide low-density housing for seasonal and long-term residents, including members of the harbor's working community. Their continued function supports the fifth operational goal for the harbor, ensuring residences remain safe and habitable for their occupants.

Both residential facilities are elevated enough to avoid tidal flooding under all scenarios, including up to 6 feet of sea level rise. This indicates that daily high tide and king tide conditions do not pose a direct threat to housing in the short-term or intermediate future. Under storm conditions, both residential areas remain unexposed to flood inundation through the medium-term future scenario characterized by 3 feet of sea level rise. However, by 6 feet of rise, flood depths of 2–3 feet begin to impact these sites (and much of the rest of Noyo Harbor). Flood depths for the present and future 100-year storm are shown in **Table 17** below.

TABLE 17. AVERAGE FLOOD DEPTHS ACROSS THE TINY HOMES & RV PARK AREA DURING 100-YEAR STORM SCENARIOS

100-year Storm Scenario	Tiny Homes & RV Park
Present-Day	0
+1ft Sea Level Rise	0
+3ft Sea Level Rise	0
+6ft Sea Level Rise	1 - 3

These flood depths are more limited, and while mobile homes are vulnerable to low levels of flood inundation, it is possible that localized adaptation measures could be taken to limit the flood vulnerability and consequence of inundation at these mobile home parks, such as elevating units, improving drainage, or fortifying utility connections. However, relocation of these parks may remain a long-term consideration, if these sites are not identified as priority assets in future planning efforts. Future land use assessments may revisit whether continued residential use of these parcels is consistent with the resilient vision for Noyo Harbor.

6.10 Roads and Access

Roadways such as North and South Harbor Drives, and their east and west entrances, support everything from commercial fishing and loading operations to visitor access, emergency response, and harbor administration. These corridors indirectly support almost every operational goal of Noyo Harbor, ensuring vessels can berth and unload, buyers and sellers can access businesses, and residents and visitors can reach recreational and service-oriented facilities. The harbor's topography, defined by steep coastal slopes and a narrow river valley, constrains access to all facilities, shops, and residences to a few low-lying corridors. As a result, these routes are especially at risk from flooding, as any inundation rendering the road unnavigable can compromise connectivity.

Under all tidal flooding scenarios, including up to 6 feet of sea level rise, none of the Harbor Drive segments or entrances are exposed to tidal inundation. However, as **Table 18** below shows, 100-year storm conditions already affect these roads today, and impacts increase substantially in future scenarios.

TABLE 18. AVERAGE FLOOD DEPTHS ACROSS NOYO HARBOR DISTRICT KEY ROADS AND ACCESS POINTS DURING 100-YEAR STORM SCENARIOS

100-year Storm Flood Depth (ft)	N Harbor Dr E Entrance	N Harbor Dr	N Harbor Dr W Entrance	S Harbor Dr
Present-Day	0	1	0	2
+1ft Sea Level Rise	0	1	1	3
+3ft Sea Level Rise	0	3	3	7
+6ft Sea Level Rise	0	6	6	7

Roads are generally considered unsafe to navigate at flood depths of just 6 inches, particularly for small vehicles. While heavy trucks and commercial-grade vehicles may tolerate slightly deeper water, even those face traction loss, stalling, and safety hazards at depths of 1 foot or more. By the time flood depths reach a few feet, all vehicles—regardless of size—are unlikely to be able to operate safely.

These results underscore the increasing exposure of North and South Harbor Drives, both of which serve critical functions for emergency response and daily harbor access. By 3 feet of sea level rise, multiple road segments experience several feet of flooding, which would render them completely impassable for all vehicle types.

Maintaining road-based access is vital for the harbor’s operational continuity and public safety. Given the increasing flood risk of these access routes to maintaining almost all harbor functions, it is recommended that transportation infrastructure be included in any resilience strategy for the harbor.

6.11 Parking

Parking areas throughout Noyo Harbor support access for commercial operations, residential, tourism and administrative use. These assets are particularly important for achieving Operational Goal 6, which emphasizes maintaining visitor-serving infrastructure such as recreational access points, restaurants, and shops. They also play a secondary role in supporting Operational Goals 2 and 3 by providing access to vessel berths and supporting infrastructure.

As shown in **Table 19**, all parking assets remain unexposed to tidal flooding under existing conditions and up to 3 feet of sea level rise. By 6 feet of sea level rise, Harbor Parking Lots 4–6 begin to experience minor tidal inundation (1 foot or less). However, several of these lots begin to flood under existing 100-year storm conditions, with flood depths increasing significantly by 6 feet of sea level rise. Harbor Parking 3–6 and South Harbor Parking experience 4 to 7 feet of flooding in some future storm scenarios, which would render them inaccessible.

TABLE 19. AVERAGE FLOOD DEPTHS ACROSS NOYO HARBOR DISTRICT PARKING LOCATIONS DURING 100-YEAR STORM SCENARIOS

100-year Storm Flood Depth (ft)	Harbor P1	Harbor P2	Harbor P3	Harbor P4	Harbor P5	Harbor P6	S Harbor Parking
Present-Day	0	0	1	1	1	1	2
+1ft Sea Level Rise	0	0	2	2	2	2	2
+3ft Sea Level Rise	1	0	4	4	4	4	4
+6ft Sea Level Rise	4	3	7	7	7	7	7

NOTE: Parking Locations are Shown Geographically in Section 4.2 – Parking.

Any parking lot(s) serving critical life-safety operations, important commercial access, and/or resident access to homes should be prioritized in a harbor-wide resilience strategy.

7. OPPORTUNITY ZONES IN NOYO HARBOR

In line with Noyo's CSP and BEVRI plans, discussions with the Noyo Harbormaster have indicated that a key priority moving forward is to improve the derelict portions of the harbor and develop them in alignment with Noyo Harbor's Vision for a Blue Economy. Based on the input and our risk assessment, we have identified three opportunity zones within the existing harbor marina that are invaluable locations for the harbor marina operations and either (1) do not contain any critical assets at high flood risk or (2) contain critical assets at high flood risk that have already been flagged by the Harbor District as future projects. These three zones, located at the site of the Dredge Containment Cell, the North Harbor between Sea Pal Cove and Princess Seafood, and the South Harbor between the South Winds Fishing Building and Makela Boat Works, are shown on **Figure 30** below.

Figure 30. Noyo Harbor – Opportunity Zones

(8.5x11)

8. CONCLUSIONS

8.1 General Conclusions

It is necessary to plan for near-term and intermediate-term impacts from both tidal inundation and high-intensity storm events, with an eye toward the potential long-term consequences of these flood scenarios. Even in the present day, the 100-year storm affects a number of assets and disrupts several core functions of the harbor. With just 1 to 3 feet of sea level rise, the 100-year storm begins to impact the highest-priority operational goals of the harbor—namely, Goal 1 (Coast Guard operations) and Goal 2 (safe vessel entry and exit). By the end of the century, under a 6-foot sea level rise scenario, a high-intensity storm like a100-year event has the potential to flood the entirety of Noyo Harbor. This scenario would compromise nearly all harbor functions, from vessel access to commercial activity to public safety.

Any resilience and adaptation plan for Noyo Harbor should include a complete strategy that ensures the resilience of the harbor and the assets that are critical to meeting whichever subset of operational goals the Harbor District decides it wants to prioritize—both now and in the future. As described in the asset-by-asset summaries, the fact that clusters of assets are impacted by the same flood scenarios suggests that a mix of large-scale and asset-specific strategies may be required to achieve long-term resilience. At the same time, it is essential to implement localized adaptation measures and downtime mitigation strategies at the most critical facilities. This includes assets such as the U.S. Coast Guard Station Noyo River and the Noyo Marine Rail and Cradle System, where even short-term disruption could have outsized consequences for the harbor's operational continuity and emergency response capacity.

Flood resilience planning implies a mix of strategies to reduce the hazard exposure to these assets as well as vulnerability and consequence to the assets and harbor functions when they are exposed to inundation. A holistic strategy will require long-term planning and sustained capital investment, with specific benchmarks defined to trigger certain adaptation actions when any operational goal(s) deemed critical are no longer able to be met. In the next phase of this project, we will introduce the concept of a multi-phase approach to resilience—one that addresses both quasi-permanent flooding (i.e., frequently recurring high tide inundation) and permanent flooding together.

As part of this long-term strategy, in coordination with the CSP and BEVRI plans, there may also be opportunities to modify or relocate certain land uses, such as select parking areas or other more inland sites, while strengthening more permanent and mission-critical uses. A more resilient harbor edge may also be necessary in the coming decades.

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Appendix A.
Existing Conditions Memorandum

Appendix B.
Sea Level Rise Scenarios Memorandum

Appendix C.
Asset Flood Exposure Results