COASTAL CORRIDOR ALLIANCE

Mountains Recreation & Conservation Authority

DRAFT

RANDALL PRESERVE/GENGA*

Coastal Resilience Strategy

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Glossary

AHT	Annual High Tide
AR6	Sixth Assessment Report
CCA	Coastal Corridor Alliance
CCC	California Coastal Commission
CoNED	Coastal National Elevation Database
CoSMoS	Coastal Storm Modeling System
CRS	Coastal Resilience Strategy
cm	Centimeters
DTL	Mean Diurnal Tide Level
ENSO	El Niño and the Southern Oscillation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FJRP	Frank and Joan Randall Preserve
ft	Feet
GIS	Geographic Information Systems
GSW	Global Surface Warming
HAT	Highest Astronomical Tide
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HOT	Highest Observed Tide
HOWL	Highest Observed Water Level
in.	Inches
IPCC	International Panel of Climate Change
Int	Intermediate
Int-High	Intermediate-High
ITF	Interagency Task Force
k	Hydraulic Conductivity
LAT	Lowest Astronomical Tide
LCP	Low-Confidence Processes
LF	Linear Feet
LOWL	Lowest Observed Water Level
m	Meters
MHW	Mean High Water
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MRCA	Mountains Recreation and Conservation Authority

MSL	Mean Sea Level
MTL	Mean Tide Level
NAVD88	North American Vertical Datum of 1988
NFAT	NASA Flooding Analysis Tool
NFHL	National Flood Hazard Analysis
NOAA	National Oceanic and Atmospheric Administration
OCFCD	Orange County Flood Control District
OCPW	Orange County Public Works
OCOF	Our Coast Our Future
OPC	State of California Ocean Protection Council
PAP	Public Access Plan
PCH	Pacific Coast Highway (Highway One)
RMP	Resource Management Plan
SAR	Santa Ana River
SART	Santa Ana River Trail
SARWQB	Santa Ana Regional Water Quality Control Board
SFHA	Special Flood Hazard Analysis
SIM	Static Inundation Modelling
SLR	Sea Level Rise
SLRVA	Sea Level Rise Vulnerability Assessment
SRT	Self-Regulating Tide
sq ft	Square Feet
SWL	Still Water Level (ft, NAVD88)
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAEP	Tribal Access and Engagement Plan
TPL	Trust for Public Land
TWL	Total Water Level (ft, NAVD88)
USGS	United States Geological Society
USACE	U.S. Army Corps of Engineers
VHE	Very High Emissions
WL	Water Level
YOI	Year of Inflection

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1. Introduction

1.1. General Overview

This report presents and recommends a set of actions designed to provide protection to the low-lying areas (lowlands) of Randall Preserve (or "Preserve") from the impacts of rising sea levels, coastal storms, and flooding. Resilience is accomplished by taking several steps including identifying and assessing the risks from sea level rise (SLR), developing adaptation plans and resiliency measures, prioritizing those measures, implementing them, and then monitoring the effectiveness of those measures.

Following guidance in the California Coastal Commission (CCC) SLR Policy Guidance Document (CCC Guidance), the objective of this Coastal Resiliency Strategy (CRS) document is to identify coastal resilience strategies intended to reduce negative impacts and improve the Preserve's ability to prepare for, withstand, and recover from extreme coastal events and rising sea levels. Strategies focus on improving resilience of the natural and built environments and include implementing solutions that are either nature-based or engineered structures, or a hybrid of the two. While this document was developed in consideration of the Preserve's site-specific needs, it was also developed with a holistic landscape perspective in mind, which considers the Preserve's connection to the Santa Ana River, adjacent uplands and communities, and its significance to the region (Figure 1).

Building on these findings, this plan outlines potential adaptation strategies to mitigate or reduce the potential impacts of SLR to vulnerable locations across the Preserve. This adaptation plan is not meant to dictate a specific set of actions the Preserve must take but rather provide a range of options to be further debated, considered, and potentially implemented in the future. It is flexible and meant to be a community planning document that is revised over time as new information emerges, climate science advances, and community preferences evolve.

FIGURE 1. LANDSCAPE PERSPECTIVE OF THEPRESERVE

In combination with the SLR Vulnerability Assessment (*full document provided in Appendix A*), these reports outline a cyclical process to address SLR hazards over time, illustrated in Figure 2. Steps 1-3, from identifying appropriate SLR projections to assessing risks to resources and development, are covered within the Sea Level Rise Vulnerability Assessment (SLRVA). Strategies on the development of adaptation measures and the implementation of these measures (Steps 4-5) are covered within this document.

FIGURE 2. COASTAL RESILIENCE STRATEGY PLANNING PROCESS

1.2. CRS Plan Objectives

As a result of melting land ice, thermal ocean expansion, and coastal land subsidence, global sea levels have been observably rising since 1900; the rate of SLR is expected to increase through the 21st century (NOAA 2015; NRC 2012). As sea levels continue to rise, portions of the Preserve and adjacent areas may experience more frequent and severe coastal hazards that will test the area's resilience.

The Coastal Corridor Alliance (CCA) and Mountain Recreation and Conservation Authority (MRCA) developed explicit objectives for the lowlands:

1. **<u>Goal #1</u>: Restore coastal processes and functions to the maximum extent possible for ecological benefit.**

   Objectives:

   1.1 Increase estuarine habitat with a mix of tidal channels, mudflat, salt marsh, and brackish/freshwater marsh.
   1.2 Enhance and maintain wetland-upland ecotone and upland habitat to support habitat resiliency and species diversity.
   1.3 Restore and maintain coastal habitat that supports species of special concern (e.g., federal and state listed species), essential fish habitat, and migratory birds.

1.4 Maintain hydrological integrity for the benefit of habitats.

2. **<u>Goal #2:</u> Plan for changing environments and design for ecological resilience.**

   Objectives:

   2.1. Design habitats to accommodate climate change related SLR and other coastal impacts (e.g., incorporate topographic and salinity gradients, habitat diversity and natural buffers and transition zones to accommodate migration of wetlands with rising sea levels).
   2.2. Prioritize nature-based solutions.
   2.3. Develop and implement a comprehensive sediment-management plan.
   2.4. Work toward increased unification and collaboration of management with appropriate entities, such as OC Parks, Orange County Vector Control, the City of Newport Beach, and U.S. Army Corps of Engineers (USACE).

3. **<u>Goal #3</u>: Identify opportunities for contiguous coastal habitat areas and increase the buffer between sensitive habitat and sources of human activities**.

   Objectives:

   3.1. Bridge wildlife connectivity between the Preserve/Genga and adjacent natural areas.
   3.2. Balance ecological sustainability with an appropriate level of public access and Tribal cultural uses.
   3.3. Increase habitat buffer zones by limiting or reducing impacts from urban infrastructure and intrusions (e.g., stormwater pipelines, powerlines, lighting, excessive noise).

The potential strategies presented in the following sections are evaluated based on their ability to meet the criteria outlined above.

2. Description of Coastal Hazards

The previous Sea Level Rise Vulnerability Assessment (SLRVA) (M&N 2025) analyzed the effects of SLR on the Preserve's existing project site and adjacent waterways using the best available science and data to determine potential coastal hazard zones in accordance with California Coastal Commission (CCC) Guidance. The State of California Ocean Protection Council (OPC) Science Advisory Taskforce compiled the best available SLR science relevant to California in the "Rising Seas in California" report (Griggs, et al. 2017). Reflecting statewide guidance, the OPC recently released the 2024 State of California SLR Guidance: Science and Policy Update in January 2024. The CCC currently recognizes this document as the best available science for SLR projections in California.

The following is a brief description of the coastal hazards evaluated in the previous vulnerability assessment. A combination of analytical methods and numerical models (described in Appendix A) were used to develop potential resilience and adaptation solutions for each type of hazard under the different SLR scenarios.

4. **Flooding Driven by Severe Storm Events and High Tides:** SLR is expected to significantly affect the extent, depth, and frequency of coastal flooding at adjacent surrounding areas (Santa Ana River [SAR], West Newport Bay, Pacific Coast Highway [PCH], etc.). It was deduced that the site is heavily protected by the existing hydraulic infrastructure (tide gates, storm drain outlets, etc.) under most scenarios; thus, highlighting the dependance on this critical hydraulics infrastructure's operability. Flood hazard projections were modeled using the USGS CoSMoS platform for both non-storm spring high tide conditions and 100-year (YR) coastal storm conditions, with an additional scenario analyzed in which no agency intervention occurs, and critical infrastructure is not retrofitted to meet increasing hazard demands (4.9 feet [ft] SLR, 100-YR storm unprotected scenario). Analysis showed that under this 4.9 ft SLR unprotected scenario, most of the lowlands including portions of wetlands, floodplain, and infrastructure — are projected to experience extensive inundation during storm events, especially where levees or coastal roadways such as PCH could be overtopped. These events could also lead to increased backflow through municipal storm drains and reduced drainage performance. Figure 1 provides a cross-section of the project site showing critical water levels as they relate to the various SLR and storm scenarios.

5. **Groundwater Emergence:** Groundwater emergence, a form of flooding driven by rising shallow groundwater tables, presents a potential risk for the site under future SLR. This occurs when groundwater levels, influenced by rising marine water levels, approach or exceed the ground surface, leading to surface flooding even in the absence of rainfall or storm surge. CoSMoS groundwater modeling was used to project water table responses under various SLR scenarios. Results indicate that much of the site will be subject to a shallow (0-3 ft) or emergent groundwater table condition under MHHW as SLR progresses. These conditions can precede surface inundation and impact underground infrastructure and result in persistent saturation of low-lying zones. As wetland creation and expansion of existing wetlands is a long-term management goal, however, groundwater emergence could make wetland creation easier at the Preserve.

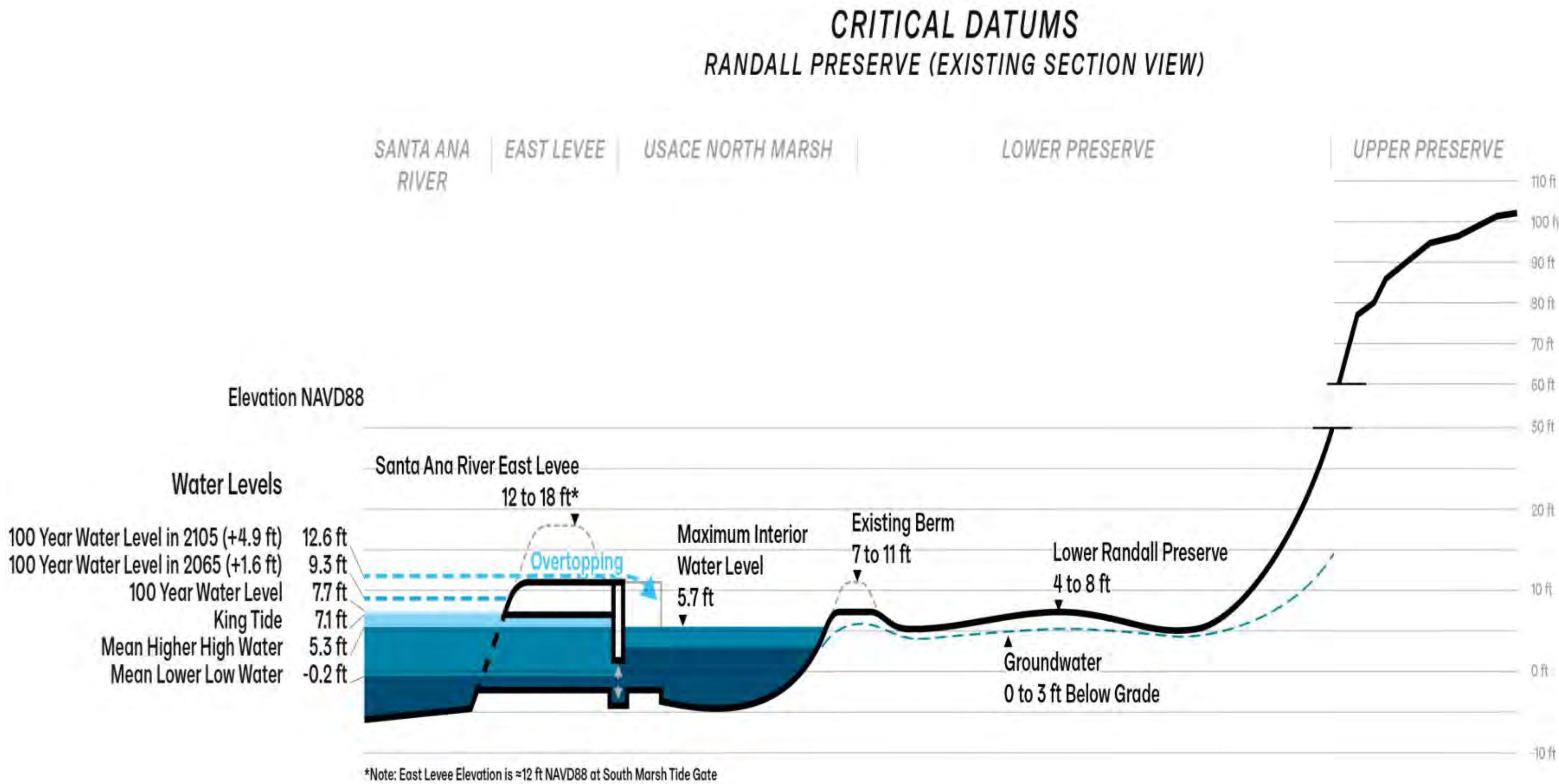


FIGURE 3. CRITICAL DATUMS AND STORM EVENTS AS THEY RELATE TO THE PRESERVE

3. Basis for Coastal Resilience Strategies

The initial phase of crafting this CRS document involved determining the vulnerability of different locations and resources within the Preserve to SLR. These findings are presented in Appendix A (the SLRVA). The SLRVA examines the vulnerability of the Preserve's assets and coastal resources under SLR scenarios ranging from 1.6 ft (0.25 meters [m]) to 4.9 ft (1.5 m), covering projected SLR from 2080 to 2140 as shown in Table 1 below.

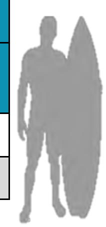
A total of seven (7) SLR and storm scenarios were mapped for the vulnerability assessment:

- Existing conditions (no SLR)
    - Non-Storm – Annual High Tide (AHT) of +6.79 ft NAVD88
    - 100-YR Storm – Highest Observed Tide (HOT) of +7.72 ft NAVD88
- 1.6 ft SLR conditions
    - Non-Storm – AHT of +6.79 ft NAVD88
    - 100-YR Storm – HOT of +7.72 ft NAVD88
- 4.9 ft SLR conditions
    - Non-Storm – AHT of +6.79 ft NAVD88
    - 100-YR Storm – HOT of +7.72 ft NAVD88
    - 100-YR Storm (*Unprotected*) – HOT of +7.72 ft NAVD88

Evidence in the updated 2024 report suggests that it is reasonable to view the *Intermediate* scenario as the most representative of the SLR expected to occur in the near term and provides a reasonable upper bound for the most likely range of SLR by 2100.

TABLE 1. PROBABLE TIMING ASSOCIATED WITH SELECTED SLR SCENARIOS FOR THE LOS ANGELES REGION (OPC, 2024)

SLR Scenarios, ft (cm)	Probable Timing Associated with SLR Projections (2024 Draft Guidance Update)				
	Low	Int-Low	Intermediate	Int-High	High
1.6 (50)	2150+	2120	2080	2065	2055
4.9 (150)	2150+	2150+	2140	2105	2090



3.1. SLRVA Summary and Findings

Vulnerability of the Preserve as it relates to SLR is defined based on three characteristics:

- **Hazard Exposure**: The hazard *type, duration, and frequency* subjected upon the Project Site. In general, the degree of flooding exposure due to SLR at a specific site typically dictates how exposed the site is to these hazards.
- **Hazard Sensitivity**: The *degree* to which a resource is impaired by exposure to hazards. It relates to the susceptibility of the site to the various coastal hazards associated with SLR and considers the ecological, social, and economic factors that make certain areas or assets more sensitive or vulnerable to hazards.
- **Adaptive Capacity**: The *ability* of a site to respond effectively to changing conditions, including coastal hazards, while maintaining or enhancing their well-being and functionality.

The overall vulnerability of coastal assets at the Preserve is determined by evaluating these three interrelated factors by first identifying key resources within and adjacent to the Preserve — such as recreational areas, infrastructure, roadways, and natural habitats — then evaluating how each of these resources responds to increasing SLR scenarios. Resources that are highly exposed to coastal hazards (e.g., tidal inundation, groundwater emergence, etc.), highly sensitive to impacts such as flooding or saturation, and lack the ability to adapt or be protected over time are classified as highly vulnerable. The resulting vulnerability classifications provide a snapshot of which assets within the Preserve are most at risk and help inform future adaptation planning. Summary vulnerability scores for different resource types and hazard conditions are provided in Table 2.

TABLE 2. SLR VULNERABILITY RATINGS AND DESCRIPTIONS

Category	Rating	Description
Hazard Exposure	N/A	No exposure to flooding or erosion.
	Low	Exposure to storm flooding in select areas.
	Moderate	Significant exposure to storm flooding and/or partial exposure to non-storm inundation.
	High	Significant exposure to non-storm inundation.
Hazard Sensitivity	Low	Minimal impacts to structure and function as a result of coastal hazards unless inundated on a regular basis.
	Moderate	Moderate impacts to structure and function during temporary storm flooding. Significant impacts if inundated.
	High	Significant impacts to structure and function from short-term storm flooding or inundation.
Adaptive Capacity	Low	Limited options for adaptation. Adaptation likely to have significant costs.
	Moderate	Multiple options for adaptation over time with relatively moderate effort and cost.
	High	Multiple options for adaptation over time with minor additional cost.

The vulnerability of coastal resources at the Preserve varies significantly depending on the presence or absence of protection provided by the existing tide gates and coastal infrastructure. To reflect these conditions, assets were evaluated under two SLR scenarios: Protected (existing, 1.6 ft, and 4.9 ft SLR with fully operational hydraulic infrastructure) and Unprotected (4.9 ft SLR with no agency intervention and allowed overtopping). The Preserve remains largely protected from direct SLR impacts under current and near-term conditions — primarily due to the functionality of existing levee, tide gates, and other hydraulic connections along the Santa Ana River.

Under the *Protected* scenario, most resources exhibit low to moderate overall vulnerability, due to reduced hazard exposure from tidal inundation and storm surge. This includes critical infrastructure such as storm drains, utilities, and natural vegetation, which benefit from the function of the tide gates and structural protections. In contrast, the Unprotected scenario shows a marked increase in vulnerability across nearly all asset categories. Lowland development, stormwater infrastructure, and recreation amenities show high overall risk, driven by increased hazard exposure and limited adaptive capacity.

This distinction reflects the differing levels of exposure to SLR-related hazards such as tidal inundation, storm-driven flooding, and groundwater emergence, and allows for a more accurate evaluation of risk based on site-specific conditions and infrastructure performance. The following tables summarize the overall vulnerability of coastal assets identified in the SLRVA, organized by this protection status.

TABLE 3. IDENTIFIED RISK ASSESSMENT FOR THE PRESERVE COASTAL RESOURCES UNDER PROTECTED (EXISTING, 1.6 FT SLR, AND 4.9 FT SLR) SCENARIOS

Resource Category	Resource	Specific Assets	Within Project Boundary	Hazard Exposure	Hazard Sensitivity	Adaptive Capacity	Vulnerability (Overall Risk)
Existing Vegetation and Habitat	*Preserve Vegetation*	Open Space Vegetation	Yes	Low	Moderate	Moderate	Low
	Submerged Waterways	Semeniuk Slough	No	Low	Low	High	
		SAR	No	Moderate	Low	Moderate	
	Uplands	Coastal Bluffs and Arroyos	Yes	N/A	Moderate	High	
	USACE SAR Marshes	North Marsh (USACE Project)	No	Moderate	Low	High	
		South Marsh (USACE Project)	No	Moderate	Low	High	
Critical Infrastructure and Development	*Hydraulic Infrastructure*	Levee	No	Moderate	Low	Low	Low
		Tide Gate Facilities	No	Moderate	Low	Moderate	
		Culverts	Yes	Moderate	Low	Moderate	
		Outlet Drains/Gates	No	Moderate	Low	Moderate	
		Easements	Yes	N/A	Moderate	Moderate	
	Lowlands Development	Bulkhead Walls	Yes	Low	Moderate	Moderate	
		Oil Operator Facilities	Yes	Low	Moderate	Moderate	
		Staging/Laydown and Other Development Areas	Yes	N/A	Moderate	Low	
		Fencing	Yes	Low	Moderate	Low	
	Upland Development	Site Access Area/Parking	Yes	N/A	Moderate	Moderate	
	Major Roadways	Pacific Coast Highway	No	High	High	Low	
	Service Roads	Industrial Way	Yes	Low	Moderate	Moderate	
		Oil Operator Service Dirt Roads	Yes	Moderate	Moderate	Moderate	
		Access Bridge (at North Marsh)	No	Low	Moderate	Moderate	
	Residential Areas	Newport Bay Residential Area	No	High	High	Low	
Utilities	*Existing Site Utilities*	Storm Drains	Yes	Moderate	Low	Moderate	Low
		Electrical (Overhead Power)	Yes	Low	High	Moderate	
		Exist Oil Piping	Yes	Low	Moderate	Low	
Recreation and Public Access	*Recreation and Public Access*	Future Access Trails and Amenities[1]	Yes	N/A	Low	Low	Low
		SART Pedestrian Trail	Yes	N/A	Low	Low	

TABLE 4. IDENTIFIED RISK ASSESSMENT FOR THE PRESERVE COASTAL RESOURCES UNDER UNPROTECTED 4.9 FT SLR SCENARIO

Resource Category	Resource	Specific Assets	Within Project Boundary	Hazard Exposure	Hazard Sensitivity	Adaptive Capacity	Vulnerability (Overall Risk)
Existing Vegetation and Habitat	*Preserve Vegetation*	Open Space Vegetation	Yes	High	Low	Moderate	High
	Submerged Waterways	Semeniuk Slough	No	High	Low	High	
		SAR	No	High	Low	Moderate	
	Uplands	Coastal Bluffs and Arroyos	Yes	N/A	Moderate	High	
	USACE Salt Marshes	North Marsh (USACE Project)	No	High	Low	High	
		South Marsh (USACE Project)	No	High	Low	High	
Critical Infrastructure and Development	*Hydraulic Infrastructure*	Levee	No	High	Low	Low	High
		Tide Gate Facilities	No	High	Low	Moderate	
		Culverts	Yes	High	Low	Moderate	
		Outlet Drains/Gates	No	High	Low	Moderate	
		Easements	Yes	High	Moderate	Moderate	
	Lowlands Development	Bulkhead Walls	Yes	High	Moderate	Moderate	
		Oil Operator Facilities	Yes	High	Moderate	Moderate	
		Staging/Laydown and Other Development Areas	Yes	Moderate	Moderate	Low	
		Fencing	Yes	High	Moderate	Low	
	Upland Development	Site Access Area/Parking	Yes	N/A	Moderate	Moderate	
	Major Roadways	Pacific Coast Highway	No	High	High	Low	
	Service Roads	Industrial Way	Yes	High	Moderate	Moderate	
		Oil Operator Service Dirt Roads	Yes	High	Moderate	Moderate	
		Access Bridge (at North Marsh)	No	High	Moderate	Moderate	
	Residential Areas	Newport Bay Residential Area	No	High	High	Low	
Utilities	*Existing Site Utilities*	Storm Drains	Yes	High	Low	Moderate	High
		Electrical (Overhead Power)	Yes	High	High	Moderate	
		Exist Oil Piping	Yes	Moderate	Moderate	Low	
Recreation and Public Access	*Recreation and Public Access*	Future Access Trails and Amenities[1]	Yes	Moderate	Low	Low	Moderate
		SART Pedestrian Trail	Yes	Moderate	Low	Low	

The following is a preliminary list of assets that have been indicated as being potentially impacted by 1.6 ft and/or 4.9 ft SLR at the Preserve:

Inside the Preserve Project Boundary

- Existing Habitat/OpenSpace/Vegetation communities
- Oil Retainer Property/Operator Facilities
- Perimeter Fencing
- Culverts at southern area of the Preserve
- Storm Drains
- Industrial Way
- Electrical Utilities (w/ Overhead Power Transmission Lines)
- Vector Control routes
- Public access paths
- Vehicular access roads
- Service access road that connects PCH to SAR East levee

Outside the Preserve Project boundary, but still pertinent:

- Santa Ana River (SAR) East Levee
- Outlet Drains/Gates (SAR East Levee)
- North Marsh (USACE) at Santa Ana River Salt Marsh (SARSM)
- South Marsh (USACE) at Santa Ana River Salt Marsh (SARSM)
- Tide Gates at USACE North Marsh and South Marsh
- Culverts at North Marsh and South Marsh that connect to the Preserve
- Newport Beach Harbor at the Channel Place Park shoreline
- West Newport Beach
- Newport Shores
- Pacific Coast Highway

3.2. Strategies from CCC SLR Policy Guidance

The California OPC's updated 2024 Sea-Level Rise Guidance provides guidance on selecting SLR projections, which helps to standardize the process across the state. It points planners and engineers toward the best available SLR science and helps them understand how to practically consider and design for SLR risks. Figure 4 summarizes the major steps.

This State guidance provides the framework for the Preserve's SLR Vulnerability Assessment including the selection of the modeling scenarios. While these are not formal design guidelines, they include information on SLR projections and risk tolerance and could form the foundation of future Preserve design guidelines. This CRS document is intended to draw upon the analyses and findings from the original SLRVA document (Steps 1-4) and explore the decision-making process as it pertains to various adaptation approaches (Steps 5-6).

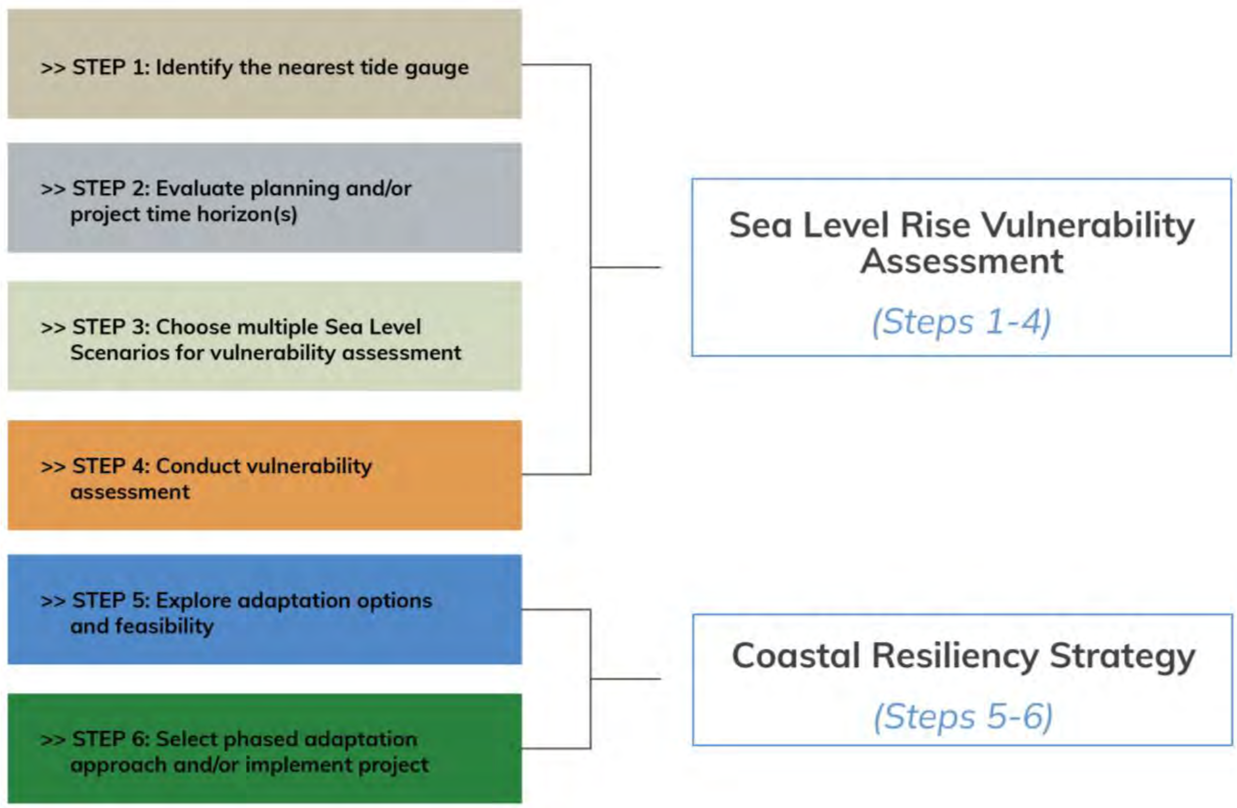


FIGURE 4. **OPC'S** UPDATED 2024 SLR GUIDANCE DECISION FRAMEWORK
(S**OURCE: OPC'S 2024** UPDATED SLR GUIDANCE)

4. Resilience and Adaptation Strategies

4.1. General Adaptation Strategies

Changing coastal hazards due to SLR can be addressed in several different ways. Though numerous adaptation methods are available, adaptation measures generally fall into one of three categories or a combination of them:

- **Protection:** Strategies that employ hardened or nature-based engineered measures to defend an existing coastal asset from future SLR hazards without making changes to the asset itself.
- **Accommodation**: Strategies that involve modifying existing assets or designing new assets in a way that reduces the potential future impacts of SLR.
- **Retreat or Relocation:** Strategies focused on relocating or removing existing assets from identified high-hazard areas while limiting construction of new assets in such areas.

In unison with all of these different strategies, adaptive management will be a continually evolving and dynamic process for implementing SLR adaptation strategies that incorporate monitoring, evaluation, and iterative decision-making in tandem with the aforementioned strategies. It enables coastal planners, engineers, and stakeholders to respond to evolving climate impacts by adjusting actions or designs based on performance, new data, or changing community needs. In practice, SLR adaptation often relies on hybrid approaches that combine elements from multiple categories over different spatial and temporal scales. Examples of these strategies are provided in Figure 5.

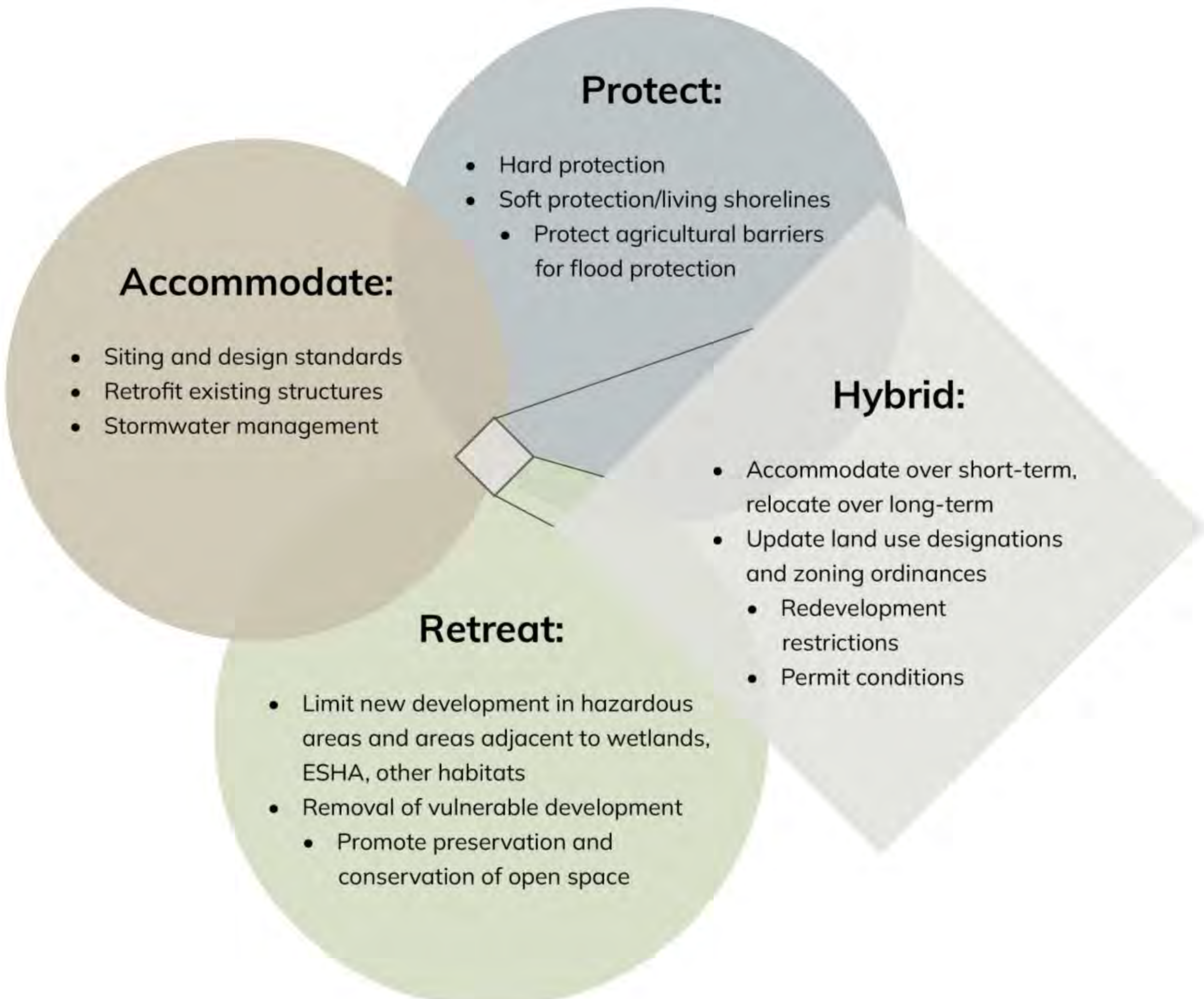


FIGURE 5. GENERAL SLR ADAPTATION STRATEGIES AND MECHANISMS

The following sections outline potential project-level resilience strategies that could be implemented within the four coastal planning areas to mitigate projected SLR-related hazards. Project-level strategies are provided for current conditions as well as projected near-term (1.6 ft) and long-term (4.9ft +) SLR scenarios. A breakdown of the potential benefits and challenges associated with various types of project-level resilience strategies are described in Section 5.

The RMP defines three distinct levels of management, which are provided in Table 5 below. They involve increasing levels of land alteration or "touch" that were developed for the RMP. Each level informs resiliency and adaptation solutions. For this CRS, the term "adaptation" is defined as those retrofitted to increase the resiliency of the existing condition or actions taken under the Low Touch and Intermediate Touch Management Levels. The term "*resilience*" is used for any solution added as part of future mitigation actions ascribed to the High-Touch Management Level.

The original SLVRA document provides analysis for the lower levels of management (Level 1: Low-Touch and Level 2: Intermediate-Touch) scenarios. Therefore, this CRS will focus primarily on higher Level 3 management approaches. The following section presents high-level concept summaries and evaluations of each resiliency and adaptation solution. These evaluations are intended to help narrow the range of options to those most suitable for potential implementation at the Preserve.

TABLE 5. SUMMARY OF MANAGEMENT LEVELS AS THEY RELATE TO COASTAL RESILIENCE AND ADAPTATION SOLUTIONS

Management Level	Focus	Key Actions	Outcomes/Goals
Level 1 – *Low Touch*	Basic preserve management and ecological stabilization	- Trail designation, signage, and safety reviews - Erosion and drainage control - Trash collection and perimeter patrols - Invasive species removal, suppression, and reliance on natural recruitment of native vegetation - Public behavior guidance (e.g., trail use, camping, vandalism)	Establish safe, sustainable public access and promote natural native vegetation recovery through weed suppression.
Level 2 – *Intermediate Touch*	Habitat enhancement and public experience improvements	- Upland road decommissioning and regrading - Native seeding and erosion control - Vernal pool and species habitat improvements - Construct amenities (e.g., platforms, trail bridges) - Establish nursery and community access points	Restore habitat in previously disturbed upland areas, enhance biodiversity, and support educational and recreational use.
Level 3 – *High Touch*	Transformative ecological restoration and tidal reconnection	- Mass grading and tidal channel excavation - Salt marsh and transitional habitat creation - Planting with temporary irrigation systems - Coordination with USACE and OCPW on tide gate management	Reestablish tidal influence in lowlands, enhance coastal wetland habitat, and achieve regional-scale ecological benefits.

Due to the limited changes in site topography under Management Levels 1 (*Low*) and 2 (*Intermediate*), the existing coastal hazard analysis presented in the SLRVA remains applicable and relevant to these approaches. In contrast, Management Level 3 involves significant site regrading and transformation, warranting additional analysis and updated hydrological modeling to assess its implications on flood risk and coastal processes on the altered proposed landscape.

4.2. Proposed Conditions (Management Level 3: *High Touch Scenario*)

Figure 6Figure 10 present an updated flood analysis consistent with the methodology used in the SLRVA but applied to a conceptual proposed final site condition. Due to legacy oil infrastructure across the site, the proposed grading plan lowers the surface elevation by approximately 3 ft throughout to accommodate anticipated subsurface conditions (Note: existing oil wells are cut-off and capped 3 ft below the existing terrain). Therefore, this assessment evaluates flood depths under combined SLR and coastal storm scenarios for the conceptual surface elevations, as described below and shown in Figure 5 through Figure 9.

- 1.6 ft SLR conditions
    - Non-Storm – AHT of +6.79 ft NAVD88
    - 100-YR Storm – HOT of +7.72 ft NAVD88
- 4.9 ft SLR conditions
    - Non-Storm – AHT of +6.79 ft NAVD88
    - 100-YR Storm – HOT of +7.72 ft NAVD88
- 100-YR Storm (*Unprotected*) – HOT of +7.72 ft NAVD88

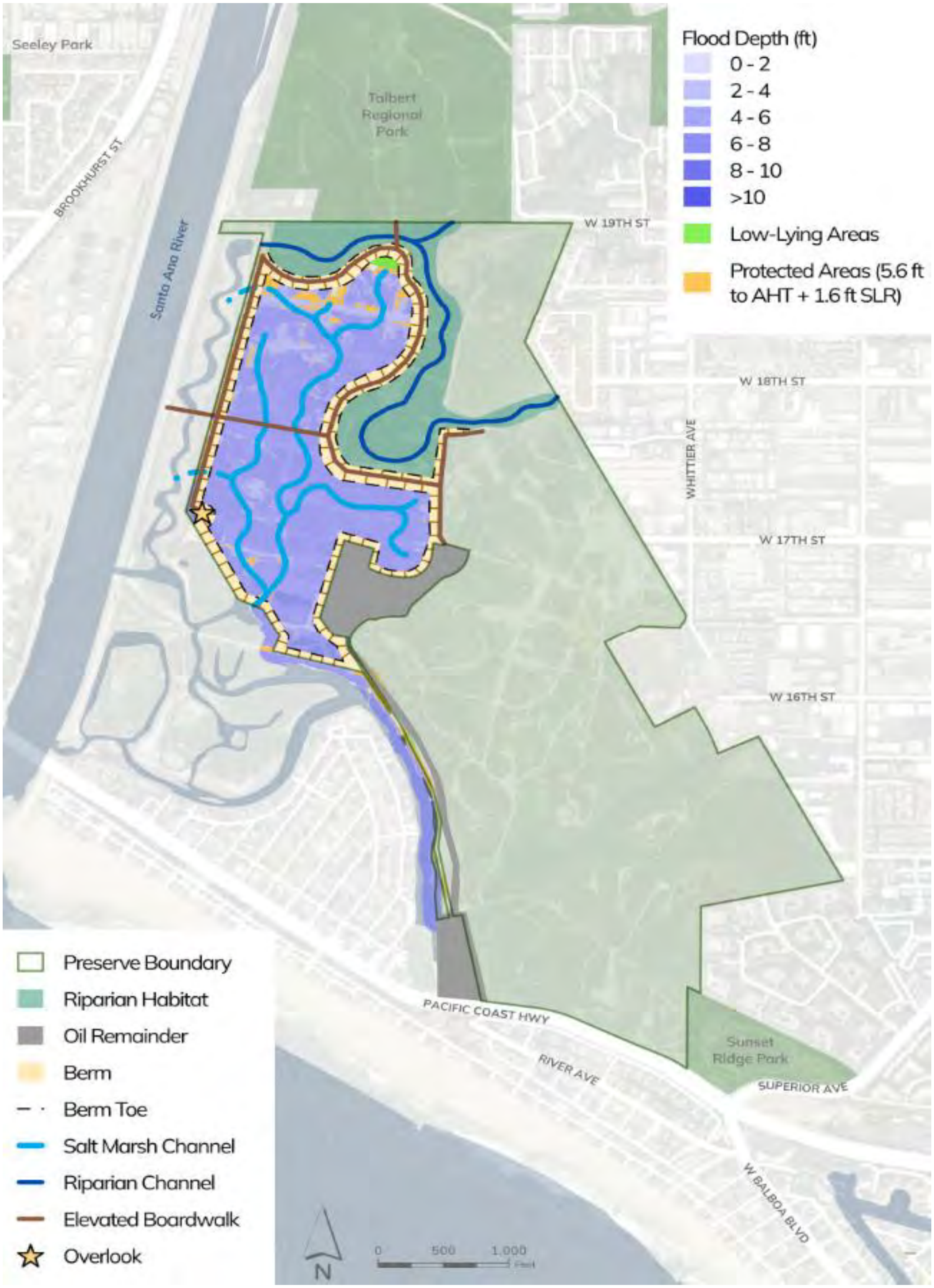


FIGURE 6. PROPOSED CONDITION UNDER 1.6 FT SLR + NO STORM

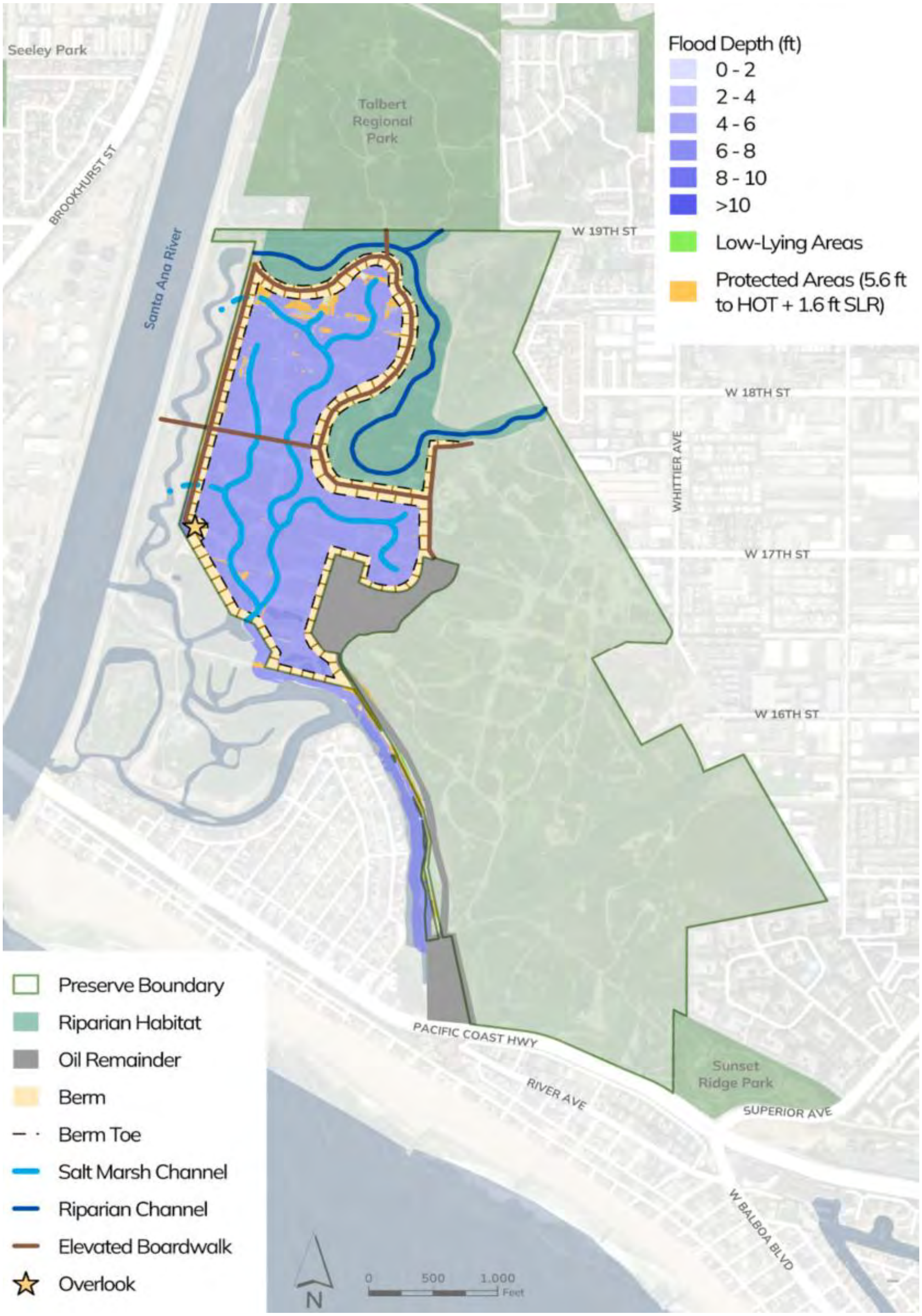


FIGURE 7. PROPOSED CONDITION UNDER 1.6 FT SLR + 100-YR STORM

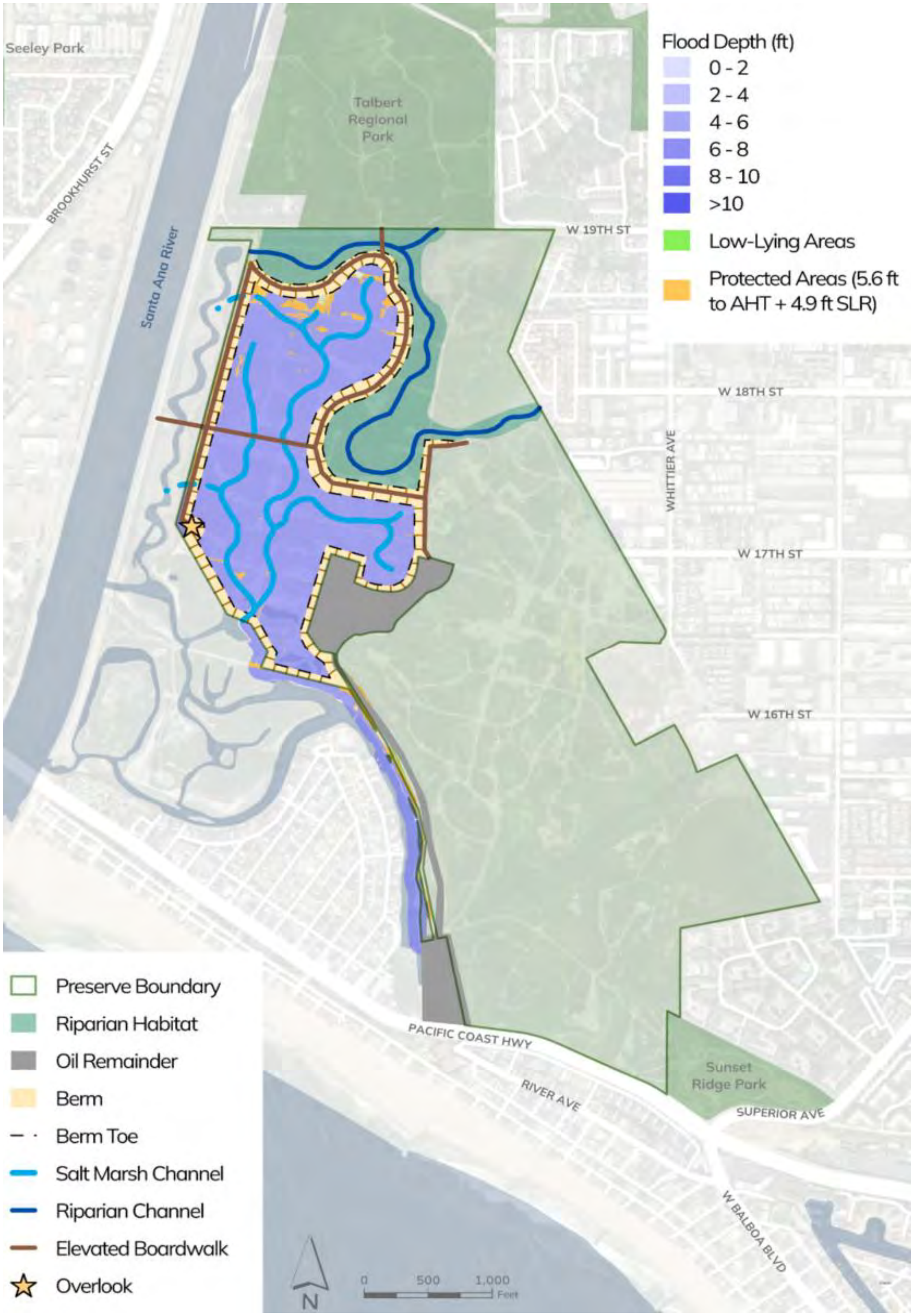


FIGURE 8. PROPOSED CONDITION UNDER 4.9 FT SLR + NO STORM

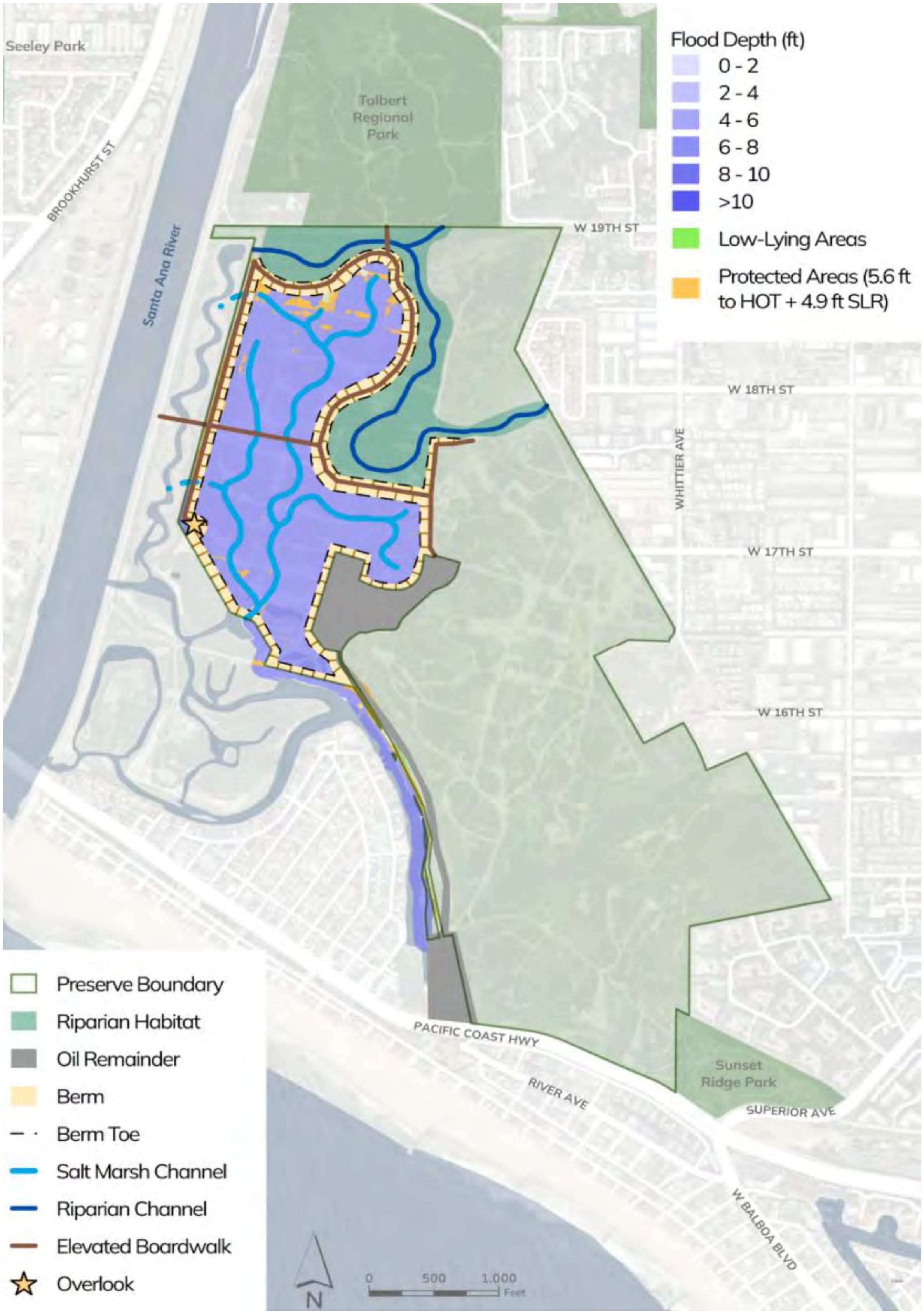


FIGURE 9. PROPOSED CONDITION UNDER 4.9 FT SLR + 100-YR STORM

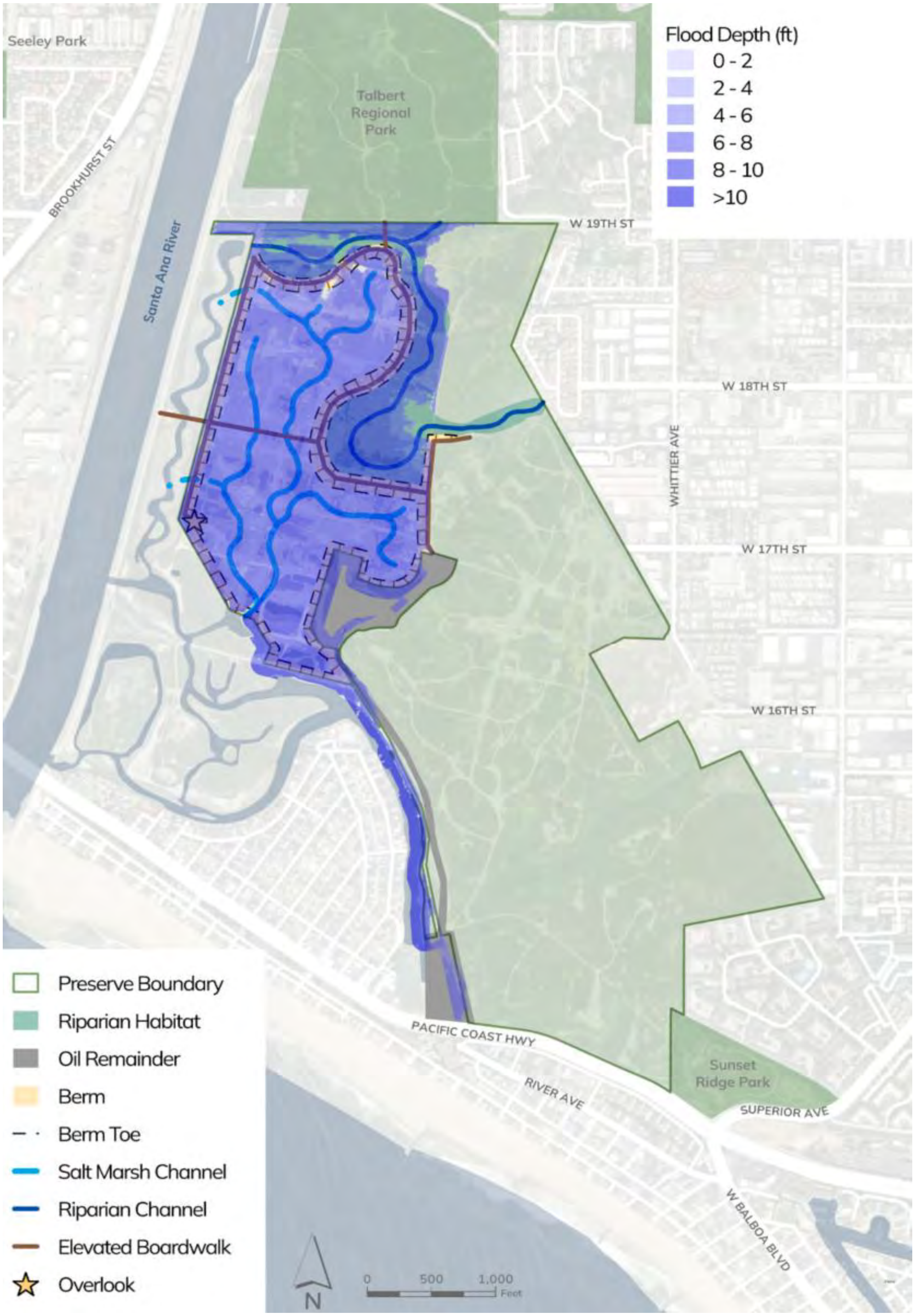


FIGURE 10. PROPOSED CONDITION UNDER 4.9 FT SLR + 100-YR STORM (UNPROTECTED)

4.3. Site-Specific Coastal Resilience Strategies

The strategies provided below will focus primarily on higher Level 3 management approaches, as these involve substantial site reconfiguration (including mass grading, restored hydrologic connectivity, and elevation changes) that significantly alter existing conditions. Unlike Levels 1 and 2, which maintain much of the current site form, Level 3 introduces transformative earthwork that requires updated hydrologic modeling, reassessment of flood pathways, and evaluation of long-term resilience under SLR scenarios. Given the complexity of these strategies, focused analysis is required to evaluate their feasibility, performance, and alignment with future environmental conditions. As such, the following section assumes that Management Levels 1 and 2 – as addressed in the broader RMP – will continue to serve as foundational components within the overall adaptation pathway. The resiliency strategies presented below are intended to help narrow the range of options to those most suitable for potential implementation at the Preserve.

4.3.1. Planning and Adaptive Management

Planning and adaptive management in the context of coastal resilience is a dynamic, iterative approach that allows communities and land managers to respond to changing coastal conditions—such as SLR, erosion, and extreme weather—over time. It involves setting clear long-term goals, identifying potential risks and vulnerabilities, implementing phased strategies, and continuously monitoring environmental and infrastructure conditions.

4.3.1.1. Strategic Partnerships

Strategic partnerships are a cornerstone of effective planning and adaptive management, particularly in complex, dynamic coastal environments like the Preserve. SLR, flooding, habitat shifts, and infrastructure vulnerability do not always adhere to defined jurisdictional boundaries making collaboration across agencies, landowners, and community groups essential. By establishing strong partnerships early, project proponents can align timelines, leverage technical expertise, and reduce redundancies in planning and implementation. These relationships also facilitate coordinated permitting, integrated data sharing, and access to joint funding opportunities that may not be available to a single entity acting in isolation. Most importantly, strategic partnerships build institutional memory and shared accountability, enabling a more nimble and resilient response as site conditions evolve and new adaptation needs emerge. In this way, partnerships are not just supportive — they are foundational to delivering long-term, flexible, and cost-effective coastal resilience.

For the Preserve in particular, strategic partnerships are essential due to its location at the intersection of multiple jurisdictions, infrastructure systems, and ecological corridors. Its long-term resilience depends on coordination with agencies such as USACE for permitting tidal connectivity, Orange County Public Works (OCPW) for levee and stormwater management, and the City of Newport Beach for future actions it might take to prevent flooding at West Newport. Without these partnerships, efforts to restore habitat, manage flood risk, or implement adaptive strategies could be delayed or rendered ineffective. Early and effective collaboration with these agencies will ensure the Preserve can operate as an integrated part of the larger coastal environment at West Newport, rather than in isolation, and allows it to serve as a model for collaborative, climate-ready land stewardship. The following is a list of potential partner organizations and agencies:

1. City of Newport Beach
   - Relevance: Jurisdictional authority over the Newport Harbor shoreline, including areas with protective bulkhead walls, community beaches, boat launching areas, the Channel Place Park neighborhood, stormwater outfalls, and local access routes such as Industrial Park Way.
   - Why it matters: These areas are among the first to flood under high SLR scenarios. Collaborative adaptation planning will ensure upstream interventions (e.g., levee improvements, tide gate operations) are not undermined by downstream vulnerabilities.
   - Coordination Topics: Public works, stormwater planning, land use planning, emergency response, coastal permitting.

2. USACE
   - Relevance: Owner and operator of the Santa Ana River Marsh (North and South Marsh), including tide gates, Santa Ana River levees, and hydraulic connections directly adjacent to and hydrologically connected with the Preserve.
   - Why it matters: Currently all high-touch restoration concepts rely on reintroducing tidal flow from the USACE-managed wetlands. Coordination is critical for culvert alignments, timing of tidal gate operations, and adaptive management of wetland hydrology.
   - Coordination Topics: Permit approvals (Section 408/404), tide gate control, infrastructure retrofits, and marsh maintenance.
3. OCPW/Orange County Flood Control District (OCFCD)
   - Relevance: Responsible for the maintenance and operation of the SAR East Levee tide gates, flood infrastructure, and related regional stormwater management assets.
   - Why it matters: Any modification to the SAR East Levee or tide gates or coordinating flood protection near the Preserve must be done with OCPW's input to maintain the regional flood control system's integrity and FEMA levee certification status.
   - Coordination Topics: Levee elevation scenarios, sediment routing, culvert design, and access to public lands.
   - Potential future connection to the Talbert Regional Park (South) to mutually benefit both sites under SLR projections that are higher than today.
4. Tribal Nations
   - Relevance: There are many Tribes that are culturally affiliated with lands encompassed by the Preserve. This includes important cultural resource areas. Why it matters: Incorporating Tribal consultation, access rights, and cultural preservation priorities is essential for equitable and culturally informed adaptation planning.
   - Coordination Topics: Access corridors, interpretive elements, and inclusion in decision-making processes.
5. Caltrans
   - Relevance: Oversees PCH, a major transportation corridor vulnerable to overtopping near the Preserve.
   - Why it matters: Under extreme SLR scenarios, Caltrans-led armoring or rerouting projects will directly impact flood pathways and backflow conditions at the Preserve.
   - Coordination Topics: Transportation resilience, design alignments, flood modeling compatibility.
6. Orange County Parks and Orange County Vector Control
   - Relevance: Co-managers or users of access infrastructure; active in mosquito abatement and vegetation maintenance.
   - Why it matters: Habitat changes tied to SLR, and wetland expansion could affect vector control responsibilities and park use. Salt marsh restoration typically reduces mosquito problems associated with freshwater ponds and freshwater habitats. This project may decrease the demand for mosquito abatement in the lowlands.
   - Coordination Topics: Public access management, invasive species control, and buffer zone planning.
7. FEMA/National Flood Insurance Program (NFIP)
   - Relevance: Regulatory body for floodplain mapping, risk designation, and flood insurance compliance.
   - Why it matters: Modifications to flood protection systems, wetlands, or levees may require FEMA approval and could influence flood insurance rate maps (FIRMs).
   - Coordination Topics: Map amendments, mitigation credit, etc.

4.3.1.2. Monitoring SLR

Ongoing monitoring of SLR is essential to inform adaptive management at the Preserve. This involves regularly reviewing data from local tide gauges, including but not limited to NOAA's National Water Level Observation Network and other regionally relevant platforms (such as gauges maintained by UC San Diego and Orange County agencies). Monitoring supports a data-driven understanding of how SLR is affecting coastal processes, habitat transitions, and the frequency or severity of inundation. At the Preserve, this monitoring effort can feed directly into the adaptive pathway framework — informing and triggering the phased implementation of restoration or infrastructure strategies once certain water level or ecological thresholds are reached. Annual updates should include both gauge data and a review of the latest SLR science, projections, and observed changes in regional hydrodynamics.

Tracking flood patterns associated with SLR across the Preserve and adjacent areas (SAR East Levee, Channel Park, etc.) helps identify vulnerable infrastructure and ecological stress points. Low-lying trails, roads, utility corridors, and marsh edges are most likely to experience recurrent flooding as SLR progresses. Recording these events — along with any access disruptions, habitat degradation, or maintenance costs — supports prioritization of site investments and informs long-term retreat or redesign strategies.

4.3.2. Nature-Based Adaptation

Nature-based adaptation refers to the intentional use of natural processes, ecosystems, and landscape features—either on their own or in combination with engineered systems—to enhance coastal resilience, reduce risk, and deliver broader environmental, economic, and social benefits. This strategy is designed to work with, rather than against, natural systems, leveraging the inherent functions of wetlands, dunes, reefs, forests, and other landscape elements to provide sustainable flood protection while also supporting habitat, water quality, recreation, and carbon sequestration. These solutions are adaptive over time and inherently multifunctional, often improving in performance as ecosystems mature.

4.3.2.1. Wetland Creation/Restoration

Wetland habitat creation and restoration at the Preserve is in and of itself is a nature-based solution. Natural environments can mitigate and reduce the impacts of flooding and bounce back from their effects better than any hardened structure. Due to the lowland's connection to the historic Santa Ana River Marsh, wetland creation within the Preserve refers to the strategic re-establishment or enhancement of tidal salt marshes, mudflats, and transitional ecotones that have been lost or degraded due to past land use, altered hydrology, or SLR. This process aims to restore the natural structure and function of a coastal salt marsh by regrading existing topography, improving tidal connectivity, increasing habitat complexity, and/or reintroducing native vegetation. In highly urbanized areas, salt marsh restoration sometimes blends engineering and ecological objectives, to create systems that deliver flood protection, carbon sequestration, biodiversity support, and recreational opportunities. Wetland restoration is both a climate adaptation strategy and a tool for improving watershed-scale resilience, and therefore a holistic resilience approach. Figure 10 shows a conceptual section view of a wetland/recreational/riverine interface at the Preserve.

FIGURE 11. CONCEPTUAL RENDERING OF RESTORATION AT THE PRESERVE (SALT MARSH, PEDESTRIAN PATH, BERM, AND RIPARIAN ENVIRONMENT)

4.3.2.2. Ecotone Levees

Any proposed berms at the Preserve could be designed to become an ecotone levee. An ecotone levee (shown in Figure 11) is a nature-based flood protection feature that blends traditional levee stability with ecological uplift by incorporating gentle side slopes, native transitional vegetation, and hydrologic connectivity. Unlike conventional levees that rely solely on engineered materials and steep armored slopes, an ecotone levee is designed to act as a multi-functional buffer zone—gradually transitioning from wetland to upland habitat while providing flood risk reduction and supporting biodiversity, sediment dynamics, and resilience to SLR. This feature may also be called a “living levee.” At the Preserve, the ecotone levee would feature a minimum slope of 1:15, designed to accommodate maintenance access and habitat migration upslope as SLR increases. This gentle grade allows for the establishment of ecological transition zones (e.g., high marsh, brackish meadow, coastal sage scrub), which are often lost in traditional levee construction. The design also encourages tidal attenuation, storm surge buffering, and adaptive flood protection — all while avoiding hardscape structures where possible.

FIGURE 12. CONCEPTUAL RENDERING OF THE ECOTONE LEVEE STRATEGY

4.3.2.3. Thin Layer Sediment Deposition

Thin Layer Sediment Deposition is a habitat enhancement and resilience-building technique where a controlled, thin layer of sediment is placed over existing wetland or transitional areas to elevate marsh surfaces, counteract subsidence, and keep pace with SLR. The approach aims to extend marsh longevity and functionality without completely burying existing vegetation or disrupting ecological processes. At the Preserve, thin layer sediment deposition may be used to raise the elevation of vulnerable wetland platforms that are at risk of drowning due to SLR, subsidence from oil extraction, or sediment supply limitations.

Sediment delivery is typically implemented using hydraulic methods, where sediment is dredged from nearby channels or designated borrow sites, mixed with water into a slurry, and then pumped through pipes to the deposition area. From there, the slurry is either sprayed (a method known as rainbowing as shown in Figure 13) or allowed to settle naturally across the wetland surface. In some cases, sediment can be rehandled on-site using low-ground-pressure equipment or amphibious excavators to shape and distribute material in more confined areas. The choice of construction method depends on site access, habitat sensitivity, available sediment sources, and the required precision of elevation gain. Containment measures — such as sediment curtains or low berms made of haybales — may also be used to manage flow and ensure even application.

Fortunately, the Preserve is well-positioned to benefit from nearby sediment dredging efforts—such as those at the Santa Ana River Mouth, Talbert Inlet Channel, and Santa Ana River Marsh— which present valuable opportunities for regional beneficial sediment reuse. This underscores the ongoing importance of strong partnerships with local and regional agencies. With thoughtful planning, future design strategies could be tailored to support sediment delivery operations by incorporating features such as widened access roads for truck transport, or channel improvements that allow small, self-operated vessels to navigate and offload material efficiently.

FIGURE 13. THIN LAYER SEDIMENT DEPOSITION CONSTRUCTION METHODS

A successful sediment delivery system requires careful attention to sediment quality, vegetation tolerance, elevation targets, and regulatory compliance. Sediment must be clean and appropriately sized to match native marsh conditions, while the existing vegetation's ability to tolerate burial—typically no more than 10 in. in a single lift—must be accounted for to avoid long-term ecological damage (USFWS Refuge Manager Experimental Findings 2015). Elevation targets should align with the optimal tidal range for the site's desired plant communities, ensuring the wetland remains resilient under projected SLR conditions. Access logistics, environmental constraints, and seasonal wildlife considerations will influence construction timing and techniques. Finally, permitting, and post-construction monitoring are critical to evaluate sediment performance, vegetation recovery, and ongoing adaptation potential.

4.3.2.4. Development of a Sediment Management Plan

Prior to permitting and implementation of any thin layers sediment deposition, an analysis of potential sediment donor sites and soil suitability must be undertaken. The plan would also include analysis of site access and sediment delivery methods as well as any regulatory constraints. This plan would developed as a precursor to importing any sediment that could be beneficially reused for wetland restoration and maintenance at the Preserve. The plan would establish strict sediment quality and grain size criteria as mandated by the regulatory agencies.

4.3.3. Protection (Engineering)

Protection involves the design and implementation of structural measures to prevent or reduce the impacts of coastal hazards (such as storm surge, wave attack, and SLR) on existing property, ecosystems, and infrastructure. The primary goal is to preserve the current existing amenities and protect assets behind it.

4.3.3.1. Raising the Elevation of the SAR Levee

Levees are critical components of flood risk management systems, acting as linear barriers that protect adjacent lands from tidal inundation, fluvial flooding, and storm surge. As SLR accelerates and extreme weather events become more frequent, existing levees—many of which were constructed decades ago—may no longer provide adequate protection for the populations, infrastructure, and habitats they were designed to defend. In many cases, raising the elevation of existing levees is a practical adaptation strategy to maintain or enhance their protective capacity over time. Elevation increases can delay overtopping, reduce the frequency of flooding, and buy time for other long-term adaptation measures to take effect (See Figure 14).

Raising the elevation of the SAR East Levee represents a potential regional adaptation strategy to manage increased flood risk driven by SLR and storm surge; however, this action lies outside the direct jurisdiction of the Preserve. Any such intervention would require close coordination with key stakeholders and agencies, including the USACE, Orange County Flood Control District (OCFCD), and the City of Newport Beach, among others. From a construction standpoint, levee raising typically involves widening the levee footprint, regrading slopes, compacting engineered fill, and potentially armoring or revegetating the new surface for durability and habitat compatibility. The feasibility of this approach depends on available space, existing utilities, regulatory approvals, and the degree to which existing design capacity has been exceeded. Additionally, raising the levee would benefit the Santa Ana River Trail (SART), which runs along the levee crown and serves as a heavily used recreational and commuter corridor. Any proposed design would need to preserve trail continuity, access, and safety—potentially through phased construction, detours, or reconfiguration of the trail alignment along the new grade. While this action is not a Preserve-led strategy, its implementation could provide critical regional protection benefits that indirectly enhance the long-term resilience of the Preserve and adjacent habitat corridors.

FIGURE 14. RAISE ELEVATION OF THE EXISTING LEVEE

4.3.3.2. Enhancements to Hydraulic Exchange Infrastructure

Enhancing the hydraulic exchange infrastructure at the Preserve would focus on modernizing and optimizing existing systems that regulate tidal flow (Figure 15), stormwater drainage, and internal water levels — key to both flood resilience and ecological function. This could include retrofitting or replacing the existing tide gates to improve their responsiveness during extreme high tides or storm events, ensuring reliable protection while maintaining tidal flushing critical for wetland health. Outlet drains and side drains may be regraded, resized, or equipped with tide-flex valves to reduce backflow, improve drainage efficiency, and prevent water stagnation in interior marsh zones. Storm drains discharging into the Marsh — particularly from adjacent urbanized areas like Newport Shores — could be fitted with more efficient sediment traps, backflow preventers, or low-impact design features to reduce pollutant loads and manage inflows more sustainably. Finally, culverts and interior hydraulic connectors may be reconfigured or expanded to restore flow between marsh zones, improving hydrologic connectivity and supporting marsh migration as part of a long-term adaptive management strategy. These upgrades, in combination, would build flexibility into the Preserve's water infrastructure and better align it with evolving SLR and habitat conditions.

FIGURE 15. EXAMPLES OF SELF-REGULATING TIDE GATES

4.3.3.3. Installation of Sluice Gates at Strategic Locations

As part of long-term adaptation planning, the installation of sluice gates at key hydraulic control points within the Preserve could offer added flexibility in managing tidal exchange, stormwater retention, and sediment movement. Strategically placed gates — particularly at culvert or channel inlet locations — can help modulate water levels, minimize backflow during extreme high tides, and regulate water levels to support habitat conditions under rising SLR scenarios (Figure 15). Sluice gates could also play a role in coordinating with regional sediment delivery, allowing for temporary closure or flow control during thin layer sediment deposition events. Their inclusion would need to be carefully evaluated based on ecological goals, hydrodynamic modeling, maintenance capacity, and compatibility with surrounding infrastructure.

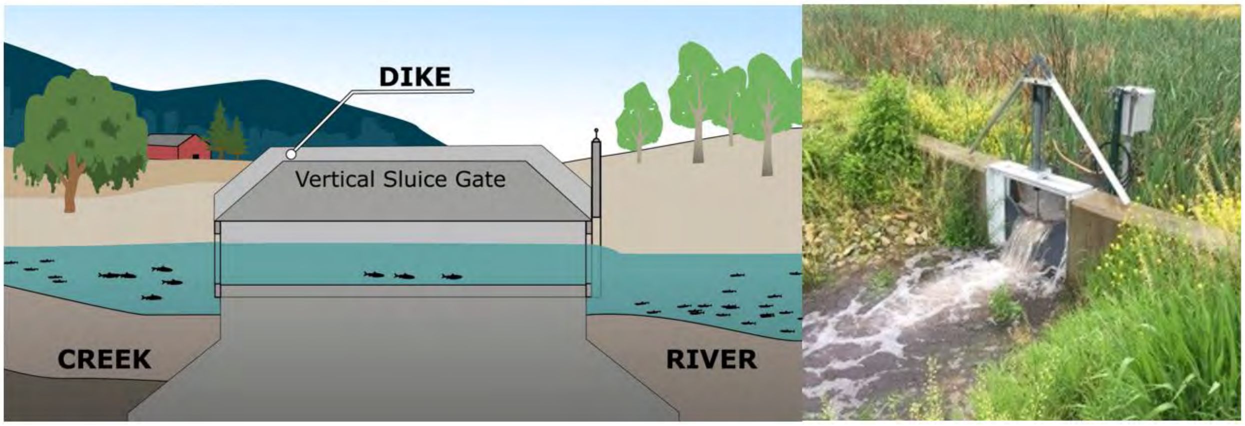


FIGURE 16. EXAMPLES OF A SLUICE GATE

4.3.4. Accommodation

Accommodation focuses on modifying existing structures and developments to withstand future SLR. This is typically achieved by elevating, retrofitting, or repurposing buildings that are exposed to coastal hazards. These measures often allow for the inland migration of SLR impacts, with fronting landscapes serving a sacrificial role.

4.3.4.1. Installation of Boardwalks

As part of a nature-compatible public access strategy, the Preserve may implement elevated boardwalks designed to float above sensitive marsh and transitional habitats, allowing for both ecological function and managed visitor experience. Unlike traditional at-grade trails, these structures would be installed on piles (typically timber) or low-impact footings, allowing sunlight, tidal flow, and vegetation to persist beneath the walkways (Figure 17). This approach minimizes trampling, soil compaction, and habitat fragmentation while enabling habitat migration in response to SLR. Strategically placed boardwalks would offer interpretive access across wetland, ecotone or regular levees, and upland zones while simultaneously supporting educational, recreational, and cultural goals without compromising ecological integrity. Where feasible, boardwalk elevations and spans could be varied to accommodate future sediment deposition operations or thin-layer sediment placement underneath. Overall, elevated boardwalks exemplify a low-impact adaptation solution that aligns visitor engagement with long-term habitat resilience.

4.3.4.1. Elevating Pedestrian Trails, Berms, and Boardwalks

A proposed resilience and access strategy at the Preserve involves constructing perimeter berms integrated with pedestrian trails and boardwalks, offering a dual function of passive flood protection and public recreation. These berms would frame key edges of the Preserve, particularly along low-lying zones, and serve as gentle, accessible walkways with panoramic views of the marsh. Initially designed at a modest elevation, the berms could be engineered with future adaptability in mind — allowing for staged elevation increases as SLR progresses. For the berms, this could involve designing the base width to accommodate additional lifts of engineered fill, incorporating geotextile reinforcement, or planning for modular trail surface adjustments over time. Vegetated side slopes would provide ecological value and erosion control, while alignment would be carefully planned to avoid sensitive habitat and accommodate marsh migration corridors. For the boardwalks, the decking could be elevated to adapt to increasing water levels while continuing to provide safe and dry access for the public (Figure 18). By embedding this elevation-flexible infrastructure, the Preserve can provide safe, engaging public access in the near term, while maintaining the ability to scale up protection in the long term as environmental thresholds are reached.

FIGURE 17. CONCEPTUAL RENDERING OF THE INSTALLATION OF BOARDWALK

FIGURE 18. CONCEPTUAL RENDERING OF ACCOMMODATION (ELEVATION OF BOARDWALKS, PATHS, ETC.) UNDER UNPROTECTED SCENARIO

4.3.5. Managed Retreat/Relocation

Managed relocation would promote the relocation, removal, and/or upslope migration of certain amenities in order to provide sufficient buffer for areas at high risk of coastal hazards, allowing natural processes to occur without interference.

4.3.5.1. Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities

For the Preserve, a managed retreat approach would involve the gradual relocation of vulnerable infrastructure — such as trails, service roads, utilities (if present), and interpretive elements — from low-lying, flood-prone areas to higher ground within the uplands. Rather than relying solely on engineered defenses, this strategy allows the landscape to naturally respond to SLR by making space for tidal marsh migration and increased inundation over time. As coastal conditions evolve, this approach supports long-term ecological resilience while minimizing future maintenance costs and damage to critical infrastructure. Managed retreat at the Preserve would be phased and adaptive; however, under any protected scenario, it is unlikely that hazard conditions would escalate to a level requiring full retreat.

4.4. Hybrid Strategies

4.4.1. Implementation of Multiple Strategies (*Over Time*)

A hybrid phased approach to coastal resilience allows different strategies to be implemented incrementally based on the progression of SLR-related hazards. By sequencing strategies across multiple time horizons, this strategy provides a framework for sites like the Preserve to evolve over time in response to changing coastal conditions and is later discussed in Section 6.

4.4.2. Implementation of Multiple Strategies (*Simultaneously*)

4.4.2.1. High Touch Wetland Restoration (Management Level 3) – The Habitat Approach

The high-touch restoration strategy within the Preserve represents a transformative hybrid SLR adaptation strategy with both engineering and nature-based solutions focused on reestablishing ecological function, hydrological connectivity, and long-term habitat resilience in the face of rising water levels and changing coastal dynamics. Historically, the Preserve's lowlands functioned as a dynamic floodplain influenced by both freshwater flows and tidal processes. However, legacy oil field activities and the channelization of the Santa Ana River for flood control have cut off the area from these vital inputs. As a result, the site is now hydraulically isolated and ecologically constrained.

A high-touch approach would restore tidal exchange by re-grading the lowlands to reintroduce tidal flow from the adjacent USACE-managed wetlands (Figure 19). This would include the excavation of a backbone network of subtidal channels, which would extend into newly established salt marsh platforms within the Preserve. Elevations would be carefully designed to support a range of habitat types—including low, mid- and high-marsh vegetation zones and transitional upland habitat surrounding capped oil wells. These higher-elevation areas would also function as future habitat migration corridors, helping the restored system adjust over time to projected SLR.

Vegetation establishment would be jumpstarted with native container plantings and could be supported by a temporary irrigation system for upland transitional zones to ensure early survival, growth, and reproductive success under variable environmental conditions. Over time, the restored marsh system would transition into a self-sustaining, tidally influenced ecosystem capable of absorbing SLR impacts while providing critical habitat, water quality benefits, and flood buffering. The Mesa Water District supplies reclaimed water, which could potentially be used as a water source for upland transitional and/or riparian zones.

FIGURE 19. PROPOSED HIGH TOUCH SCENARIO (HYBRID STRATEGY)

4.4.2.2. Elevating and Vegetating the Existing Levee – The Perimeter Approach

As SLR increases the frequency and severity of tidal flooding, raising protective features (such as the levee and/or berms) incrementally can extend their protective function, helping buffer interior wetlands and trails from encroaching water. Designing these elements with broad, gently sloped profiles creates opportunities for vegetated surfaces — including native grasses, shrubs, and transitional plant communities — that provide both erosion control and habitat value. These vegetated berms not only stabilize soil and improve water filtration but also serve as important corridors for wildlife and pollinators, creating a natural interface between marsh and upland environments. Over time, these features can be incrementally built up with additional sediment lifts or engineered fill as environmental thresholds are met. Their multi-functional design supports public access, shoreline resilience, and habitat continuity—positioning them as an adaptable and ecologically integrated SLR defense system for the Preserve. This measure can be implemented for existing berms and any proposed levee.

4.4.2.3. Elevating Access Paths + Thin Layer Sediment Deposition –Raising Internal Features Approach

A hybrid adaptation strategy that combines elevating access roads and paths with Thin Layer Sediment Deposition offers a balanced solution that supports both public use and ecological resilience at the Preserve. As SLR and higher groundwater levels increase the risk of frequent inundation and marsh submergence, raising existing access routes ensures that maintenance, monitoring, and recreational use can continue uninterrupted. At the same time, Thin Layer Sediment Deposition allows for targeted placement of clean, compatible sediment across low-lying wetland areas to gradually increase marsh surface elevation—helping existing vegetation within the lower elevation ranges stay within the optimal tidal range for survival and growth. Together, these actions preserve hydrologic function, facilitate marsh migration, and extend habitat viability without full reconstruction. Access routes can be elevated in phased lifts to match SLR projections, while sediment application can be done incrementally to reduce stress on plant communities. This integrated approach supports both human and habitat needs, allowing the Preserve to evolve with changing conditions while minimizing long-term disruption and maximizing adaptability.

4.4.3. Implementation of Multiple Strategies (*Holistically Integrated Approach*)

Rather than applying a single broad solution across the entire project site, the combined approach allows for adaptive interventions based on the unique physical conditions, exposure levels, and challenges of each area.

Figure 20 below illustrates a conceptual example of how combining various standalone strategies highlights how different strategies could be applied within the various areas of the project site, each suited to their localized conditions but with a connection to the overall vision. Note that the following examples are intended to illustrate potential conceptual approaches; final designs may vary based on further analysis, stakeholder input, and site-specific conditions. For instance, the Preserve could consider the following provided in Table 6.

TABLE 6. HOLISTIC INTEGRATED OPTIONS

Strategy	Segment/Area	Advantage
Ecotone Levee	Levee near Semeniuk Slough	Localized resilience for Industrial Way without the high cost of doing the whole site
Elevate Perimeter Pedestrian Trails and Berms	Berm bordering North Marsh	Provides resilience via elevation gain at most vulnerable lowland inundation areas
Ecotone Levee/Vegetated Berm	Berm dividing riparian and wetland areas	Provides resilience for large runoff flows and coastal hazards alike
Installation of Sluice Gates at Strategic Locations	At proposed riparian area and various South marsh locations	Boosts hydraulic exchange control within the site
Relocate Vulnerable Main Service Roads (ex. Industrial Way)	Lower portions of Industrial Way	Allows for only the main service roads to be relocated

FIGURE 20. CONCEPTUAL HOLISTICALLY INTEGRATED APPROACH

4.5. Summary of Analyzed Solutions

The following table provides a summary of each coastal adaptation strategy categorized by solution type, including Planning and Adaptive Management, Nature-Based Adaptation, Protection (Engineering), Accommodation, and Managed Retreat/Relocation. Each strategy includes a brief description outlining its purpose, mechanism, and relevance to enhancing the resilience of coastal resources and infrastructure. These strategies are intended to inform a flexible, site-responsive adaptation pathway for the Preserve in the face of SLR and evolving coastal hazards.

TABLE 7. SUMMARY OF PROPOSED STANDALONE STRATEGIES

Strategy Category	Strategy	Description
Planning and Adaptive Management	Strategic Partnerships	This involves building collaborative relationships between agencies, tribes, NGOs, academic institutions, and/or adjacent property owners to coordinate resilience planning and implementation. For the Preserve, this could strengthen alignment with regional plans and leverage shared resources for long-term adaptation.
	Identify Grant Funding Source(s) for Resiliency	Some funding sources for resiliency are already available (see Section 7), and in some instances, funders look for projects that provide a regional benefit. If the Preserve partnerships benefit from a collaborative approach then maybe there can also be a collaborative funding approach to finding and applying for grant funds.
	Monitor SLR	Monitoring SLR involves consistently tracking changes in sea level using data from various observational tools and leveraging agencies like NOAA. This type of monitoring is critical for understanding the local impacts of SLR, determining the rate of change, and identifying areas that are increasingly vulnerable to flooding or coastal hazards. At the Preserve, real-time data can track "triggers" and inform timely adaption pathways to avoid reactive emergency measures.
Nature-Based Adaptation	Wetland Restoration	Restoring degraded tidal wetlands to improve ecosystem services and promote biodiversity. At the Preserve, this can buffer flooding impacts while enhancing biodiversity and resilience of marsh ecosystems.
	Ecotone Levees	Levees are wide areas with raised ground that are constructed along coastlines to reduce the risks of flooding by presenting a physical barrier to the incoming floodwaters. "Ecotone " levees are hybrid levees with gentle, vegetated slopes (rather than steep armored sides) that support transitional habitats and reduce erosion. At the Preserve, they could replace existing berms to allow for migration of wetlands inland.
	Thin Layer Sediment Deposition	This strategy involves the targeted placement of small amounts of clean sediment across marsh or wetland surfaces to raise elevation and help natural systems keep pace with SLR. It mimics natural sedimentation processes and supports the vertical accretion necessary for tidal marshes to remain viable over time. At the Preserve, this could help maintain marsh elevation and vegetation health while only temporarily disrupting ecosystem function.
Protection (Engineering)	Raising the Elevation of the Levee	Increasing levee height provides greater protection from storm surge and tidal inundation. At the Preserve, the existing East SAR levee provides protection from hazards associated with SLR. Low crest elevations nearest the SAR mouth are vulnerable to hazards associated under 4.9 ft SLR if left unaltered. This strategy would need to be coordinated with regional partners but would greatly impact the site.
	Replacement or Enhancement of Hydraulic Exchange Infrastructure	This strategy involves upgrading or modifying existing water conveyance features—such as culverts, tide gates, storm drains, and outfalls—to improve tidal exchange, manage water levels, and enhance ecosystem resilience. At the Preserve, this is especially relevant given the presence of two tide gates on the SAR east levee, along with several culverts and stormwater outfalls that currently regulate hydrologic connectivity between the river, marsh, and adjacent lowlands.
	Installation of Sluice Gates at Strategic Locations	Sluice gates manage water levels by controlling tidal inflow at specific points. For the Preserve, this may offer flexible control over flooding in sensitive zones, especially where wetland function and access routes intersect.
Accommodation	Installation of Boardwalks	Elevated walkways allow public access through wetlands without damaging vegetation and provide passive flood resilience. At the Preserve, boardwalks could preserve trail connectivity even during seasonal or tidal inundation. Boardwalks also allow for channels and water sources to flow freely underneath them.
	Elevating Pedestrian Trails, Berms, and Boardwalks	Raising existing infrastructure prevents chronic flooding and improves safety/access. This is essential in the Preserve for maintaining public access and emergency response routes as sea levels rise.
Managed Retreat/Relocation	Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities	This entails moving infrastructure away from high-risk flood areas. For the Preserve, this could apply to vulnerable access roads or recreational facilities to ensure long-term usability without costly armoring. Because the site has enough space, any service roads (such as Industrial Way) could be re-routed to areas that are more protected and upland.

5. Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis of Adaptation Strategies and Alternatives

This section provides a comparative summary of the potential strategies, evaluating their respective pros and cons, effectiveness in mitigating coastal hazards, estimated construction and maintenance costs, and potential regulatory hurdles and legal challenges. These comparisons are intended to assess the viability of each solution if implemented as a stand-alone measure. Some of the identified limitations could potentially be addressed by implementing hybrid solutions (discussed previously in Section 4) as a more holistic approach to solve multiple problems with selective approaches.

5.1. General Overview

To further support decision-making and comparative evaluation of the proposed solutions, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis was conducted. This qualitative assessment summarizes the internal advantages and limitations (strengths and weaknesses), as well as the external factors that may present favorable conditions or pose potential challenges (opportunities and threats).

The SWOT framework provides an additional layer of insight to complement the technical evaluations presented above, supporting the selection and refinement of coastal resiliency strategies with each solution being evaluated based on the following criteria:

- **Pros and Cons**. Refer to Table 8.
- **Coastal Hazards Mitigation (Level of Protection)**. Tools were evaluated for their effectiveness in mitigating coastal hazards such as future SLR and groundwater emergence, both with and without elevation adjustments or further adaptation. See Table 10. Green shading indicates the most effective mitigation for a given hazard.
- **Probable Construction and Maintenance Costs.** Table 11 provides a relative comparison of construction and maintenance costs. These rankings and associated dollar symbols are not intended to represent exact cost estimates but serve as a relative cost comparison. The left column reflects relative construction costs, while the right column indicates relative maintenance costs (which will vary depending on the tool and frequency of maintenance). Darker shading and a greater number of dollar signs indicate higher costs.
- **Regulatory Hurdles/Potential Legal Issues.** Table 13 compares the relative difficulty of securing regulatory permits under current laws, along with the potential challenges related to property rights and ownership. Dark shading indicates increased difficulty in obtaining permits and resolving property rights/legal concerns.
- **Alignment with CRS Plan Goals.** Each strategy was evaluated based on its ability to support the primary goals identified in the CRS. These include restoring coastal processes and ecological function, planning for changing environments with resilient design, and increasing habitat connectivity while buffering human impacts. Strategies that directly advance one or more of these goals were prioritized for further consideration. See Table 14.

To support informed decision-making, each proposed strategy was evaluated using the above criteria to help drive the SWOT analysis. By pairing the SWOT framework with these technical assessments, decision-makers gain a more holistic understanding of each solution's feasibility and impact. This integrative approach ensures that both practical performance and implementation realities are factored into the selection and refinement of the most appropriate adaptation pathways.

5.2. Pros and Cons

Table 8 below provides a comparison of the Pros/Cons for each of the analyzed alternatives.

TABLE 8. COMPARISON OF SOLUTIONS (PROS AND CONS)

Strategy	Pros	Cons
Strategic Partnerships	✓ Strengthens coordination and resource sharing ✓ Builds regional support for resilience projects ✓ Facilitates information sharing	☒ Time consuming and requires long-term stakeholder commitment and engagement. Potentially requires a long lead up time to obtaining desired outcomes and results ☒ Success depends on sustained participation ☒ Partners might not agree to partner unless there is a mutual benefit or win-win scenario by taking a prescribed action
Monitor SLR	✓ Provides critical scientific data to inform adaptive triggers ✓ Low cost compared to hard infrastructure solutions	☒ Does not directly mitigate hazards—only informs decision-making ☒ Long-term funding for monitoring may be uncertain
Ecosystem Restoration	✓ A nature-based way to reduce flood risks while simultaneously fostering biodiversity and public access ✓ Many projects around Southern California to reference	☒ May require long establishment periods ☒ Regulatory permitting timeline (e.g., Clean Water Act Section 404) can be lengthy and expensive ☒ Engineering design and construction costs are high
Ecotone Levees	✓ Blends flood protection with habitat creation ✓ Allows for gradual upland wetland migration	☒ Higher upfront construction cost than traditional levees ☒ Requires larger footprint area or space than a berm or levee with steep slopes
Thin Layer Sediment Deposition	✓ Relatively low-impact, cost-effective way to maintain marsh elevation against rising sea levels ✓ Can use dredged sediment from nearby sources to benefit salt marsh	☒ Equipment access and constructability may pose a challenge and would have to be carefully thought out and planned ☒ Dredging is relatively expensive compared to land-based construction
Raising the Elevation of the SAR Levee	✓ Most direct and cost-effective way of providing protection against overtopping and storm surge caused by SLR ✓ Long-term resilience strategy	☒ High construction cost ☒ Could potentially require significant regulatory approvals (e.g., FEMA, USACE) and is out of the Preserve's jurisdiction
Enhancements to Hydraulic Exchange Infrastructure	✓ Improves ecosystem health and flood resilience ✓ Extends useful life of infrastructure without massive rebuilds	☒ High construction costs and more permitting effort for retrofits ☒ Needs detailed hydrologic studies and design reviews
Installation of Sluice Gates	✓ Offers adjustable control over tidal flows and floodwaters within the Preserve ✓ Protects infrastructure while maintaining some ecological function ✓ Can be integrated as part of an oil spill response plan	☒ Expensive to install and maintain ☒ Operational complexity; may require staffing or automation
Installation of Boardwalks	✓ Provides resilient public access even as water levels rise ✓ Impact to habitat can be minimized if well-designed	☒ Moderate construction cost; periodic maintenance (decking, supports) needed ☒ Coastal Commission permits and ADA compliance required ☒ Fragments habitat
Elevating Pedestrian Trails, Berms, and Boardwalks	✓ Maintains trail access and visitor experience during minor flooding or weather events ✓ Adds protection via vertical increases	☒ Higher construction cost than at-grade trails ☒ Requires additional planning and a more interconnected design ☒ Fragments habitat
Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities	✓ Reduces the long-term hazard exposure to these amenities ✓ Frees up open space for wetland creation, wetland migration, and nature-based design solutions	☒ High upfront planning and relocation costs ☒ Potential loss of public access or utility service if not carefully reconfigured
Hybrid 1: Full High Touch Scenario	✓ Strong dual benefit — wetlands absorb and purify floodwaters, boardwalks and berm pathways maintain resilient public access ✓ Likely strong agency and public support; regulatory complexity moderate (restoration permits, ADA for paths)	☒ Need coordination with multiple agencies (e.g., USACE, Coastal Commission), especially around wetland delineations and public access plans ☒ Slower to realize full flood protection compared to hard structures (time for wetland establishment)
Hybrid 2: Elevation + Vegetation	✓ Elevation provides immediate passive flood protection; vegetation stabilizes soil, adds ecological value ✓ Lower regulatory burden compared to levee construction; more likely to qualify as enhancement rather than new development	☒ Hauling/importing fill can become expensive depending on sourcing ☒ Potential impacts to existing wetlands could trigger mitigation requirements
Hybrid 3: Elevation + Thin Layer Sediment Deposition	✓ Supports both short-term protection (elevation) and long-term resilience (ecosystem adaptation) ✓ Seen favorably as "nature-positive" adaptation; could be easier to permit under beneficial reuse frameworks.	☒ Elevation gain from thin layer sediment alone may be incremental and require repeated applications ☒ Need sediment quality testing and possible water quality certifications

5.3. Hazard Mitigation Efficacy (Level of Protection)

Table 10 below provides a comparison of the effectiveness of each analyzed alternative as it pertains to mitigating hazards. Darker shades of green represent an increasingly effective mitigation for that particular hazard.

TABLE 9. LEGEND FOR TABLE 10

Legend	Hazard Mitigation Effectiveness
ΔΔΔ	Beyond 4.9 ft SLR
ΔΔ	Up to 4.9 ft SLR
Δ	Up to 1.6 ft SLR

TABLE 10. COMPARISON OF SOLUTIONS (HAZARD MITIGATION EFFICACY/LEVEL OF PROTECTION)

Strategy	Groundwater	Future SLR
Strategic Partnerships	ΔΔΔ	ΔΔΔ
Monitor SLR	ΔΔΔ	ΔΔΔ
Ecosystem Restoration	ΔΔΔ	ΔΔΔ
Ecotone Levees	ΔΔΔ	ΔΔΔ
Thin Layer Sediment Deposition	ΔΔ	ΔΔ
Raising the Elevation of the SAR Levee	ΔΔΔ	ΔΔΔ
Enhancements to Hydraulic Exchange Infrastructure	ΔΔΔ	ΔΔΔ
Installation of Sluice Gates	Δ	Δ
Installation of Boardwalks	ΔΔ	ΔΔ
Elevating Pedestrian Trails, Berms, and Boardwalks	ΔΔΔ	ΔΔΔ
Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities Upland	ΔΔ	ΔΔΔ
Hybrid 1: Full High Touch Scenario	ΔΔΔ	ΔΔΔ
Hybrid 2: Elevation + Vegetation	ΔΔΔ	ΔΔΔ
Hybrid 3: Elevation + Thin Layer Sediment Deposition	ΔΔΔ	ΔΔΔ

5.4. Probable Construction and Maintenance Costs

Table 11 below provides a rough comparison of the construction and maintenance costs associated with each solution. Darker shading and a greater number of dollar signs indicate higher costs. Note that these are not detailed opinions of probable costs but rather are provided to differentiate the different rough order of magnitude (ROM) probable costs for planning and decision-making purposes only.

TABLE 11. COMPARISON OF SOLUTIONS (PROBABLE CONSTRUCTION AND MAINTENANCE COSTS)

Strategy	Construction Cost	Maintenance Cost
Strategic Partnerships	$	$
Monitor SLR	$	$
Ecosystem Restoration	$$$	$$$
Ecotone Levees	$$$	$$
Thin Layer Sediment Deposition	$$$$	$$
Raising the Elevation of the SAR Levee	$$$$$	$$$$
Enhancements to Hydraulic Exchange Infrastructure	$$$$	$$$$
Installation of Sluice Gates	$$$	$$$$
Installation of Boardwalks	$$	$$
Elevating Pedestrian Trails, Berms, and Boardwalks	$$$	$$
Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities	$$$	$$
Hybrid 1: Full High Touch Scenario	$$$$	$$$$
Hybrid 2: Elevation + Vegetation	$$$	$$
Hybrid 3: Elevation + Thin Layer Sediment Deposition	$$$$	$$$$

5.5. Regulatory/Permitting

Table 13 below provides a rough comparison of the potential regulatory hurdles and potential legal issues associated with each solution. A legend for the table is provided below in Table 12. Darker shading indicates increased difficulty in obtaining permits and resolving property rights/legal concerns and relying on other agencies or outside stakeholders.

TABLE 12. LEGEND FOR TABLE 13

Relative Degree of Difficulty for Obtaining Regulator Permits	Legend	Relative Degree of Difficulty in Addressing Property Rights, Ownership Issues, Relying on Other Agencies, etc.
Impossible/Extremely Difficult	•••••	Lengthy Process
Very Difficult	••••	Very Difficult
Difficult	•••	Difficult
Challenging but Feasible	••	Challenging but Feasible
No Issues, within Current Preserve Boundaries	•	No Issues, within Current Preserve Boundaries
N/A to Stakeholders	N/A	N/A to Stakeholders

TABLE 13. COMPARISON OF REGULATORY HURDLE/POTENTIAL ISSUE DIFFICULTY

Strategy	Relative Degree of Difficulty for Obtaining Regulatory Permits	Relative Degree of Difficulty in Addressing Property Rights, Ownership Issues, Relying on Other Agencies, etc.
Strategic Partnerships	•	••
Monitor SLR	•	•
Ecosystem Restoration	••	••
Ecotone Levees	•	•
Thin Layer Sediment Deposition	••	•••
Raising the Elevation of the SAR Levee	.••	•••••
Enhancements to Hydraulic Exchange Infrastructure	••••	••••
Installation of Sluice Gates	•••	•••
Installation of Boardwalks	•	••
Elevating Pedestrian Trails, Berms, and Boardwalks	•	•
Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities	••	•
Hybrid 1: Full High Touch Scenario	••	••
Hybrid 2: Elevation + Vegetation	•	•
Hybrid 3: Elevation + Thin Layer Sediment Deposition	••	•••

5.6. Alignment with CRS Plan Goals

This section evaluates each proposed adaptation strategy based on its alignment with the goals outlined in the Coastal Resilience Strategy (CRS) Plan. Specifically, the assessment considers how well each strategy supports the three primary goals: (1) restoring coastal processes and maximizing ecological benefit, (2) designing for climate resilience and future environmental conditions, and (3) enhancing habitat connectivity and buffering against human-related impacts. Each strategy is qualitatively reviewed to determine whether it supports or does not support the objectives associated with these goals.

Table 14 below provides an additional layer of decision-making criteria to ensure that proposed solutions not only address physical risk but also contribute meaningfully to the long-term ecological and management vision for the Preserve. Strategies that directly satisfy each objective are designated with a checkmark ("✓"), while strategies that only partially or indirectly satisfy each objective are designated with a dot ("•"). Those that do not satisfy the objective are intentionally left blank. Objectives for each goal can be found in Section 1 of this report.

TABLE 14. SUMMARY OF EACH **STRATEGY'S** ALIGNMENT TO CRS GOALS AND OBJECTIVES

The Strategy	Goal #1: *Restore Coastal Processes and Functions to the Maximum Extent Possible for Ecological Benefit*				Goal #2: *Plan for Changing Environments and Designs for Ecological Resilience*				Goal #3: *Identify Opportunities for Contiguous Coastal Habitat Areas and Increase the Buffer between Sensitive Habitat and Sources of Human Activities*		
Objectives	*1.1*	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*2.3*	*2.4*	*3.1*	*3.2*	*3.3*
Strategic Partnerships	•	•	•	•	✓	•	•	✓	•	✓	•
Monitor SLR	•	•	•	•	•	•		✓	•	•	•
Ecosystem Restoration	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓
Ecotone Levees	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	•
Thin Layer Sediment Deposition	•	✓	✓	✓	✓	✓	✓	✓	•	•	•
Raising Elevation of the SAR Levee	•	•	•	✓	•			✓		✓	✓
Replacement or Enhancements of Hydraulic Exchange Infrastructure	•	•	•	✓	•	•		✓	✓		•
Installation of Sluice Gates	•	•	•	✓	•	•		✓	•		•
Installation of Boardwalks	√	•	•	✓	•	•			•	✓	
Elevating Pedestrian Trails, Berms, and Boardwalks	•	•	•	•	✓	•			•	✓	•
Relocation and Reconfiguration of Service Roads, Paths, and/or Facilities	•	•	•		✓				•	✓	✓
Hybrid 1: Full High Touch Scenario	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓
Hybrid 2: Elevation + Vegetation	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓
Hybrid 3: Elevation + Thin Layer Sediment Deposition	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓

5.7. Summary

The following table provides a comparative SWOT analysis summary between all the solutions presented in the previous section. Definitions for each of the SWOT elements are presented below:

- **Strengths:** What the strategy does well (e.g., strong hazard mitigation, ecosystem benefits, scalability)
- **Weaknesses:** Limitations (e.g., high cost, time to implement, maintenance burdens)
- **Opportunities:** External chances for success (e.g., grant funding, alignment with state/federal priorities, public support)
- **Threats:** Potential risks or barriers (e.g., permitting challenges, stakeholder opposition, climate uncertainties)

TABLE 15. SWOT ANALYSIS SUMMARY OF EVALUATED SOLUTIONS

Strategy	Strengths	Weaknesses	Opportunities	Threats
Strategic Partnerships	• Shared funding and expertise • Builds cross-agency trust	• Coordination complexity • Differing timelines or priorities	• Long-term collaboration • Joint grant opportunities	• Conflicting agendas • Delays due to partner misalignment
Monitor SLR	• Real-time data to inform action • Supports adaptive management	• Does not prevent damage • Needs consistent and proactive attention	• Informs thresholds for adaptation • Enhances long-term planning	• Data gaps • Inaction from prolonged monitoring
Ecosystem Restoration	• Improves resilience and biodiversity • Passive adaptation benefits	• Potential long lead time for ecological function • Sensitive to disturbances	• Supports habitat goals • Unlocks ecological funding	• SLR outpaces habitat establishment • Invasive species
Ecotone Levees	• Dual benefit: habitat + flood control • Supports transitional zones	• Requires wide footprint • Complex design	• Natural buffer integration • Increases flood attenuation	• Not enough funding • High permitting burden
Thin Layer Sediment Deposition	• Elevates habitat with minimal disruption • Encourages natural growth	• Requires sediment sourcing • Temporary impacts to existing habitat and vegetation	• Boosts habitat function • Enhances ecological resilience; • Nearby maintenance dredging activities	• Stringent permitting and testing process • Potential contaminants in sediment if not tested thoroughly
Raising the Elevation of the SAR Levee	• Direct flood defense • Protects area from severe storm events	• Expensive and visually intrusive • Out of the Preserve's direct jurisdiction	• Better preserves assets for longer time period • Opportunity to integrate ecotones	• No agency intervention will lead to devastating impacts (unlikely) • Funding
Enhancements to Hydraulic Exchange Infrastructure	• Restores tidal flow • Improves habitat quality	• Engineering-intensive • Needs agency coordination	• Enhances hydraulic exchange and water quality • Supports species movement	• Conflicting agendas amongst different stakeholders or agencies • Infrastructure vulnerability
Installation of Sluice Gates	• Flexible water control • Protects during storms and emergency oil spill situations	• Requires active management • Mechanical risks	• Balances flood protection and habitat access • Opportunity for emergency response protection to be adapted in broader response plan framework	• Gate failure • SLR may surpass gate height if not planned properly
Installation of Boardwalks	• Maintains and elevates access • Provides ability for channels to flow through wetlands without additional hydraulic infrastructure	• Can be expensive and have large impact footprint • Maintenance required	• Public education tool and ability to have informative signage • Scenic, ADA-friendly access opportunity	• Material degradation • More vulnerable to unprotected SLR hazards such as extreme storm flows (unlikely due to operational infrastructure)
Elevating Pedestrian Trails, Berms, and Boardwalks	• Maintains recreational use while accommodating future SLR • Creates long-standing resilience and public access	• Can be expensive if not planned properly • Visual obstruction and larger footprint	• Enhances public engagement • Resilient trail network	• Limited ecological benefit • High cost of retrofitting
Relocation and Reconfiguration of Service Roads, Paths, and/or Other Facilities	• Removes assets from high-risk zones • Opens space for restoration	• High upfront cost • Typically met with stakeholder resistance	• Enables long-term retreat • Avoids recurring damage	• Political pushback • Potential loss of public utility
Hybrid 1: Full High Touch Scenario	• Maximizes resilience and habitat connectivity • Comprehensive planning	• Potential long lead time for full ecosystem development and restoration • Multi-agency complexity	• Region-wide transformation • Eligible for high-level grants	• Execution challenges • Long implementation timeline
Hybrid 2: Elevation + Vegetation	• Integrates green infrastructure • Balanced risk reduction from both engineering and nature-based perspectives	• Requires ongoing maintenance and monitoring • More intricate design process	• Adaptable design • Supports ecological uplift	• Long implementation timeline • May underperform in extreme events in an unprotected scenario
Hybrid 3: Elevation + Thin Layer Sediment Deposition	• Ability to do more than once to accommodate SLR intervals • Enhances wetland function and resiliency in the long-term	• Logistics-intensive • Requires sediment access	• Scalable solution • Compatible with restoration goals	• Sediment sourcing limitations • Permitting delays

6. Preferred Adaptation Pathway

There is still significant uncertainty associated with when the SLR and storm surge projections may actually occur. The severity of future SLR largely depends on global efforts to decrease greenhouse gas (GHG) emissions and slow the effects of climate change. Because the adaptation planning timeline is looking forward 30 to 80 years and beyond, it is likely that the projections and science will change and that global policies will advance. To guide long-term decision-making, adaptation strategies are linked to a series of defined “triggers” rather than fixed timelines. These triggers represent measurable thresholds that, once reached, signal the need for implementation of specific adaptation actions. Examples of various trigger types include, but are not limited to:

- *Environmental Triggers* – Actual observed SLR benchmarks passing certain thresholds;
- *Operational Triggers* – Functional impacts to critical infrastructure such as overtopping or inundation of nearby critical infrastructure;
- *Biological Triggers* – Ecological shifts such as the decline or loss of key marsh vegetation communities.

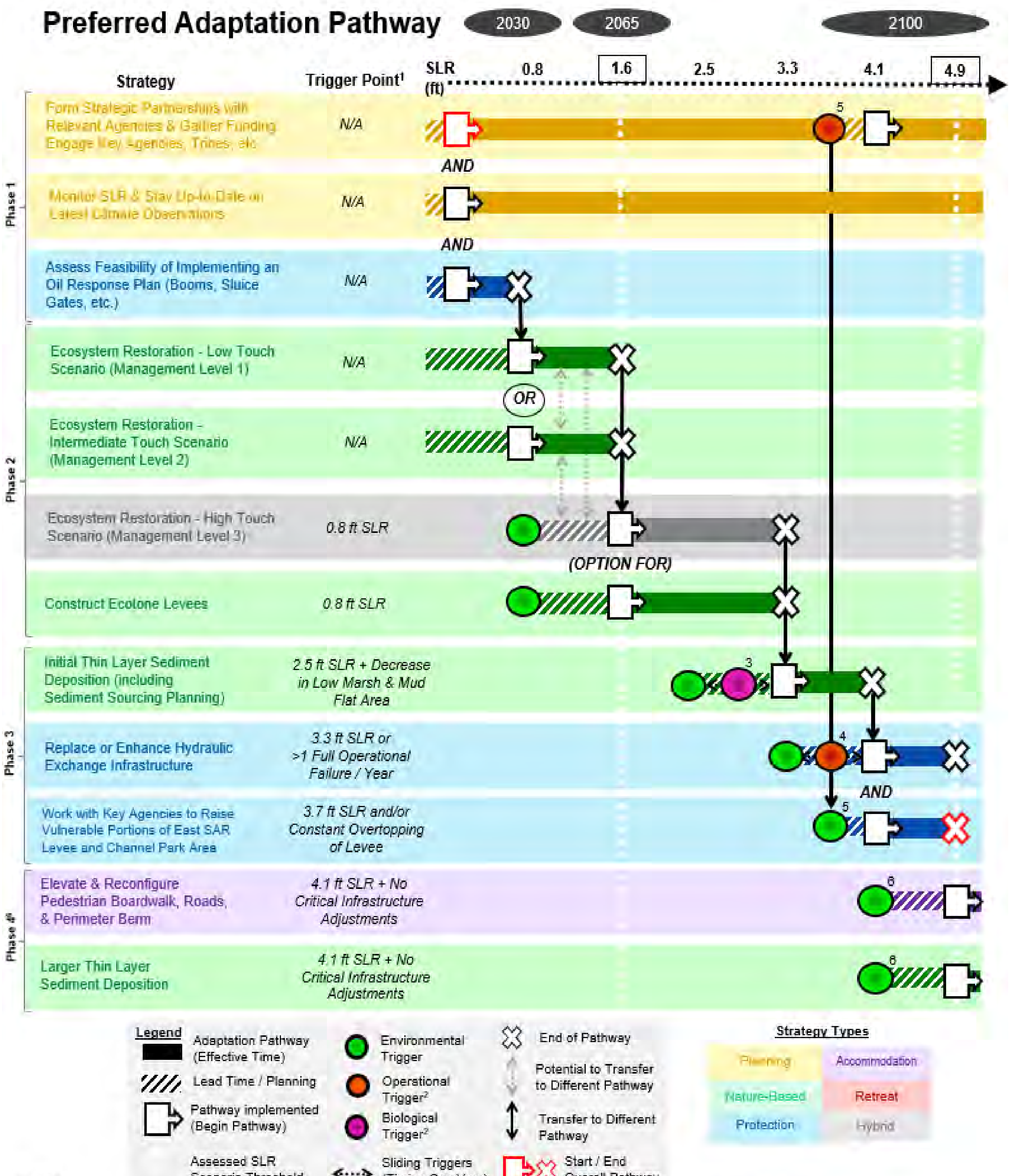
This trigger-based approach allows Preserve managers to make informed, responsive decisions as SLR materializes, enabling timely action based on real-world conditions rather than relying solely on projected future scenarios. The adaptation strategies are primarily presented as either/or options at different points in time, although in some cases more than one action could be taken for a given timeframe. Adaptation strategies are intended to build on one another once an earlier phase of the strategy ends or certain triggers occur. More advanced or aggressive strategies are triggered by higher levels of SLR. The exact timing of when those triggers will be reached is uncertain and requires constant monitoring.

The wants and needs of the local communities are likely to change as well, and planning efforts should offer the flexibility to adjust accordingly. For example, it is difficult for anyone to envision the major changes and improvements that may ultimately be required to protect the waterfront of the adjacent areas; however, these changes may present opportunities to enhance the features that attract people to the Preserve and uphold the qualities that residents love. For that reason, a range of potential future options are provided rather than a single set of solutions where possible.

Regardless of the uncertainty, adaptation planning is an important process to prepare decision makers and stakeholders for upcoming impacts and to implement strategies proactively. A long-term coastal resiliency strategy and adaptation plan should include the following core principles:

- Multiple Lines of Defense
- Flexibility to Adapt Over Time
- Integration of Green and Grey Infrastructure for Greater Resilience
- Multi-functional Solutions that Provide Broader Benefits

The following *Preferred Adaptation Pathway* for the Preserve is meant to be flexible and allow space to be revised over time as new information emerges, climate science advances, and community preferences evolve. The pathway provides an illustrative example of effectiveness at different planning horizons under the assumed *Intermediate-High* SLR scenario (Figure 21).



NOTES:

1. Trigger points indicate when to begin planning for implementation. This should be at least one (1) SLR scenario before projected impacts.
2. Operational and Biological Triggers are estimated based on proposed conditions and the best available science at the time of this report. In the case or scenario that the timing varies; pathway beginnings may be adjusted to accommodate changing conditions.
3. Biological trigger timing can vary. Thin Layer Sediment Deposition to occur once a noticeable decrease in low marsh and mud flat area occurs.
4. Operational Trigger timing can vary. Replacement or Enhancement of Hydraulic Exchange Infrastructure should occur at whichever trigger occurs first between 1.6 ft SLR or >1 operational failure / year of any hydraulic infrastructure.
5. Ensure agency & stakeholder coordination begins plan of raising the vulnerable portions of the East SAR Levee near the mouth and Channel Park in Newport Bay.
6. Phase 4 strategies only required in unlikely event that surrounding critical infrastructure does not receive retrofits from Agencies and Regional Stakeholders.

FIGURE 21. PREFERRED ADAPTATION PATHWAY FOR THE PRESERVE

TABLE 16. ADAPTATION PATHWAY SUMMARY

Phase		Pathway Strategy	Planning Horizon	Effective Horizon	Occurs If	Can Be Coupled With	Protects Until (Min.)	Likely?
1	A	Form Strategic Partnerships with Relevant Agencies and Gather Funding. Engage Key Agencies, Tribes, etc.	Now	Now to 2105+	N/A	All	2105+	Yes
	B	Monitor SLR and Stay Up to Date on Latest Climate Observations	Now	Now to 2105+	N/A	All	2105+	Yes
	C	Assess Feasibility of Implementing an Oil Response Plan (Booms, Sluice Gates, etc.)	Now	Now to 2045	N/A	1A, 1B, 2A, 2B	2105+	Yes
2	A	Ecosystem Restoration - Low Touch Scenario (Management Level 1)	Now to 2045	2045 to 2065	N/A	1A, 1B, 1C	2065	Yes
	B	Ecosystem Restoration - Intermediate Touch Scenario (Management Level 2)	Now to 2045	2045 to 2065	N/A	1A, 1B, 1C	2065	Yes
	C	Ecosystem Restoration - High Touch Scenario (Management Level 3)	2045 to 2065	2065 to 2085+	0.8 ft SLR	1A, 1B, 2D	2085	Yes
	D	Construct Ecotone Levees	2045 to 2065	2065 to 2085+	0.8 ft SLR	1A, 1B, 2C	2085	Yes
3	A	Initial Thin Layer Sediment Deposition (including Sediment Sourcing Planning)	2075 to 2085	2085 to 2095+	2.5 ft SLR + Decrease in Low Marsh and Mudflat	1A, 1B	2095	Yes
	B	Replace or Enhance Hydraulic Exchange Infrastructure	2085 to 2095	2095 to 2105+	3.3 ft SLR + >1 Full Operational Failure/Year	1A, 1B, 3C	2105	Yes
	C	Work with Key Agencies to Raise Vulnerable Portions of East SAR Levee and Channel Park Area	2090 to 2095	2095 to 2105+	3.7 ft SLR and/or Constant Overtopping at Levee	1A, 1B, 3B	2105	Yes
4	A	Elevate and Reconfigure Pedestrian Boardwalk, Roads, and Perimeter Berm	2095 to 2105	2105+	4.1 ft SLR + No Critical Infrastructure Adjustments	1A, 1B, 4B	2105+	No
	B	Larger Scale Thin Layer Sediment Deposition	2095 to 2105	2105+	4.1 ft SLR + No Critical Infrastructure Adjustments	1A, 1B, 4A	2105+	No

Phase 1 begins with foundational strategies already in motion, including forming strategic partnerships with relevant agencies and tribes (**1A**), maintaining alignment with the latest and most up-to-date SLR science (**1B**), and exploring emergency oil spill response measures (**1C**). These coordination-based actions are both feasible and crucial for long-term success. Importantly, these early-phase strategies will set the foundations and carry through the entirety of the Preserve's adaptation pathway.

Phase 2 focuses on ecosystem-based interventions that prioritize resilience through restoration. This includes Management Levels 1 and 2 — low and intermediate-touch ecosystem restoration strategies (**2A** and **2B**) — which aim to improve ecological function while maintaining most of the site's existing form and functions. These are likely to be implemented by 2045 and provide resilience benefits through at least 2065.

Management Level 3 (**2C**), however, represents a more transformative ecological strategy that are not technically required until 0.8 feet of SLR and is projected to remain effective through 2085+. This strategy extends protection to approximately 2085 and marks the transition point between nature-based solutions and more engineered interventions.

Phase 3 strategies are focused on infrastructure adaptations that become necessary as higher levels of SLR are observed, tide range decreases within the Preserve, and the lower wetland zones (mudflat and low marsh) increase in area while higher intertidal areas decrease. These include thin layer sediment deposition to offset marsh loss (**3A**), and replacement or redesign of hydraulic infrastructure (**3B**), such as culverts, tide gates, or levees. These strategies are not initiated until 2.5–3.7 ft of SLR is observed and the distance between the highest observed water levels and the top of the levee (freeboard) decreases to less than 2 feet at key levee points.

Phase 4 includes adaption measures such as raising pedestrian boardwalks and increasing the elevation of the Preserve's perimeter berms (**4A**) or undertaking larger-scale thin layer sediment deposition across the site to increase the marsh plain elevation and prevent the marsh from being submerged by SLR (**4B**). These adaptation measures are only triggered under extreme conditions i.e., 4.1 ft of SLR or more, assuming no prior infrastructure adaptation. However, Phase 4A is considered unlikely to be necessary due to anticipated regional interventions led by state, county, and local agencies. Specifically, agencies are expected to prioritize protection of major critical infrastructure such as the SAR levee and at residential areas like Channel Place Park in Newport Harbor - which lies at a lower elevation and is vulnerable to early SLR impacts.

The pathways are phased to allow for adaptive decision-making that aligns with real-world observations. Management Levels 1 and 2 form the backbone of near- and mid-term resilience and are covered by existing hazard modeling and environmental review. Management Level 3 represents transformational shifts in land use, requiring additional feasibility analyses, updated hydrologic modeling, and sustained investment. By coupling ecosystem-based restoration with engineered adaptations as needed, this adaptive approach extends resilience for decades while maintaining flexibility in the face of uncertainty about rising sea levels. It positions the Preserve to be both responsive to environmental thresholds and proactive in safeguarding critical natural and cultural resources.

7. Funding Opportunities for Implementing Resilience Strategies

A list of sources for financing projects that implement resilience projects is presented on the following page. Since some funding sources change over time, we recommend the list be maintained for tracking and updates.

Funding Entity	Funder Type	Grant	Purpose	Approximate Grant Award Value	Program Funding Interval	Match Required	Notes
California Coastal Conservancy	State Agency	Coastal Conservancy Grant Program	Provides funding for projects that restore and protect the California coast, expand public access to it, and enhance its resilience to climate change.	No set minimum or maximum, however, most grants will be from $200,000 -$5 million	Rolling	Not required but encouraged	Applications are accepted on a rolling basis and will be evaluated when they are received. Two-step process – the first step is to submit a pre-application. If a pre-application meets the Conservancy's eligibility criteria and there is available funding for the project, applicants will be invited to submit a full application. Coastal Conservancy Grants – California State Coastal Conservancy
Caltrans	State Agency	Climate Adaptation Planning Grant	Supports local, regional and Tribal identification of transportation-related climate vulnerabilities through the development of climate adaptation plans as well as project level adaptation planning to identify adaptation projects and strategies for transportation infrastructure.	$100,000-$1 M for a single organization, up to $1.5 M for partnership applications.	Annual	11.47% match required	Application deadline was January 22, 2025. Eligible primary applicants include MPOs, RTPAs, transit agencies, cities and counties, Native American Tribal Governments, Joint Exercise of Powers Authority, Local Transportation Authority. Eligible sub-applicants include Primary Applicants, Universities and Community Colleges, Community-Based Organizations, Non-Profit Organizations (501.C.3), Other Public Entities* $31.9 M available. Sustainable Transportation Planning Grants | Caltrans Contact: Julia Biggar, Caltrans Julia.Biggar@dot.ca.gov

Funding Entity	Funder Type	Grant	Purpose	Approximate Grant Award Value	Program Funding Interval	Match Required	Notes
Wildlife Conservation Board	State Board	Habitat Enhancement and Restoration Program	Provides funding for projects that involve habitat restoration to protect wildlife values and habitat.		Rolling	Not required	Pre-applications are accepted on a continuous basis. Habitat Enhancement and Restoration Program (ca.gov)
National Oceanic and Atmospheric Administration	Federal Agency	Coastal Habitat Restoration and Resilience Grants for Underserved Communities	Supports projects that will advance the coastal habitat restoration and climate resilience priorities of tribes and underserved communities, support community-driven habitat restoration and build the capacity of tribes and underserved communities to more fully participate in restoration activities.	$75,000- $2,000,000	Annual	Not required	Deadline for 2025 funding is May 12, 2025. $20 million in funding available. Coastal Habitat Restoration and Resilience Grants for Underserved Communities | NOAA Fisheries Contact: underserved.community.grants@noaa.gov
National Oceanic and Atmospheric Administration	Federal Agency	Transformational Habitat Restoration and Coastal Resilience Grants Under the Bipartisan Infrastructure Law	Supports transformational habitat restoration projects that restore marine, estuarine, coastal, or Great Lakes ecosystems, using approaches that enhance community and ecosystem resilience to climate hazards.	$750,000- $10,000,000 over 3 years	Annual	Not required but encouraged	Application deadline for 2025 was April 16, 2025. $100 million was available Eligible applicants are institutions of higher education, non-profits, for profit organizations, U.S. territories, and state, local, and tribal governments. Transformational Habitat Restoration and Coastal Resilience Grants | NOAA Fisheries Contact: resilience.grants@noaa.gov
National Fish and Wildlife Foundation	Non-Profit	National Coastal Resilience Fund Grant Program	Seeks to restore, increase and strengthen natural infrastructure to protect coastal communities while also	Planning and Design: $100,000 - $1 million Implementation:	Annual	Not required but encouraged	Pre-proposal deadline is May 6, 2025. Full proposals by invitation only due July 17, 2025.

Funding Entity	Funder Type	Grant	Purpose	Approximate Grant Award Value	Program Funding Interval	Match Required	Notes
			enhancing habitats for fish and wildlife.	$1 million- $10 million			National Coastal Resilience Fund | NFWF
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8. Gathering and Sharing Information

Inspired by NOAA's Climate Program Office, the CRS will recommend enhancements to the Preserve Website – to include a portal or web page where the public can access important information and tools that help keep the Preserve resilient. This strategy involves the development and sharing of science-based information and planning decisions to inform the coastal communities and advance the resilience of and coastal\marine ecosystems.

9. Conclusion and Recommendations

Based on the evaluation of resilience strategies (Section 4), SWOT analysis (Section 5), and the development of the adaptation pathway (Section 6), this Coastal Resiliency Strategy recommends a phased, hybrid approach to adaptation that supports both ecological restoration and public access while planning for future SLR conditions.

- The strategy begins with Phase 1, which consists of early actions already underway or readily achievable —such as continued coordination with regional partners, ecological monitoring, and maintenance of the Preserve's foundational infrastructure. These actions establish a strong base for future adaptation while supporting immediate resilience and habitat stewardship in the *near term*.
- Phase 2 focuses on nature-based restoration strategies that align with Management Levels 1 and 2, including ecosystem uplift through vegetation management, thin-layer sediment deposition, and strategic grading. These actions enhance tidal connectivity and habitat health without significant topographic change and are compatible with current use and access conditions.
- Phases 3 and 4 also include nature-based and hybrid strategies and represent longer-term, higher-touch activities that have longer planning horizons. This includes potential mass grading and tidal reconnection to adjacent USACE-managed wetlands, which would reestablish tidal exchange and support marsh function at the Preserve. These high-touch strategies are not assumed to be immediately necessary but are included in the pathway to support planning, permitting, and phased readiness—ensuring the Preserve can respond effectively if and when conditions call for more transformative change.

Throughout all phases, the pathway recommends that infrastructure — such as berms, trails, and boardwalks — be designed with elevation flexibility in mind. These design elements serve both recreational and functional needs and can be adapted incrementally as SLR conditions evolve. Ultimately, the recommended pathway supports a layered, dynamic approach to adaptation that enables the Preserve to evolve in step with environmental factors, avoids premature overdesign, and aligns with broader regional efforts. The strategies in this document were developed to begin the planning for the technical, regulatory, and partnership groundwork that will be necessary to ensure the Preserve remains resilient for generations.

CoSMoS Modeling results indicate that the Preserve is highly protected. However, localized flood hazards could impact the project site and surrounding areas under long-term SLR projections—particularly during extreme storm events and if existing infrastructure is not maintained or upgraded.

The Preserve is unique in that its habitat will not feel the effects of rising sea levels for several decades (until greater than 4 feet of SLR occurs). This makes resiliency feasible inside the lowlands, but it also makes resiliency highly dependent on the infrastructure that protects it. The vulnerability of coastal resources at the Preserve varies significantly depending on the presence or absence of existing infrastructure and protection provided by the Santa Ana River East Levee and the existing tide gates that provide a hydraulic connection to the Santa Ana River.

<u>Key Findings:</u>

- Flood exposure remains minimal under all protected scenarios, assuming the tide gates and existing hydraulic structures remain fully functional. However, under higher SLR scenarios, the site's resilience is highly dependent on the continued operability of this infrastructure to prevent significant inundation.
- The surrounding infrastructure that protects the Preserve makes it possible to integrate nature-based and holistic designs at all scales within the lowlands.
- Groundwater emergence is expected to increase significantly under higher SLR scenarios, particularly in the low-lying freshwater marshes and riparian areas of the Preserve. Under existing conditions, groundwater remains below the surface in most areas. However, as SLR reaches 1.6 ft, isolated areas—especially in the southern and central lowlands—may begin to experience shallow groundwater close to the surface, potentially causing soil saturation, changes in plant community composition, and infrastructure degradation. Under the 4.9-foot SLR scenario,

groundwater is projected to emerge at the surface in many low-lying areas, even without direct coastal flooding. This includes areas that are otherwise protected from surface water inundation by tide gates or levees.

- Under a 4.9 ft SLR scenario combined with a 100-YR storm event, the site is projected to experience widespread flooding in an unprotected condition (i.e., without agency-led improvements to infrastructure along the SAR, Newport Bay, or PCH). This includes inundation of wetlands, floodplains, and nearby infrastructure, as well as backflow through storm drains and utilities, which could compromise drainage systems and lead to localized flooding.
- Within the project site, lowland areas are projected to be more at risk of widespread inundation under scenarios in which the existing infrastructure fails and little to no agency intervention occurs, which is unlikely.
- Under the *Protected* scenario, most resources exhibit low to moderate overall vulnerability, due to reduced hazard exposure from tidal inundation and storm surge. This includes critical infrastructure such as storm drains, utilities, and natural vegetation, which benefit from the function of the tide gates and structural protections. In contrast, the Unprotected scenario shows a marked increase in vulnerability across nearly all asset categories. Lowland development, stormwater infrastructure, and recreation amenities show high overall risk, driven by increased hazard exposure and limited adaptive capacity.
- This distinction reflects the differing levels of exposure to SLR-related hazards such as tidal inundation, storm-driven flooding, and groundwater emergence, and allows for a more accurate evaluation of risk based on site-specific conditions and infrastructure performance.

Recommendations:

- Proceed with improvements planned for the Preserve but develop relationships with the agencies responsible for maintaining and operating the SAR East Levee and tide gates at North Marsh and South Marsh.
- Due to its regional setting, consider the Preserve’s potential for tidal flows and connectivity to the adjacent USACE wetland projects and Talbert Regional Park (South) to increase the overall coastal wetland acreage and open space in this region.
- Periodically track tide levels at West Newport Harbor to see if the coastal area within the vicinity of Channel Park Place begin to experience the effects of rising tide levels. Nature will provide specific environmental cues such as loss of beach area or flooding of the beach park, public sidewalks, and streets (River Avenue and Channel Park Place). If flooding begins to emerge in this area, that is a trigger to start planning for rising sea level.
- Apply for grants to support wetland creation, enhancement, and resiliency.
- Create a portal on the Preserve website where SLR science and planning information about the Preserve can be shared with the public.
- This document provides land managers of the Preserve with a roadmap of activities to implement. It presents a series of measures that could be planned and initiated as standalone projects or in combination with other ones. Before adopting and implementing any pathways and measures described in this report it is recommended that the public and State and Federal agencies be involved in the planning process.

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Appendix A
Final SLRVA

moffatt & nichol

FRANK AND JOAN RANDALL PRESERVE

Sea Level Rise (SLR) Vulnerability Assessment

FINAL REPORT

Produced For Coastal Corridor Alliance (CCA), Mountains and Recreation Conservation Authority (MRCA), & Dudek&

Date: 5/5/2025

Document Verification

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Glossary

AHT	Annual High Tide
AR6	Sixth Assessment Report
CCA	Coastal Corridor Alliance
CCC	California Coastal Commission
CoNED	Coastal National Elevation Database
CoSMoS	Coastal Storm Modelling System
CRS	Coastal Resilience Strategy
cm	Centimeters
DTL	Mean Diurnal Tide Level
ENSO	El Niño and the Southern Oscillation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
ft	Feet
GIS	Geographic Information Systems
GSW	Global Surface Warming
HAT	Highest Astronomical Tide
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HOT	Highest Observed Tide
HOWL	Highest Observed Water Level
in.	Inches
IPCC	International Panel of Climate Change
Int	Intermediate
Int-High	Intermediate-High
ITF	Interagency Task Force
k	Hydraulic Conductivity
LAT	Lowest Astronomical Tide
LCP	Low-Confidence Processes
LF	Linear Feet
LOWL	Lowest Observed Water Level
LSARSM	Lower Santa Ana River Salt Marsh
m	Meters
MHW	Mean High Water

MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MRCA	Mountains Recreation and Construction Authority
MSL	Mean Sea Level
MTL	Mean Tide Level
NAVD88	North American Vertical Datum of 1988
NFAT	NASA Flooding Analysis Tool
NFHL	National Flood Hazard Analysis
NOAA	National Oceanic and Atmospheric Administration.
OCFCD	Orange County Flood Control District
OCOF	Our Coast Our Future
OPC	State of California Ocean Protection Council
PAP	Public Access Plan
PCH	Pacific Coast Highway (Highway 1)
RMP	Resource Management Plan
SAR	Santa Ana River
SART	Santa Ana River Trail
SARWQB	Santa Ana Regional Water Quality Control Board
SFHA	Special Flood Hazard Analysis
SIM	Static Inundation Modelling
SLR	Sea Level Rise
SLRVA	Sea Level Rise Vulnerability Assessment
SRT	Self-Regulating Tide
sq ft	Square Feet
SWL	Still Water Level (ft, NAVD88)
TAEP	Tribal Access and Engagement Plan
TPL	Trust for Public Land
TWL	Total Water Level (ft, NAVD88)
USGS	United States Geological Society
USACE	U.S. Army Corps of Engineers
VHE	Very High Emissions
WL	Water Level
YOI	Year of Inflection

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This study is qualified in its entirety by, and should be considered in light of, these limitations, conditions and considerations.

1. Introduction

1.1. Project Overview

The Frank and Joan Randall Preserve ("Preserve"), previously known as Banning Ranch, and its Tribal name to be determined, offers one of the most significant ecological and scenic landscapes along the Southern California coastline. In December 2022, the Trust for Public Land (TPL), in partnership with the Mountains Recreation and Conservation Authority (MRCA) and the Coastal Corridor Alliance (CCA, formerly the Banning Ranch Conservancy), successfully completed the acquisition of 387 acres of land. This acquisition was made possible through the decades-long dedication of the Tribal and local communities, who advocated for the land's preservation. These efforts, combined with TPL's six-year, $97 million conservation campaign, culminated in protecting this vital coastal area. With its protection, a new phase of community-driven public and Tribal access planning began. The acquisition was significantly supported by a generous donation from Frank and Joan Randall, in addition to public funding from various entities including the Wildlife Conservation Board, California Natural Resources Agency, State Coastal Conservancy, U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Wildlife. As part of the agreement, MRCA took title to the property and the responsibility of developing a comprehensive management plan. The comprehensive management plan includes a Resource Management Plan (RMP) and a Tribal Access and Engagement Plan (TAEP), for which the goal is to inform a Public Access Plan (PAP). Additionally, the CCA, as a project partner, secured funding to develop plans, alongside a Coastal Resilience Strategy (CRS), which must be completed by December 2025.

As an active oil field since World War II (Trust for Public Land, 2022), the property is currently undergoing an extensive two- to three-year remediation process, managed by the previous oil operator and overseen by the Santa Ana Regional Water Quality Control Board (SARWQCB). As part of this process, this Sea Level Rise Vulnerability Assessment (SLRVA) document will serve as a portion of the greater CRS that informs the PAP and RMP.

1.2. Study Approach

This SLRVA for the Preserve assesses potential impacts to the Project area across multiple sea level rise (SLR) scenarios. Analyses first focus on the extent to which local coastal hazards change under multiple SLR and storm scenarios. The overlap of projected future hazard zones and the Project area is then used to identify potential future vulnerabilities and the SLR thresholds at which the Project could be impacted. Key questions that guide the SLRVA are illustrated in Figure 1 below.

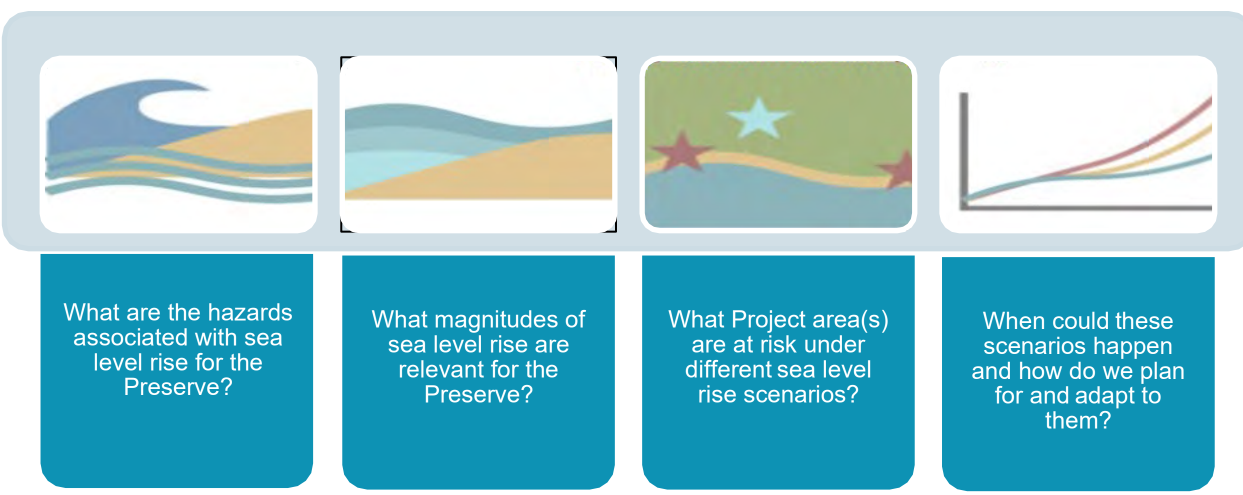


FIGURE 1: KEY QUESTIONS USED TO GUIDE THE SEA LEVEL RISE VULNERABILITY ASSSESSMENT

The vulnerability of the Preserve to future SLR hazards is evaluated through an analysis of hazard exposure, sensitivity, and adaptive capacity. Within this assessment, exposure refers to the type, duration, and frequency of coastal hazards to a specific resource under a given SLR scenario. Sensitivity represents the degree to which a resource is impaired by exposure to coastal hazards. Adaptive capacity refers to the ability of a resource to cope with changes in coastal hazards over time. The SLR projections used within this study are discussed in Section 3. A discussion of the specific coastal hazard analysis methodologies used within the study can be found in Section 4. SLR hazard vulnerability results are discussed in more detail in Section 5.

1.3. Project Study Area

The project site and study area for the Preserve, which is managed by MRCA, are shown in Figure 2 . Located at the lower reach of the Santa Ana River (SAR) between the cities of Costa Mesa and Huntington Beach, the Preserve is situated in a prime underdeveloped coastal area within the City of Newport Beach, California, spanning approximately 387 acres of diverse landscapes. Positioned just inland from the Pacific Ocean, it is bordered by the Santa Ana River Salt Marsh to the northwest and adjacent to the SAR, with its southern edge near Pacific Coast Highway (PCH). The Preserve lies near popular coastal destinations such as Huntington State Beach to the west and City of Newport Beach to the south. This expansive area includes a mix of coastal bluffs, wetlands, riparian, arroyos and upland grasslands with vernal pools, making it one of the last remaining large open spaces along the coast of Orange County's heavily developed coastline. The Preserve offers sweeping views of the Pacific Ocean and provides an opportunity for the site to be restored as an ecological and recreational resource, providing critical habitat for endangered species (such as migratory birds and endangered species) while offering future opportunities for public access and nature education. Being at the intersection of a coastal and riverine environment gives the site a unique and valuable ecological footprint, which is integral to its coastal resiliency and the environmental health of the greater region.

The site condition is highly disturbed due to oil facilities and access roads that were constructed for oil extraction purposes. The elevation of the existing terrain influences hydrological flow patterns, causing upland rainfall to drain into naturally occurring ponded water basins distributed throughout the site. The landscape features two distinct elevation zones, transitioning from *lowlands* (approximately 137 acres ranging +4 to 15 feet [ft] North American Vertical Datum of 1988 [NAVD88]) to *uplands* (approximately 250 acres ranging from +15 ft to +100 ft NAVD88). As the elevation increases, lowlands transition to coastal bluffs and arroyos, which are embedded in upland areas and serve as the natural drainage pathways for upland runoff. The lowlands function as a hydrological buffer, facilitating the movement of water between existing hydraulic connections and natural upland drainage basins, which help regulate site-wide water retention and discharge. Perennial flows and stormwater runoff from the arroyos and uplands replenish the lowlands with nutrients and sediment, which helps sustain the existing habitat for a variety of species. Due to the existing topography, some of the site remains above the tidal range and the lowlands are comprised largely of large expanses of non-native ruderal vegetation and freshwater riparian areas or areas that were disturbed by the construction of oil roads and the oil field.

FIGURE 2: PROJECT SITE AND STUDY AREA

Flood control projects along the lower reach of the SAR in combination with the North Marsh and South Marsh restoration projects undertaken by the United States Army Corps of Engineers (USACE) have changed the hydrological interactions between the Preserve and the SAR, but the connection is still central to the ecological dynamics of the lowlands. Currently, two (2) self-regulating tide (SRT) gates limit the larger tides and control the amount of water entering the marsh during high flooding events (Figure 3). The river levee also plays a key role in protecting the Preserve. It is critical infrastructure that functions as a barrier to storm surge while also allowing the Preserve to drain, helping to mitigate inland flooding. This is an important hydrological relationship that must be maintained if the site is to remain resilient to the impacts of rising sea levels. Without the existing critical infrastructure, sea levels rise and tidal influence from the Pacific Ocean is expected to move farther upstream, increasing the likelihood of tidal backflow into the wetlands and low-lying areas of the Preserve, particularly during high tide and storm surge events. If the levee is allowed to overtop, this would result in frequent flooding and increased salinity in the freshwater systems, potentially disrupting the existing balance of freshwater and brackish ecosystems in the lowlands. Additionally, the SAR's sediment supply will become increasingly critical in combating rising seas that erode coastal areas. The sediment that accumulates inside the river is a prized resource that can be used to raise the elevation of coastal wetlands and stabilize the shoreline. As such, managing the Preserve's interaction with the river is essential for ensuring the long-term resilience of both the wetlands and upland ecosystems in the face of evolving hydrological pressures.

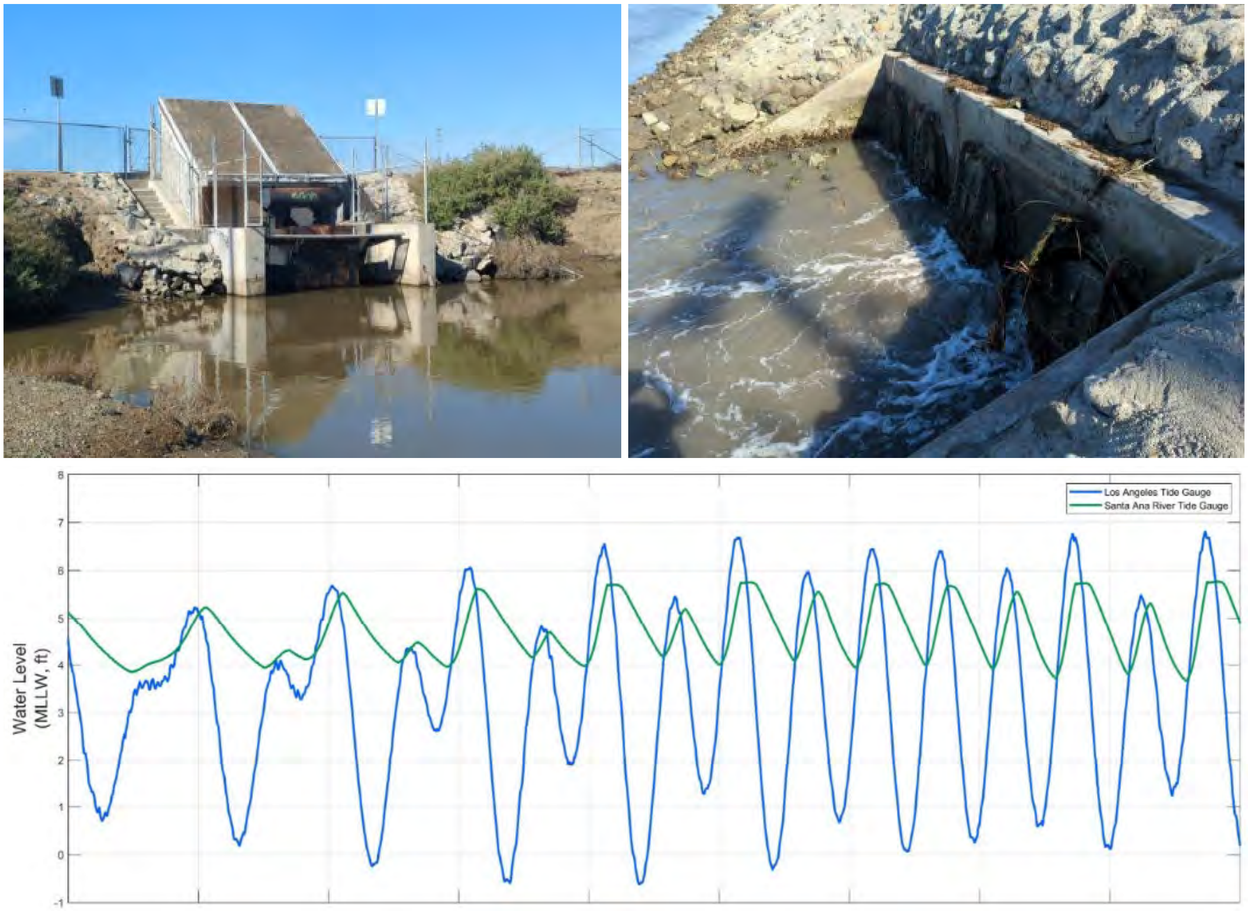


FIGURE 3: (TOP LEFT) TIDE GATE OF UPPER MARSH IN OPEN POSITION, (TOP RIGHT) LOWER SAR OUTLET GATES, & (BOTTOM) WATER LEVEL TRUNCATION WITH PROJECT AREA DUE TO TIDE GATES FROM RECENT TIDAL REPORT (COASTAL FRONTIERS, 2023)

1.4. Coastal Resource Inventory and Site Features

The coastal resources defined in this assessment come from topographic survey and Geographic Information Systems (GIS) data with additional assets determined through analysis of aerial imagery provided by Dudek. The inventory of coastal resources and specific assets within or adjacent to the Preserve were analyzed in this study and are summarized in Table 1. Resources beyond the project boundary that play a critical role in site flooding are also included in the analysis. Further discussion on each resource is provided later in Section 6.

TABLE 1: COASTAL RESOURCE INVENTORY

Resource Category	Resource	Specific Assets	Within Defined Project Boundary	Data Source
Existing Vegetation & Habitat	*Existing Preserve Vegetation*	Open Space Vegetation of the Preserve	Yes	City of Newport Beach GIS, 2024 Dudek Survey
	Submerged Waterways	Lower Santa Ana River Salt Marsh SAR	No No	City of Newport Beach GIS
	Uplands	Coastal Bluffs & Arroyos	Yes	City of Newport Beach GIS
	USACE Salt Marshes	North Marsh (USACE Project) South Marsh (USACE Project)	No No	Final Environmental Assessment[2]
Critical Infrastructure & Development	*Hydraulic Infrastructure*	Levee Tide Gate Facilities Culverts Outlet Drains / Gates	No No Yes No	As-Builts[3], 2024 Dudek Survey
	Lowlands Development	Bulkhead Walls Oil Operator Facilities Other Development Areas[1] Staging / Laydown Areas Fencing	Yes Yes Yes Yes Yes	City of Newport Beach GIS
	Upland Development	Site Access Area / Parking	Yes	City of Newport Beach GIS
	Major Roadways	Pacific Coast Highway	No	City of Newport Beach GIS
	Service Roads	Industrial Way Oil Operator Service Dirt Roads Access Bridge (at North Marsh)	Yes Yes No	City of Newport Beach GIS
	Residential Areas	Upper Newport Bay Residential Area	No	City of Newport Beach GIS
Utilities	*Existing Site Utilities*	Storm Drain Utilities (Storm Drains, Sewage and Catch Basins) Electrical Utilities (with Overhead Power Transmission Lines) Existing Oil Piping[1] Easements	Yes Yes Yes Yes	City of Newport Beach GIS
Recreation & Public Access	*Recreation & Public Access*	Future Public Access Trails & Access Amenities SART Pedestrian Trail	No No	City of Newport Beach GIS

Notes:
1. To be demolished prior to the commencement of the project
2. Lower Santa Ana River Channel As-Built Drawings (USACE 1991)
3. Final Environmental Assessment: Santa Ana River Marsh Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual (USACE, 2024)

The Preserve is surrounded by a diverse mix of land uses that protect the site from coastal hazards such as wave attack during large storms and coastal flooding (Figure 4). To the north, residential neighborhoods, commercial zones, and Talbert Regional Park in Costa Mesa border the site, showcasing the region's urban character. To the northeast, open space transitions into Newport Beach's coastal bluffs, residential development, and scenic views with natural connections to the coastline. To the south, the USACE South Marsh restoration project, Lower Santa Ana River Salt Marsh (or LSARSM), PCH, recreational beaches at West Newport Beach, and the neighborhood of West Newport Beach buffer the Preserve from coastal hazards. Access roads (such as an access road that parallels LSARSM and Industrial Park Way) intersect with the eastern levee at SAR and at PCH. To the west, the USACE North Marsh and the SAR forms the boundary between the Preserve and the City of Huntington Beach

FIGURE 4: OBLIQUE AERIAL PHOTOGRAPHY OF THE PROJECT SITE (DUDEK, 2024)

1.4.1. Existing Vegetation and Habitat

The USACE wetland restoration and mitigation sites ("North Marsh" and "South Marsh" Projects) are part of the Santa Ana River Mainstem Project. The USACE set aside 8 acres as mitigation and 84 acres for restoration for a total of 92 acres of restored wetlands. This initiative focused on flood control, habitat restoration, and ecological compensation for impacts associated with flood control improvements and river management. The South Marsh includes the LSARSM, where tidal flows have been reestablished to create habitats for protected species. These two restored areas enhance regional biodiversity, improve water quality, and highlight successful integration of ecological preservation with critical infrastructure resilience.

LSARSM and the North and South Marshes contain rare coastal salt marsh habitat that supports a unique blend of salt-tolerant vegetation (including pickleweed and cordgrass), which provide essential breeding and foraging grounds for birds, fish, and invertebrates. For example, the "Least Tern Island" at South Marsh is a sand-capped island designed specifically to support nesting habitat for the endangered California least tern (see Figure 5).

FIGURE 5: (LEFT) LEAST TERN ISLAND IN SOUTH MARSH, & (RIGHT) INTERIOR CHANNEL VEGETATION NEAR USACE MITIGATION SITE

Within the Preserve itself, large expanses of ruderal vegetation communities mixed with some stands of native vegetation are present. These vegetative communities include Encelia Californica (~28 acres), Baccharis Salicifolia (~27 acres), Non-Native Grasslands (~17 acres), and Coastal Prickly Pear Scrub (~16 acres). These native and non-native communities rely on the site's existing hydrological regime, which plays a large role in how plant communities are distributed at the Preserve.

Another feature of the Preserve is its connection to the uplands and coastal bluffs, which rise above the wetlands and offer spectacular views of the coastline. These bluffs, however, can be susceptible to erosion from inland runoff. With SLR and more frequent extreme weather events, these areas may face the risk of increased erosion, slope destabilization, and habitat loss. Several arroyos, or ephemeral stream channels, are present within the Preserve and serve as natural drainage pathways from the uplands to the lowlands during rainfall events. These features play a crucial role in stormwater runoff management, directing flow across the landscape and into adjacent lowland areas. Similarly, the SAR itself contributes to the complex hydrology of the site, as riverine flows and tidal waters transport sediment from the river into the Preserve. Historically the SAR shaped the lowlands inside the Preserve and much of coastal Orange County.

1.4.2. Critical Infrastructure & Development

Used as an oil production facility in the last century, the project site contains remnants of oil extraction infrastructure, including decommissioned wells, surface pipelines, and access roads. Many of these features are in the process of being removed with oil wells cut off and capped at varying elevations throughout the site. The dirt roads, originally built to support heavy equipment, now provide unvegetated corridors to fragmented habitat that supports native and non-native vegetation. Approximately 7,000 square feet (sq ft) of decommissioned oil infrastructure and 3,500 linear feet (LF) of existing pipelines span the area; however, most of these facilities will be decommissioned and removed by the end of the remediation process.

Tide gates, one at North Marsh and one at South Marsh, play a crucial role in regulating tidal inflows, protecting sensitive habitats like LSARSM and the adjacent marshlands. These engineering features mitigate flood risks and sustain local ecosystems that support migratory birds and marine life. The intake elevation of the tide gates is approximately -4.0 ft Mean Sea Level (MSL) (or -6.6 ft NAVD88) with a minimum flow area of 38 sq ft. Recent monitoring data indicates a maximum observed water level of +5.67 ft NAVD88, marking the highest tidal inflow observed at the site (Coastal Frontiers Corporation, 2023).

The manmade levee lies between the marshes and SAR. This is a flood control feature of the SAR and is maintained by Orange County Flood Control District (OCFCD). The levee itself is essential for managing water flow during high discharge events. Various storm drains originating from the Newport Shores subdivision empty directly into LSARSM, which is connected to the Marsh, and are then conveyed through the SAR levee outlet drains (Figure 6). The Marsh side of the culverts are submerged and not visible. The outlet culverts are equipped with downstream one-way flap gates, allowing water to drain from the Marsh to the SAR even when the tide gates are closed. This drainage capability ensures that appropriate water levels are maintained within the Marsh and LSARSM, enabling the tide gates to reopen effectively.

The two (2) tide gates play a crucial role in regulating tidal inflows, protecting sensitive habitats like the LSARSM and adjacent marshlands. These tidal features mitigate flood risks and sustain local ecosystems that support migratory birds and marine life. The intake elevation of the tide gates is approximately -4.0 ft MSL (or -6.6 ft NAVD88) with a minimum flow area of 38 sq ft. Recent monitoring data indicates a maximum observed water level of +5.67 ft NAVD88, marking the highest tidal inflow observed at the site (Coastal Frontiers Corporation, 2023).

FIGURE 6: (LEFT) OUTLET DRAINS IN SOUTH MARSH, & (RIGHT) OUTLET DRAINS IN NORTH MARSH (USACE 2024)

Approximately 5 miles of site access roads traverse both the lowland and upland portions of the site and are predominantly elevated dirt roads with the exception of an asphalt access road that parallels LSARSM and Industrial Park Way. The access road connects to the eastern levee of the SAR and provides restricted access from PCH. These roads were used for efficient access for heavy machinery and oil operator vehicles and connect the uplands to the lowlands. Most of the oil infrastructure can be found in the lowlands with the exception of a main access point and parking lot situated in the elevated southeastern portion of the site near PCH. Currently, the main oil operator facilities are situated within the southcentral portion of the lowlands. Chain link fencing is present around the site to delineate certain aspects of the project site such as property ownership.

Within the southwestern portion of the site, three (3) interior culverts are present, two (2) of which are within the immediate project footprint (Figure 7). The third interior culvert is outside the project footprint and connects the North and South Marshes hydraulically. It is comprised of four (4) 18-inch (in.) PVC pipes designed to facilitate water exchange between the two USACE projects (USACE 2024). These culverts must be consistently maintained to remain clear and unobstructed, as blockages can severely restrict water movement. Concrete headwalls on both ends structurally support these pipes, enhancing their stability and protecting against erosion. Adequate water exchange through these culverts is critical, as any blockage or reduced capacity could increase flood risks.

FIGURE 7: CULVERTS UNDER DIRT ACCESS ROADS (USACE 2024)

1.4.3. Utilities

Overhead electrical lines traverse portions of the site, supported by utility poles that provide power to surrounding communities and the oil operation facilities. Currently, approximately 50 overhead utility poles support 8,000 LF of overhead electrical lines in the central portion of the site, spanning from the uplands to the lowlands (Figure 8). The project site's proximity to urban developments also means it interfaces with municipal stormwater systems, which channel urban runoff from upland drains and culverts into the Preserve's lowlands and SAR.

As mentioned previously, numerous other culverts connect the SAR and the adjacent marshes. The function of these culverts is to drain the salt marshes when water levels are high. These drains are set at a higher elevation than the intake water control structures at North Marsh and South Marsh and are functional during times of extreme precipitation when the river is at flood stage.

FIGURE 8: (LEFT) OVERHEAD ELECTRICAL WIRE POLES, & (RIGHT) SIDE DRAINS

1.4.4. Recreation & Public Access

The Preserve area ties together regionally significant habitats, such as the Newport Bay Estuary and SAR, with recreational features like the Santa Ana River Trail (SART). The SART is a multi-use pathway that spans the length of the river, offering opportunities for hiking, biking, and scenic engagement with Southern California's landscapes. Positioned atop the SAR flood-control levees, the trail elevation ranges from +12 to +18 ft NAVD88, providing resilience against tidal and flood impacts while ensuring accessibility for the public (Figure 9).

There is an access bridge in the North Marsh that is a prestressed concrete slab resting upon two abutments at approximately +8-9 ft NAVD88. This structure is necessary for the maintenance of utilities and facilities within the North Marsh and could potentially be used for public access as a bridge that connects Randall Preserve to SART. The bridge contains handrails and utility crossings, though the usage history of this access bridge is unknown at this time.

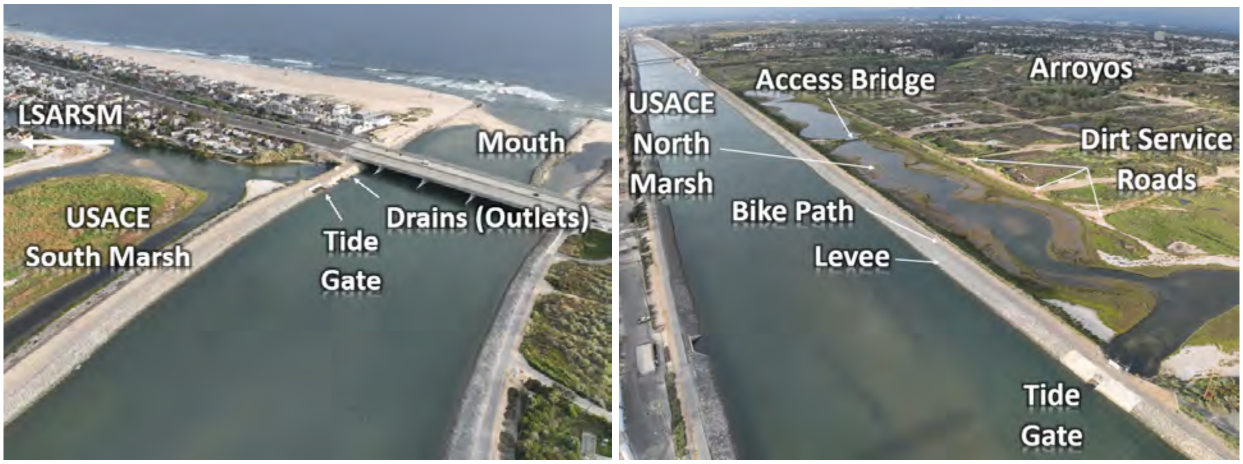


FIGURE 9: EXISTING SITE FEATURES & ACCESS

2. Coastal Processes

2.1. Tides

Newport Beach tides are semi-diurnal with pronounced diurnal inequalities (i.e., two high and low tides each 24.6-hour period with varying elevations); otherwise known as mixed tides. The tidal range in the region is typically ~5.5 ft between Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW) (Table 2). Tidal water level variability in the open ocean is measured at National Oceanographic and Atmospheric Administration (NOAA) Tide Station 9410660 (Los Angeles, CA), situated approximately ~10 miles upcoast. All open ocean tidal elevations are provided relative to the NAVD88. Tides in the wetlands are muted and delayed in time from those in the ocean.

TABLE 2: TIDAL DATUMS AT STATION 9410660 (LOS ANGELES): 1983-2001 TIDAL EPOCH

Description	Datum	Elevation (ft, NAVD88)
Highest Observed Water Level (1/10/2005)	HOWL	7.72
Highest Astronomical Tide	HAT	7.14
Mean Higher-High Water	MHHW	5.29
Mean High Water	MHW	4.55
Mean Tide Level	MTL	2.64
Mean Sea Level	MSL	2.62
Mean Diurnal Tide Level	DTL	2.54
Mean Low Water	MLW	0.74
North American Vertical Datum of 1988	NAVD88	0.00
Mean Lower-Low Water	MLLW	-0.20
Lowest Astronomical Tide	LAT	-2.22
Lowest Observed Water Level (12/17/1933)	LOWL	-2.93

Ocean water levels typically vary within predictable ranges; however, it is not uncommon to experience sea level anomalies due to El Niño Southern Oscillation events or storm surges that increase the predicted water level above the normally occurring astronomical tide. These events can increase the predicted tides over the course of several days to several months. Astronomical tides account for the most significant amount of variability in the total water level. Typical daily tides range from MLLW to MHHW, a tidal range of about 5.5 ft. During spring tides, which occur twice per lunar month, the tide range increases due to the additive gravitational forces caused by alignment of the sun and moon. During neap tides, which also occur twice per lunar month, the forces of the sun and moon partially cancel out, resulting in a smaller tide range. The largest spring tides of the year, which occur in the winter and summer, are sometimes referred to as “King” tides and result in high tides of 7 ft above NAVD88 and tidal ranges of more than 8 ft. King tides can lead to dry-weather or “nuisance” flooding in low-lying coastal areas, even in the absence of a storm or swell event, although this is currently not an issue within the study area.

2.2. Extreme Water Levels

High water levels are caused by extreme astronomical tides, natural climate fluctuations (such as El Niño), and large storms. The co-occurrence of these phenomena could potentially trigger the highest amount of flooding and coastal erosion. Because the extreme high-water levels data is not available at the Newport Bay Entrance tide station, extreme water levels from the nearest available NOAA CO-OPS Station (9410660 – Los Angeles Outer Harbor) are shown in Figure 10 relative to MHHW; Table 3 provides the extreme high water level elevations relative to NAVD88 for the current tidal epoch (1983-2001); the 100-year return period water level is highlighted.

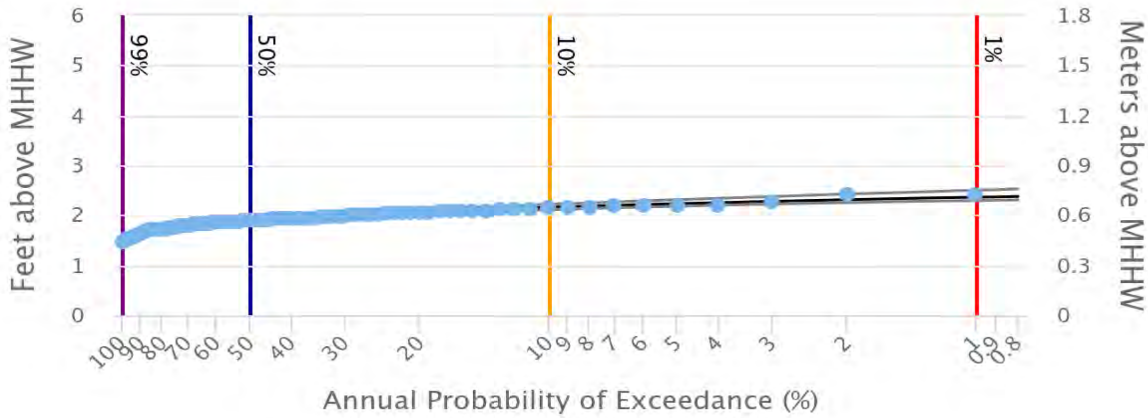


FIGURE 10: EXTREME WATER LEVELS AT NOAA CO-OPS STATION 9410660: LOS ANGELES, CA (1924-2022).

Note that the 100-year water level is similar to the highest water level measured at the NOAA tide gauge, which was caused by the co-occurrence of a king tide, storm surge, and El Niño on January 10th, 2005 (National Centers for Environmental Information, 2005). Thus, the 100-year still water level condition is appropriately representative of extreme conditions associated with astronomical tides, large-scale climate oscillations, and storms.

TABLE 3: EXTREME WATER LEVELS AT NOAA CO-OPS STATION 9410660: LOS ANGELES, CA.

Return Period	Elevation (ft NAVD)
1 year	6.73
10 years	7.42
50 years	7.55
100 years	7.72

2.3. Wave Climate and Littoral Processes Near Project Site

Locally, wave refraction causes wave energy to focus at specific points along the West Newport Beach shoreline. In this curved embayment, wave amplification becomes more pronounced as swells from the south approach and refract, increasing their energy towards the SAR mouth (Figure 11). This phenomenon is particularly notable because southern swells refract more sharply than those from the west, leading to higher energy waves that enhance the potential for sediment transport towards the SAR mouth. Increased sedimentation (shoaling) often occurs at the river mouth, which can help protect the project site by breaking the wave energy as waves enter the mouth. The mouth in particular experiences incoming wave energy, especially due to its exposure to both southern and northwestern swell patterns typical along Southern California's coast. This wave energy has substantial effects on sediment transport and coastal erosion, influencing the formation and maintenance of the sandbars and nearshore zone at the river mouth itself.

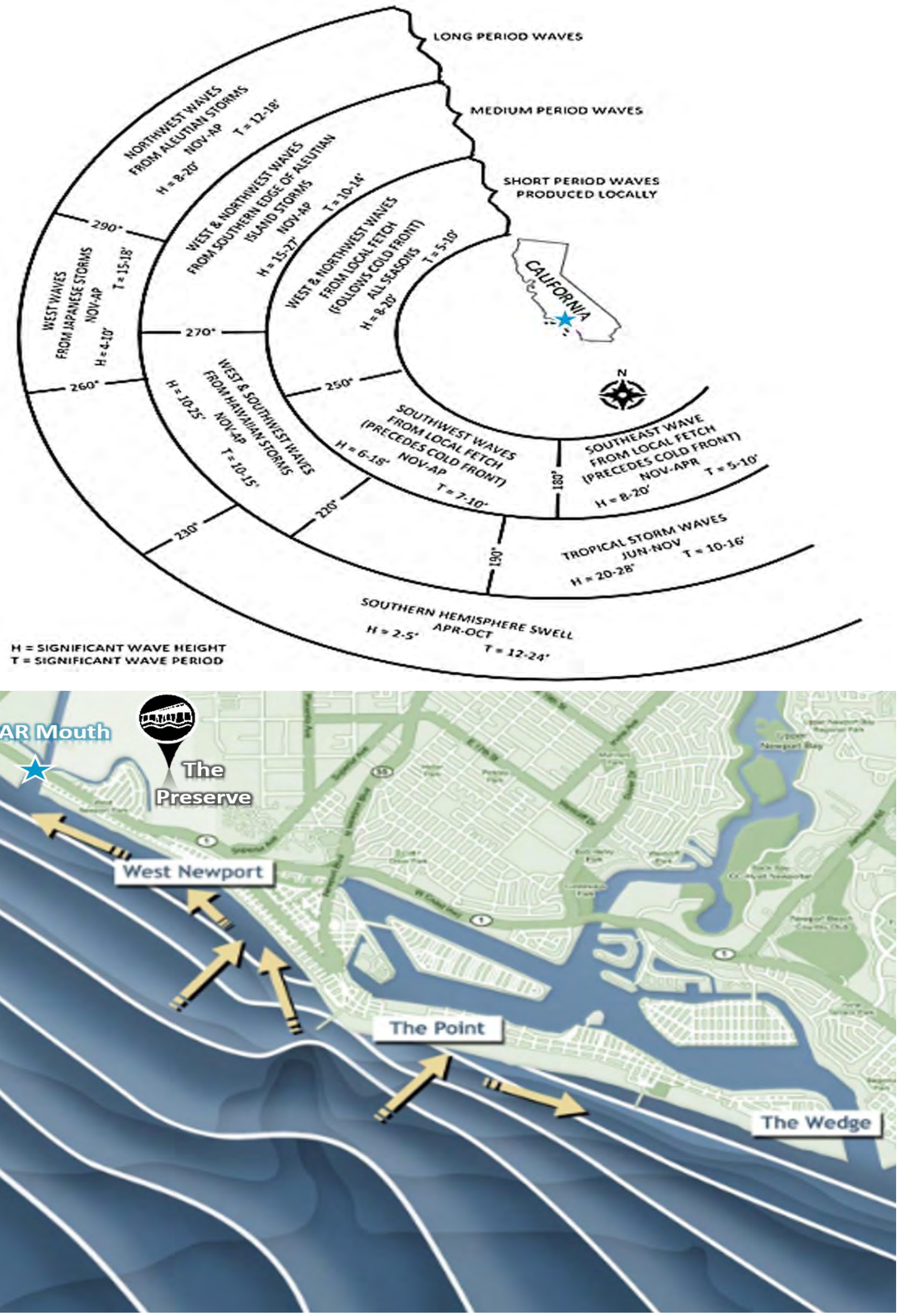


FIGURE 11: TOP: CALIFORNIA WAVE CLIMATE (USACE, 1993), & BOTOM: WAVE REFRACTION ON ONCOMING SOUTHERN SWELL WAVE ENERGY (M&N, 2019)

Although there seems to be challenges associated with the incoming wave energy and sedimentation, there is little evidence suggesting that any of that wave energy travels upstream towards the project site and is therefore of little overtopping concern. Most of the hydraulic energy that shapes the project site is a byproduct of the dynamic interaction between the brackish downstream river flow and fluctuating ocean tides. It is not anticipated that the levee will experience any significant wave energy or runup as waves would need to travel more than 1,000 ft to reach the tide gate area and the dominant wave direction is parallel to the levee (Figure 12).

FIGURE 12: MODELLED WAVE HEIGHTS AT THE PROJECT SITE (OCOF HAZARD MAP ONLINE VIEWER): 1.6 FT SLR + ANNUAL STORM (LEFT) & 4.9 FT SLR + 100-YEAR STORM (RIGHT)

Note that the figure above outlines the comparison between the wave heights associated with both a 1.6 ft SLR + Annual Storm event and the 4.9 ft SLR + 100-year storm scenario modelled under the Our Coast Our Future (OCOF) SLR model (Figure 12). The 4.9 ft + 100-year storm scenario shows water encroaching into the Newport Shores residential community and towards PCH under the more severe SLR + storm scenario which may be overrepresented as it does not account for any future accommodations to critical infrastructure needed on a broader or more regional scale (which is further discussed in later sections).

As mentioned previously, the SAR tidally influences the project site. Increased sediment movement as a byproduct of increased wave energy due to SLR could have potential implications for the Randall Preserve, which is located slightly upstream of the SAR mouth. As sediment accumulates near the river mouth, the project site temporarily experiences alterations in its hydrology and habitat characteristics, especially in response to SLR or extreme weather events (Figure 13). The Newport Submarine Canyon, located just offshore and to the southeast, affects littoral sediment transport and may influence shoaling at the SAR mouth.

The area is part of the Huntington Beach Littoral Sub-Cell, where sediment is primarily transported southeastward along the shore due to wave action and coastal processes. This movement is largely driven by seasonal fluctuations in wave energy, with larger winter swells contributing to sediment loss and summer waves aiding in the deposition of sand, while significant sediment sinks are found at Anaheim Bay and Newport Bay (Everest 2013). Historical beach nourishment efforts, including the placement of millions of cubic yards (CY) of sand between 1935 and 2009 as part of the Surfside/Sunset Beach Nourishment Project by the USACE, have also contributed to the annual shoaling experienced at the mouth. Though nearby beaches vary seasonally and remain dynamic, the Preserve is largely unaffected due to its sheltered location with a majority of the site sitting at higher elevations and ~1 mile inland. This fronting beach area acts as the first defense against incoming wave energy and therefore protects the site from any direct wave-structure forces experienced upstream.

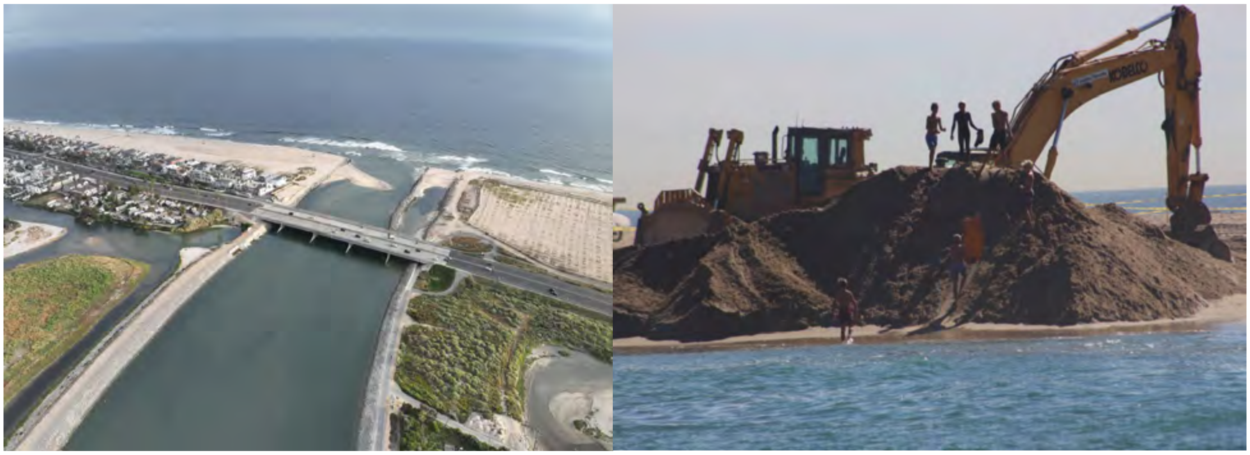


FIGURE 13: SANTA ANA RIVER MOUTH DREDGING

3. Sea Level Rise Projections

Sea Level Rise (SLR) science involves analysis of both global and local physical processes, as illustrated in Figure 14. Numerical models are created based on the best scientific understanding of these global and local processes to provide predictions of future SLR. Global climate and oceanographic processes are complex and dynamic. Hence, modeling efforts and predictions are periodically updated to reflect any changes in scientific knowledge. At the state level, the California Coastal Commission (CCC) recommends using the best available SLR science, which is expected to be updated approximately every 5 years.

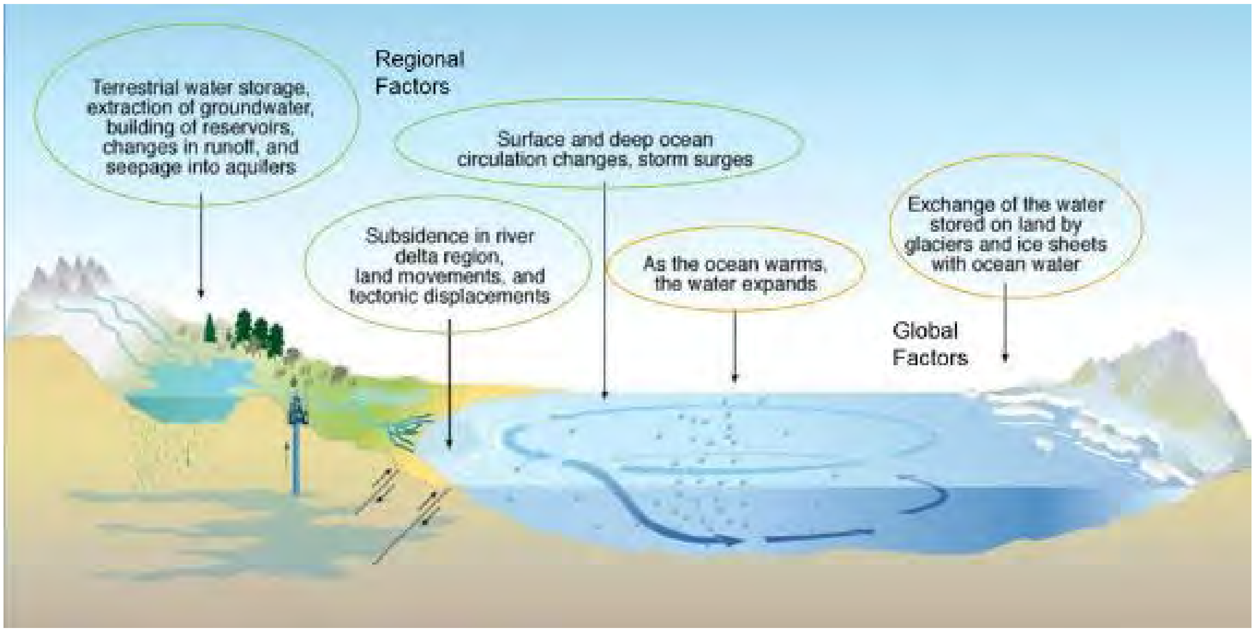


FIGURE 14: GLOBAL AND REGIONAL FACTORS THAT CAN INFLUENCE LOCAL RATES OF SLR

3.1. Probability and Timing

The Los Angeles tide gauge has measured a relative increase in sea level of roughly +0.04 in. per year since 1924 (1924-2024; NOAA CO-OPS Station 9410660). This rate is anticipated to increase over time due to climate change. In line with state-wide guidance, the Ocean Protection Council (OPC) recently released an updated draft of the state SLR guidance, available for public review and comment, in the State of California SLR Guidance: 2024 Science and Policy Update, issued in January 2024. The CCC currently recognizes the 2024 updated State of California SLR Guidance report as the current best available science on SLR projections for California.

SLR projections and related project planning approaches presented in the 2024 guidance for the short SLR time horizon are based on discrete predictions over the next 30 years. This resulted in a smaller range of prediction values for a given time horizon compared to earlier reports. For example, 2018 guidance SLR projections for 2050 varied from 1.1 to 2.7 ft, a range of 19 in. of rise relative to year 2000 recorded oceanic water levels. However, the latest science, including findings from the International Panel of Climate Change (IPCC) Sixth Assessment Report (AR6) suggests a much narrower variability in SLR values by 2050, 0.5 to 1.2 ft, a range of only 8 in. in Figure 15 (IPCC, 2023). This reduction in variability from 2024 compared to 2018 OPC guidance primarily reflects a considerable decrease in the maximum expected SLR based on the most current understanding of climate change. The range of potential SLR broadens for mid-term (2050-2100) and long-term (2100+) time horizons under the new guidance due to uncertainties in how different emissions scenarios and specific physical phenomena (e.g., the rapid melting of ice sheets) may affect future warming and sea level trends. By the end of the century and beyond, these uncertainties, especially those concerning ice sheet dynamics, contribute to a wider array of possible sea level variability. It is therefore recommended by the State SLR Collaborative in the 2024 updated policy guidance, in reference to Senate Bill 1, that long-term projections (e.g., beyond 2100) should be used with caution (Atkins, 2021).

Given the project is fairly risk tolerant and adaptive, the 2024 guidance highly recommends evaluations of water levels encompassing a range from *Intermediate-Low* to *Intermediate-High* scenarios combined with and without storm conditions (100-year storm conditions are advised) for project planning purposes (Figure 15). The range of scenarios used in the analyses with 2024 updated probable timing associated with each for the Los Angeles region are provided in Table 4.

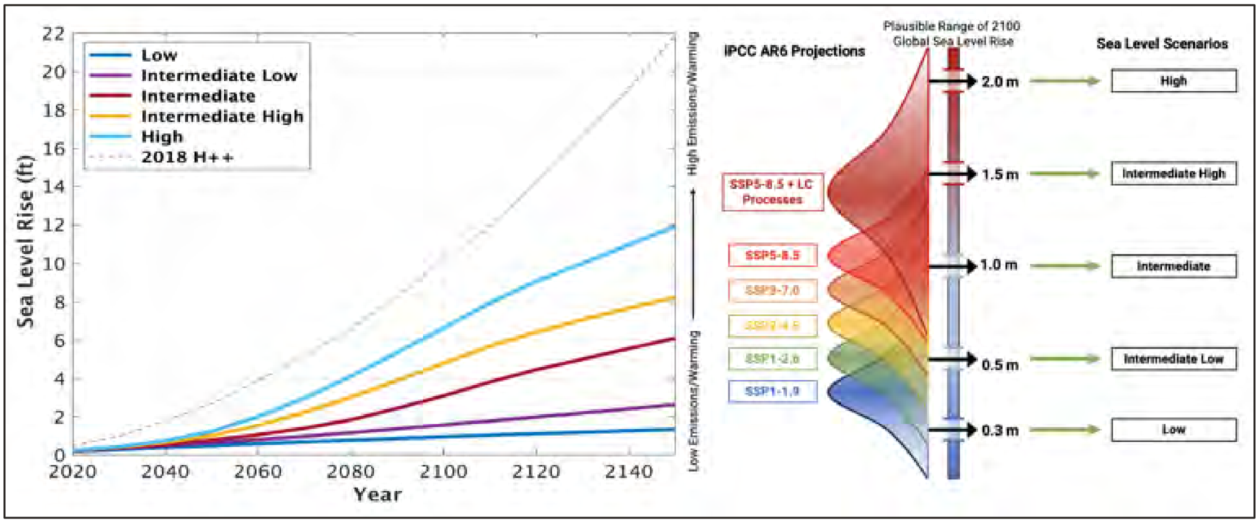


FIGURE 15: UPDATED SEA LEVEL SCENARIOS FROM 2020 TO 2150, IN FT, RELATIVE TO A BASELINE VALUE OF YEAR 2000 RECORDED SEA LEVELS. THE H++ PROJECTION FROM THE 2018 OPC CALIFORNIA SEA-LEVEL GUIDANCE IS NO LONGER USED BUT INCLUDED FOR COMPARISON TO PROVIDE PRIOR EXTREME VALUE PREDICTIONS.

Across all three (3) time horizons (short-, mid-, and long-term), the 2018 Low Risk Aversion scenario closely tracks the range covered by the *Intermediate* scenario in the newly updated guidance. The 2018 Medium-to-High Risk Aversion Low and High Emission scenario corresponds to the *Intermediate-High and High* scenarios between 2100 and 2150, although the 2024 projections are lower in the short and mid-term time horizons. Evidence in the updated 2024 report suggests that it is reasonable to view the *Intermediate* scenario as the most representative of the SLR expected to occur in the near term and provides a reasonable upper bound for the most likely range of SLR by 2100. It should be noted that the Intermediate-High and High scenarios reflect SLR at time horizons that have <1% chance of being met or exceeded by 2100 under assumed global the mean surface air temperature increases at or below 3°C.

The 2022 U.S. Interagency Task Force (ITF) report (Sweet et. al, 2022) provides the likelihood that global mean sea level will meet or exceed the ITF scenarios given various levels of global warming/emissions from IPCC AR6 climate models. The likelihood that global SLR will meet or exceed the selected *Intermediate-High* Scenario by 2100 is:

- *Exceptionally unlikely* for 3ºC of global average surface warming (0–1% chance)
- *Exceptionally unlikely* for 5ºC of global average surface warming (0–1% chance)
- *Unlikely* for very high greenhouse gas emissions when including the potential for marine ice cliff instability (0–33% chance)

The likelihood that global SLR will meet or exceed the selected *High* Scenario by 2100 is:

- *Exceptionally unlikely* for 3ºC of global average surface warming (0–1% chance)
- *Exceptionally unlikely* for 5ºC of global average surface warming (0–1% chance)
- *Very unlikely* for very high greenhouse gas emissions when including the potential for marine ice cliff instability (0–10% chance)

Table 4 shows specific amounts of local SLR and specific probabilities that global SLR will meet or exceed ITF report scenarios. Columns for 2050 and 2100 show amounts of SLR since 2000 for each scenario by the years 2050 and 2100. Columns for 3ºC global surface warming (GSW) and 5ºC GSW show the percent chance (or likelihood) that SLR meets or exceeds each scenario for 3ºC and 5ºC of average GSW by 2100. The VHE/LCP column shows the percent chance (or likelihood) that SLR meets or exceeds each scenario under Very High Emissions (VHE) when including Low-Confidence Processes (LCP) such as marine ice cliff instability. For more details about the calibrated language used for likelihood and its relationship to probability, please refer to Box 1.1 of the IPCC AR6 report.

TABLE 4: LOCAL OPC 2024 SLR AND SPECIFIC PROBABILITIES THAT GLOBAL SLR WILL MEET OR EXCEED THE ITF SCENARIOS (ADAPTED FROM TABLE 2.4 OF THE ITF REPORT)

Scenario	Local OPC 2024 SLR Projections			*Probabilities of Global SLR Meeting/Exceeding*		
	2050 (ft)	2100 (ft)	2150 (ft)	*3° C (%)*	*5° C (%)*	*VHE/LCP (%)*
Low	0.4	0.6	0.8	*>99%*	*>99%*	*>99%*
Int Low	0.5	1.3	2.1	*82%*	*97%*	*96%*
Intermediate	0.7	2.8	5.5	*5%*	*10%*	*49%*
Int-High	0.9	4.5	7.7	*<1%*	*1%*	*20%*
High	1.1	6.3	11.3	*<1%*	*<1%*	*8%*

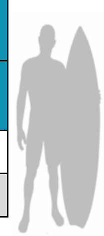
3.2. Selected SLR Scenarios

For this proposed project, the closest tide gauge is at **Los Angeles, CA.** The anticipated project life is assumed to be **50 years** with anticipated construction to begin in **2040**. For the purpose of this study, the Los Angeles tide gauge projections for the ***Intermediate-High*** and ***High*** scenarios were chosen for the analysis, as recommended by the California Coastal Commission SLR Policy Guidance (CCC 2024). These scenarios were selected as conservative estimates of potential future sea levels, as recommended by the CCC.

The following analysis evaluates the **1.6 ft SLR (Int 2080, Int-High 2065)** and **4.9 ft SLR (Int 2140, Int-High 2105)** scenarios, respectively under **non-storm** (annual high tide) and **severe (100-year) storm conditions** (Table 5) to represent conditions between present day, the projected end of the 50-year design life, and beyond. For example, assessing the lower end scenario of 1.6 ft SLR provides potential insight into SLR impacts experienced within the project's design life and is more probable to be encountered within the 50 years following the anticipated construction of the project. The upper end scenario of 4.9 ft SLR was selected to encompass a highly improbable SLR scenario beyond the anticipated project's design life and is representative of a condition in which the levee separating the SAR and project site is projected to be overtopped if no agency intervention is to occur. It should be noted that the state guidance advises using caution with projections beyond 2100 due to the higher levels of uncertainty in SLR projections.

TABLE 5: PROBABLE TIMING ASSOCIATED WITH SELECTED SLR SCENARIOS FOR THE LOS ANGELES REGION (OPC, 2024)

SLR Scenarios, ft (cm)	Probable Timing Associated with SLR Projections (2024 Draft Guidance Update)				
	Low	Int-Low	Intermediate	Int-High	High
1.6 (50)	2150+	2120	2080	2065	2055
4.9 (150)	2150+	2150+	2140	2105	2090



4. SLR Hazard Analysis

4.1. USGS Coastal Storm Modeling System (CoSMoS) & Static Inundation Modelling (SIM)

The effects of SLR on storm and non-storm related flooding were evaluated using initial results of the Coastal Storm Modeling System (CoSMoS) Version 3.0, Phase 2. This is a multi-agency modeling effort led by the USGS designed to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for California. Other SLR hazard viewers such as the NOAA SLR Viewer are also available, but they do not have the regional focus and depth of information provided by the CoSMoS modeling results.

The CoSMoS modeling system incorporates state-of-the-art physical process models to enable prediction of currents, wave height, wave runup, and total water levels (Erikson et al., 2017). A total of 10 SLR scenarios are available, increasing in 0.8 ft (0.25 meters [m]) increments from 0 to 6.6 ft (0 to 2 m). CoSMoS modeling results provide predictions of shoreline erosion, cliff erosion, and coastal flooding under non-storm, high spring tide, and multiple storm conditions. All modeling results are based on existing topography and structures. As a result, they do not consider the effect of any proposed structures or future grade changes on hazard predictions.

Additional numerical modeling or independent verification of CoSMoS data was performed via static inundation modelling of the existing site under “bathtub” conditions. Hazard analyses within this assessment focus primarily on coastal flood modeling results and assume no erodible shoreline and bluffs within the study area. The hazards depicted in this report are presented based on the assumptions and limitations accompanying the CoSMoS data available at the time of the present study.

4.1.1. Coastal Flood Projections

CoSMoS coastal flooding projections simulate the effects of erosion, wave runup, and overtopping during storm events. Coastal flood extents are calculated and mapped at transects spaced approximately 300 ft along the shoreline. The projected coastal water levels used in flood mapping consider future shoreline change, tides, sea level anomalies like El Niño and the Southern Oscillation (ENSO), storm surge, and SLR (Figure 16).

FIGURE 16: EXAMPLE MODEL OUTPUT FOR COSMOS FLOOD PROJECTIONS

Coastal flood events are modeled in conjunction with a high spring tide (Erikson et al., 2017). CoSMoS coastal flood modeling results assume that any future shoreline retreat will be halted at the existing development line under an existing “hold the line” scenario. Projected coastal flood extents are however permitted by the model to extend beyond the line of development. Flood projections (both depth and extent) under each SLR and storm scenario are presented in Figure 17 through Figure 26.

Topography data at the site was taken from a recent survey conducted by Dudek and 2010 CoNED open-source LiDAR data from NOAA (NOAA Office for Coastal Management, 2024). The two data sources were appended together to create a more accurate surface representative of the existing condition at which the SLR projections are analyzed.

A total of seven (7) SLR and storm scenarios were mapped for the vulnerability assessment:

- Existing conditions (no SLR)
  - Non-storm – Annual High Tide (AHT) of +6.79 ft NAVD88
  - 100-Year Storm – Highest Observed Tide (HOT) of +7.72 ft NAVD88
- 1.6 ft SLR conditions
  - Non-storm – AHT of +6.79 ft NAVD88
  - 100-Year Storm – HOT of +7.72 ft NAVD88
- 4.9 ft SLR conditions
  - Non-storm – AHT of +6.79 ft NAVD88
  - 100-Year Storm – HOT of +7.72 ft NAVD88
  - 100-Year Storm (*Unprotected*) – HOT of +7.72 ft NAVD88

4.1.2. Modelling Assumptions and Limitations

The AHT (+6.79 ft NAVD88) was used as the modelled boundary condition for all non-storm conditions, while the HOT (+7.72 ft NAVD88) was used as the modelled boundary conditions to represent 100-year storm conditions.

All SLR scenarios analyzed in this study assume that the tide gates remain fully functional and protect the Preserve, with the exception of the 4.9 ft SLR *unprotected* scenario, in which sea level rise overtops the levee assuming no agency intervention or modifications to existing critical infrastructure. This study otherwise assumes the tide gates function as designed and regulate waters entering the lowlands during high tide and flood conditions. Additional assumptions are described in further detail in the following sections.

In the modeling results presented below, *flood extent* refers to the geographical area that is projected to be inundated under specific SLR and storm scenarios. It illustrates the extent of coastal flooding, showing which regions are at risk of inundation. *Flood depth* represents the height of water above the ground surface in a given area during a flooding event. It provides critical information on the severity of inundation by showing how deep floodwaters are expected to be under the various SLR and storm scenarios.

In the figures presented below, *Low-Lying Areas* (shown in *light green* on the maps) are locations identified in the model with the potential to be flooded - but are not hydraulically connected to a source of flooding (i.e. ponding). These areas may not have direct surface hydrologic connection to the ocean but lie below the projected water surface elevation. These areas may also be vulnerable to flooding if there is a subsurface connection like a storm drain, or if surrounding protections fail (e.g., a berm or levee). *Protected Areas* (shown in *orange* on the maps) are locations that the model initially describes as flooded but would remain dry if the tide gates are functioning properly. Assuming the tide gates operate as intended, then the areas with elevations of at least 5.6 ft NAVD88 or higher are protected from flooding. The elevation ranges for Protected Areas vary under different SLR conditions and are shown in the corresponding figures below. The “unprotected” scenario assumes the scenario that the tide gates are inoperable or overtopping of the SAR levee or overtopping of PCH occurs. The Protected area elevation is determined by the total condition (Still Water Level [SWL] associated with given storm condition) + SLR.

Though not directly within the project boundary, the modeled area also contains the eastern levee of the SAR, West Newport Beach, and areas south of PCH that are in the vicinity of the project site. These areas were included in the analysis to show the source of flood risk for the Preserve under the most severe SLR and storm scenarios. In the 4.9 ft of SLR non-storm and 4.9 ft of SLR + 100-year coastal storm protected scenarios, it is assumed that improvements to PCH or Balboa Cove will be made by relevant agencies or stakeholders so that no flooding occurs south of PCH; hence, the mapping shown in the following section omits flooding from these areas under every SLR scenario presented in this report, except the 4.9 ft SLR unprotected scenario. Under the 4.9 ft SLR unprotected scenario, the area south of PCH is shown again, but with flooding, due to a vulnerability along the shoreline of Newport Bay at Balboa Cove. Under this unprotected scenario, SLR also overtops the eastern levee of the SAR near the PCH Bridge. It is unlikely that governing agencies with jurisdiction will ever allow neighborhoods in West Newport Beach to be flooded or PCH to be flooded or the levee of the SAR to be overtopped, but for the purpose of this study, these risks are made known. It should also be noted that the timeline for this SLR scenario is not estimated to occur until sometime between the Year 2105 and 2140, which affords communities ample time to implement coastal adaptation measures.

4.1.3. Coastal Flood Mapping

4.1.3.1. Existing Conditions

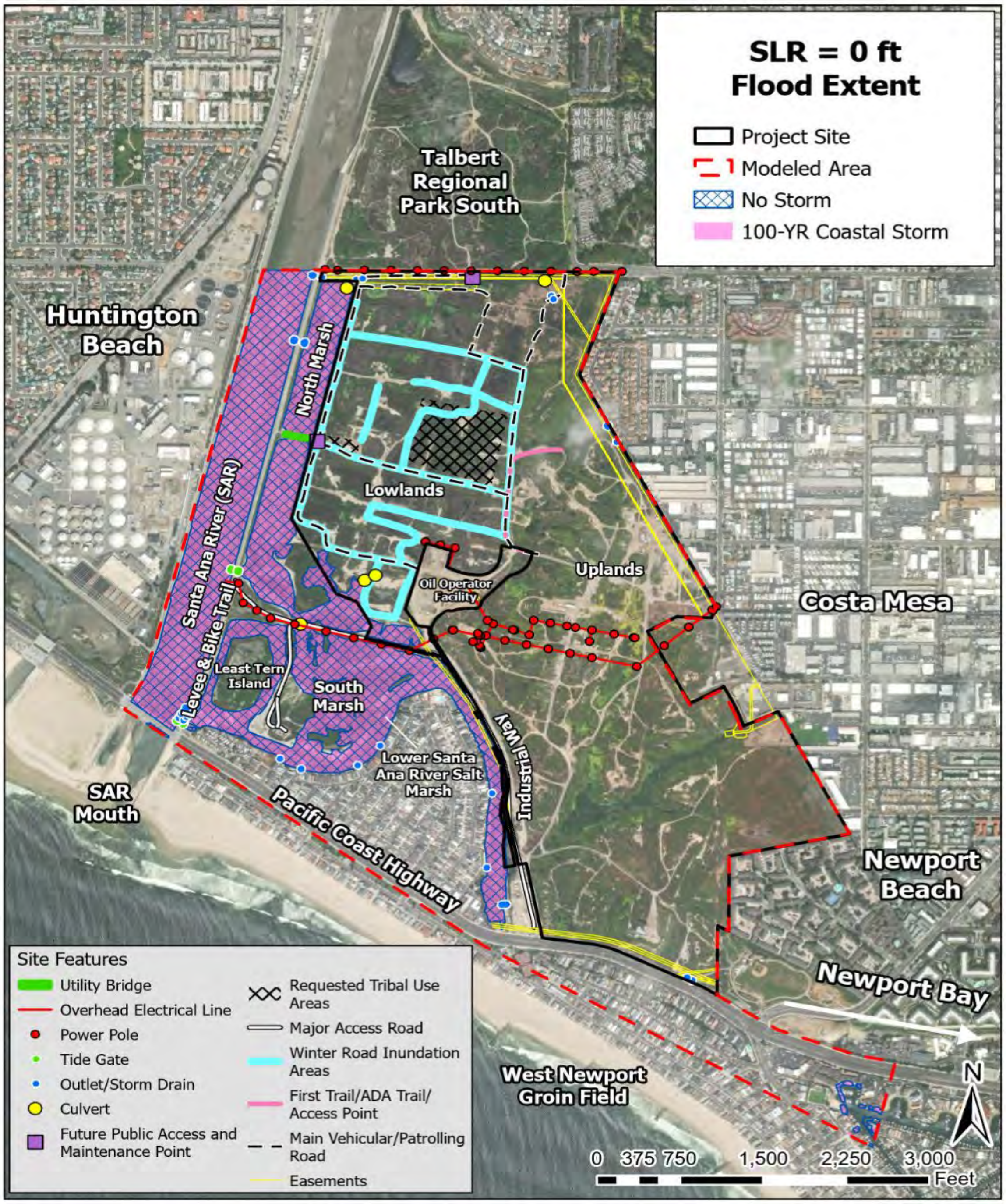


FIGURE 17: FLOOD EXTENT PROJECTIONS UNDER EXISTING NON-STORM AND 100-YEAR STORM CONDITIONS

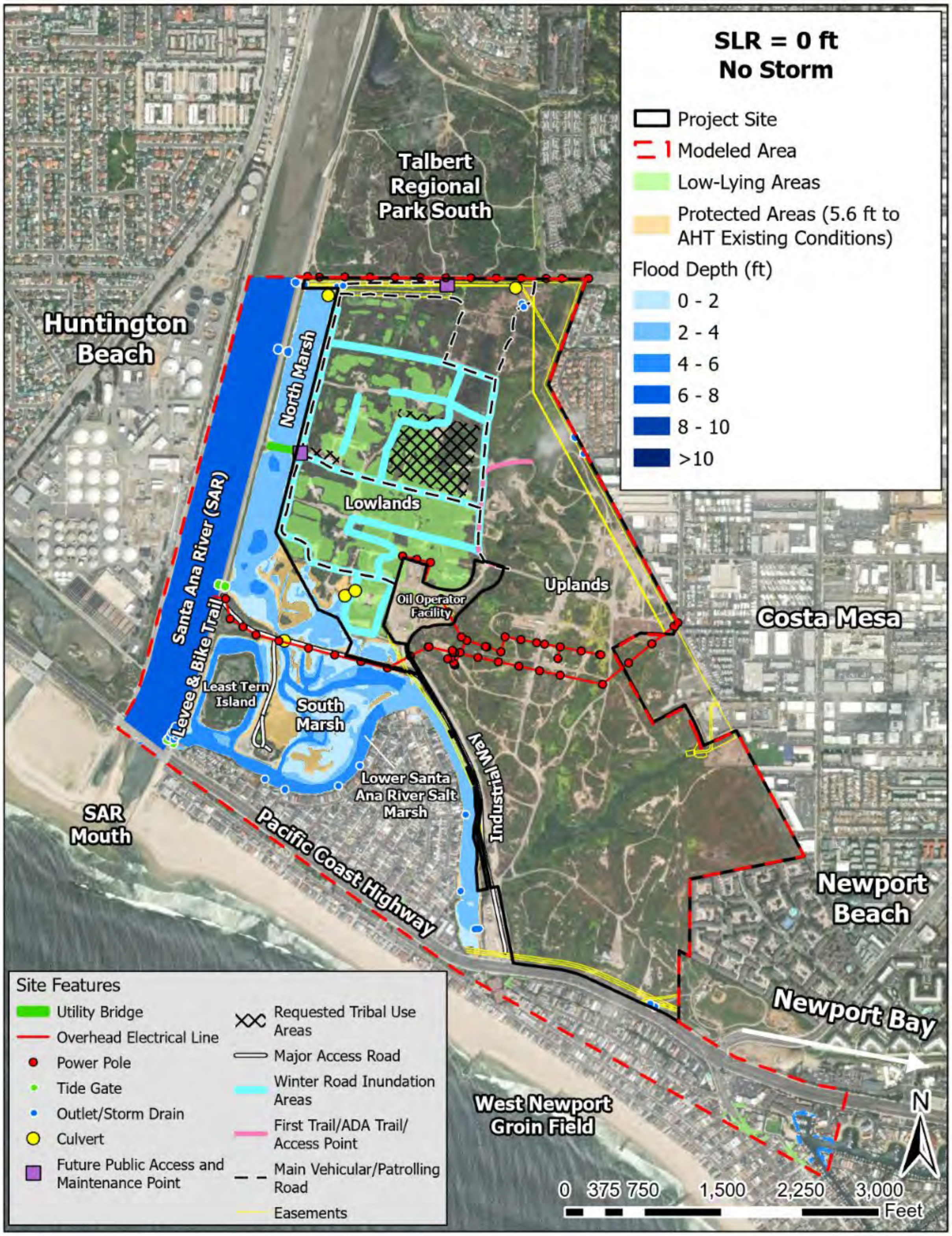


FIGURE 18: FLOOD DEPTH PROJECTIONS UNDER EXISTING NON-STORM CONDITIONS

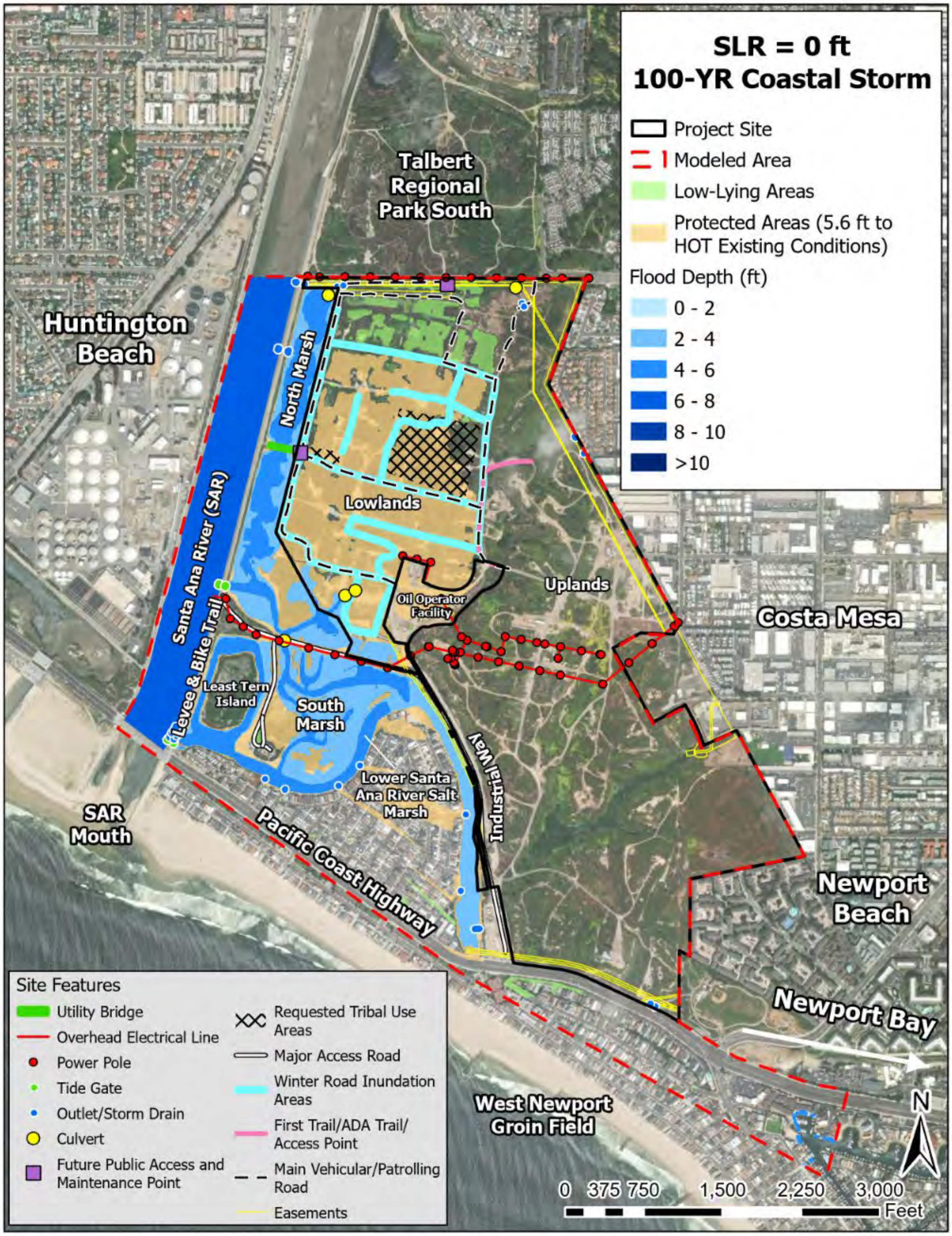


FIGURE 19: FLOOD DEPTH PROJECTIONS UNDER EXISTING 100-YEAR STORM CONDITIONS

4.1.3.2. 1.6 ft SLR (Int 2080, Int-High 2065)

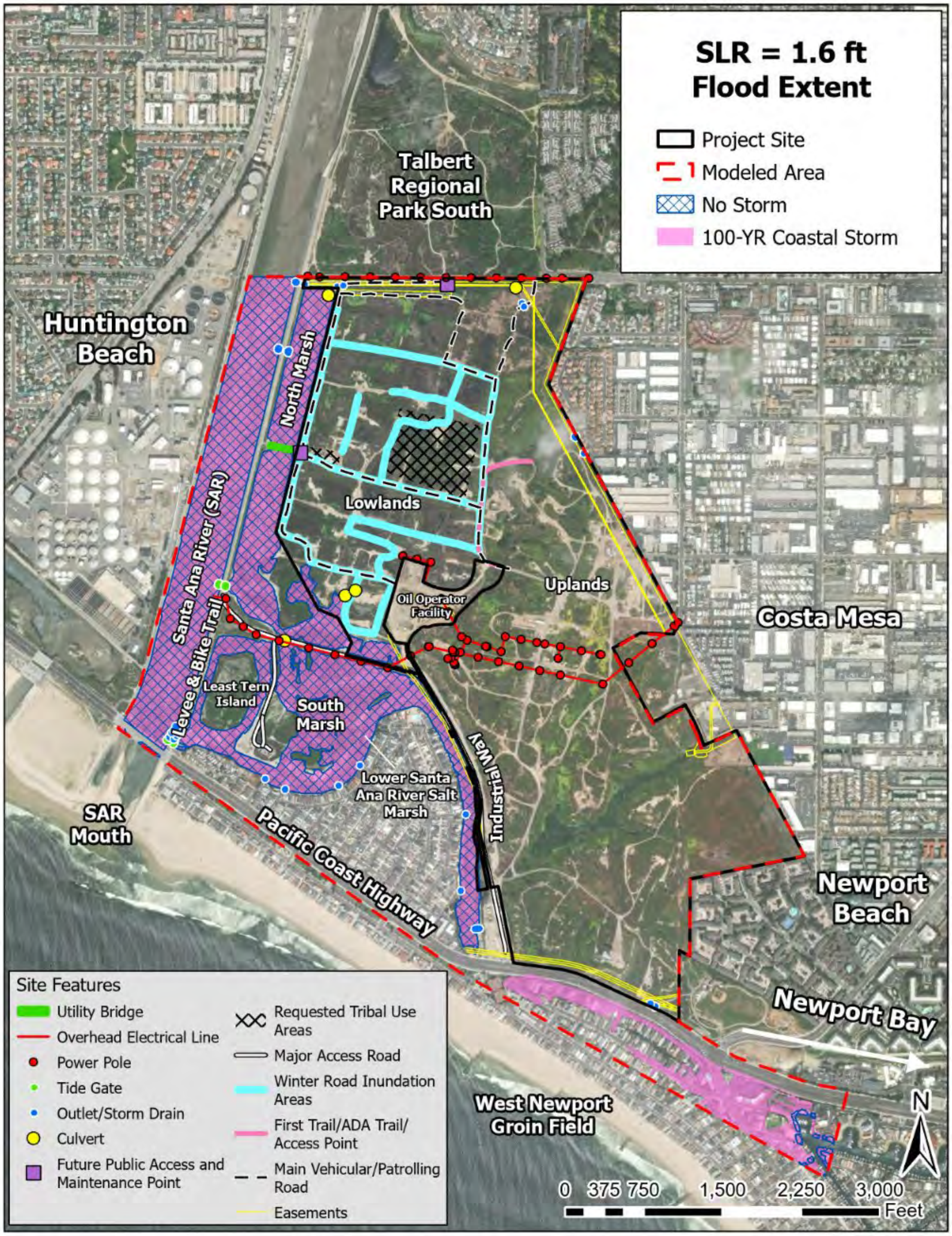


FIGURE 20: FLOOD EXTENT PROJECTIONS UNDER 1.6 FT OF SLR NON-STORM AND 100-YEAR STORM CONDITIONS

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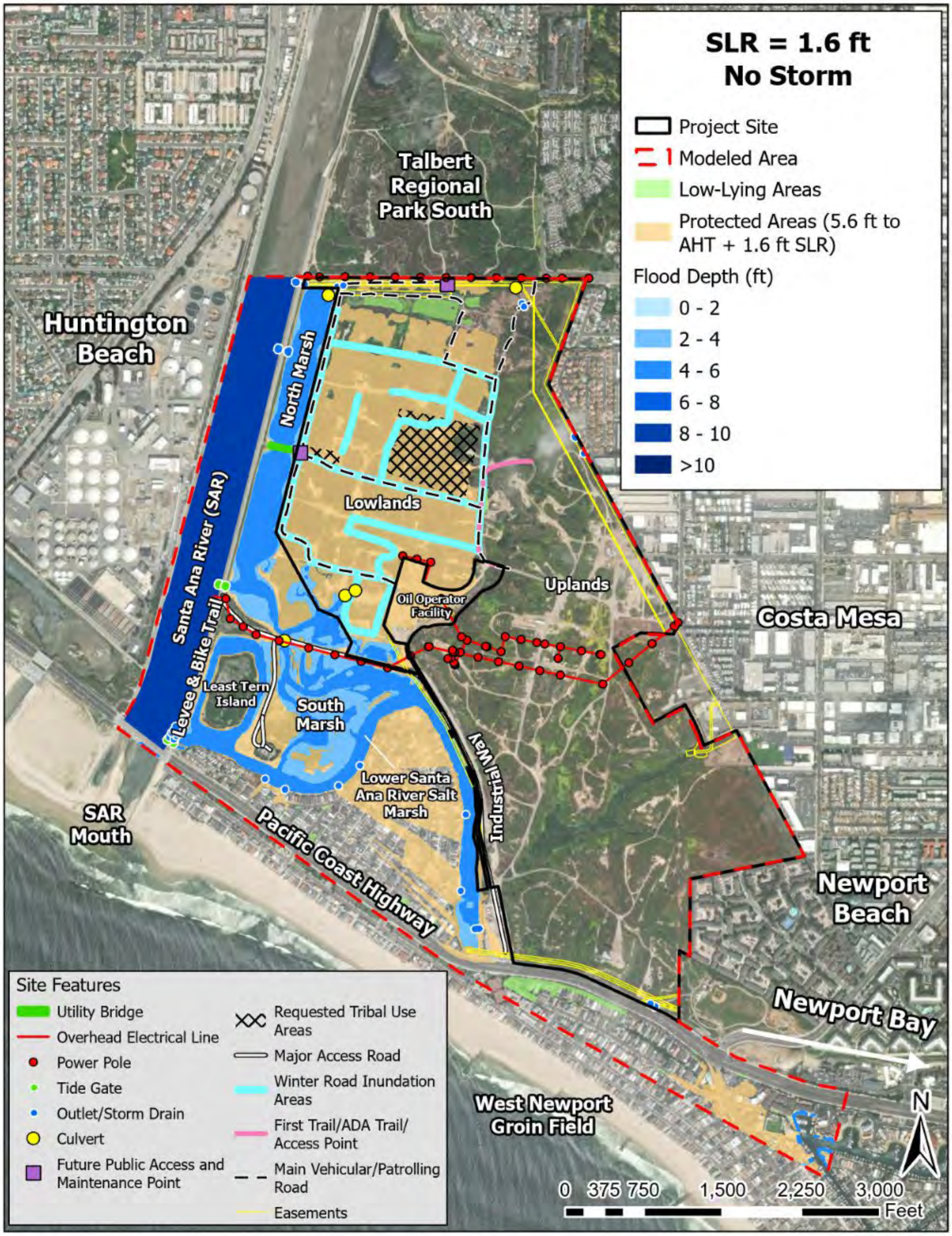


FIGURE 21: FLOOD DEPTH PROJECTIONS UNDER NON-STORM CONDITIONS WITH 1.6 FT OF SLR

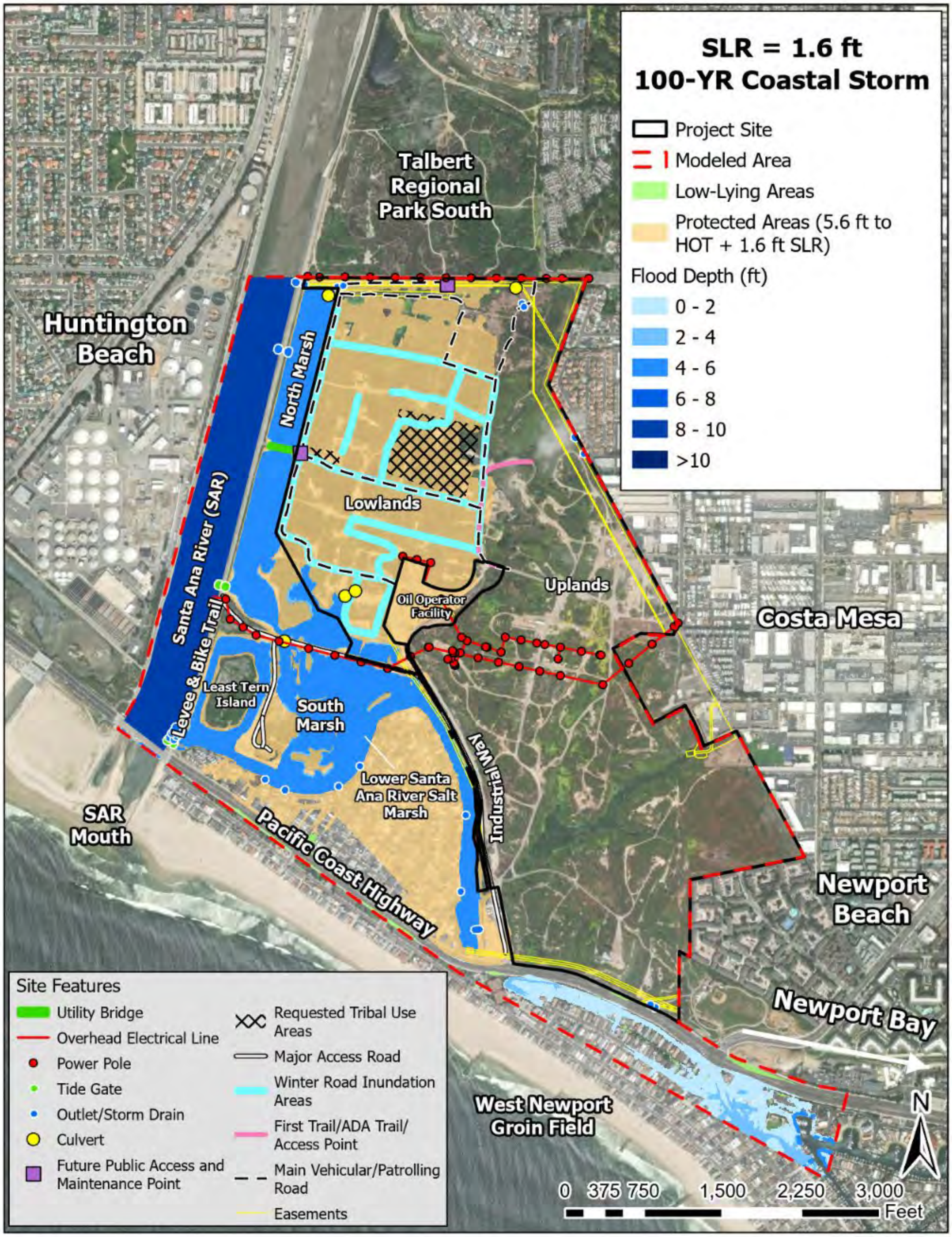


FIGURE 22: FLOOD DEPTH PROJECTIONS UNDER 100-YEAR STORM CONDITIONS WITH 1.6 FT OF SLR

4.1.3.3. 4.9 ft SLR (Int 2140, Int-High 2105)

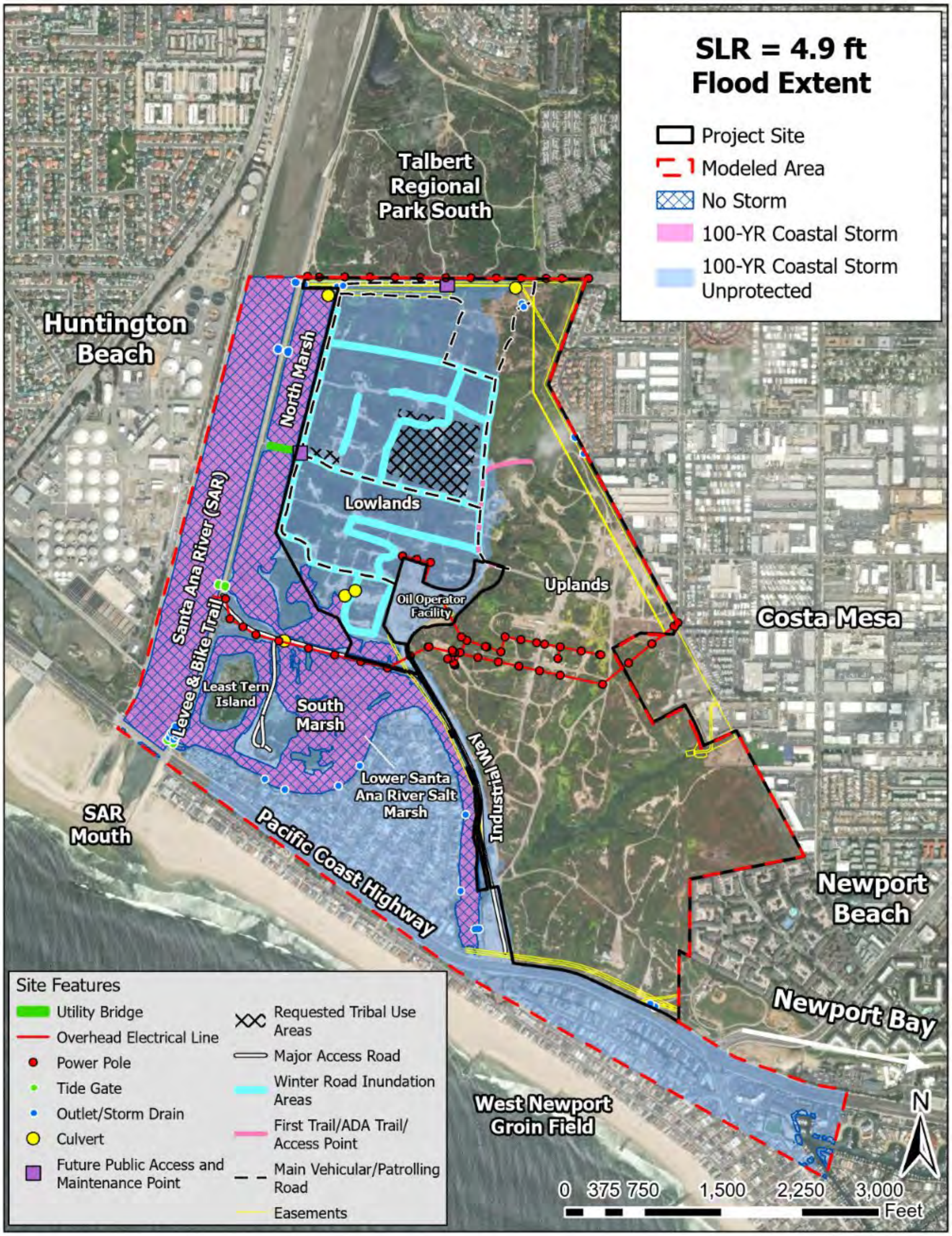


FIGURE 23: FLOOD EXTENT PROJECTIONS UNDER 4.9 FT OF SLR NON-STORM, 100-YEAR STORM AND 100-YEAR STORM *UNPROTECTED* CONDITIONS

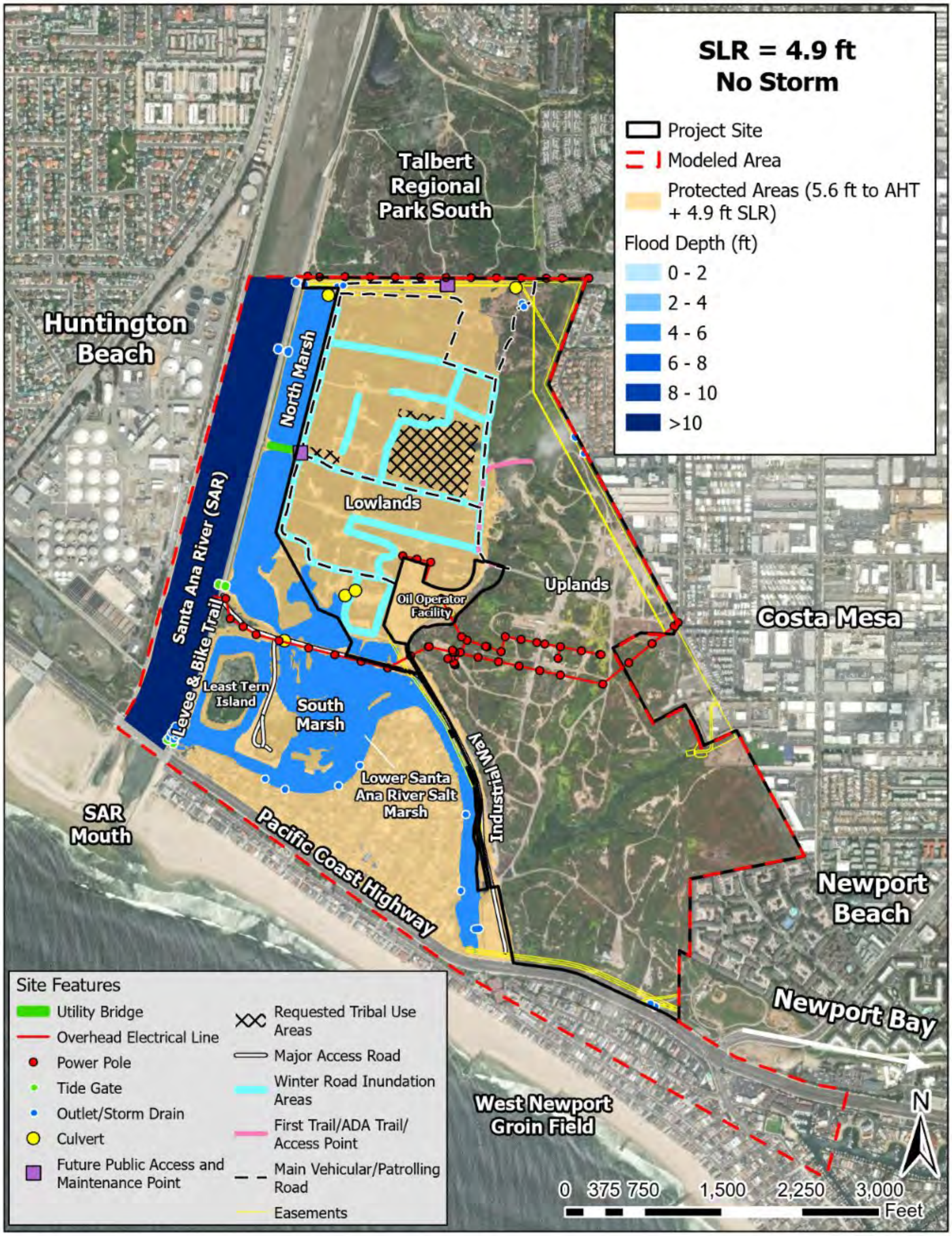


FIGURE 24: FLOOD DEPTH PROJECTIONS UNDER NON-STORM CONDITIONS WITH 4.9 FT OF SLR

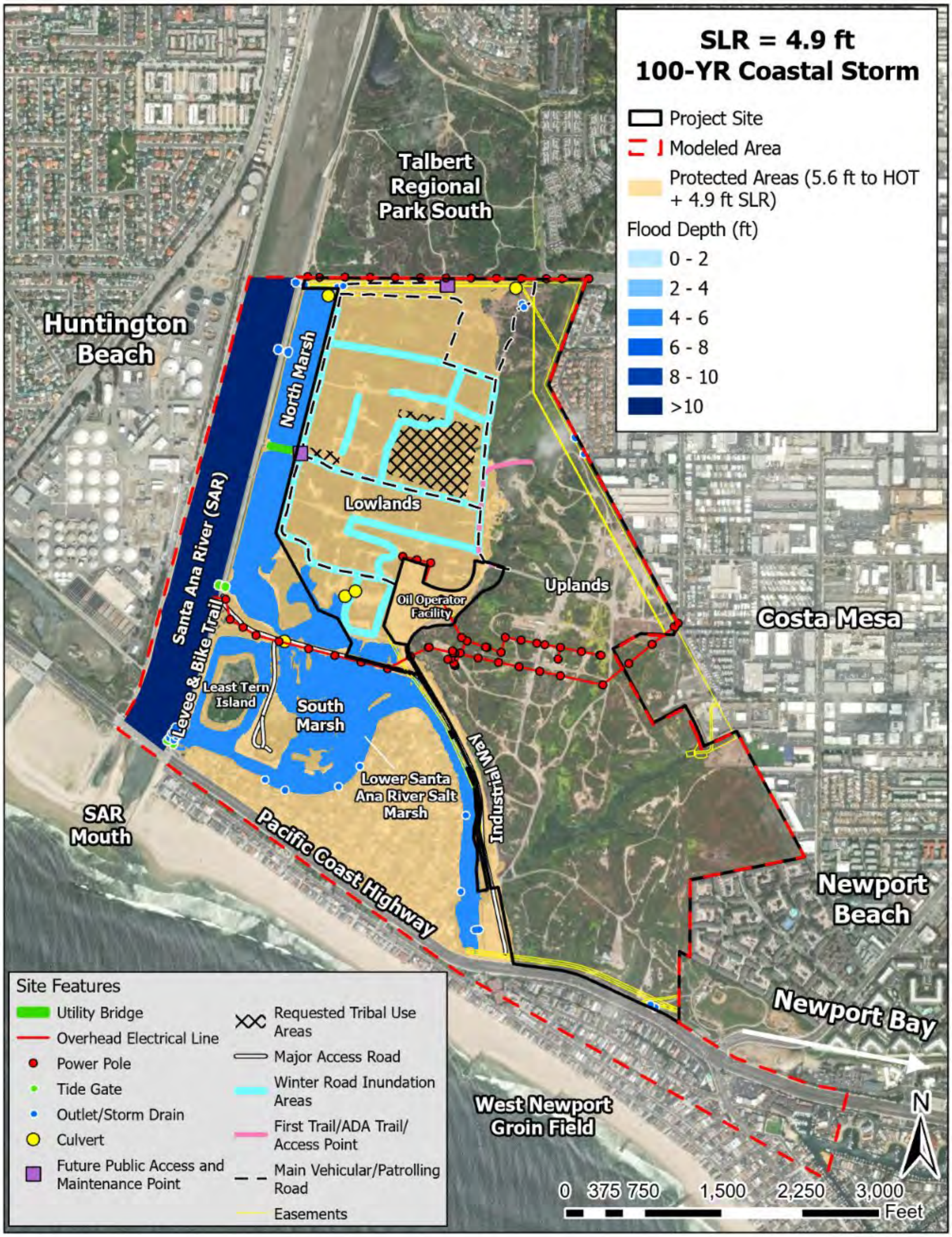


FIGURE 25: FLOOD DEPTH PROJECTIONS UNDER 100-YEAR STORM CONDITIONS WITH 4.9 FT OF SLR

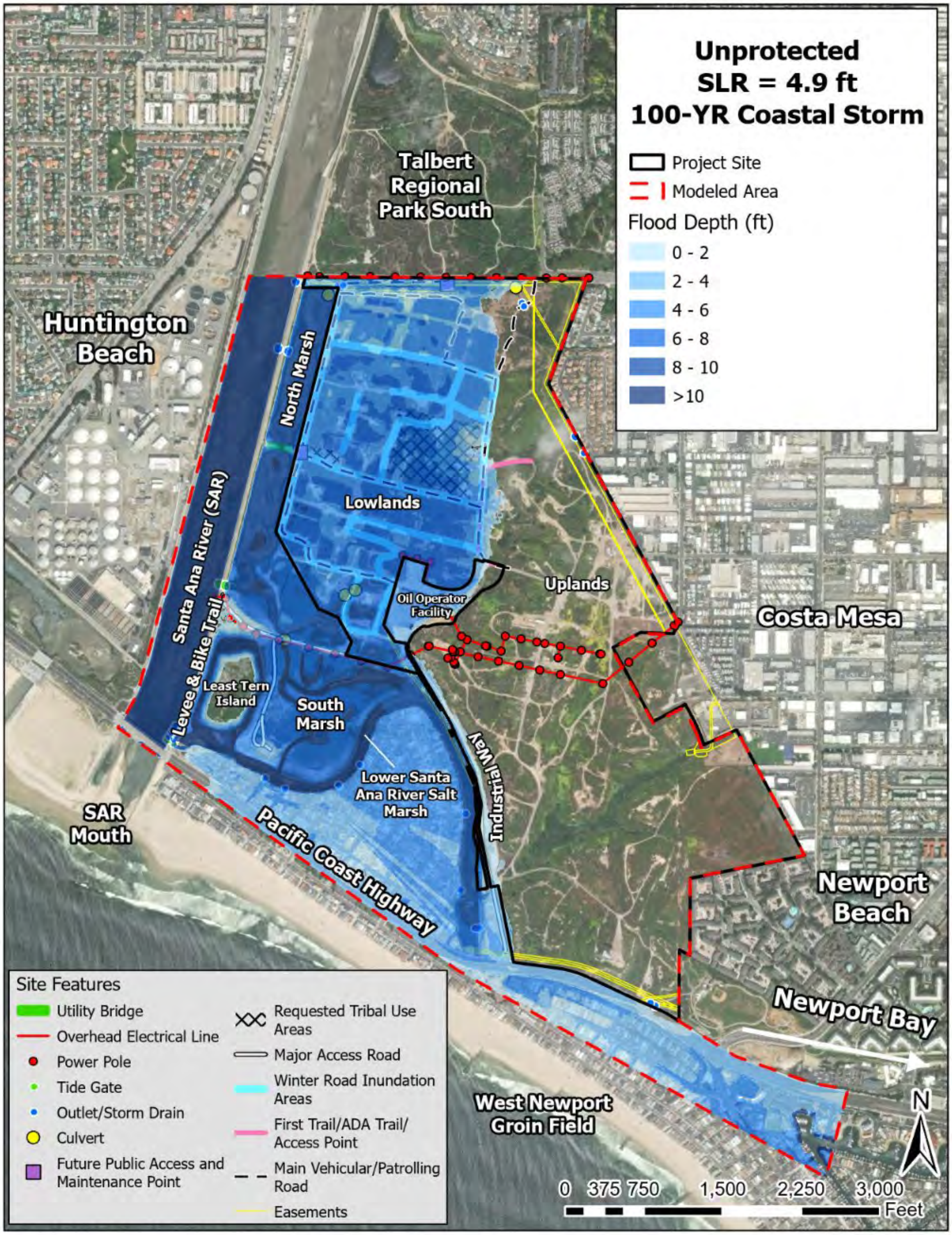


FIGURE 26: FLOOD DEPTH PROJECTIONS UNDER 100-YEAR STORM *UNPROTECTED* CONDITIONS WITH 4.9 FT OF SLR

4.2. NASA Flooding Analysis Tool (NFAT)

High-tide flooding occurs during high tide but is influenced more by tidal forces of the moon and sun. Other factors, spanning astronomical, seasonal, and climatic scales, contribute to these events. For instance, the spring-neap cycle, driven by the alignment of the Earth, moon, and sun, causes high tide levels to fluctuate twice per month. Additionally, rising sea levels amplify these tides, increasing the frequency of flooding events. Tidal amplitude itself varies not only on a monthly basis but also seasonally and over multi-year cycles, such as the 4.4- and 18.6-year tidal cycles, which significantly affect coastal flooding patterns. Ocean circulation changes, phenomena like El Niño, and variations in the Gulf Stream further influence average sea levels, causing fluctuations over months or years. Short-term ocean variability, including storms and eddies, also contributes to differences in flooding frequency between months or years.

The NFAT is an advanced system that provides real-time flood risk assessment by integrating satellite-based data and hydrological models. Using GIS and models such as the Hydrologic Engineering Center - River Analysis System (HEC-RAS), NFAT simulates flood extent, depth, and duration while mapping vulnerable areas based on local population, infrastructure, and land use.

4.2.1. Observed Flooding

NFAT data is sourced and evaluated from the nearest available NOAA Tide Station (9410660: Los Angeles). It is observed that the 1-year flooding threshold is 1.44 ft above MHHW, for a total elevation of 6.73 ft NAVD88. A 1-year flooding threshold refers to a statistical measure of water levels with a 100% chance of being exceeded at least once annually, while king tides typically refer to the highest predicted high tide of the year, driven by the gravitational alignment of the Earth, moon, and sun during a perigean spring tide (when the moon is closest to Earth). As a result, they exceed the average high-tide level represented by MHHW. However, the 1-year flooding threshold elevation provides a slightly conservative estimate of king tides in the region and is therefore used in this analysis.

Figure 27 shows the occurrence of individual flooding days for the selected threshold (top) and the number of flooding days in each meteorological year (May–April, bottom). Note that flooding days do not tend to be evenly distributed in time. There may be an overall increase during the record due to SLR. There may also be years or months when many events cluster together due to the confluence of multiple factors—such as high sea level, higher than normal high tides, and greater storminess. Between 2012 and 2021, the average sea level in Los Angeles was 0.3 ft higher than during 1970–1979. This increase in sea level corresponds to a rise in flooding days, from 58 days during the 1970–1979 decade to 153 days during 2012–2021. It is virtually certain (99–100% probability) that this rise in sea level has driven the observed increase in flooding days. These probabilities were calculated using methodologies outlined in the IPCC AR6 Report (IPCC, 201), which compares observed changes in flooding days to random decade-pair comparisons while removing average sea-level differences.

During the 98-year observation period (1923–2021), water levels in Los Angeles exceeded the 1-year flood threshold on 749 days. On average, this equates to approximately seven flooding days per year. The highest number of flooding days recorded in a single year occurred in 2005 (highly active Pacific Jet Stream with heavy rainfall) and 2016 (El Niño), with 23 days each. Flooding days in Los Angeles exhibit pronounced seasonal patterns. The highest frequency of flooding days occurred in December (22% of occurrences), followed by July (18%) and January (15%). The maximum number of flooding days observed in a single month was six, occurring in December 1986, December 1994, January 2010, and December 2015.

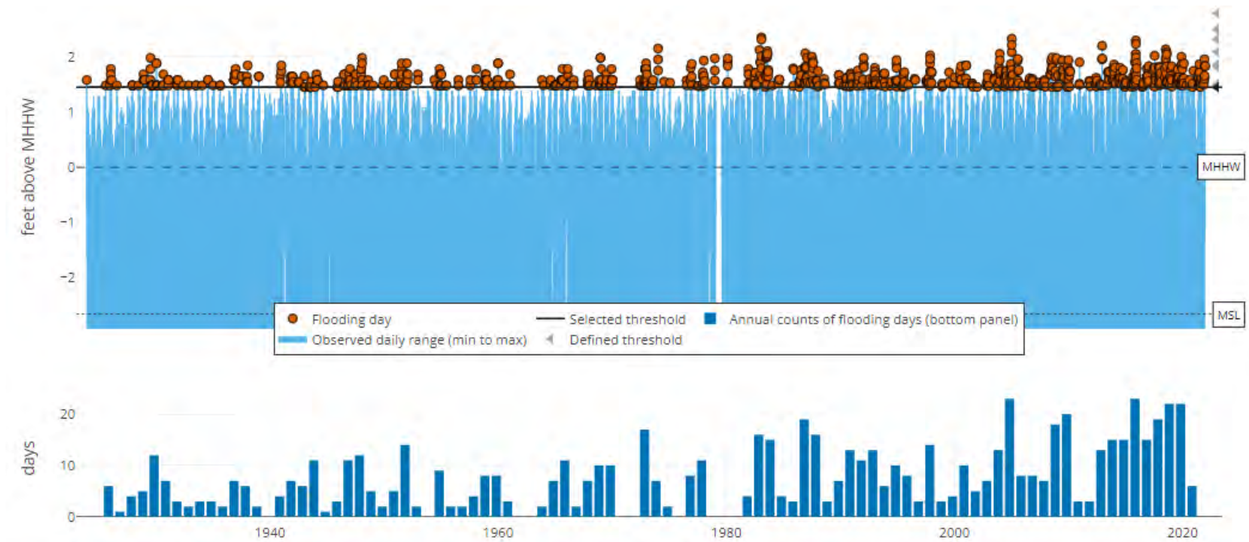


FIGURE 27: OBSERVED FLOODING DAYS AT NOAA STATION 9410660 (LOS ANGELES) FOR 1-YEAR FLOOD THRESHOLD

It should be noted that the 100-year extreme water level (WL) flooding threshold has only ever occurred twice in the historical WL record in 1982 and 2005 (Figure 28). Flooding days for this threshold have never occurred during other months. It should also be noted that the localized 100-year extreme WL elevation at NOAA Tide Station 9410580: Newport Bay Entrance is slightly higher than that of the Los Angeles gage with observed flooding occurrences never exceeding this elevation threshold. This could potentially be due to the limited data availability of the Newport gauge.

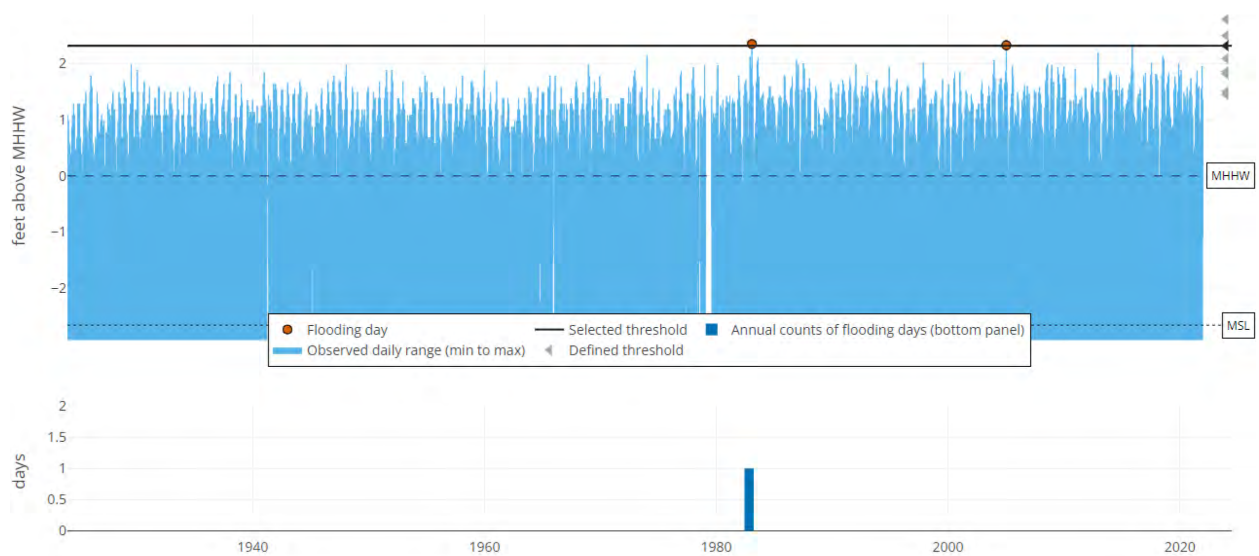


FIGURE 28: OBSERVED FLOODING DAYS AT NOAA STATION 9410660 (LOS ANGELES) FOR 100-YEAR FLOOD THRESHOLD

4.2.2. Projected Future Flooding

Future projections are based on the approach of Thompson et al. (2021) but updated to incorporate the 2022 ITF scenarios. The projections account for changes in tides over years and decades, as well as a range of possibilities influenced by unpredictable sea-level variations driven by ocean circulation and natural climate fluctuations, such as El Niño. Projected flooding analyses for the two (2) selected SLR scenarios from Section 3.2 (*Intermediate-High and High*) are provided below.

SLR is expected to lead to routine and chronic flooding, impacting an increasing number of locations and thresholds over time. For the *1-year* flooding threshold and *Intermediate-High* SLR scenario, *routine flooding* - defined as occurring at least 20 days per year - becomes likely (greater than 66% probability) on an annual basis starting in 2022. *Chronic flooding*—defined as at least 50 flooding days per year—is projected to become likely beginning in 2039. Additionally, there is a 67% chance of experiencing at least 50 flooding days during a single year as early as 2030.

The Year of Inflection (YOI) marks the point when the frequency of flooding begins to increase rapidly, following a period of relatively slower change. The degree to which this inflection occurs depends on the location, threshold, and scenario. For Los Angeles under the 1-year flooding threshold and Intermediate-High SLR scenario, the YOI is projected to occur in 2033. In the decade leading up to the YOI, the annual frequency of flooding is expected to decrease slightly, from an average of 31 days to 27 days per year (a 13% reduction). However, in the decade following the YOI, the frequency of flooding is projected to triple, rising sharply from 27 days to an average of 81 days per year. This rapid escalation highlights the nonlinear relationship between SLR and flooding frequency, underscoring the importance of timely adaptation measures.

Figure 29 and Figure 30 below illustrate how the frequency of flooding is projected to evolve throughout the 21st century for the selected location, threshold, and scenario. The first graph (left) displays the annual number of flooding days, while the second graph (right) shows how these flooding days are distributed within a future year. The "likely" and "very likely" ranges indicate a range of outcomes, accounting for unpredictable natural fluctuations in sea level and storm activity.

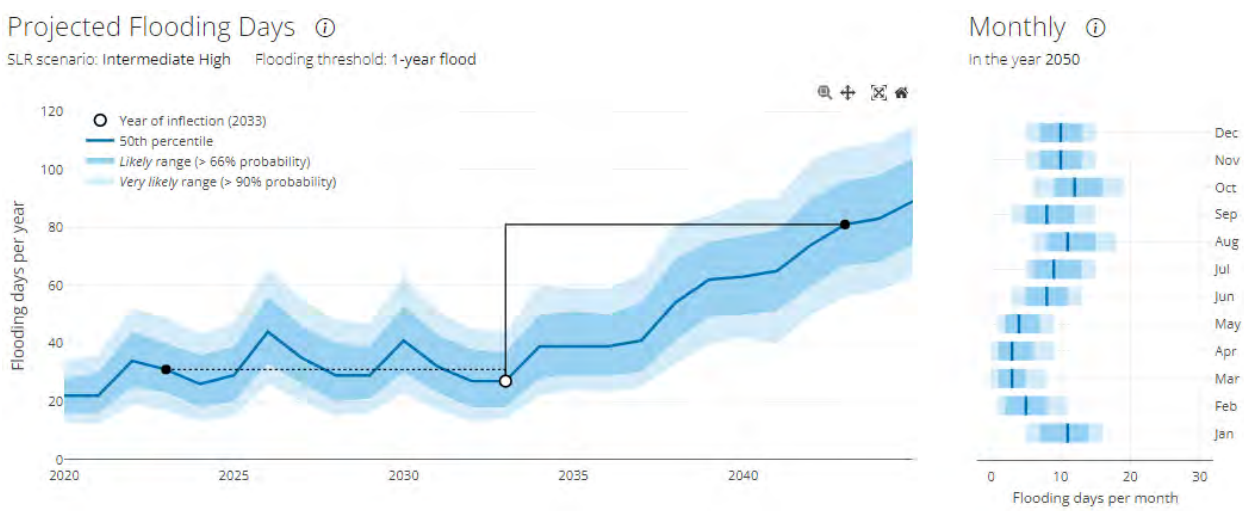


FIGURE 29: PROJECTED FLOODING DAYS (LEFT) AND ANNUAL DISTRIBUTION OF FLOODING DAYS BY MONTH (RIGHT) AT NOAA STATION 9410660 UNDER A 1-YEAR FLOODING THRESHOLD AND INTERMEDIATE-HIGH SLR SCENARIO

For the *1-year* flooding threshold and *High* SLR scenario, routine flooding becomes likely (greater than 66% probability) on an annual basis starting in 2021. Chronic flooding is projected to become likely beginning in 2038. Additionally, there is a 76% chance of experiencing at least 50 flooding days during a single year as early as 2030. For Los Angeles under the 1-year flooding threshold and High SLR scenario, the YOI is projected to occur in 2032. In the decade leading up to the YOI, the annual frequency of flooding is expected to decrease slightly, from an average of 34 days to 30 days per year (a 13% reduction). However, in the decade following the YOI, the frequency of flooding is projected to more than triple, rising sharply from 30 days to an average of 91 days per year.

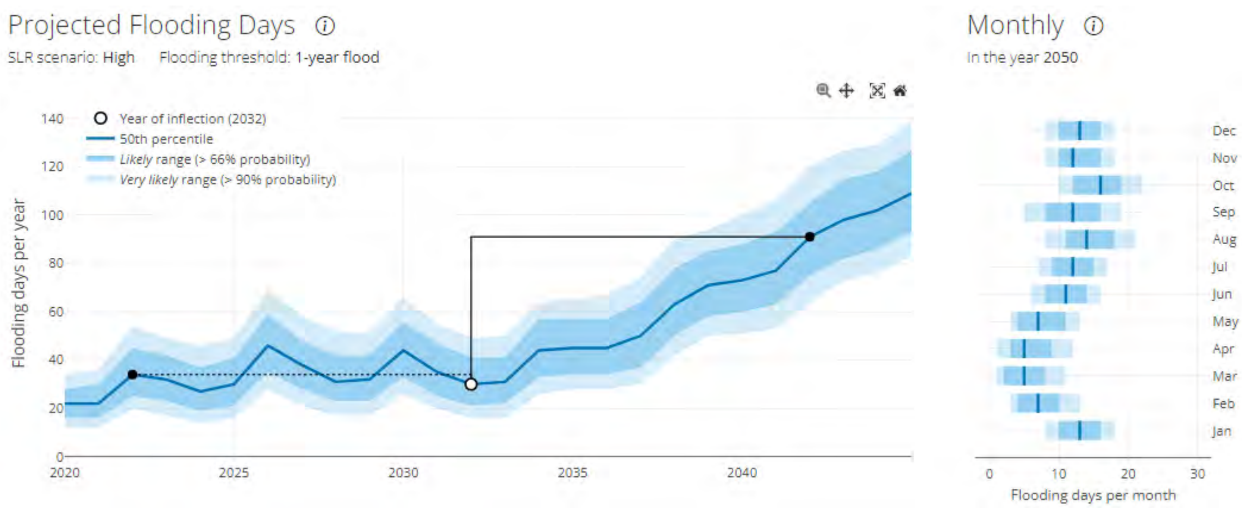


FIGURE 30: PROJECTED FLOODING DAYS (LEFT) AND ANNUAL DISTRIBUTION OF FLOODING DAYS BY MONTH (RIGHT) AT NOAA STATION 9410660 UNDER A 1-YEAR FLOODING THRESHOLD AND HIGH SLR SCENARIO

Figure 31 uses blue circles to represent the average number of flooding days per month during future five-year periods for the selected threshold and scenarios, while red circles show the number of flooding days during the most severe month of each five-year period. The vertical lines indicate the likely range for each value. Coastal engineers typically design structures to withstand rare extreme events rather than average conditions, and similarly, coastal communities should prepare for extreme months when numerous high-tide flooding events cluster together. This visualization highlights the difference between average flooding days and the most extreme monthly occurrences during each five-year period.

As flooding becomes more frequent, extreme months are projected to grow increasingly severe. Under the *Intermediate-High* SLR scenario (left), the Extreme Months graph indicated that during the period 2020-2024, monthly flooding was likely to average 2–3 days, with the most extreme month experiencing 9-13 flooding days. By 2030, there is a 97% chance of at least 10 flooding days occurring within a single month, rising to a 62% chance of at least 15 flooding days in a single month by 2040. Both future projections highlight the escalating severity of extreme flooding events over time. Under the *High* SLR scenario (right), projections for 2020-2024 indicated an average of 2–3 flooding days per month, with the most extreme month experiencing 9-13 flooding days. By 2030, there is a 98% chance of at least 10 flooding days occurring in a single month, and by 2040, the likelihood of at least 15 flooding days in a single month rises to 81%. These projections highlight the growing intensity of extreme flooding events over time.

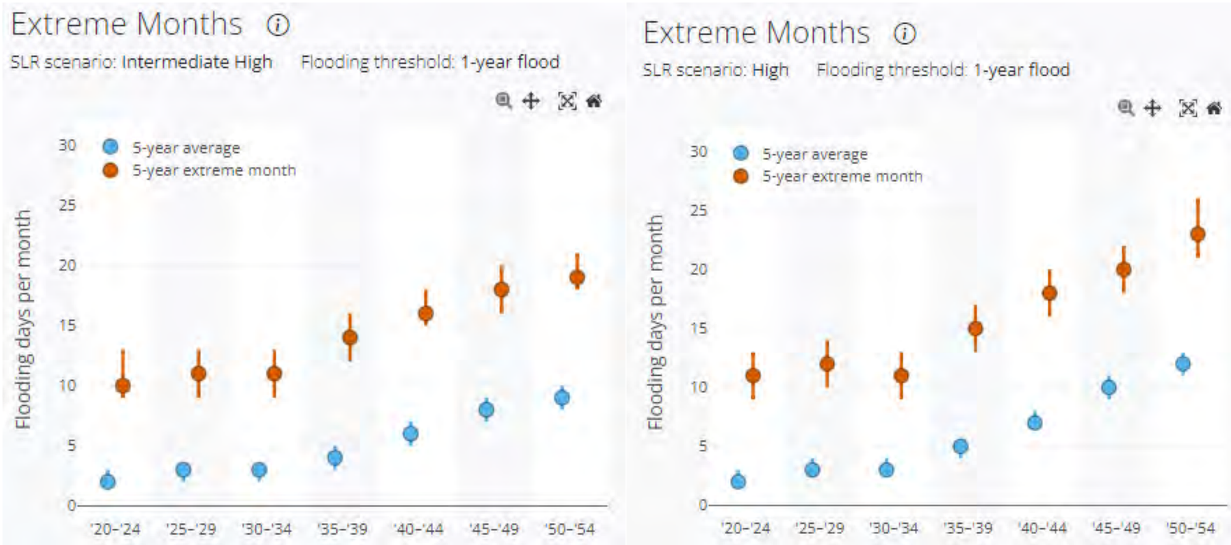


FIGURE 31: EXTREME MONTH FREQUENCY FOR 1-YEAR FLOODING THRESHOLD (INT-HIGH ON LEFT, HIGH ON RIGHT)

While NFAT provides extensive data and robust modeling capabilities, it is primarily dependent on satellite data, which can be limited by cloud cover and temporal resolution. Local conditions, such as land cover changes and small-scale terrain features, may also affect accuracy, and regional adjustments may be necessary for precise applications. Additionally, NFAT's predictive accuracy is heavily influenced by the quality of meteorological data, which can vary based on regional climate patterns and seasonal variability.

4.3. Groundwater Emergence Projections

Different soil types have different hydraulic characteristics due to variations in pore space and connectivity, which affect how quickly water can move through the soil. Permeable materials such as gravel and coarse sands allow groundwater to flow through it more easily, resulting in less groundwater accumulation and a deeper water table. Less permeable materials such as clays and silts make it more difficult for groundwater to flow and/or drain through them, resulting in an accumulation of groundwater and a shallower water table. Although the geology of a region often changes when moving vertically through the subsurface material, a single value for the hydraulic conductivity (k) can be used to quantify the permeability of subsurface geology for groundwater modeling purposes.

SLR can cause groundwater levels to rise, potentially leading to flooding even without significant rainfall or coastal storms if the water table elevation extends above the ground surface. This type of flood hazard is referred to as a groundwater emergence hazard. An increase in the marine water level will also cause shallow groundwater to rise and decrease the thickness of the water table, or the vertical "dry zone" from the ground surface to the boundary where groundwater saturates subsurface material. Surface flooding can occur when the water table rises above the ground surface and cause impacts further inland much sooner than flooding from marine inundation as a result of SLR. Shallowing of the water table can also impact underground infrastructure and mobilize contaminants in the soil.

SLR impacts on groundwater are evaluated using the USGS CoSMoS results for projected responses of the coastal water table using future SLR scenarios. Detailed information on shallow subsurface coastal geology is limited for much of California; as such, the CoSMoS groundwater model uses three representative k values that capture a range of common geologies across the state. Results presented within this memo are based on model results using a MHHW boundary condition. Groundwater hazards can be influenced by a number of local factors that may not be captured in regional modeling efforts. Modeling data are available in 25 cm SLR increments. Every SLR scenario ranging from 2.5 ft (75 centimeters [cm]) to 6.6 ft (200 cm) is used to represent the range of projected conditions at the end of the Project's 75-100-year design life. CoSMoS groundwater hazard modeling results for the moderate permeability condition under various levels of SLR are shown in Figure 32 through Figure 34. The moderate permeability material (k = 1 m/day) is comparable to fine- to medium-grained sand and has the best overall fit to groundwater data across the state. It is recommended for use if the local geology is unknown for a given project.

The red areas signify emergent groundwater during MHHW conditions, which occurs in parts of the Project site for all analyzed SLR scenarios. The other areas of the Project site have a very shallow (0 to 1 m, 0 to 3.3 ft) water table which is signified by the orange areas. The northeast border of the Project boundary is primarily a shallow (1 to 2 m, 3.3 to 6.6 ft) water table which is signified by yellow. Blue signifies marine/tidal inundation which begins increasing significantly under 4.9 ft of SLR at the project site.

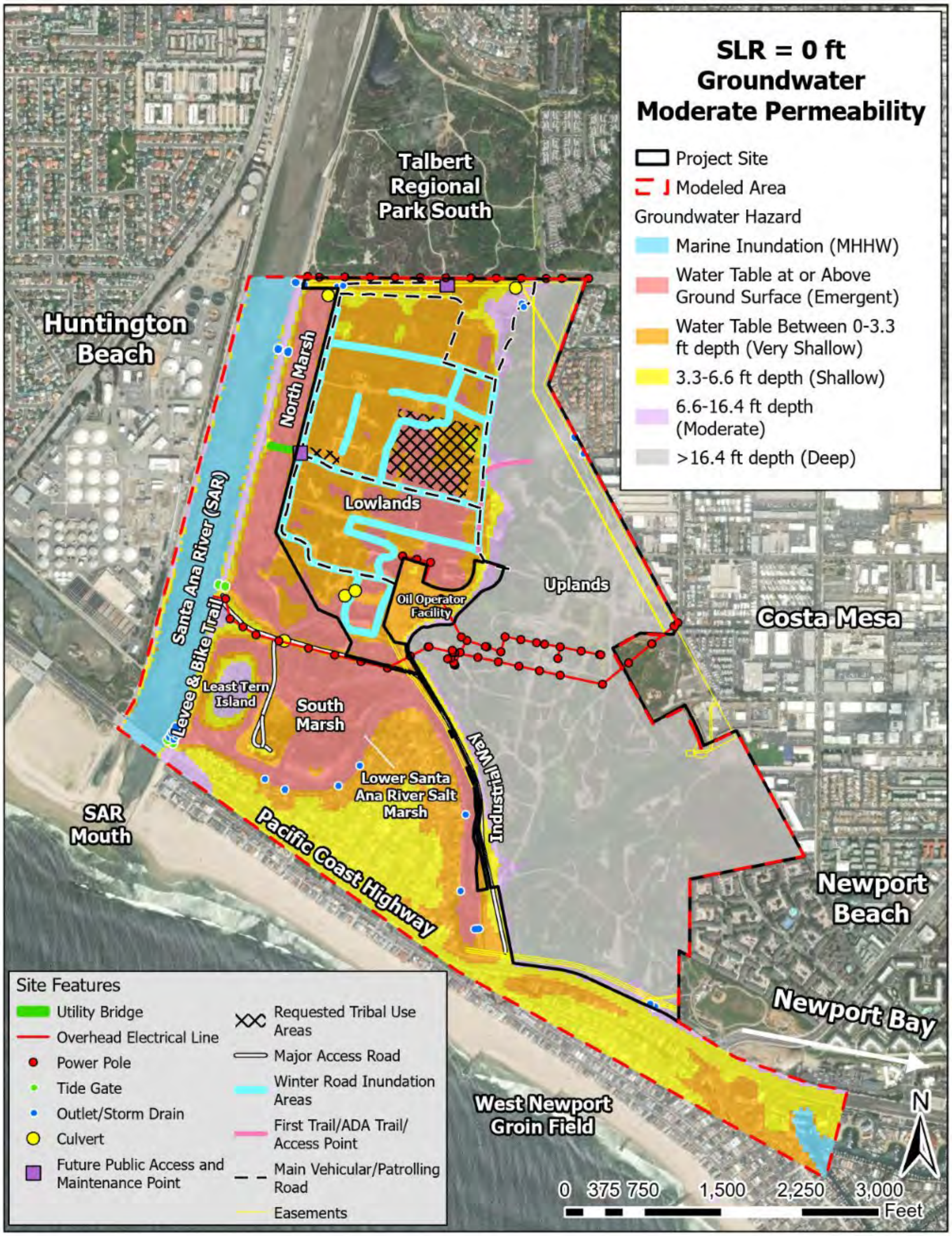


FIGURE 32: COSMOS GROUNDWATER AZARD PROJECTIONS UNDER EXISTING CONDITIONS (MODERATE PERMEABILITY)

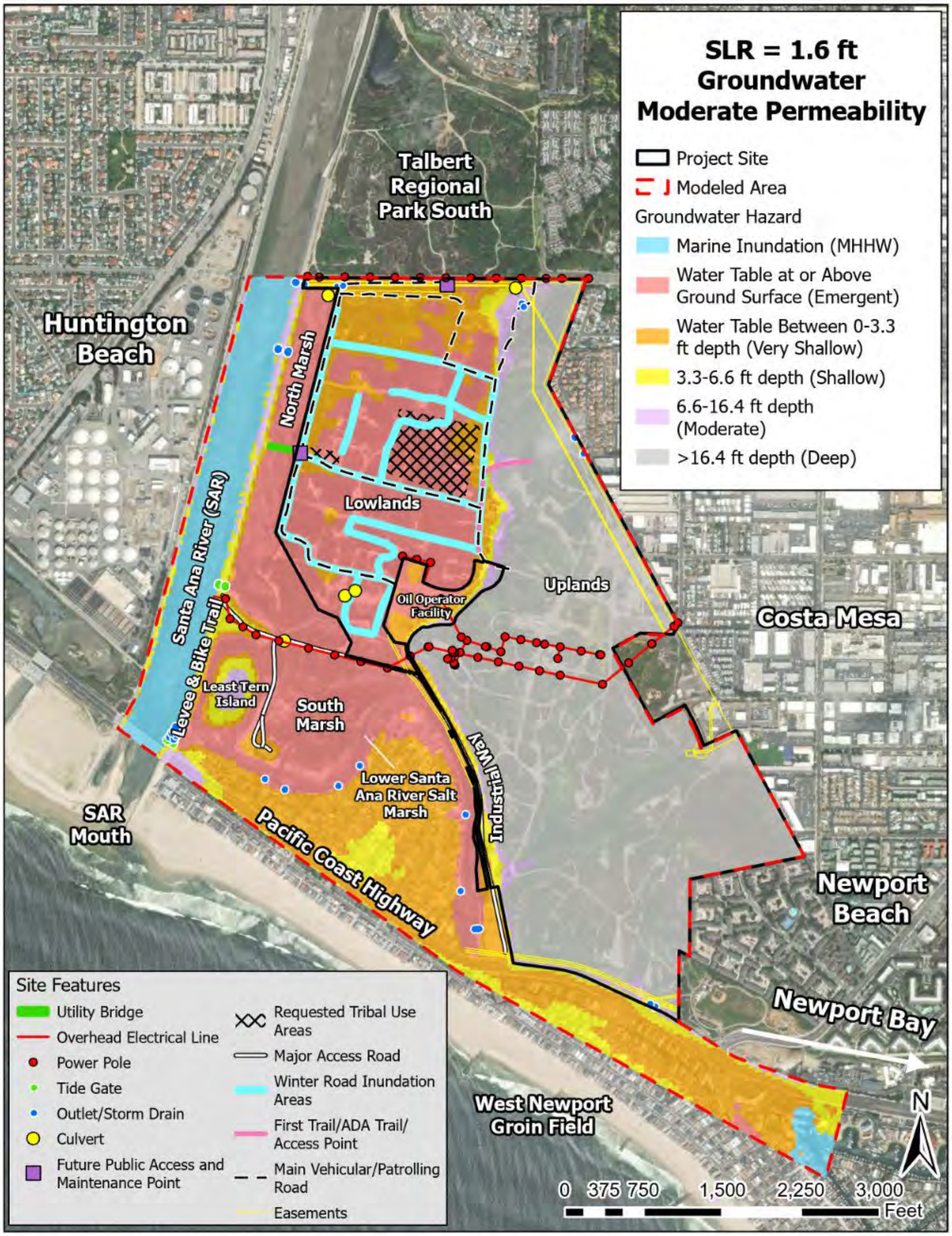


FIGURE 33: COSMOS GROUNDWATER HAZARD PROJECTIONS UNDER 1.6 FT OF SLR CONDITIONS AND WITH MODERATE PERMEABILITY.

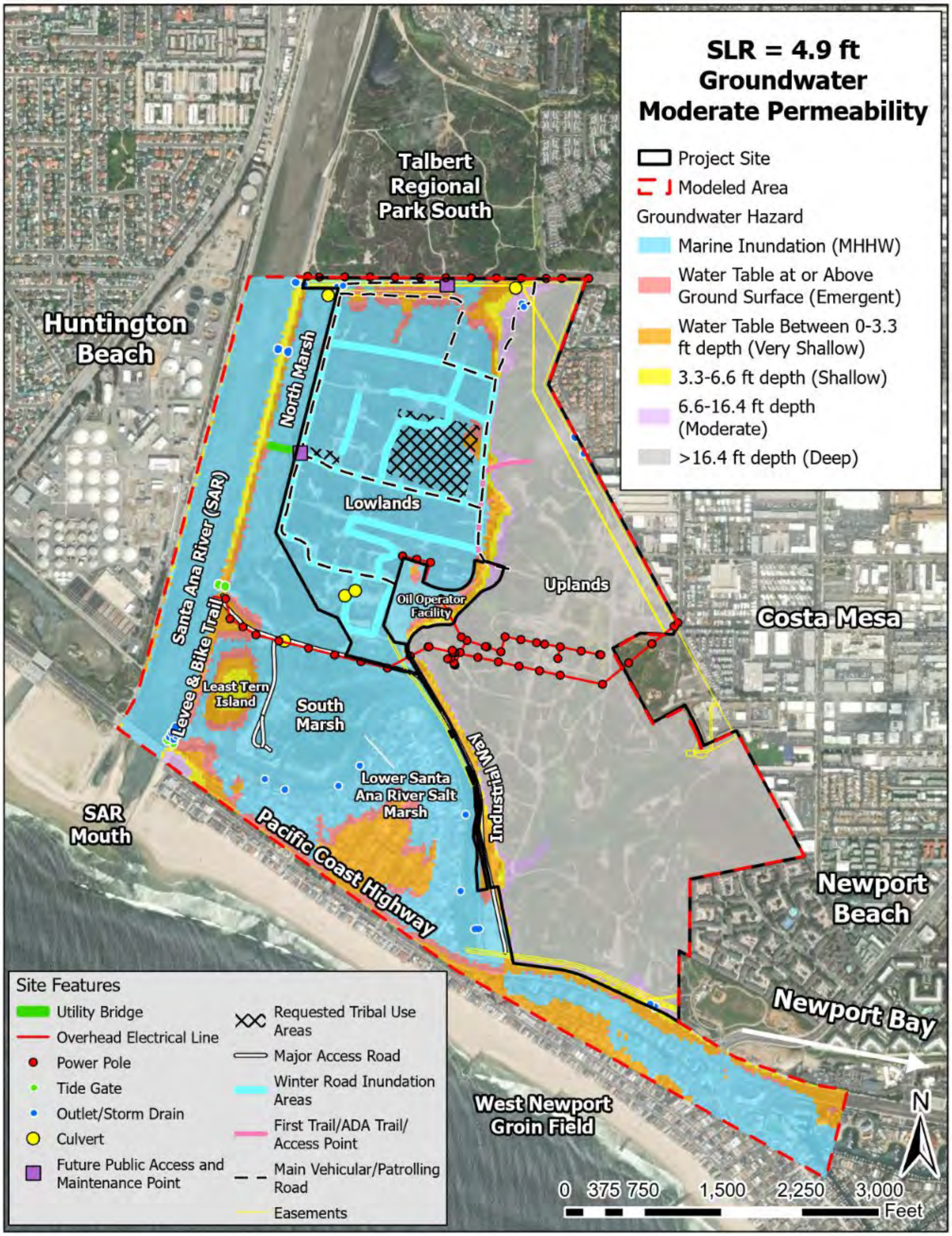


FIGURE 34: COSMOS GROUNDWATER HAZARD PROJECTIONS UNDER 4.9 FT OF SLR CONDITIONS AND WITH MODERATE PERMEABILITY.

4.4. FEMA's National Flood Hazard Layers (NFHL) Viewer

FEMA's Flood Insurance Rate Maps (FIRMs) categorize areas into different flood zones based on their level of flood risk. These flood zone categorizations are important for determining flood insurance requirements and guiding local floodplain management for development. Flood zones that have the highest risk of flooding are referred to as Special Flood Hazard Areas (SFHAs), which typically include properties that have a 1% or greater chance of flooding in any given year (100-year storm). The Project site lies within several FEMA-designated flood zones along the SAR and highlights the varying levels of flood risk (Figure 35). Most of the project site falls within **Zone X** (Shaded), which indicates a low flood risk. These areas are outside of the anticipated 100-year floodplain but within the 500-year floodplain, meaning there is a 0.2% annual chance of flooding. The flood risk at the Preserve is mitigated by the eastern SAR levee that offers substantial protection from frequent flooding, but may still be subject to rare extreme events. The uplands at the site are outside the 500-year floodplain. The Preserve is hydraulically connected to the USACE North Marsh and South Marsh sites and ultimately the SAR, which is classified as Zone A and is prone to an annual 1% chance of flooding.

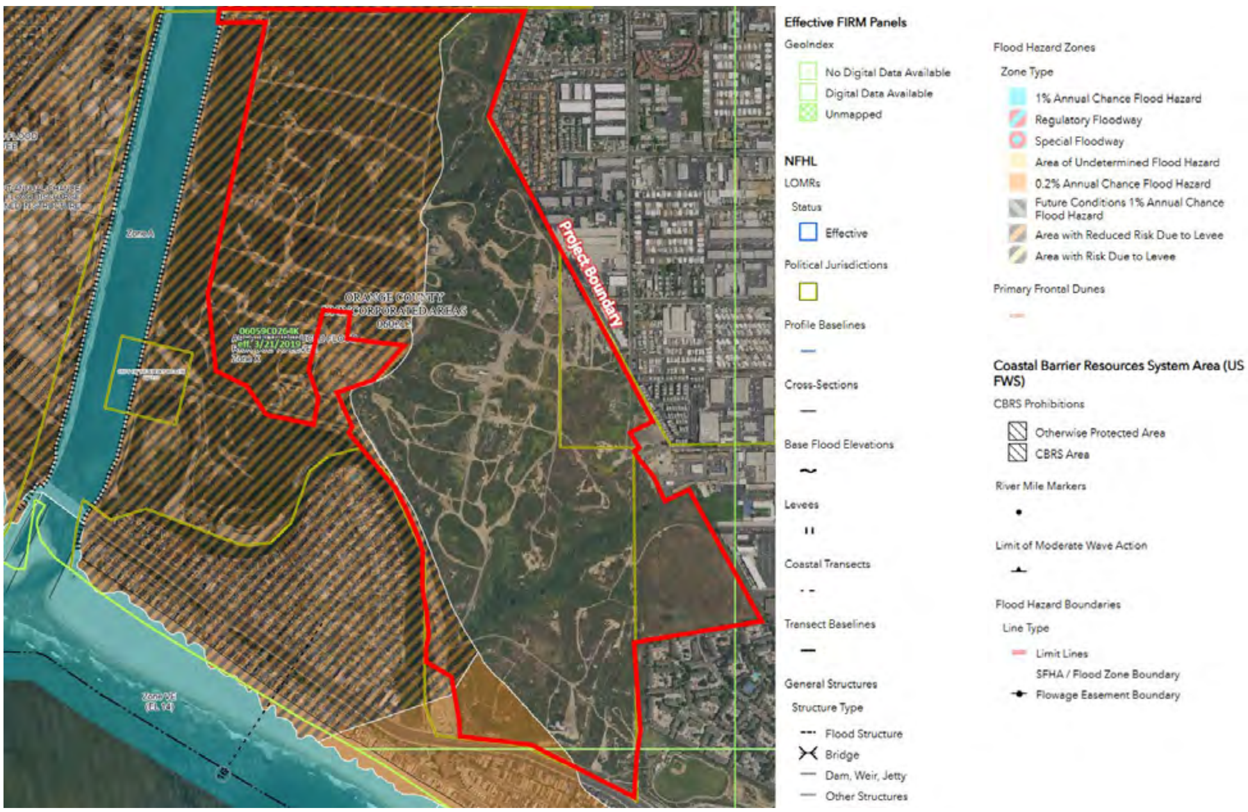


FIGURE 35: FEMA ZONE DELINEATIONS AT PROJECT SITE (NFHL VIEWER)

5. Evaluation of Coastal Hazards and Vulnerability Assessment

This SLR analysis provides a qualitative evaluation of potential vulnerabilities in the Project area and neighboring areas due to future SLR hazards. The intersection of potential SLR hazard zones and the Project area was determined using GIS software (Snover, et al., 2007) and *California Adaptation Planning Guide, Planning for Adaptive Communities* (California Emergency Management Agency & California Natural Resources Agency, 2012).

In accordance with these and other state SLR planning guidelines (California Coastal Commission, 2018), SLR vulnerability within different areas of the project is assessed as a function of exposure, sensitivity, and adaptive capacity. These concepts, in the context of how they are used within this SLR analysis, are illustrated in Figure 36.

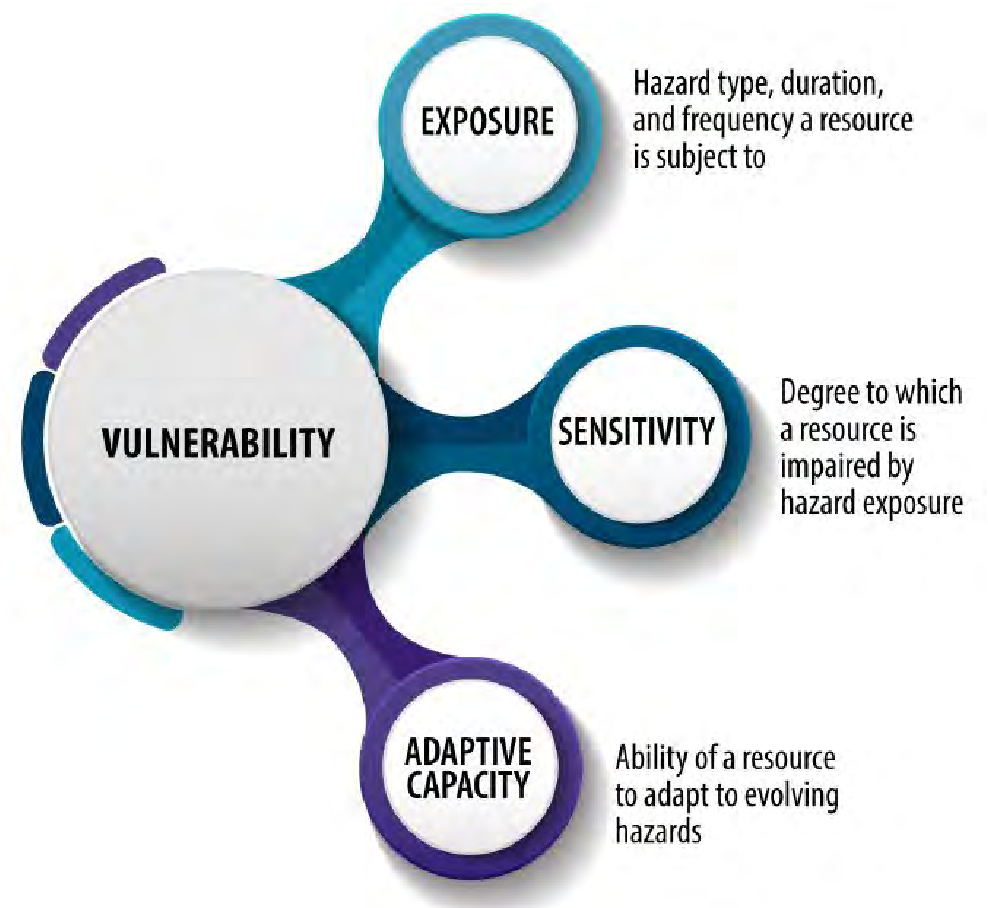


FIGURE 36: COMPONENTS OF SEA LEVEL RISE VULNERABILITY AS DEFINED WITHIN THIS STUDY

The vulnerability of an asset increases with both exposure and sensitivity, while adaptive capacity is inversely related to vulnerability. As an example, large residential structures typically have a high sensitivity to SLR hazards because even minor flooding or erosion can cause significant and costly damage. Large structures may also have a low adaptive capacity to SLR in that they cannot be easily relocated or raised to cope with consequences, compounding overall vulnerability. An alternative example would be structures such as floating docks, which are highly exposed to coastal hazards, but often maintain a low vulnerability to SLR because they can easily adapt to increasing water levels. Hazard exposure and hazard sensitivity are given qualitative ratings as outlined in Table 6.

TABLE 6: SLR VULNERABILITY RATINGS AND DESCRIPTIONS

Category	Rating	Description
Hazard Exposure	N/A	No exposure to flooding or erosion.
	Low	Exposure to storm flooding in select areas.
	Moderate	Significant exposure to storm flooding and/or partial exposure to non-storm inundation.
	High	Significant exposure to non-storm inundation.
Hazard Sensitivity	Low	Minimal impacts to structure and function as a result of coastal hazards unless inundated on a regular basis.
	Moderate	Moderate impacts to structure and function during temporary storm flooding. Significant impacts if inundated.
	High	Significant impacts to structure and function from short-term storm flooding or inundation.
Adaptive Capacity	Low	Limited options for adaptation. Adaptation likely to have significant costs.
	Moderate	Multiple options for adaptation over time with relatively moderate effort and cost.
	High	Multiple options for adaptation over time with minor additional cost.

5.1.1. Hazard Exposure

Coastal hazard exposure refers to the degree to which natural or anthropogenic hazards, such as coastal erosion, SLR, storms, and flooding interact with or affect specific areas or assets within the coastal zone. In general, the degree of flooding exposure due to SLR at a specific site typically dictates how exposed the site is to these hazards. Overall, the existing topography within the project area is situated at elevations above the flood scenarios projected within the Project's useful life with the exception of portions of the surrounding roads, which are lower and more susceptible to flooding. Hazard exposure for the Project is summarized below. The time horizons for SLR projections are based on the selected 2024 OPC Guidance intermediate and int-high scenarios.

5.1.1.1. Existing Conditions

The term "existing conditions" is used to represent current site conditions at the time of writing of this report with no proposed alterations. Under these existing conditions, model results show that there is limited flood exposure for the non-storm and 100-year storm conditions at the Preserve (Figure 17). All hydraulically connected areas within the project site are exposed to daily tidal fluctuations up to the max operational tide gate function. The non-storm condition shows that floodwater enters from the tide gates located along the east SAR levee and flows through the existing marsh channels. Minimal inundation is projected within the project boundary at places with the lowest elevations in the southern part of the Preserve. As shown in the Figures that follow, these areas are adjacent to the North Marsh and are projected to experience some tidal inundation. Because the tide gates limit the amount of water entering the site, the flood extent is projected to remain mostly within the existing marsh channels and pass through interior hydraulic connection structures (e.g., tide gates and culverts) without any issues. Some site features such as the road (Industrial Way) and the utility bridge at North Marsh remain unimpacted. No amenities in the uplands are projected to be impacted under existing conditions. For both scenarios, no flooding is projected to occur in the modeled area south of PCH except for a small portion of Balboa Cove.

Figure 18 presents the flood depths and low-lying areas under existing conditions and a non-storm scenario. Portions of the South and North Marshes are projected to be inundated up to 4 ft with flooding following the naturally existing channel delineations. The lower elevations in the southwest portion of the project site are projected to be sporadically low-lying between some of the lowland dirt roads.

Figure 19 presents the projected flood depths and low-lying areas under existing 100-year storm conditions. Under 100-year storm conditions, actual projected flooding still remains minimal though the footprint of potentially low-lying areas increases in the western lowlands portion of the project site. The flood depths within the wetland areas are projected to remain the same due to the functionality of the tide gates and storm drain infrastructure. Portions of the winter road access routes near the southern boundary already face shallow inundation (~0–2 ft), particularly during these larger storm events. Most utilities, access easements, requested tribal access areas, and main vehicular patrolling roads remain dry under existing conditions.

Under both the existing non-storm and 100-year storm conditions, the site is projected to be protected from inundation. Most of the projected inundation area occurs in the existing wetland areas with very little impacts to existing infrastructure. Existing infrastructure such as the levee, tide gates, drains along the levee, SART, remaining oil facilities, and utility poles are projected to remain protected. Figure 37 below provides an overall depiction of the existing vegetation within the project boundary, which totals approximately ~387 acres. As shown in the Figure, the non-storm condition is analogous to the 100-year storm condition (provided in Figure 38) due to the flood extents and depths dictated by the hydraulic connection structures. Approximately 328 acres of the 387-acre project footprint are vegetated. Approximately 3.5 acres (~1%) of the 328-acre vegetation footprint is projected to be impacted under these conditions.

FIGURE 37: EXISTING VEGETATION CONDITIONS (NON-STORM)

FIGURE 38: IMPACTED VEGETATION (EXISTING CONDITIONS, 100-YEAR STORM)

5.1.1.2. 1.6 ft SLR (Int 2080, Int-High 2065)

The time horizon estimated for 1.6 ft of SLR is projected to range from 2065 (Intermediate-High scenario) and 2080 (High scenario) according to Table 4. When considering a 50-year design life, this SLR scenario is representative of a potential middle to end of useful life flood exposure for the project. CoSMoS model results show that flood exposure is present for both the non-storm and 100-year storm conditions at Randall Preserve (Figure 20). Under this SLR scenario, functionality of the tide gates becomes important to prevent widespread inundation of the site. Flood depths in the SAR increase slightly to water levels mimicking the open ocean, increasing to depths of up to 8-10 ft. This increased SWL would increase the frequent inundation experienced on the SAR side of the levee.

Similar to existing conditions, projected inundation under a non-storm scenario enters from the tide gates located along the east SAR levee for the areas shown inundated north of PCH. Non-storm flooding is projected to extend up to approximately 2,000 ft east of the SAR and into the existing marsh areas via a series of existing culverts and channels but remain within the same footprint as existing conditions. The existing utilities and site features are protected by the critical infrastructure currently protecting the site. The flood extent is only projected to increase under 100-year storm conditions in the southeast portion of the modelled area from Balboa Cove. West Newport neighborhoods south of PCH are projected to experience some flooding under a 1.6 ft SLR + 100-year storm scenario with flood depths reaching up to 4 ft in some areas. Some portions of PCH are also projected to be impacted by 0-2 ft of flooding. Both scenarios impact urban development and West Newport residents and would necessitate a broader planning framework to address these issues at a local level. It should be noted, however, that CoSMoS results in this area may be overly conservative due to its protected and tucked away location in the upper portion of Newport Bay (i.e. wave modelling may be overly conservative at this specific location due to its sheltered nature).

Under the 100-YR storm scenario with 1.6 ft of SLR, the exposure of Preserve features is projected to increase moderately. Shallow inundation (0–2 ft) is projected to affect additional segments of the Winter Road Inundation Areas, particularly along low-lying access paths near the South Marsh and adjacent to SAR. Select easements and ADA trail access points begin to experience minor flood depths, and Tribal Use Areas near the western edge show limited encroachment by stormwater. While major vehicular and maintenance roads remain largely serviceable, expanded flooding along the southern perimeter reduces reliability in key circulation routes. At this stage, all features remain operable but may require temporary closures or design upgrades to preserve accessibility and function during storm events.

Areas projected to be low-lying have elevations ranging from +5.6 to +7.4 ft NAVD88. Figure 21 presents the projected flood depths and low-lying areas under non-storm conditions with 1.6 ft of SLR. Increased flooding is projected in all the hydraulically connected areas and at the lower elevations in the western portion of the site. Though the overall system is well-equipped to handle fluctuations in water level from the SAR and open ocean via the tide gates, increased maintenance and oversight of things such as the levee, storm drains, and interior culverts may be required to prevent any sort of backflow or loss due to operational failure. Flooding under both the non-storm and 100-year storm scenarios is not projected to overtop the levee that separates the Preserve and North Marsh from the SAR. The upland areas of the site and the existing oil facility infrastructure in the lowlands remain protected at slightly higher elevations of SLR. If the tide gates were not functioning, the risk of flooding to some site features such as the lower portion of Industrial Park Way and southern portions of the lowlands would significantly increase. Impacted vegetation within the project site specifically remains the same as previous conditions with only ~1% of vegetation being impacted (Figure 39 and Figure 40).

FIGURE 39: IMPACTED VEGETATION (1.6 FT SLR, NON-STORM)

FIGURE 40: IMPACTED VEGETATION (1.6 FT SLR, 100-YEAR STORM)

5.1.1.3. 4.9 ft SLR (Int 2140, Int-High 2105)

The time horizon estimated for 4.9 ft of SLR is projected to range from 2140 (Intermediate-High scenario) to 2105 (High scenario) according to Table 4. This SLR scenario is therefore representative of a scenario well beyond the project's 50-year design life under either SLR scenario. Because it is well outside the anticipated design life, it is assumed that improvements to major infrastructure and existing mitigation measures (such as PCH and the levee) that currently protect the site will be reinforced as part of a broader regional adaptation plan prior to the extreme magnitude of exposure. For the purpose of this analysis, however, the site is analyzed under both *protected* (assumes improvements have been made to PCH, and that the SAR levee will not be overtopped) and *unprotected* (Infrastructure is assumed to be overtopped with no future improvements made between now and the distant time horizons) conditions for the 100-year storm scenario.

Model results indicate that both non-storm and 100-year storm conditions under a 4.9 ft SLR scenario would not have major impacts to the project site as the associated water level (WL) increase in the SAR and open ocean would still be limited by the tide gates. While flood hazard exposure would theoretically remain the same, increased flooding of these hydraulic structures would increase the usage and therefore would increase the potential risk of overuse. Flood depths in the SAR are projected to be greater than 10 ft deep and would have a SWL close to the crest elevation of the existing levee.

Figure 24 presents the projected flood depths and low-lying areas under non-storm conditions with 4.9 ft of SLR. Flood extent under the 4.9 ft SLR non-storm scenario remains within a similar footprint due to the functionality of the tide gates and elevations of the existing levee that separates the SAR from the site. No flooding is projected to occur at West Newport or south of PCH under this protected scenario as it is assumed that city-wide or regional improvements are implemented to mitigate flood risks from Newport Bay\Balboa Cove. The extent of low-lying areas under non-storm conditions expands to cover approximately half of the modeled area and entire neighborhood adjacent to the marsh channel.

Figure 25 presents the projected flood depths and low-lying areas under protected 100-year storm conditions with 4.9 ft of SLR. Areas projected to be low-lying have elevations between 5.6 to 12.6 ft. The figure depicts a portion of the site heavily relying on the protection provided by the tide gates and levee. For the purpose of this study, it is assumed that agency and/or stakeholder intervention has already taken place sometime between the 1.6 ft SLR scenario and this scenario, or sooner, to address flooding concerns that may arise in West Newport neighborhoods, along PCH, and the portion of the eastern levee closest to PCH Bridge. Under protected conditions with 4.9 ft of SLR, most of the Preserve's western and southern lowlands become moderately inundated (2–6 ft), affecting nearly all low-lying features. Winter roads, ADA trail access points, and projected Tribal Use Areas along the western edge face multiple feet of floodwater, while easements near the SAR and the oil facility experience periodic inundation, limiting accessibility for utility maintenance. Public access and maintenance points, especially near the South Marsh, are exposed to several feet of flooding, posing safety and operability challenges. Although the protective levee and PCH continue to hold back catastrophic flooding, site functionality in these zones is significantly reduced without elevation or retreat measures. Under both the non-storm and 100-year storm conditions, impacts to existing vegetation remain less than <1% of the total acreage of vegetation.

FIGURE 41: IMPACTED VEGETATION (4.9 FT SLR, NON-STORM)

FIGURE 42: IMPACTED VEGETATION (4.9 FT SLR, 100-YEAR STORM)

Although the Preserve is located inland and sheltered, the area is still subject to some flood risk, particularly under a SLR scenario of 4.9 ft + 100-year storm event. Under this scenario coastal areas within the vicinity of the Preserve will see increased storm surge and water levels during high tides or storms, which can cause inland flooding. This scenario assumes that protective measures are not implemented and increased water levels travel farther inland, pushing floodwaters from Lower Newport Bay toward PCH and the Preserve and making portions of West Newport Beach and PCH vulnerable. Additionally, this scenario assumes the eastern levee of the SAR near PCH bridge could be overtopped by waves during extreme storm conditions and a high tide due to a low spot on top of the levee at that location (Note: this low spot is not considered topographically low under present-day sea level conditions. Rather it *becomes* a low spot relative to rising water levels i.e., when local sea level increases to 4.9 ft and higher).

For the 4.9 ft SLR + 100-year storm unprotected scenario, flooding is analyzed under the most conservative scenario. This scenario assumes no agency / stakeholder intervention, failure of the critical infrastructure and no accompanied repairs, and that current existing conditions remain the same – despite the magnitude of SLR and increased future inland flooding . Figure 26 presents the projected flood depths under 100-year storm unprotected conditions with 4.9 ft of SLR. Under this condition, widespread tidal inundation is projected at the Preserve and approximately ~140 acres of the site are projected to be completely inundated.

Floodwaters are projected to overtop the lower portions of the SAR levee and overtopping of PCH is projected to occur due to a vulnerability along the shoreline of Newport Bay at Balboa Cove. Widespread flooding (greater than 10 ft) is anticipated to flood portions of the South Marsh completely overwhelming the interior culverts and the lower portions of Industrial Park Way and paved access road, which sits at approximately +10 ft NAVD88. The oil operator facilities – in the central and southwestern lowland portions of the site – are anticipated to experience up to 8 ft of flooding, which would render them completely inoperable along with the entire lowland network of dirt roads. Widespread inundation is projected outside of the project boundary from both the upper Newport Bay area into adjacent neighborhoods and through the North and South Marsh systems.

Under this scenario, widespread flooding is projected to merge with previously isolated ponded areas into a single, expansive waterbody, significantly altering hydrological conditions at the site. Site features such as the Utility Access Bridge and storms drains are projected to be submerged. Utilities within the lowlands are projected to encounter up to 10 ft of inundation, with almost 50% of the overhead electrical lines having the lower third of their wooden posts completely submerged. PCH, one of the most critical state highways, is projected to be completely inundated with portions of the highway reaching a flood depth of 6-8 ft. Nearly all Winter Road Inundation Areas, public access points, Tribal Use Areas, and vehicular/patrol roads are submerged—rendering them inaccessible or nonfunctional without major retrofits. Flooding extends well into utility easements and ADA access points, fully compromising their operability and safety. Due to the increased inundation footprint, more than 34% (~112 acres) of the total vegetation is projected to be impacted with greater than 99% of lowland vegetation affected (Figure 43).

FIGURE 43: IMPACTED VEGETATION (4.9 FT SLR, UNPROTECTED 100-YEAR STORM)

5.1.2. Hazard Sensitivity

Hazard sensitivity can be defined by the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. It relates to the susceptibility of the site to the various coastal hazards associated with SLR and considers the ecological, social, and economic factors that make certain areas or assets more sensitive or vulnerable to hazards.

Overall, a majority of the project site has relatively low sensitivity to SLR hazards due to the assumed integrity of the existing critical infrastructure such as the levees and tide gates. The following coastal resources are assessed for hazard sensitivity as they relate to the SLR scenarios modelled.

FIGURE 44: STEPWISE ROADMAP OF VULNERABILITY ANALYSIS

5.1.2.1. Existing Preserve Vegetation & Habitat

Natural habitats have a higher sensitivity if they provide potential or known habitat for Federal and State threatened or endangered species. These areas may be a critical stopover for migratory bird species, offering refuge and sustenance during their long journeys along the Pacific Flyway. The Preserve is also home to sensitive species such as the California gnatcatcher and the Least Bell's Vireo, which rely on the intact habitats for survival. General SLR could pose a significant threat to wetland wildlife and biodiversity by altering habitat composition, increasing salinity, and accelerating erosion in the coastal ecosystem at the site. Increased salinity intrusion can disrupt any freshwater-dependent or brackish species, altering food webs and reducing biodiversity. All habitats that are exposed to SLR and/or storm tides have sensitivity to damage. However, natural habitats have an inherent resilience to occasional storm tides. It is the recurring, or extreme events, which may permanently damage or destroy these habitats.

Coastal salt marshes play a crucial role in buffering storm surges, filtering pollutants, and supporting ecological resilience, but without proactive conservation and adaptation strategies, these ecosystems may be unable to adapt quickly enough to rising sea levels. The loss of wetlands would not only reduce biodiversity but also weaken the region's natural defenses against climate change, underscoring the urgency of long-term resilience planning. Additionally, the salt marsh's ecological functions contribute to water quality improvement by filtering pollutants and buffering surrounding communities against storm surges and flooding, making it a valuable natural asset for biodiversity and resilience in coastal environments. These areas are more adaptive in response to potential SLR increases.

However, as sea levels rise groundwater tables are also elevated. Higher base water levels can impede natural outflow, causing water retention and prolonged inundation in low-lying areas of the Preserve. Additionally, increased storm intensity may accelerate arroyo erosion, leading to sediment displacement that can degrade habitat quality and alter vegetated morphology. If left unmanaged, these changes could impact adjacent infrastructure, access roads, or habitat connectivity, necessitating adaptive flood mitigation strategies, such as reinforced erosion controls, bluff stabilization measures, and integrated watershed planning to enhance resilience against future hydrological changes.

Most of the upland natural areas comprising the eastern portion of project site have a low sensitivity to flooding hazards and are likely to be generally resilient to temporary flooding. The site contains numerous areas of natural habitat with some of the lower areas being more sensitive to flooding. Water levels inside the existing salt marshes and channel systems are controlled by the tide gates and are therefore anticipated to remain less sensitive under all of the protected scenarios. Though flooding is projected to substantially increase under the unprotected 4.9 ft SLR 100-year storm scenario, the existing marshes and habitat areas should be able to withstand increased saltwater exposure if this scenario were ever to occur. The increase in flood exposure under this specific scenario could, however, alter the tidal regime and success rates of certain vegetation if inundated over extended periods of time; thus, altering the existing ecosystem.

5.1.2.2. Utilities

Utilities within the project site are highly sensitive to SLR hazards. Flooding and erosion may damage above-ground infrastructure, such as power lines, pumping stations, and access roads, leading to service disruptions and costly repairs. Additionally, more frequent extreme weather events and tidal surges could overwhelm drainage systems, increasing the risk of contamination and infrastructure degradation. Flooding of utility easements, for example, may interrupt operations or delay critical repairs. Buried infrastructure is especially at risk if not water-sealed or properly maintained.

Both temporary flooding and/or prolonged exposure to saltwater could accelerate corrosion of metal components (such as guy wires), any connectors, transformers, or hardware. Things such as transformers are the most vulnerable due to direct exposure to floodwaters. They may require retrofitting, elevation, or relocation to mitigate any risks. Wooden poles are more susceptible to rot and weakening when exposed to consistent moisture from flooding or rising groundwater tables. Additionally, the poles may not be structurally rated to handle the additional loads caused by wet or increasingly saturated soils.

The site's proximity to urban development further compounds its exposure to coastal hazards, as it interfaces with municipal stormwater systems designed to manage runoff from nearby areas. These systems channel stormwater through a network of drains and culverts, ultimately discharging into the Preserve. These upland systems do not appear to be at risk of backflow during high tides or storm surge events because these facilities are located at high elevations along the bluffs.

5.1.2.3. Critical Infrastructure & Development

For this study, it is assumed that all of the oil operations will be removed and remediated on the property prior to public access and restoration work. The presence of aging oil infrastructure poses potential risks under SLR and increased flooding scenarios, though most are assumed to be removed prior to the commencement of any restoration or adaptation work. Rising groundwater tables could mobilize residual contaminants trapped in subsurface oil piping, increasing the risk of leachate contamination into surrounding soils and water bodies. Additionally, increased storm intensity and surface flooding could accelerate infrastructure deterioration, leading to structural failures that may introduce pollutants into wetland ecosystems.

All oil pipelines within the project site are expected to be fully removed or capped at approximately three feet below grade prior to the start of any restoration activities. As such, no residual contamination, structural instability, or surface-level infrastructure related to oil operations is anticipated to remain onsite. While the risk of soil disturbance during grading or restoration remains a general consideration, the removal and/or capping of oil infrastructure to regulatory standards greatly reduces the potential for mobilized contaminants. Accordingly, no heavy machinery, stockpiles, or remnant construction materials associated with oil operations will be stored or staged onsite. Therefore, it is assumed that the project site will not contain any legacy hazards that could complicate future grading or wetland restoration activities.

Oil operator facilities are not expected to remain within the project boundary. However, fencing and access roads associated with previous operations may still exist at the margins of the site. These remaining features should be evaluated for their long-term viability under projected sea level rise (SLR) and storm conditions. For example, the southern boundary of the site—where fencing demarcates the property line—is more vulnerable to inundation during higher SLR and extreme storm events. If these features are retained for site security or delineation purposes, they may require future elevation or relocation to less flood-prone areas. Any such adjustments should be coordinated with long-term adaptation planning for adjacent infrastructure and access routes.

Additionally, the presence of dirt access roads, initially designed for heavy equipment, suggests a potential for soil compaction and erosion, particularly where these roads intersect areas of ponding water that support native fauna and vegetation. Though these roads could handle temporary inundation, prolonged storm events, tidal backflow, and/or rising groundwater levels may accelerate erosion and sediment displacement, potentially impacting road stability and increasing sediment loads. Roads that may be essential for emergency response, maintenance, and operational access (such as Industrial Way, some of the winter inundation roads, etc.) may be vulnerable to saturation, erosion, and impassability under SLR-driven storm conditions.

Since the operation of the tide gates depends on water levels within the Marsh, failure to drain properly through the outlet culverts could result in gate malfunction and stagnation of interior waters if left unaddressed. Therefore, it is essential that these outlet drains remain clear of debris, sediment, and vegetation. The drains are equipped with screens on the Marsh side to prevent blockage, while flap gates on the river side open only when a positive hydraulic gradient exists from the Marsh side.

The levee infrastructure, while critical for flood protection, introduces additional sensitivities due to its role in housing tide gates, hydraulic connection structures, and public access routes like bike trails. Any modifications to the levee system must consider its function as a flood control measure, ensuring that structural integrity is maintained while allowing for ecological connectivity. The interior levee that separates North Marsh from the Preserve further complicates hydrological dynamics, as changes to its structure could influence water flow and habitat viability within the project area (though not anticipated without significant agency intervention prior).

FIGURE 45: EXISTING INFRASTRUCTURE: *(LEFT)* DEVELOPMENT AND SITE ACCESS NEAR PCH, AND *(RIGHT)* LOW-LYING DEVELOPMENT - EXISTING OIL OPERATOR SITE, NETWORK OF PIPES, DIRT ROADS, AND UTILITY POWER LINES (DUDEK 2024)

Although not directly located at the site, PCH (Highway 1) also plays a critical role in the accommodation and planning strategy associated with future potential SLR at the site. As sea levels rise, increased frequency of extreme events, higher storm surges, and tidal flooding lead to more frequent road closures, infrastructure damage, and loss of functionality as a major state highway. In vulnerable sections, especially near the project site, chronic flooding could necessitate costly repairs, realignments, or even managed retreat strategies. Long-term adaptation planning will require the incorporation of broader resilience measures to mitigate disruptions not only at the site, but at a city-wide planning level.

Beyond the immediate site, some areas within Newport Bay present large-scale hydrological challenges, particularly under rising sea levels and increased storm activity. As tidal backflow and storm-driven surges intensify, the potential for chronic flooding within the greater watershed may increase. These regional hydrodynamic shifts are projected to directly impact the project site's flood resilience under unprotected conditions, necessitating broader coordinated flood mitigation strategies. Long-term adaptation efforts will require multi-agency collaboration to integrate regional flood defenses and potential mitigation strategies in this highly vulnerable area.

5.1.2.4. Recreation & Public Access

Recreational and public access is generally less sensitive to flood hazards, though impacts can still be significant if flooding occurs on a frequent basis. Constructed atop the levee system bordering the SAR, the trail benefits from an elevated position designed primarily for flood control purposes. This elevation not only offers trail users panoramic views of the surrounding landscapes but also provides a natural buffer against potential flooding events. Paved roadways and paths (like the segment in the southern portion of the site bordering the South Marsh and LSARSM near Industrial Way) are generally resilient to temporary flooding, especially in the absence of any significant wave impacts, as floodwaters are free to wash over and recede from paved areas with little overall structural damage. If inundated more regularly, as projected for most of the southwestern dirt roads under the unprotected 4.9 ft SLR 100-year storm scenario, public accessways may experience increased damage and loss of usefulness as visitors become unable to safely transverse these areas.

5.1.3. Adaptive Capacity

Adaptive capacity refers to the ability of a site to respond effectively to changing conditions, including coastal hazards, while maintaining or enhancing their well-being and functionality. Escalating SLR projections make it clear that infrastructure often faces increasing risk and is more susceptible to damages associated with increasing hazard exposure. It is equally apparent, however, that proactive adaptive mitigation measures can significantly enhance their flood resilience and adaptive capacity; thus, reducing their overall vulnerability.

Overall, a majority of the project site has a relatively high adaptive capacity to SLR hazards due to the assumed integrity of the existing hydraulic control structures such as the levees and tide gates. The following coastal resources are assessed for hazard sensitivity as they relate to the SLR scenarios modelled. In the absence of additional adaptive measures being implemented, the coastal resource inventory assets mentioned above are independently subject to varying degrees of flood risk at higher levels of SLR and changing storm intensities. For example, findings from the CoSMoS flood depth mapping exercise indicate that the less adaptive infrastructure (such as the levee, tide gates, or PCH) may only experience flooding and/or overtopping under the most extreme 4.9 ft SLR + 100-year storm scenario. This situation would most likely necessitate a mitigation approach in line with a broader adaptation framework involving several agencies. In contrast, portions of the western lower-lying habitat areas and existing dirt roads are projected to be flooded under less distant future SLR scenarios. Therefore, more traditional and less complex flood mitigation actions may be implemented as viable options to address these temporary, storm-driven flood impacts.

5.1.3.1. Existing Preserve Vegetation & Habitat

Wetland habitats often possess varying degrees of adaptive capacity in response to SLR, depending on factors such as sediment availability, hydrodynamic conditions, and the presence of migration space. Some wetlands can naturally accrete sediment and adapt their elevation relative to rising sea levels, allowing them to be resilient to the effects of climate change. The adaptive capacity of natural habitats is also highly dependent upon the inherent resiliency of the habitat to change, the ability to recover from individual extreme events, capability to migrate in response to climate pressures, and the location of nearby habitats that can serve as refugia. If wetland migration is restricted by urban development, levees, or other barriers, these habitats may experience drowning or conversion to open water. Additionally, tidal wetlands rely on complex ecological feedback mechanisms, such as vegetation trapping sediment and root growth stabilizing substrate, to sustain their resilience. Restoration efforts, including sediment augmentation and strategic retreat planning, can enhance the adaptive capacity of these critical ecosystems. Without proactive adaptation measures, low-lying wetlands may face significant degradation under the more extreme scenarios, leading to the loss of biodiversity, reduced carbon sequestration, and diminished coastal protection functions.

Natural habitats, such as pickleweed marshes and brackish water environments, evolved in an intertidal saline water environment and therefore have some inherent adaptive capacity to withstand temporary tidal flooding events. However, these habitats cannot sustain permanent inundation. Natural habitats that have evolved in freshwater or on dryland have a lower adaptive capacity to SLR and storm tides because they have lower tolerances for saline conditions. Non-native grasslands or any inland grass species are examples of habitats with lower adaptive capacity, whereas coastal vegetation communities such as coastal salt marsh and prickly pear scrub are examples of habitats with higher adaptive capacity.

Due to the expansive nature of the habitat area within the project site, there is sufficient space for most of the habitats to migrate upwards and out of the flood zone as needed. Existing salt marshes at the site such as LSARSM and the North and South Marshes are only projected to experience greater flood depths as SLR increases under an unprotected 4.9 ft SLR scenario due to the assumed functionality of tide gate regulating the amount of water within the site. Lower-lying areas that currently remain dry are also at risk of inundation under this unlikely extreme SLR scenario, which is projected to occur well outside the anticipated project design life. While these natural habitats exhibit a high degree of adaptability to rising water levels, the shifting hydrodynamics may alter biodiversity patterns, redistributing species and potentially transforming ecosystem functions. Under the unprotected scenario, preserving the ecological resilience of these wetlands will require adaptive management strategies to support habitat sustainability and species diversity. However, the existing vegetation and natural habitats are protected assuming that the tide gates continue to function properly. It is also assumed that agency intervention will likely need to occur well before the SLR scenario of 4.9 feet occurs.

5.1.3.2. Utilities

The adaptive capacity of utilities within the project site depends on the feasibility of implementing resilient infrastructure measures to mitigate SLR impacts. Elevating or retrofitting critical components, such as any transformers and electrical connectors, could help reduce their exposure to floodwaters. Utilities within easements can be floodproofed, elevated, or re-engineered. Strong coordination with utility providers will enhance resilience and redundancy. Utility poles could be replaced with more resilient materials, such as composite or reinforced concrete, to withstand prolonged moisture and soil saturation. Additionally, adaptive strategies like relocating power lines to dry areas only, installing corrosion-resistant materials, and/or integrating flood-resistant designs for stormwater management systems can improve long-term resilience. The site’s proximity to urban infrastructure provides an opportunity for coordinated regional adaptation efforts, such as upgrading stormwater control structures to prevent backflow during high tides or storm surges. Nature-based solutions, including wetland restoration and permeable surfaces, could also enhance flood absorption and reduce erosion risks around utility foundations.

5.1.3.3. Critical Infrastructure & Development

Critical infrastructure often possesses varying degrees of adaptive capacity highly dependent on the location and type. Decommissioned oil infrastructure, including wells and pipelines, may require remediation and site stabilization to prevent contamination risks as SLR alters groundwater levels and soil conditions. Adaptive management strategies, such as soil restoration and capping techniques, could help mitigate exposure to residual pollutants while allowing for safe ecological restoration. Dirt access roads could be repurposed or graded to improve drainage, reduce erosion, and enhance habitat connectivity. Roads can be regraded, hardened, or elevated, but may require phased retrofitting. Realignment options exist for some segments depending on habitat constraints. Additionally, the levee system’s adaptive potential lies in integrating nature-based solutions, such as marsh restoration and sediment augmentation, to bolster flood resilience while maintaining public access and hydrological functionality. The presence of tide gates and hydraulic structures presents an opportunity for upgraded flood control measures, including improved water flow management to support both infrastructure stability and ecological processes. Therefore, creating strategic collaborative partnerships will also be an important coastal resiliency strategy.

5.1.3.4. Recreation & Public Access

The adaptive capacity of recreational and public access infrastructure largely depends on strategic modifications to enhance resilience against rising sea levels. The SART located atop the levee benefits from its elevated position, reducing its vulnerability under most SLR scenarios. However, dirt roads and lower-elevation pathways may require elevation, reinforcement, or conversion to more flood-resistant materials, such as permeable pavement, to maintain accessibility. Adaptive strategies could also include raised boardwalks, improved drainage systems, and managed retreat of certain pathways to ensure continued public use while minimizing maintenance needs. Where frequent inundation is projected, designated seasonal closures or alternative routes could provide flexibility for users while preserving the integrity of the accessways. Additionally, nature-based solutions such as enhanced vegetation buffers and restored wetlands can help absorb floodwaters and reduce erosion impacts. By incorporating these adaptive measures, recreational and public access can remain functional and accessible despite the long-term challenges posed by SLR.

5.1.4. Summary of SLR Vulnerability

Figure 46 through Figure 49 provide a summary of the overall vulnerability of the various assets at the project site. The ratings provided below are evaluated based on the definitions provided in Table 6.

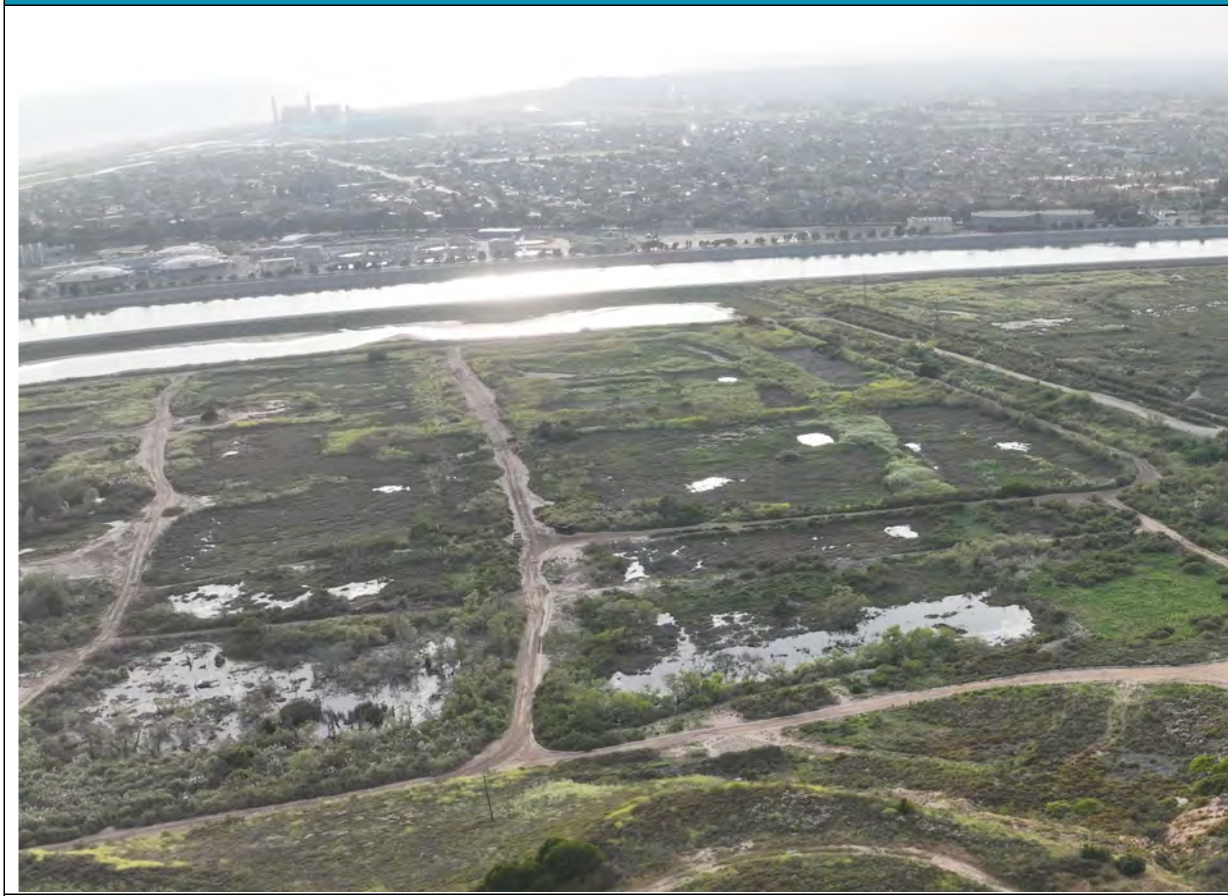
<table>
<tr><th colspan="7">Existing Preserve Vegetation</th></tr>
<tr><td colspan="7"></td></tr>
<tr><th colspan="7">Hazard Exposure</th></tr>
<tr><th>Present-Day Existing Conditions (Non-storm)</th><th>Present-Day Conditions (100-YR Storm)</th><th>1.6 ft SLR (Non-storm)</th><th>1.6 ft SLR (100-YR Storm)</th><th>4.9 ft SLR (Non-storm)</th><th>4.9 ft SLR (100-YR Storm) - Protected</th><th>4.9 ft SLR (100-YR Storm) - Unprotected</th></tr>
<tr><td>Low</td><td>Low</td><td>Low</td><td>Low</td><td>Moderate</td><td>Moderate</td><td>High</td></tr>
<tr><th colspan="7">Hazard Sensitivity</th></tr>
<tr><td colspan="7">Low</td></tr>
<tr><th colspan="7">Adaptive Capacity</th></tr>
<tr><td colspan="7">High</td></tr>
</table>

FIGURE 46: HAZARD EXPOSURE, HAZARD SENSITIVITY, & ADAPTIVE CAPACITY: *WETLAND RESOURCES AND COASTAL BIODIVERSITY*

Utilities						
						
Hazard Exposure						
Present-Day Existing Conditions (Non-storm)	Present-Day Conditions (100-YR Storm)	1.6 ft SLR (Non-storm)	1.6 ft SLR (100-YR Storm)	4.9 ft SLR (Non-storm)	4.9 ft SLR (100-YR Storm) Protected	4.9 ft SLR (100-YR Storm) Unprotected
Low	Low	Low	Low	Moderate	Moderate	High
Hazard Sensitivity						
High						
Adaptive Capacity						
Moderate						

FIGURE 47: HAZARD EXPOSURE, HAZARD SENSITIVITY, & ADAPTIVE CAPACITY: UTILITIES

Infrastructure						
						
Hazard Exposure						
Present-Day Existing Conditions (Non-storm)	Present-Day Conditions (100-YR Storm)	1.6 ft SLR (Non-storm)	1.6 ft SLR (100-YR Storm)	4.9 ft SLR (Non-storm)	4.9 ft SLR (100-YR Storm) - Protected	4.9 ft SLR (100-YR Storm) - Unprotected
Low	Low	Low	Low	Moderate	Moderate	High
Hazard Sensitivity						
Moderate						
Adaptive Capacity						
Moderate						

FIGURE 48: HAZARD EXPOSURE, HAZARD SENSITIVITY, & ADAPTIVE CAPACITY: INFRASTRUCTURE

Public Access & Recreation

Hazard Exposure

Present-Day Existing Conditions (Non-storm)	Present-Day Conditions (100-YR Storm)	1.6 ft SLR (Non-storm)	1.6 ft SLR (100-YR Storm)	4.9 ft SLR (Non-storm)	4.9 ft SLR (100-YR Storm) Protected	4.9 ft SLR (100-YR Storm) Unprotected
Low	Low	Low	Low	Moderate	Moderate	High
Hazard Sensitivity						
Low						
Adaptive Capacity						
Moderate						

FIGURE 49: HAZARD EXPOSURE, HAZARD SENSITIVITY, & ADAPTIVE CAPACITY: PUBLIC CCCESS & RECREATION

6. Conclusion: Recommendations & Next Steps

The effects of two SLR scenarios (1.6 ft and 4.9 ft) on storm-related (100-year) and non-storm flooding were evaluated using results from the CoSMoS Version 3.0, Phase 2 and integrated SIM model. A qualitative evaluation of potential vulnerabilities was conducted consisting of the project area and adjacent neighboring coastal resources to assess the overall hazard exposure, sensitivity, and adaptive capacity of critical infrastructure, ecological systems, utilities, and public access in response to future SLR hazards.

In general, modeling efforts show the potential for minimal localized flood hazard impacts throughout the project site and surrounding areas under long-term SLR projections only if the site and adjacent infrastructure remain operational, particularly during severe storm conditions. The following conclusions summarize key findings from the conducted analyses:

- Flood hazard exposure at the site remains minimal under *all protected* scenarios, provided the tide gates continue to function effectively in restricting higher water levels. Under high levels of SLR, the site heavily relies on the full operability of the existing hydraulic structures to reduce flood exposure within the site.
- A 100-year storm event under the 4.9 ft SLR scenario is projected to inundate much of the project site under the *unprotected* condition (assuming no alterations or intervention from agencies to vulnerable infrastructure along SAR, Newport Bay, or at PCH), including sections of the wetlands, floodplain, and portions of adjacent infrastructure due to the levee and PCH being potentially overtopped. This scenario also poses an increased risk of backflow through municipal storm drain systems and existing utilities, potentially impacting drainage efficiency and causing localized flooding.
- Higher levels of SLR will likely necessitate a broader adaptation framework at a regional scale, as critical infrastructure beyond the project site, including PCH, is projected to experience more frequent tidal and storm-induced flooding if local adaptation measures are not taken. Chronic inundation of PCH and adjacent urban areas will disrupt transportation, emergency response, and coastal access, emphasizing the need for coordinated resilience planning across multiple jurisdictions. Regional adaptation strategies may include elevating or realigning roadways, implementing improved flood control infrastructure, and integrating ecosystem-based approaches to enhance long-term coastal resilience.
- The findings of this document will be incorporated into a subsequent (CRS) document to determine and assess the various mitigation alternatives.

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