Sea Level Rise Vulnerability Assessment & Coastal Resiliency Report

JUNE 2019

PORT of SAN DIEGO

PORT of SAN DIEGO

In collaboration with

NEXUS PLANNING & RESEARCH

ICF

Acknowledgments

Port of San Diego Environmental Advisory Committee – Sea Level Rise Ad-Hoc

Center for Sustainable Energy
San Diego Port Tenants Association
Shelter Island Marina
United States Fish and Wildlife
United States Navy Region Southwest
Southwest Wetlands Interpretive Association (not a member of the EAC)

Participating Agencies

City of Coronado
City of Chula Vista
City of Imperial Beach
City of National City
City of San Diego
San Diego Association of Governments
San Diego County Regional Airport Authority
California Coastal Commission

Advisors

Army Corps of Engineers
Scripps Institution of Oceanography—Center for Climate Change Impacts and Adaptation
Tijuana River National Estuarine Research Reserve
United States Geological Survey
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Energy Policy Initiatives Center, University of San Diego

Web Accessibility: The document has made all attempts to be consistent with California State Assembly Bill 434.

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Commonly Used Terms

Analyses	Evaluation of the physical or financial impacts to assets.
Inundation	Potentially recurring flooding resulting from projected SLR.
Projections	Probability of future projected SLR based on best available science.
Scenarios	Used in the USGS CoSMoS models based on SLR projections.
Temporary coastal flooding from a 100-year storm event	Intermittent inundation of land and/or assets resulting from 100-year storm event caused by storm surge.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014).
Vulnerability Assessment	A practice that identifies who and what is exposed and sensitive to change and how able a given system is to cope with extremes and change (Tompkins et al, 2005).

Acronyms and Abbreviations

2018 OPC SLR Guidance	Guidance Ocean Protection Council's State of California: Sea-Level Rise Guidance - 2018 Update
AB 691	California State Assembly Bill 691
AB 691 Report	Port of San Diego Sea Level Rise Vulnerability Assessment & Coastal Resiliency Report
Airport	San Diego International Airport
Airport Authority	San Diego County Regional Airport Authority
Bay	San Diego Bay
CCC	California Coastal Commission
CoSMoS	Coastal Storm Modeling System
District	San Diego Unified Port District
Framework	Adaptive Management Framework
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OPC	Ocean Protection Council
Port Act	San Diego Unified Port Act
RCP	Representative Concentration Pathways
SLC	State Lands Commission
SLR	Sea Level Rise
Tidelands	San Diego Unified Port District jurisdiction
USGS	United States Geological Survey

Considerations Regarding Methodology and Approach

1. Sea level rise (SLR) projections from the Ocean Protection Council (OPC) were provided in feet. The United States Geological Survey's CoSMoS 3.0 model used to map the extent of flooding operates using the metric system. The OPC SLR projections (with associated timeframes) were matched to the closest value in CoSMoS for use in the District's analyses. As a result, the scenario elevations from CoSMoS may differ from the OPC projections.

2. CoSMoS flood maps illustrate the potential extent of inundation and/or temporary coastal flooding from a 100-year storm event resulting from projected sea level rise for specific water elevations. As the projected water level is calculated from mean sea level, the depth of flooding on land may be less than the projected water elevation and may also vary by location based on topography.

3. Potential inundation and temporary coastal flooding from a 100-year storm event resulting from projected sea level rise were modeled using USGS CoSMoS 3.0. Potential flood extents represented in CoSMoS were derived from elevation data established between 2009-2011. As such, the maps illustrate potential flooding on current conditions without any adaptation measures or new development/redevelopment. The District developed a local model using specific ground elevations to assess impacts to buildings. As the District's

ground elevations may differ from those used in the CoSMoS model, buildings may appear potentially impacted on the CoSMoS flood maps that were not identified as potentially impacted in the District's local building model. The use of the two disparate models may result in inconsistency between the maps and the exposure tables and financial cost estimates related to buildings. Please refer to Chapter 2 and Chapter 3 for more detail.

4. Financial estimates of potential impacts to assets that may result from projected sea level rise induced inundation and/or temporary coastal flooding represent the replacement cost of the asset. The financial estimates of potential impacts should not be construed as the estimated cost of adapting to projected sea level rise for a specific water elevation.

Executive Summary

Legislative Requirements – California Public Resource Code Section 6311.5

In 2013, the State Legislature passed Assembly Bill (AB) 691, which was codified as Section 6311.5 of the California Public Resource Code (herein referred to as AB 691 or Section 6311.5) (SLC 2013). AB 691 requires local trustees of public trust lands whose gross public revenues average over $250,000 between January 1, 2009 and January 1, 2014 to prepare and submit to the State Lands Commission (SLC) by July 1, 2019 an assessment of how the local trustee proposes to address projected sea level rise (SLR). (Section 6311.5(c).) The assessment must include the following:

- An analysis of the impacts of projected SLR, as described in the Resolution of the California Ocean Protection Council (OPC) on Sea-level Rise and the latest version of the State of California Sea-Level Rise Guidance Document;
- Maps showing areas that may be affected by projected SLR in years 2030, 2050 and 2100, including potential impacts of a 100-year storm event;
- An estimate of financial costs of the impact of projected SLR on granted public trust lands, including the potential cost of repair of damage to and the value of lost use of improvements and land, as well as the anticipated cost to prevent or mitigate potential damage; and
- A description of how the local trustee proposes to protect and preserve existing and proposed natural and built environment resources and facilities, including, without limitation how wetlands and restoration and habitat preservation would mitigate impacts to projected SLR. (Section 6311.(c)(1)-(c)(4).)

In addressing projected SLR, the local trustee shall collaborate with lessees, appropriate local, state and federal agencies, as well other users of granted public trust lands. (Section 6311.5(e).) However, AB 691 does not require a local trustee to implement any specific actions to address projected SLR. (Section 6311.5(j).)

San Diego Unified Port District's Approach to AB 691/Section 6311.5

In 1963, the State Legislature passed the San Diego Unified Port Act (Port Act), which was codified as California Harbors and Navigation Code, Appendix 1. The Port Act created the San Diego Unified Port District (District) and granted certain state tidelands and submerged lands in and around San Diego Bay and Imperial Beach oceanfront (collectively, the Bay or the San Diego Bay) to the District, as trustee for all Californians.

As a trustee of state tidelands and submerged lands, the District is subject to Section 6311.5. Pursuant to the requirements of Section 6311.5, as well as to better understand projected SLR and its potential impacts to the District's granted tidelands and submerged tidelands (herein referred to as the "District's jurisdiction")[1] in 2030, 2050 and 2100 and, to quantify the potential impacts of projected SLR, the District initiated a formal SLR assessment (AB 691 Report).

This AB 691 Report analyzes and addresses projected SLR impacts within the District's jurisdiction, including the San Diego International Airport, which the District leases to the San Diego County Regional Airport Authority (Airport Authority).[2]

Specifically, the AB 691 Report:

- Uses best available science to assess the vulnerability of projected SLR on the District's jurisdiction, including the updated OPC's *State of California Sea-Level Rise Guidance: 2018 Update* (2018 OPC SLR Guidance), as required by AB 691;
- Provides maps of areas that may be potentially impacted by projected SLR for the years 2030, 2050, and 2100;

[1]The term "District's jurisdiction" is not intended to indicate permitting authority.
[2]Note that the District has one upland property that is excluded from the AB 691 Report.

- Estimates the financial costs of impacts on granted trust lands; and
- Describes how the District proposes to address projected SLR to protect and preserve natural and built environment resources and facilities on trust lands.

The AB 691 Report is organized based on the requirements of AB 691. Chapter 1 provides an introduction. Chapter 2 provides the methodology for the District's vulnerability assessment and can be used as guidance for future, site-specific assessments. Chapter 3 presents the findings of the District's vulnerability assessment, including the required maps, potential impacts and estimated financial costs of potential SLR impacts. Chapter 4 discusses adaptation planning and strategy implementation. Chapter 5 is the conclusion.

As is called for in Section 6311.5, District staff engaged regional stakeholders, and subject matter experts from public agencies, non-profit groups, and private companies during the development of the AB 691 Report to gather information and learn from SLR and coastal resiliency experts. Stakeholders included the U.S. Navy, federal, state, regional, and local government agencies, academia, environmental interest groups, District tenants, and the San Diego Port Tenants Association.

District's Proposed Method for Addressing Projected Sea Level Rise–Adaptive Management

Given the current science and its level of uncertainty in projections of projected SLR, the District's ability to be flexible in adapting to projected SLR is crucial. For this reason, the District is proposing an adaptive management approach to address projected SLR, defined by the Intergovernmental Panel on Climate Change as "a process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change" (IPCC 2014). Adaptive management is not a new scientific concept and has been used by the District for many of its environmental management programs. Extending the adaptive management approach to projected SLR will allow the District to adjust policies and/or strategies that help to reduce the risks associated with potential inundation and/or temporary coastal flooding from a 100-year storm event from projected SLR based on monitoring and as new information regarding climate science and/or techniques to address coastal hazards emerge.

The Adaptive Management Framework (Framework) as illustrated in Figure ES.1 is composed of three stages: (1) A Vulnerability Assessment, (2) Adaptation Planning, and (3) Strategy Implementation. This Framework promotes a cyclical process whereby each stage can be continually improved as new information is collected and integrated.

Sea Level Rise Projections: Methodology

The District, in consultation with stakeholders, chose SLR projections consistent with the 2018 OPC SLR Guidance. The 2018 OPC SLR Guidance incorporates advances in SLR modeling and improved understanding of the processes that may drive extreme global projected SLR from ice loss from the Greenland and Antarctic ice sheets. This guidance serves as the best available science for this AB 691 Report. Specifically, the District used SLR projections representing the 95th percentile (1-in-20 chance) for the years 2030, 2050, and 2100 (see Table ES.1).

Given the uncertainty of climate science and the variability in projections towards the end of the century, the District also chose to analyze projected SLR impacts using the 50th percentile projection for 2100. The District assessed projected SLR impacts using the four different projections without, then with, 100-year

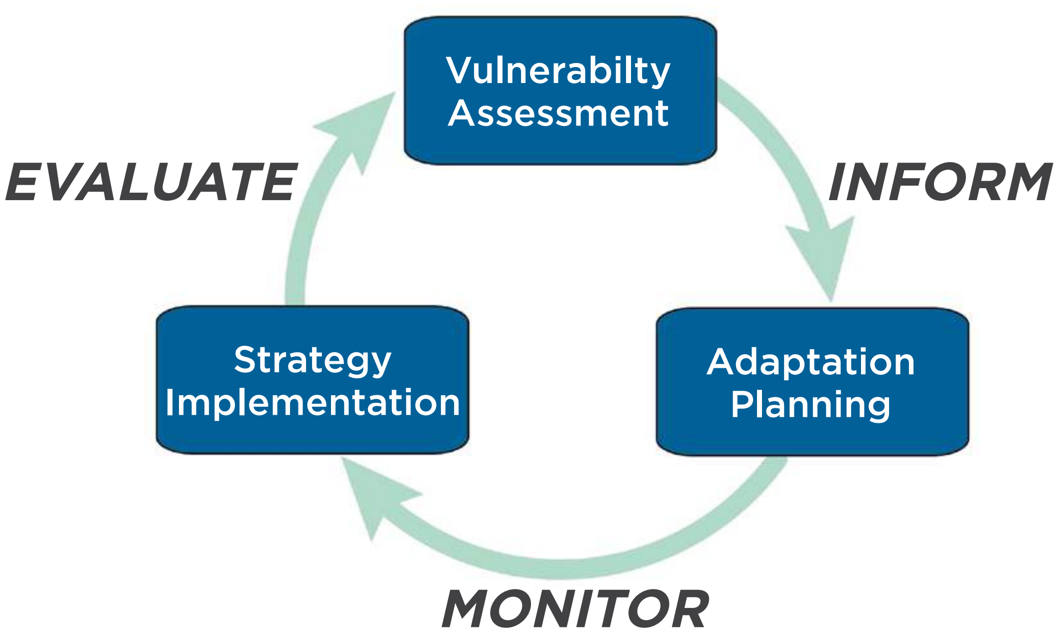


Figure ES.1 Sea Level Rise Adaptive Management Framework storm events. The intention of separating the analyses was to help the District better understand the impacts caused by potential inundation compared to temporary coastal flooding from a 100-year storm event. (It is also required by Section 6113.5.) Table ES.1 illustrates the single range of SLR projections for years 2030 and 2050 and multiple ranges for the year 2100. See Chapter 2 for more detail regarding selection of SLR projections.

Sea Level Rise Mapping

The projected SLR mapping consists of a quantitative geospatial assessment of future projected SLR and storm surge impacts to District assets for 2030, 2050 and 2100 as required by AB 691. To assess exposure to projected SLR, the District utilized the United States Geological Survey Coastal Storm Modeling System (CoSMoS) 3.0 (USGS 2019). CoSMoS is a dynamic SLR model which allows users to couple projected SLR scenarios with storm events to measure impacts to assets and operations. Since CoSMoS operates in fixed 0.8 foot increments of projected SLR, the OPC SLR projections (with associated timeframes) were matched to the closest value in CoSMoS for use in the District's analyses. As a result, the

Table ES.1 Selected Sea Level Rise Projections

Feet (Meters) Above 1991 – 2009 mean	Median		Likely Range		1-in 20 Chance		1-in 200 Chance	
Year/ Percentile	50% probability SLR meets or exceeds		67% probability SLR is between		5% probability SLR meets or exceeds		0.5% probability SLR meets or exceeds	
	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
2030	0.5	0.15	0.4 - 0.6	0.12 - 0.18	0.7	0.21	0.9	0.28
2050	0.9	0.27	0.7 - 1.2	0.21 - 0.37	1.4	0.43	2.0	0.61
2100 (RCP 8.5)	2.6	0.79	1.8 - 3.6	0.55 - 1.10	4.5	1.4	7.1	2.16

scenario elevations from CoSMoS may differ slightly from the OPC projections. The selected CoSMoS SLR scenarios and the corresponding OPC projections and are listed in Table ES.2 See Chapter 2 for more detail regarding selection of SLR mapping.

Impacts on Built Environment and Natural Resources

The District assets that were analyzed for potential impacts in this assessment include the transportation network such as roads, rail, bike routes, and pathways; infrastructure such as building structures, parks, sewer lifts and storm drains, marine terminals, wharves, and piers; and natural resources such as nearshore habitats and least tern nesting areas.

Sea Level Rise Vulnerability Results and Potential Impacts

Potential Physical Impacts – Built Environment

Low lying built environment assets in or adjacent to the water, such as beach accessible areas, boat launches, and sewer lifts are projected to experience impacts from potential inundation at 0.8 feet of projected SLR. Assets that provide public access (e.g., pathways, bikeways, piers) and recreational opportunities (e.g. parks) become increasingly impacted by potential inundation and

Table ES.2: Alignment of San Diego Sea Level Rise Projections with CoSMoS Projected Sea Level Rise Scenarios

CoSMoS Model Levels in Meters	Recommended Ocean Protection Council[1] SLR Probabilistic Projections	
	Increase Above Current Levels	Emissions Scenario
0.8 feet/0.25 meters	0.7 feet (0.21 meters)	2030 (1-in-20 Chance)
1.6 feet/0.5 meters	1.4 feet (0.43 meters)	2050 (1-in-20 Chance)
2.5 feet/0.75 meters	2.6 feet (0.79 meters)	2100 (Median)
4.9 feet/1.5 meters	4.5 feet (1.4 meters)	2100 (1-in-20 Chance)

Median = 50% probability SLR meets or exceeds...

1-in-20 Chance = 5% probability meets or exceeds...

[1]Ocean Protection Council 2018. California Sea-Level Rise Guidance 2018 Update

then exacerbated by storm surge from a 100-year storm event starting at 1.6 feet of projected SLR. At 4.9 feet of projected SLR, with and without a 100-year storm event, most District assets are projected to be at risk of projected SLR-induced flooding.

Critical infrastructure such as roads, rail, and the stormwater system are particularly sensitive to potential inundation or a 100-year storm event may obstruct business operations, limit public access, and/or lead to potential reductions in public safety including emergency response and recovery. The quantity of critical infrastructure and associated consequences are projected to occur with potential inundation at 4.9 feet of projected SLR or temporary coastal flooding from a 100-year storm event at 2.5 feet of projected SLR.

The District contains approximately 7,500 slips or moorings for recreational, commercial fishing, sportfishing, marine services, and Harbor Police. While slips and moorings can be elevated for increased projected SLR, substantially larger storm events combined with elevated sea levels may lead to more extensive damage and longer recovery times. Although this analysis did not evaluate impacts to floating docks nor the fueling infrastructure, these assets could also be damaged with higher sea levels and associated storm events.

Tables ES.3 and ES.4 summarize the potential exposure results for each of the assets across all four CoSMoS scenarios in the District. These tables correspond to Figures ES.2 – 5 illustrating projected SLR impacts for all four scenarios. See Chapter 3 for more detail regarding District and Planning District exposure to projected SLR.

Potential Physical Impacts to Natural Resources

Natural resource management is an important part of the District's administration of the public trust. Various natural resources including without limitation subtidal, intertidal, and upland habitats, exist in and around San Diego Bay. As required by AB 691, an evaluation of potential impacts to eelgrass, coastal salt marsh, uplands, and beach and dune habitats was conducted. These habitats exist at specific elevation ranges, in and out of the water column and may be able to persist with rising water elevations if there is available area to which to migrate. Therefore, the natural resource analysis focused on whether there was undisturbed area in and around San

Table ES.3: District Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	47.9	HIGH	LOW	1%	1%	2%	26%
Rail (linear miles)	16.2	HIGH	LOW	0%	0%	0%	57%
Bikeways (linear miles)	5.9	LOW	HIGH	1%	2%	10%	55%
Pathways (linear miles)	22.2	LOW	HIGH	7%	8%	15%	60%
Marine Terminals (acres)	233.4	HIGH	LOW	0%	0%	1%	37%
Buildings (count)	590	HIGH	LOW	0%	0%	1%	23%
Piers (count)	15	HIGH	LOW	0%	0%	0%	75%
Stormwater Management (count)	458	HIGH	LOW	4%	4%	7%	45%
Sewer Lifts (count)	10	HIGH	HIGH	20%	20%	30%	70%
Boat Launch Ramps (count)	3	LOW	HIGH	100%	100%	100%	100%
Beach Accessible Areas (acres)	11	HIGH	LOW	71%	75%	80%	93%
Parks (acres)	144.6	LOW	HIGH	3%	3%	6%	45%

Table ES.4: District Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	4,987.3	HIGH	LOW	2%	5%	16%	46%
Rail (linear miles)	16.2	HIGH	LOW	0%	0%	12%	83%
Bikeways (linear miles)	5.9	LOW	HIGH	10%	17%	34%	82%
Pathways (linear miles)	22.2	LOW	HIGH	14%	24%	43%	78%
Marine Terminals (acres)	233.4	HIGH	LOW	0%	0%	9%	69%
Buildings (count)	590	HIGH	LOW	1%	3%	8%	46%
Piers (count)	15	HIGH	LOW	0%	19%	32%	88%
Stormwater Management (count)	458	HIGH	LOW	5%	14%	30%	66%
Sewer Lifts (count)	10	HIGH	HIGH	30%	30%	50%	90%
Boat Launch Ramps (count)	3	LOW	HIGH	100%	100%	100%	100%
Beach Accessible Areas (acres)	11	HIGH	LOW	79%	83%	90%	95%
Parks (acres)	144.6	LOW	HIGH	6%	11%	25%	72%

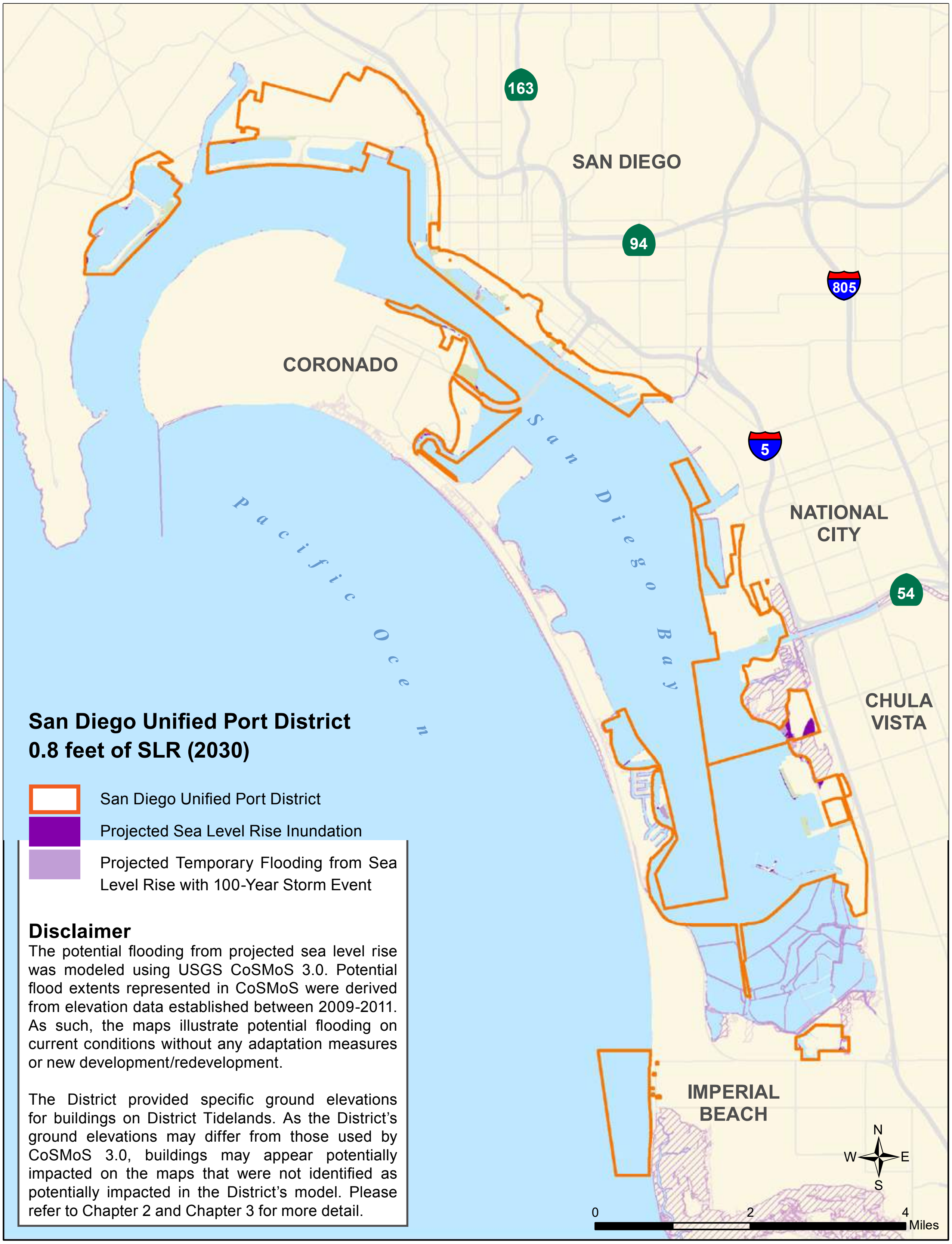


Figure ES.2: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2030

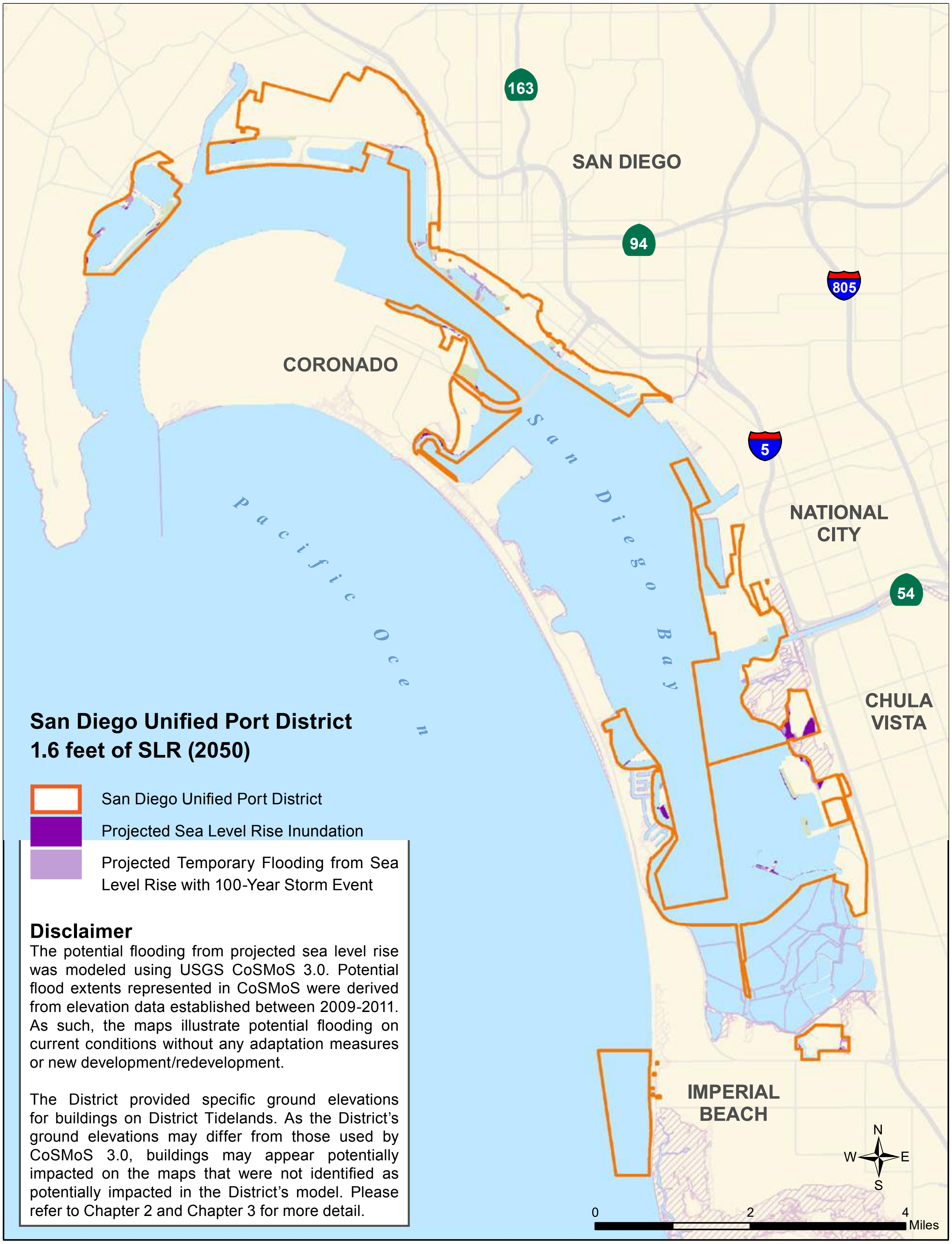


Figure ES.3: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

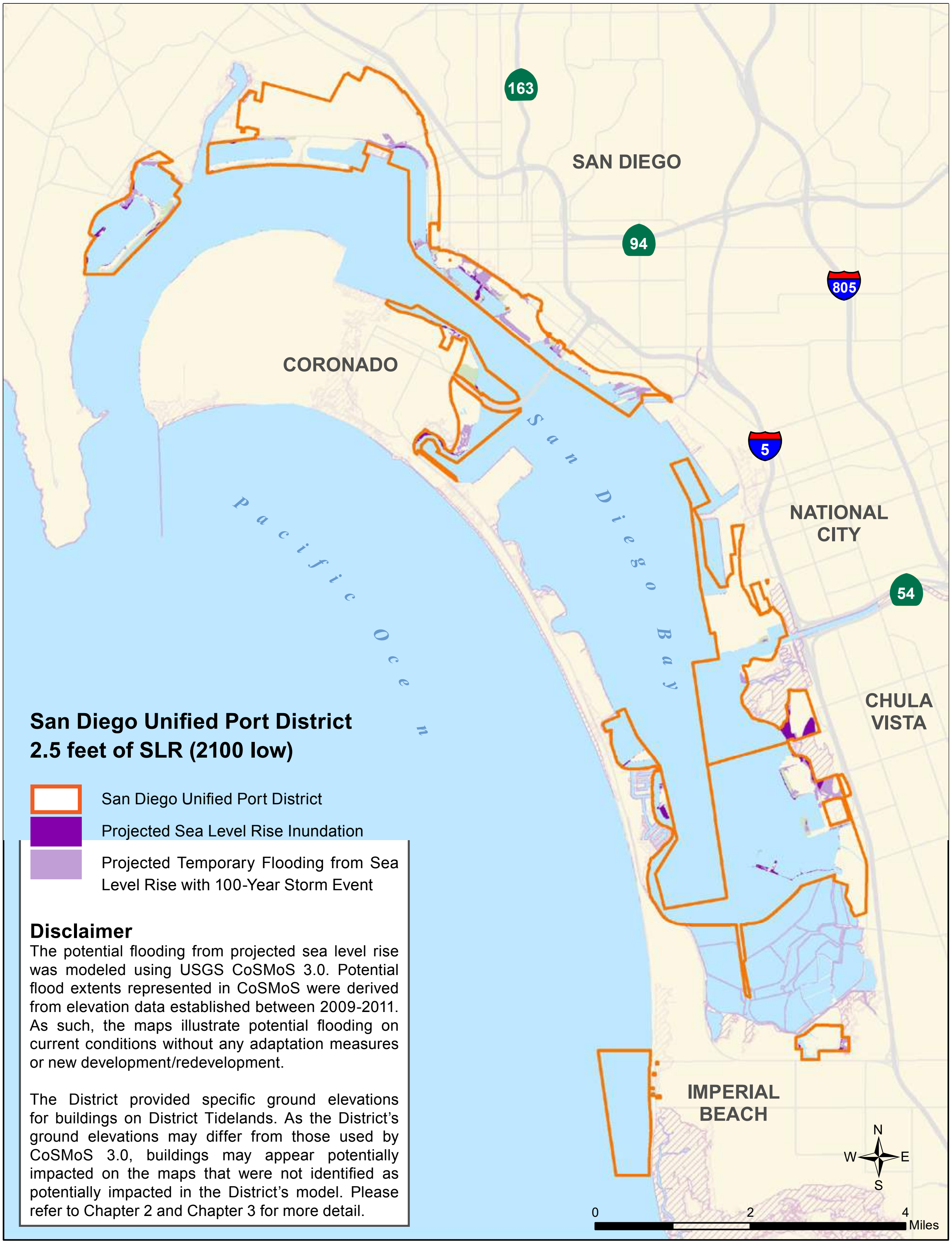


Figure ES.4: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

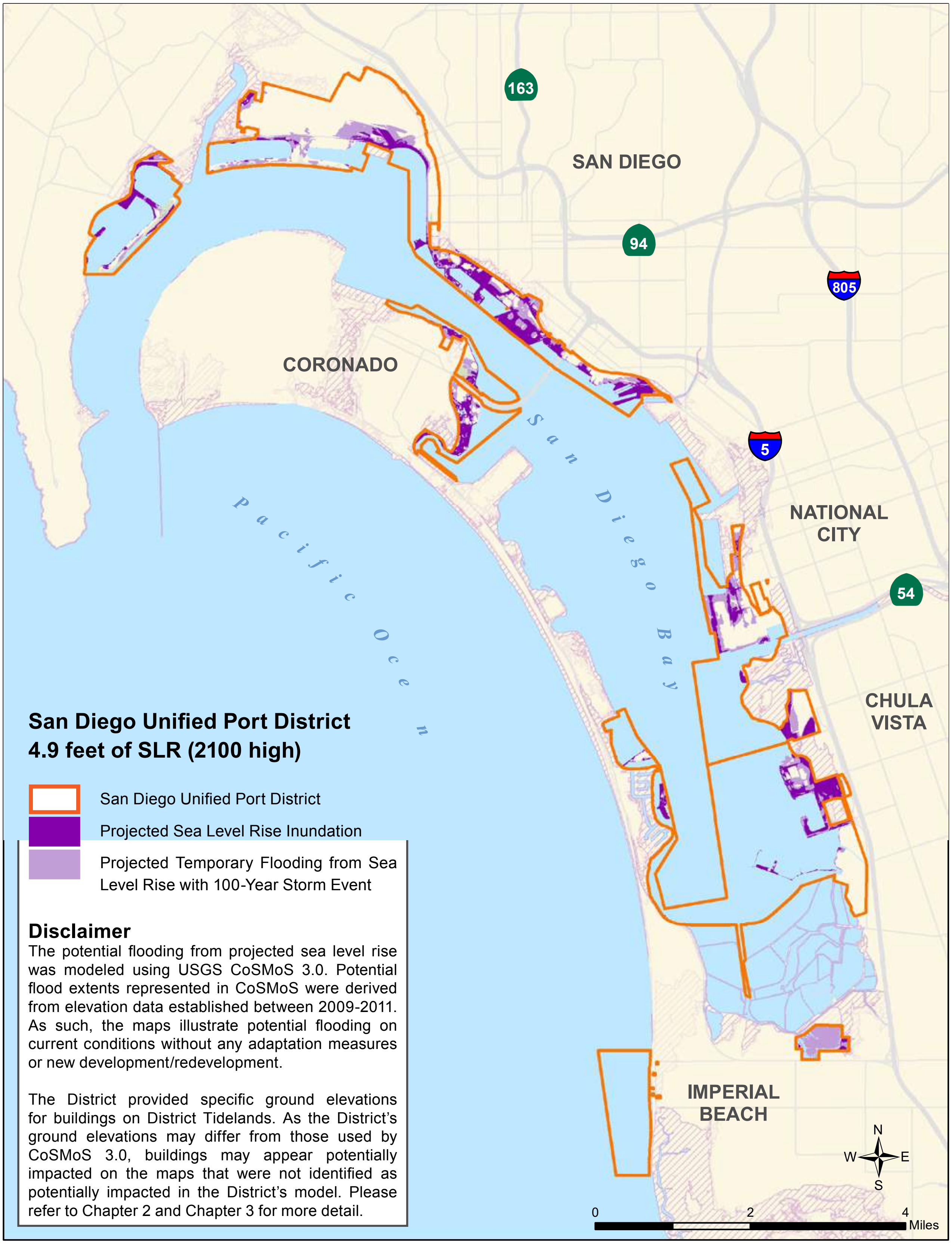


Figure ES.5: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

Diego Bay with appropriate elevations to support these habitats with increasing sea levels. As such, the projected SLR scenarios described in ES.2 were used to assess the potential distribution of each habitat with the assumption that the habitat can move unless otherwise hindered by the built environment.

Overall, the available area that may support salt marsh, beach/dune, and upland habitats decline with increasing projected SLR scenarios. However, the eelgrass habitats showcase a unique trend whereby their acreage increases under the 1.6 feet and 2.5 feet projected SLR scenarios but sharply decline under the 4.9 feet projected SLR scenario. With 4.9 feet of projected SLR, a loss of acres for eelgrass is driven by a reduction in available area to which to move coupled with a loss of area at the deeper portion of its elevation range as water levels increase.

It should be noted that although the total available area for specific habitats may decrease, the area occupied by specific habitat is much less. This indicates that given the right conditions and proper management, the current acreage of habitats may be able to expand over time. For example, the occupied area for salt marsh remains relatively stable throughout the projected SLR scenarios. However, upland habitats that support environmental management objectives such as preservation of nesting sites for California least terns may limit transition of salt marsh. Habitat management objectives will need to be monitored and actively managed among natural resource managers to promote ecological health as projected SLR increases. See Chapter 3 and Appendix B for more detail regarding potential habitat impacts.

Potential Financial Impacts

Table ES.6 shows primary and secondary impacts that may occur from projected SLR. The District selected property and infrastructure that may be damaged from projected SLR, whether due to permanent flooding or temporary coastal flooding from a 100-year storm event.

The potential damages without a storm event represent damages that would result from potential inundation under the “no action” (no adaptation strategies) conditions. That is, potential damages would be caused by increased projected SLR that could permanently

Table ES.5: Future Habitat Distribution

Habitat Type	Baseline: No Sea Level Rise		Sea Level Rise Scenarios: Year 2030 +0.8 feet		Year 2050 +1.6 feet		Year 2100 Low +2.5 feet		Year 2100 high +4.9 feet	
	Available	Occupied	Available	Occupied	Available	Occupied	Available	Occupied	Available	Occupied
Eelgrass	1,718	915	1,752.7	982.8	1,762.3	1,016.3	1,747.5	979.4	1,621.5	668.2
Salt Marsh	532	81	472.6	75.9	432.7	74.4	415.1	75.2	370.5	78.3
Beach/ Dune[1]	13	-	-	12.7	-	11.6	-	10.7	-	8.6
Uplands	426	97	394.5	90.1	360.0	82.2	322.1	73.4	222.6	50.8

[1]Beach/dune habitat is assumed to exist where those historical habitats occurred prior to development and have been maintained or allowed to remain. As both are driven by sediment and wind processes, they are considered static with no additional areas available.

flood land, structures, parking lots, and transportation and other infrastructure if no adaptation strategies were enacted to mitigate potential damages. Potential inundation could lead to a loss of District revenue due to a loss of land that support park events, parking, and leases.

For all projected SLR scenarios without a storm event, the greatest potential financial impacts would be due to loss of transportation and other infrastructure (Tables ES.6 and ES.7). For the 0.8- and 1.6-feet scenarios, transportation and other infrastructure combined estimated damages may be over $45 million; and for the 2.5- and 4.9-feet scenarios, estimated damages may be over $95 million, and for the 4.9 feet scenario, infrastructure estimated damages may be over $600 million.

The potential damages from a 100-year storm event represent additional damages that would occur on top of potential inundation damages for the corresponding projected SLR water height (The assessment's SLR projections are associated with water heights before a storm event (i.e., 0.8-, 1.6-, 2.5-, and 4.9-feet). A 100-year storm event could result in an additional temporary coastal flooding from a 100-year storm event. On average, a

Table ES.6: Estimated Financial Impacts: Potential Inundation with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet	2030 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2030.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$1,200,000
		Transportation infrastructure	$18,400,000
		Other infrastructure	$27,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$16,100,000
		Total	$62,900,000
1.6 feet	2050 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2050.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$1,200,000
		Transportation infrastructure	$23,900,000
		Other infrastructure	$27,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$16,100,000
		Total	$68,500,000
2.5 feet	2100 SLR with no storm event under 50% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$6,300,000
		Transportation infrastructure	$61,400,000
		Other infrastructure	$34,700,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$24,800,000
		Total	$127,100,000
4.9 feet	2100 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$266,900,000
		Transportation infrastructure	$551,700,000
		Other infrastructure	$64,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$39,200,000
		Total	$922,100,000

Table ES.7: Estimated Financial Impacts: Potential Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet + water increase from 100-yr storm event	2030 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2030.[3] Estimating per storm event the potential coastal flooding damages in the year 2030.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$1,500,000 $1,500,000
1.6 feet + water increase from 100-yr storm event	2050 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2050.[3] Estimating per storm event the potential coastal flooding damages in the year 2050.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$6,300,000 $6,300,000
2.5 feet + water increase from 100-yr storm event	2100 SLR under 50% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$12,100,000 $12,100,000
4.9 feet + water increase from 100-yr storm event	2100 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$152,400,000 $152,400,000[5]

Note: Sea level rise estimated damages that occur without a storm event (inundation) are not included in the 100-yr storm estimates. 100-year storm flooding damages represent only those potential damages that would occur in addition to the loss due to sea level rise without a storm event.

[1]Impacted buildings were identified by the District and may not be consistent with the CoSMoS inundation and coastal flooding boundaries. Impacted parking lots were determined from CoSMoS boundaries. Therefore, parking lot and building impacts may not be consistent.

[2]Following the NOAA *What Will Adaptation Cost? Impact Assessment* methodology, this estimate only represents the annual loss for the corresponding scenario year in 2018 dollars. The Impact Assessment methodology estimates damages based on water height and one point in time. However, if the property were lost, the revenue loss would occur for subsequent years as well.

[3]Estimates represent the financial impact from temporary coastal flooding from a 100-year storm event with the corresponding projected SLR elevations.

[4]Cleanup, traffic control, and emergency response are included in annual operating budgets of the District staff. These potential impacts are discussed qualitatively in the report.
[5]Because inundation damages are expected to be substantially greater under the 4.9 feet scenario, 100-year storm event coastal flooding damages are less than previous scenarios.

100-year storm event could result in further flooding of up to approximately 3.77 feet depending upon the scenario and land elevation (OCOF, 2019). Thus, storm event flooding would result in added damages. For example, at 0.8 feet, it is estimated that $62.9 million in potential damages would result from potential inundation plus an additional $1.5 million is estimated if there were 100-year storm flooding event. Again, these estimates assume damages that could transpire without implementing additional adaptation strategies.

The total value ($/year) of each habitat and for those services valued for the whole system under baseline conditions and four projected SLR scenarios (0.8-, 1.6-, 2.5-, and 4.9-feet). Results were found by multiplying the estimated acreage by the total dollar per acre ($/acre) for each habitat.

Current value services provided by natural resources within the District range from an estimated $40 million - $61 million per year. The ecosystem services identified for each of the habitats were combined to estimate the total value of the District's natural resources. With projected SLR, the extant of different habitats has the potential to change, leading to changes in the predicted value of these resources. Under the most extreme projected SLR scenario

(4.9 feet), the value of District natural resources may decrease to a range of $29 million to $45 million. See Chapter 3 and Appendix C for more detail about the financial cost estimates.

Adaptation Planning

For this AB 691 Report, the District is not providing specific adaptation strategies for each potentially vulnerable asset or area on Tidelands (as described in Chapter 3). Due to the diversity and unique characteristics of the Public Trust lands managed by the District, a "one-size-fits-all" strategy is not conducive as adaptation strategies would need to be applied based on site-specific characteristics and vulnerabilities. In addition, the District applies concepts set forth by Assembly Bill 2800, identifying climate-safe infrastructure (and coastal-dependent assets) that are sustainable, adaptive, and that meets design criteria that aim for resilience in the face of shocks and stresses caused by the current and future climate (CSIWG 2018). To remain "climate-safe," the infrastructure and assets should be monitored, and adaptive measures taken to address long-term resiliency.

Instead, this AB 691 Report provides an adaptation planning process that can be used by the District and relevant stakeholders to plan for, and respond to, projected SLR. Developing a process, rather than select strategies that will be applied in the future when conditions may change, provides greater flexibility and potential cost-effectiveness. The District has elected to identify a process developed by the U.S. Navy for its planners and engineers to properly select adaptation strategies based on several criteria using a step-wise decision-making formula (NAVFAC 2017).

Strategy Implementation

The last stage of the proposed SLR planning approach is Strategy Implementation. A "trigger" approach to strategy implementation is intended to set into motion a series of actions to reduce the vulnerability of the asset to potential SLR inundation and temporary coastal flooding from a 100-year storm event. Following an iterative, cyclical process informed by best available climate science, updated with new data about District environmental and economic conditions, and that evaluates the effectiveness of strategies through incorporation of site-specific

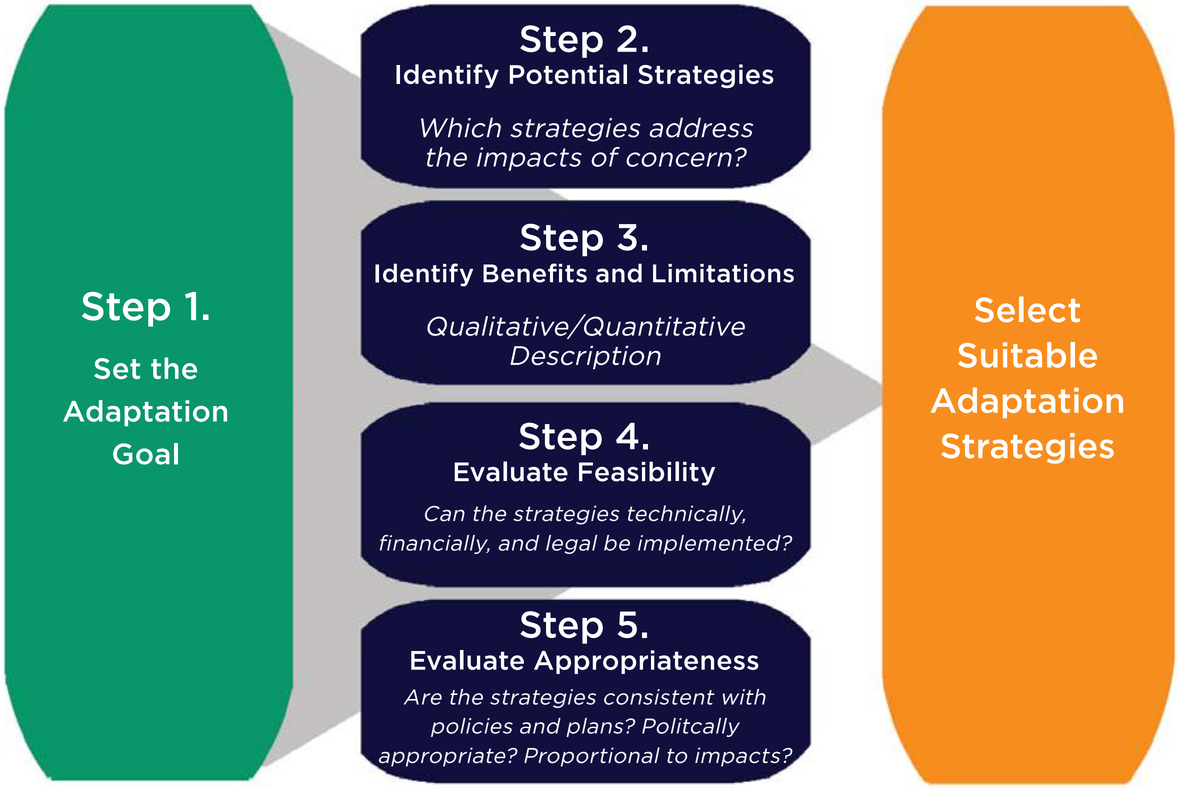
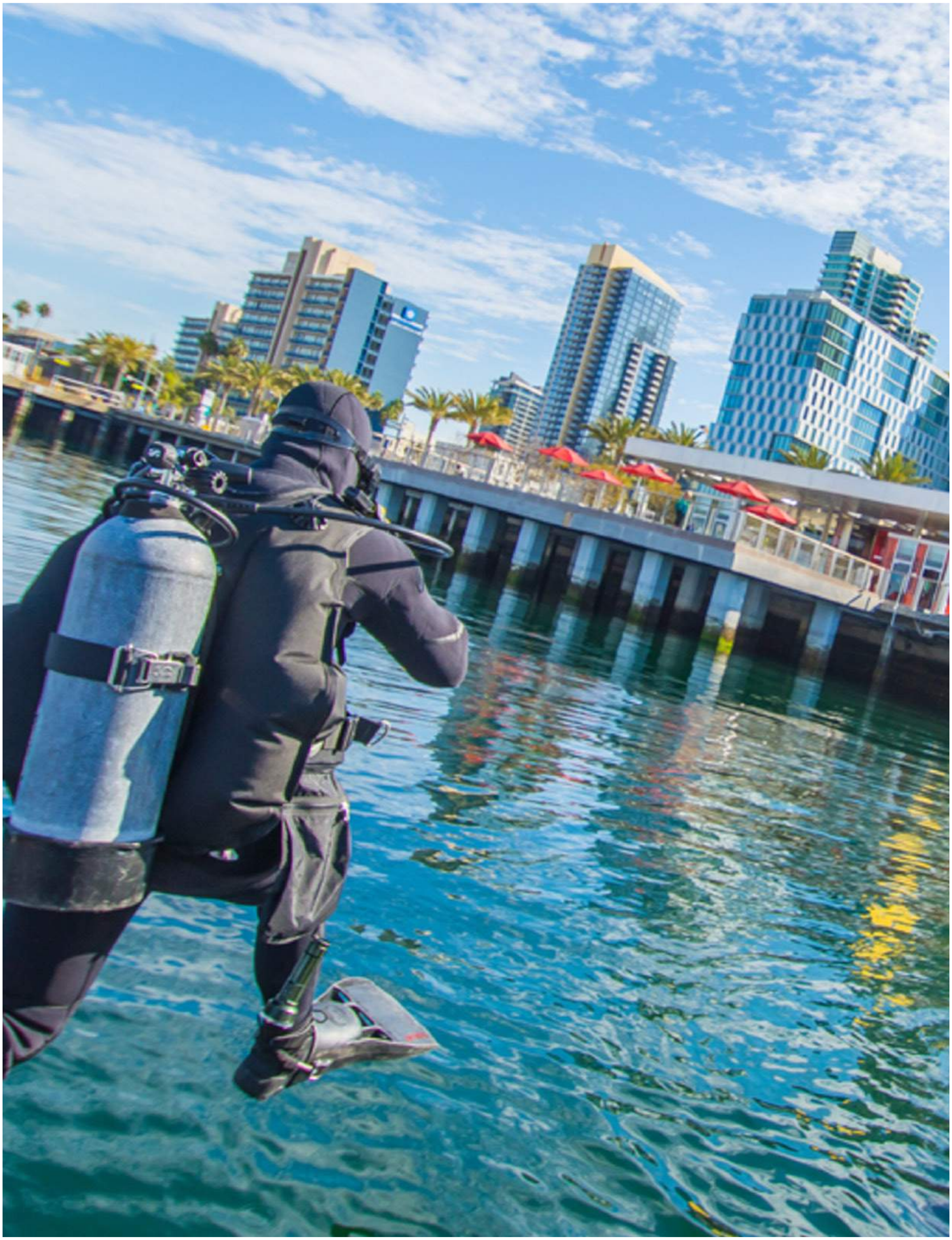


Figure ES.6: Proposed Adaptation Selection Process

assessments, the Framework can be continually improved and refined to reduce the risks associated with potential inundation and temporary coastal flooding from a 100-year storm event from future projected SLR.

Application of the adaptive management approach to potential projected SLR impacts would allow the District to plan and implement adaptation strategies in the near-term while remaining flexible enough to adjust future strategies in the face of uncertain conditions.

See Chapter 4 for more detail regarding adaptation planning and strategy implementation.



Diving at Centre City Embarcadero

Chapter 1 Introduction

In 2013, the State Legislature passed Assembly Bill (AB) 691, which was codified as Section 6311.5 of the California Public Resource Code (herein referred to as AB 691 or Section 6311.5). In promulgating Section 6311.5, the Legislature found that the "effect of climate change and sea level rise ([projected SLR]) will have an enormous implications for the state's economic and social future..." The Legislature also declared that "[a]ddressing the impacts of [projected SLR] . . . shall be among the management priorities of a local trustee." Accordingly, AB 691 requires local trustees of public trust lands whose gross public revenues average over $250,000 between January 1, 2009 and January 1, 2014 to prepare and submit to the State Lands Commission an assessment of how the local trustee proposes to address projected SLR. (Section 6311.5(c).)

Pursuant to AB 691 and subsequent direction from the SLC, and to be a useful tool for the District moving forward to address projected SLR impacts, the objectives of this document (AB 691 Report) are:

- Uses best available science to assess the vulnerability of projected SLR on the District's jurisdiction, including the updated OPC's State of California Sea-Level Rise Guidance: 2018 Update, as required by AB 691;
- Provides maps of areas that may be potentially impacted by projected SLR for the years 2030, 2050, and 2100;
- Estimate the potential impacts and financial costs associated with those potential impacts on granted trust lands in the District;
- Describe how the District proposes to address projected SLR to protect and preserve natural and built environment resources and facilities on trust lands.

1.1 AB 691

In conducting the projected SLR assessment, the local trustee shall consider and use relevant information from the *2009 California Climate Adaptation Strategy* prepared by the Natural Resource Agency, the *Report on Sea Level Rise Preparedness* prepared by the State Lands Commission, the *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*, a report prepared by the National Academy of Sciences, the *Resolution of the California Ocean Protection Council on Sea-Level Rise, the State of California Sea-Level Rise Guidance Document*, and any subsequent updates to those reports that become available six months prior to the date the local trustee submits the assessment to the SLC. (Section 6311.5(d).) The assessment must include the following:

- An analysis of the impacts of projected SLR, as described in the Resolution of the California Ocean Protection Council on Sea-level Rise and the latest version of the State of California Sea-Level Rise Guidance Document;
- Maps showing areas that may be affected by projected SLR in years 2030, 2050 and 2100, including potential impacts of a 100-year storm event;
- An estimate of financial costs of the impact of projected SLR on granted public trust lands, including the potential cost of repair of damage to and the value of lost use of improvements and land, as well as the anticipated cost to prevent or mitigate potential damage; and
- A description of how the local trustee proposes to protect and preserve existing and proposed natural and built environment resources and facilities, including, without limitation how wetlands and restoration and habitat preservation would mitigate impacts projected SLR. (Section 6311.(c)(1)-(c)(4).)

In addressing projected SLR, the local trustee shall collaborate with lessees, appropriate local, state and federal agencies, as well other users of granted public trust lands. (Section 6311.5(e).) However, AB 691 does not require a local trustee to implement any specific actions to address projected SLR. (Section 6311.5(j).) The assessment must be submitted to SLC by July 1, 2019. (Section 63115.(c).)

1.2 Trustee Background

This AB 691 Report analyzes projected SLR impacts for the District, including the San Diego International Airport (Airport), which is located on District tidelands but leased to the San Diego County Regional Airport Authority (Airport Authority).

1.2.1 San Diego Unified Port District

The District was formed by the State Legislature in 1962 through the San Diego Unified Port Act (Port Act), codified in California Harbors and Navigation Code, Appendix 1, and granted certain public trust tidelands and submerged tidelands in and around San Diego Bay (Bay). The District encompasses portions of five cities – San Diego, National City, Chula Vista, Imperial Beach and Coronado - and the San Diego International Airport. With approximately 5,750 acres of water and land, the District hosts a wide range of public trust compliant uses and improvements including public access, maritime, commercial, industrial, institutional, conservation, and recreation.

1.3 Historic Sea Level Rise Measurements in San Diego Bay

The National Oceanic and Atmospheric Association (NOAA) placed tide gauges around the country to track long-term trends in national oceanographic conditions, including changes in water levels. A tide gauge in San Diego Bay was placed in 1906 and is located on the Broadway Pier, which provides over one hundred years of data monitoring water levels and oceanographic conditions in San Diego Bay.

Over the past century, mean global sea level has risen approximately 0.07 inches per year up until 1993 where mean global projected SLR accelerated to a rate of 0.13 inches after 1993 (Church et al. 2013). From 1906 to 2017, the tide gauge in San Diego Bay recorded a rise of approximately 0.09 inches per year (NOAA 2019), equating to an approximate .71 feet, or 8.5 inches of projected SLR in San Diego in total during the 20th century (NOAA 2019).

1.4 Historic Projected Sea Level Rise Information

SLR is projected to potentially impact the coastal lands along the San Diego Bay, creating a set of challenges and related opportunities to build the resilience and adaptive capacity of the area. The potential impacts from projected SLR, such as inundation, storm events, and increased risk of flooding and coastal erosion, have the potential to impact the District, including natural resources, public access, infrastructure, and business operations.

Previous SLR vulnerability assessments in the region highlighted the vulnerability of coastal areas of San Diego to increasing water elevations. The ICLEI 2012 found that the greatest projected SLR impact in the near-term could be an increase in the frequency and intensity of the kind of flooding that the region already experiences due to waves, storm surge, El Niño events, and very high tides.

Starting around 2050, the Bay may become more vulnerable to potentially reoccurring inundation of certain locations and assets, some of which are being planned and built today.

As a result, this longer term risk of potential inundation should be a consideration in today's decision-making (ICLEI 2012). Recent science summarized in California's 4th Climate Change Assessment noted that projected SLR in San Diego is expected to "increase rapidly in the second half of the century and will be punctuated by short periods of storm-driven extreme sea levels that will imperil existing infrastructure, structures, and ecosystems with increasing frequency" (Kalansky, et. al. 2018). Other studies have highlighted the impacts of projected SLR to commercial and other economic activities within the area, if no adaptation actions are implemented (MIIS 2018).

Biking in Coronado

Chapter 2 Methodology and Approach

The first stage in the District's AB 691 compliance was to undertake a vulnerability assessment, using current, best available science for SLR projections and associated modeling to incorporate new climate science and advances in technology.

The vulnerability assessment (Chapter 2: Methodology and Approach and Chapter 3: Vulnerability Assessment) also provides an opportunity to update the District's inventory of assets and/or changes to geography or topography. By using the best available science and updated assets and topography, the projected SLR mapping can reflect changes over time that may reveal changes in risk associated with changes in exposure, sensitivity, or adaptive capacity.

This chapter summarizes the District's methodology and approach for this AB 691 Report, as required by Section 6113.5. The methodology and approach of the assessment were developed and adapted from best practices used in other projected SLR vulnerability assessments (County of San Mateo 2018). They were also informed by state projected SLR guidance documents (OPC 2018, CCC 2018).

2.1 Project Area

The area of San Diego Bay encompassed by the historic mean high tide line amounts to approximately 15,000 acres of filled and submerged lands, and an existing shoreline around the Bay of approximately 54 miles in length. In accordance with Section 6113.5,

Figure 2.1: San Diego Unified Port District

this AB691 Report evaluates only the tidelands and submerged tidelands granted to the District.

The District has been granted approximately 5,750 acres or about 37 percent of all state tidelands and submerged tidelands around San Diego Bay. The shoreline frontage is approximately 34 miles, which is equivalent to 61 percent of the Bay's total shoreline. The District's tidelands are divided into ten planning districts that correspond to the District's Port Master Plan. Planning district boundaries conform closely to the boundaries of established municipal jurisdictions following logically grouped geographic areas.

The Harbor Island Planning District also includes the Airport. While the District still owns and holds the Airport's underlying land in trust, the Airport, including all land uses, activities, and improvements, is under direct jurisdiction of the Airport Authority. The Airport Authority recently completed an assessment that evaluates risks of projected SLR on the Airport. A summary of potential projected SLR inundation and coastal flooding on the Airport is included in this AB 691 Report.

2.2 Stakeholder Engagement

AB 691 requires local trustees of public trust lands to collaborate with its lessees, local, state and federal government agencies, and users of the granted public trust lands to address projected SLR. District staff, regional stakeholders, and subject matter experts from public agencies, non-profit groups, and private companies were engaged during the development of the AB 691 Report to gather information and learn from projected SLR and coastal experts. Stakeholders included the U.S. Navy, federal, state, regional, and local government agencies, academia, environmental interest groups, District tenants, and the San Diego Port Tenants Association.

Beginning in the fall of 2017 and concluding in the winter of 2018, stakeholders provided technical feedback and offered support for the District's projected SLR approach, including selection of SLR projections to be used in the vulnerability assessment, coastal flooding model, and assets to be evaluated. Stakeholders also provided input on the vulnerability assessment including flood maps in Chapter 3 and the projected SLR planning process described in Chapter 4. The stakeholder process led to a deeper understanding of SLR projections, asset management, and potential impacts and the creation of the Framework.

2.3 Sea Level Rise Science

The *State of California Sea-Level Rise Guidance Document*, initially released in 2010 and first updated in 2013, provided guidance for incorporating SLR projections into planning, design, permitting, construction, investment, and other decisions. In 2012, the National Research Council (NRC) released *Sea-Level Rise for the Coasts of California, Oregon, and Washington - Past, Present and Future* provided estimates and projections of future sea-level rise (NRC 2012).

The future sea level projections from NRC 2012 guided agencies in their SLR planning in the subsequent years. Since the NRC study, a new Intergovernmental Panel on Climate Change (IPCC) report was published containing updated SLR projections based on new scenarios, model simulations, and scientific advances (Church et al. 2013). New research was also published on the primary drivers of sea level change, which includes important new work on ice sheet mass loss in Antarctica, as well as on new methods for producing probabilistic projections of local sea level change (Kopp et al., 2014).

In April 2017, at the request of the Ocean Protection Council (OPC), a Working Group of OPC's Science Advisory Team released a report synthesizing the state of projected SLR science entitled *Rising Seas in California: An Update on Sea-Level Science* (2017 OPC Science Report). The 2017 OPC Science Report was prepared and peer-reviewed by some of the nation's foremost experts in coastal processes, climate and SLR science, observational and modeling science, the science of extremes, and decision-making under uncertainty. The 2017 OPC Science Report provides a new method for determining probabilistic projections of SLR at historic tide gauges throughout California including the tide gauge in San Diego Bay.

The 2017 OPC Science Report, provided the scientific foundation for the 2018 OPC SLR Guidance (Griggs et al., 2017), which included advances in SLR modeling and improved understanding of the processes that could drive extreme global SLR from ice loss from the Greenland and Antarctic ice sheets. The 2018 OPC SLR Guidance, along with other authoritative peer-reviewed science (if not less precautionary than the foundation set forth by the 2017 OPC Science Report) serves as the best available science to date on which to base future planning and investing decisions in California at the time this AB 691 Report was completed.

The California Coastal Act directs the California Coastal Commission (CCC) and local governments to use the best available science in coastal land use planning and development. The CCC *Sea Level Rise Policy Guidance 2018* recommends using the SLR projections from the 2018 OPC SLR Guidance as best available science to inform planning decisions and project design. For this AB 691 Report, best available science refers to the 2018 OPC SLR Guidance projections as illustrated in Table 2.1.

Extreme Sea Level Rise Projections

The 2018 OPC SLR Guidance includes an estimation of a potential extreme SLR projection based on research indicating that over 10 feet of projected SLR may be possible by the end of the century. Unlike the RCP 8.5 projections, the 2018 OPC SLR Guidance was not able to provide probabilities of occurrence for this extreme scenario, shown as H++ in Table 2.1. Researchers have been trying to parameterize computer models to predict the influence of melting ice in the West Antarctic, the primary

Table 2.1: Ocean Protection Council Probabilistic Projections in Feet

(Based on Kopp et al., 2014)	Median	Likely Range	1-in 20 Chance	1-in 200 Chance	H++ scenario (Sweet et al., 2017) *Single scenario
	50% probability SLR meets or exceeds...	66% probability SLR is between...	5% probability SLR meets or exceeds...	0.5% probability SLR meets or exceeds	
		Low Risk Aversion		Medium-High Risk Aversion	Extreme Risk Aversion
High emissions 2030		0.4 - 0.6	0.7	0.9	1.1
2050	0.9	0.7 - 1.2	1.4	2.0	2.8
High emissions 2100	2.6	1.8 - 3.6	4.5	7.0	10.2

[3]Edwards et al. 2019. Revisiting Antarctic Ice Loss Due to Marine Ice-Cliff Instability. *Nature*.

contributor to the H++ scenario, to better understand its contribution to SLR. New research released in January 2019 indicates that the extreme SLR scenario may be overestimated.[3] As a result, the District did not include this extreme SLR scenario in its assessment. As the scientific conversation continues to evolve, the District plans on integrating new projections of SLR into future vulnerability assessments and its planning process.

2.4 Selection of Sea Level Rise Projections

The District, in consultation with its stakeholders, chose SLR projections consistent with the 2018 OPC SLR Guidance that represents the 95th percentile (1-in-20 chance) for the years 2030, 2050, and 2100 (see Table 2.2).

Given the uncertainty of climate science and the variability in projections towards the end of the century, the District also opted to analyze projected SLR impacts using the 50th percentile projection for 2100. As required by AB 691, the District assessed projected SLR impacts using the four different projections without, then with, 100-year storm events. The intention of separating the analyses was to help the District better understand the impacts caused by potential daily tidal inundation compared to temporary

Table 2.2: Selected Sea Level Rise Projections

Feet (Meters) Above 1991 – 2009 mean	Median		Likely Range		1-in 20 Chance		1-in 200 Chance	
Year/ Percentile	50% probability SLR meets or exceeds		67% probability SLR is between		5% probability SLR meets or exceeds		0.5% probability SLR meets or exceeds	
	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
2030	0.5	0.15	0.4 - 0.6	0.12 - 0.18	0.7	0.21	0.9	0.28
2050	0.9	0.27	0.7 - 1.2	0.21 - 0.37	1.4	0.43	2.0	0.61
2100 (RCP 8.5)	2.6	0.79	1.8 - 3.6	0.55 - 1.10	4.5	1.4	7.1	2.16

coastal flooding from a 100-year storm event caused by a 100-year storm surge. Table 2.2 illustrates the single range of SLR projections for the years 2030 and 2050 and multiple ranges for the year 2100.

2.5 Sea Level Rise Mapping

The SLR mapping consists of a quantitative geospatial assessment of projected SLR and 100-year storm surge impacts to District assets. For the District, the best available modeling data was the USGS CoSMoS 3.0. CoSMoS is a publicly available, federally supported system and is the primary model used by coastal jurisdictions and agencies along the California coast to assess vulnerabilities from potential inundation and temporary coastal flooding from a 100-year storm event.

United States Geological Survey (USGS) Coastal Storm Modeling System

CoSMoS is a collection of potential inundation maps produced for the California coast by the USGS. CoSMoS incorporates SLR projections and makes detailed predictions (meter-scale) over large geographic scales (hundreds of kilometers) of potential inundation and storm-induced coastal flooding and erosion. CoSMoS combines 0.8 feet projected SLR increments and four different storm return periods (daily, annual, 20-year, 100-year) into a series of inundation maps.

AB 691 requires local trustees to map and assess impacts of projected SLR for the years 2030, 2050, and 2100 (including the potential impacts of 100-year storm events). USGS presents these modeled data independent of any projected analysis timeframe (i.e., they do not indicate when any projected SLR increment will occur). As CoSMoS operates using set 0.8 feet increments of projected SLR, the OPC SLR projections (with associated timeframes) selected by the District were matched to the closest value in CoSMoS for use in the District's analysis. As a result, the scenario elevations from CoSMoS may differ slightly from the OPC projections. The selected CoSMoS SLR scenarios and the corresponding OPC projections and are listed in Table 2.3.

For each CoSMoS mapping increment, both potential daily inundation layers, as well as temporary coastal flooding from a 100-year storm event (storm surge) are included in the analysis. Exposure maps were created by overlaying the

Table 2.3: Alignment of San Diego Sea Level Rise Projections with CoSMoS Projected Sea Level Rise Scenarios

CoSMoS Model Levels in Meters	Recommended Ocean Protection Council[1] SLR Probabilistic Projections	
	Increase Above Current Levels	Emissions Scenario
0.8 feet/0.25 meters	0.7 feet (0.21 meters)	2030 (1-in-20 Chance)
1.6 feet/0.5 meters	1.4 feet (0.43 meters)	2050 (1-in-20 Chance)
2.5 feet/0.75 meters	2.6 feet (0.79 meters)	2100 (Median)
4.9 feet/1.5 meters	4.5 feet (1.4 meters)	2100 (1-in-20 Chance)

Median = 50% probability SLR meets or exceeds...
1-in-20 Chance = 5% probability meets or exceeds...

[1]Ocean Protection Council 2018. California Sea-Level Rise Guidance 2018 Update

CoSMoS scenarios on District tidelands and submerged tidelands. District assets within the extent of projected SLR inundation or temporary coastal flooding from a 100-year storm event were determined to be exposed unless specific elevation data for the asset demonstrated that it was not within projected water elevations for each projected SLR scenario.

2.5.1 Built Environment Assets and Natural Resources

Built environment assets that were analyzed in this assessment include the transportation network such as roads, rail, bike routes, and pathways; infrastructure such as building structures, parks, sewer lifts and storm drains, marine terminals, wharves, and piers. Natural resources such as nearshore habitats and least tern nesting areas were also included.

Built Environment Assets

With input from District staff and stakeholders, assets were further categorized as critical infrastructure (see Table 2.4). Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services essential to public health and safety, national security, the regional economy, or effective functioning of the District. Critical infrastructure can be stand-alone or interconnected and interdependent within and across

Table 2.4: District Assets Analyzed for Vulnerability

Assets	Critical Infrastructure
Transportation	
Roads	X
Rail	X
Pathways	
Bikeways	
Infrastructure	
Buildings	X
Marine Terminals	X
Docks and Piers	X
Stormwater Systems	X
Sewer Lifts	
Wastewater Systems	
Sanitary Pumpouts	
Parks	
Boat Launch Ramps	
Fuel Docks	
Natural Resources/Environmental	
Beach Accessible Areas	
Habitats	

the District's boundaries. Disruptions, incapacitation, or destruction of critical infrastructure could result in public safety issues, adverse economic effects, and harm to the District's essential operations.

Additional assets, including but not limited to, communication networks and utilities are critical infrastructure that would be impacted by potential inundation and/or temporary coastal flooding from a 100-year storm event. As this data was not available at the time of AB 691 Report development, it was not included. Omission of this data is not meant to construe the lack of importance of these assets or recognition of potential impacts from projected SLR.

All physical asset data was provided by the District in a spatial format. A more detailed discussion of each asset type evaluated in this AB 691 Report is provided in Appendix A.

Natural Resources

Pursuant to AB 691, the vulnerability assessment evaluated projected SLR impacts to the District's natural resources including subtidal, intertidal, and upland nearshore habitats. Habitats may be able to respond to changing sea levels if they can keep pace with future water elevations by migrating vertically or upslope. However, habitat area may be constrained by the built environment or conflicting environmental management priorities, which favor one type of habitat over another. Given the geographic and ecological considerations, the assessment of projected SLR impacts necessitated a different method than the geographic overlay approach as applied to other physical assets in the District.

The analysis of future impacts to habitats focused on eelgrass, salt marsh, uplands, and beach/dune habitats found within the District's jurisdiction. A baseline extent or area of each habitat were measured, and their current vertical elevation determined in 0.8 feet elevation increments. The vertical elevation range of each habitat was then used to calculate the *total available area* of undisturbed submerged land or tidelands that could potentially support each habitat. The *absolute occupancy* of each habitat within their corresponding elevation range was calculated by dividing the existing habitat extent by the total available area. Furthermore, *relative occupancy* within each 0.8 feet elevation increment was calculated by dividing the occupied extent per 0.8 feet elevation increment by the total habitat extent within the elevation range. It was assumed in this analysis that these occupancy values remain consistent across all projected SLR scenarios. This information was used to determine predicted occupancy for each habitat as projected SLR increases and habitats migrate upwards.

With an increase in projected SLR, it was assumed that habitats could keep pace and move upslope unless hindered by the built environment. For each SLR scenario, the elevation range of each habitat was adjusted upwards. The total available area of each habitat's new elevation range was calculated. Using the absolute and relative occupancy values, the occupied horizontal extent of each habitat was calculated per projected SLR scenario. This allowed for a comparison of total available area for each habitat as well as the extent of occupied habitat. Further explanation of the data and model assumptions to assess impacts to habitats can be found in Appendix B.

2.6 Sensitivity and Adaptive Capacity

Vulnerability from projected SLR, as addressed in this document, is composed of three major components: exposure, sensitivity, and adaptive capacity.

- Exposure: How much an asset is subject to potential inundation or temporary coastal flooding from a 100-year storm event. ICF International, Inc. provided and performed the exposure analysis using the OPC projections and CoSMoS.
- Sensitivity: The degree to which the function of an asset or resource would be impaired (i.e., weakened, compromised, or damaged) by the impacts of projected SLR. See Table 2.5. for a description of low and high sensitivity.
- Adaptive Capacity: The inherent ability of an asset or resource to adjust to projected SLR impacts without the need for substantial intervention or modification. See Table 2.6. for a description of low and high adaptive capacity.

In coordination with District staff, assets were categorized according to their sensitivity and adaptive capacity to potential inundation and temporary coastal flooding from a 100-year storm event. Given the broad scope of this assessment and the requirements of AB 691, site-specific assessments were not performed for individual assets exposed to potential inundation and/or temporary coastal flooding from a

Table 2.5: Sensitivity

Category	Rating	Description
Sensitivity	LOW	Asset or resource is not affected or minimally affected by coastal hazards at a given SLR scenario.
	HIGH	An asset or resource would experience major damage or long-term service interruptions due to coastal hazard impacts, requiring significant effort to restore/rebuild to original condition.

Table 2.6: Adaptive Capacity

Category	Rating	Description
Adaptive Capacity	HIGH	Asset or resource can easily be adapted or has the ability and conditions to adapt naturally.
	LOW	Asset or resource has limited ability to adapt without substantial changes.

Table 2.7: Summary of Asset Sensitivity and Adaptive Capacity to Sea Level Rise

Asset	Sensitivity	Adaptive Capacity
Roads	HIGH	LOW
Rails	HIGH	LOW
Bikeways	LOW	HIGH
Pathways	LOW	HIGH
Marine Terminals	HIGH	LOW
Piers	HIGH	LOW
Stormwater Management	HIGH	LOW
Wastewater Management	HIGH	LOW
Sewer Lifts	HIGH	HIGH
Sanitary Pump Outs	LOW	HIGH
Buildings	HIGH	LOW
Beach Accessible Areas	HIGH	LOW
Parks	LOW	HIGH
Boating Facilities	LOW	HIGH
Fuel Docks	HIGH	HIGH
Boat Launch Ramps	LOW	HIGH

100-year storm event. While assets of the same type (e.g. different parks in the District) may have different levels of sensitivity or adaptive capacity given specific site conditions, they have been generalized for this assessment as shown in Table 2.7.

The sensitivity and adaptive capacity of an asset should be used in conjunction with exposure to assess the overall vulnerability of an asset to projected SLR and a 100-year storm event. Those assets with a "HIGH" sensitivity and "LOW" adaptive capacity (shown in orange) are generally at more risk than assets with a "LOW" sensitivity and "HIGH" adaptive capacity (shown in green). (See Appendix A for more detail about the District's assets and their sensitivity and adaptive capacity to potential inundation and temporary coastal flooding from a 100-year storm event resulting from projected SLR.)

2.7 Financial Impacts Analysis

The financial analysis represents a high-level approximation, with generic structure and infrastructure replacement or repair costs that may not reflect actual costs and specifications in the event of a real loss. Financial costs of assets were collected from local sources, including the District and national construction databases. Revenue losses were calculated using District sources. All costs are in 2018 dollars.

Financial estimates were calculated by primarily following the methodology found in the NOAA report, *What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure* (NOAA 2013). The report provides a framework for comparing the costs and benefits of adaptation strategies that would lessen the coastal flooding impacts of current and future projected SLR. Because AB 691 required an estimate of financial impacts and the cost of adaptation strategies without conducting a more comprehensive comparative benefit-cost analysis, this study utilizes the relevant NOAA methodology for estimating the financial impacts rather than the full benefit-cost estimates.

2.8 Limitations

Certain limitations and data constraints shaped the scope of the AB 691 Report, as described below. Additionally, as stated below, certain disclaimers apply to the AB Report and usage of the report by third-parties.

2.8.1 Data Availability

This AB 691 Report used readily available data to identify vulnerable areas and assets and estimate costs. This information was augmented by interviews with District staff and site visits. All asset data, including associated revenue, were provided by the District or from national construction databases.

2.8.2 Use of this AB 691 Report

Consistent with AB 691, data and assessment in this AB 691 Report is intended to be used for informational and planning purposes only. The data in the AB 691 Report shall be submitted to the SLC as required by Section 6113.5 and may be used by the District in analyzing potential projected SLR and associated California Coastal Act consistency of the proposed Port Master Plan Update at a programmatic level in the proposed Environmental Impact Report. As development or projects move forward, site-specific evaluations are anticipated to be needed to customize projected SLR and associated adaptation measures depending on the location and type of project proposed.

2.8.3 Sea Level Rise Modeling Limitations

This vulnerability assessment relied on existing projected SLR modeling tools. The maps in the AB 691 Report are intended to provide a District-wide scale assessment of potential inundation and temporary coastal flooding from a 100-year storm event due to specific projected SLR and 100-year storm event scenarios.

Flooding due to projected SLR and 100-year storm events were predicted using the currently available best science at a District-wide scale, but there exists a possibility of flooding in areas outside of those predicted, and even the best predictions cannot guarantee the safety of an individual or structure.

All underlying data for the potential inundation and temporary coastal flooding from a 100-year storm event is from CoSMoS 3.0 (with exception of buildings and piers, see below). The model incorporates wave projections, tides, and regional atmospheric forcing to generate sea and surge levels. The CoSMoS Digital Elevation Models (DEM) are based data was derived from the Coastal California Data Merge Project which includes LiDAR data collected from 2009 through 2011 and multi-beam bathymetry collected between 1996 and 2011 extending out to the three nautical mile limit of California's state waters. Consequently, any post-2011 changes to the topography are not captured by the DEM. All projected SLR modeling and mapping were performed by ICF International, Inc. With exception of buildings and piers, all asset exposure tables and hazard mapping reflect output provided by ICF.

CoSMoS does not recognize existing buildings that may overhang the water or piers. As a result, these buildings and piers are incorrectly shown to be impacted by zero water elevation using the CoSMoS model. To account for this issue, the District chose to develop and implement a local model for buildings to account for footprints that are on land and water and for piers. Instead of using the CoSMoS topographic file, the District provided specific ground elevations for buildings within the District and subtracted the projected water levels for the four SLR scenarios. This local model was applied to all buildings and piers. The application of two differing models resulted in inconsistencies between the CoSMoS projected SLR impacts and the local model. Specifically, some buildings shown to be impacted by potential inundation or temporary coastal flooding from a 100-year storm event in the CoSMoS model, where not show to be impacted using the District's local model. As a result, exposure tables in the AB 691 Report show fewer impacts to buildings from potential inundation and temporary coastal flooding from a 100-year storm event than as illustrated in the flood maps produced by the CoSMoS model. This may result in an underestimation of financial impacts to assets.

The Airport Authority used more recent on-airport ground elevation data than the default settings within the CoSMoS tool. This was done to ensure that all modeled scenarios took into consideration the Airport Authority's recent redevelopment projects.

2.8.4 Financial Analyses Limitations

The adaptation strategy cost estimates are intended to provide an approximation of per unit project costs and do not represent conceptual level of design costs, preliminary design costs, or final design costs. The actual project descriptions for adaptation strategies (and construction costs) may differ from what is provided herein. It is recommended that financial feasibility not be assessed until any preliminary design is accomplished, based on a more thorough consideration of coastal processes, regulatory and environmental opportunities and constraints, and engineering.

The financial impact assessment contains an analysis of recurring revenues and costs to the District from potential loss of property and services. It is based on estimates, assumptions, and other information developed from our research, interviews, telephone discussions with District staff, and information collected through fiscal impact analyses previously prepared.

The financial impact analysis is not considered to be a "financial forecast" nor a "financial projection," as technically defined by the American Institute of Certified Public Accountants. The word "projection" used within this report relates to broad expectations of future events or market conditions. The analysis also does not consider potential projected SLR impacts on public health, socio-economic issues, or environmental damage (e.g., oils spills and discharge of pollution).

The sources of information and basis of the estimates are stated herein. While we believe the sources of information are reliable, the District and the authors of this AB 691 Report do not express an opinion or any other form of assurance on the accuracy of such information. The analyses are based on estimates and assumptions that are inherently subject to uncertainty and variation depending on evolving events. Some assumptions inevitably will not materialize, unanticipated events and circumstances may occur, and actual results may vary from the projections. Therefore, the District and authors of the AB 691 Report cannot and do not represent that the results presented here will be achieved.

Disclaimers:

The District implies no warranties or guarantees regarding any aspect or use of this information. The maps contained herein are not detailed to the parcel scale and a party that uses or relies on said maps does so at its own risk. The District and the authors of this AB 691 Report do not assume liability for any injury, death, property damage, or other effects of projected SLR or any flooding, whether associated with a 100-year storm event or otherwise. Any user (other than the District and SLC) of this report and associated data, findings, recommendations, etc. assumes all responsibility for the use thereof, and further agrees to hold the District and the authors of this AB 691 Report harmless from and against any damage, loss, or liability arising from any use of this information.

Chapter 3 Vulnerability Assessment

3.1 Introduction

This chapter focuses on District vulnerabilities from potential inundation caused by projected SLR, and temporary coastal flooding from a 100-year storm event. Following the methodology presented in Chapter 2, a summary of impacts to District assets from the four modeled SLR scenarios, with and without a 100-year storm event, is provided on a District-wide scale, and at the planning district level. Where impacts to specific assets cannot be quantified, a qualitative summary of the potential consequences to District operations and infrastructure is presented.

Finally, this chapter concludes with a discussion of the estimated financial impacts to the District from projected SLR under the "no action" condition.

3.2 District Vulnerability: Key Takeaways

Overall, potential exposure to District assets is driven by coastal storm events coupled with rising sea levels between 0.8 to 2.5 feet. Beyond 2.5 feet of projected SLR, potential inundation may increase across the District. Low lying assets in or adjacent to the water, such as beach accessible areas, boat launches, and sewer lifts are projected to experience impacts from potential inundation at 0.8 feet of projected SLR. Assets that provide public access (e.g., pathways, bikeways, piers) and recreational opportunities (e.g. parks) become increasing impacted by potential inundation, and then exacerbated by storm surge from a 100-year storm event starting at 1.6 feet of projected SLR.

At 4.9 feet of projected SLR, with and without a 100-year storm event, most

Table 3.1: District Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	47.9	HIGH	LOW	1%	1%	2%	26%
Rail (linear miles)	16.2	HIGH	LOW	0%	0%	0%	57%
Bikeways (linear miles)	5.9	LOW	HIGH	1%	2%	10%	55%
Pathways (linear miles)	22.2	LOW	HIGH	7%	8%	15%	60%
Marine Terminals (acres)	233.4	HIGH	LOW	0%	0%	1%	37%
Buildings (count)	590	HIGH	LOW	0%	0%	1%	23%
Piers (count)	15	HIGH	LOW	0%	0%	0%	75%
Stormwater Management (count)	458	HIGH	LOW	4%	4%	7%	45%
Sewer Lifts (count)	10	HIGH	HIGH	20%	20%	30%	70%
Boat Launch Ramps (count)	3	LOW	HIGH	100%	100%	100%	100%
Beach Accessible Areas (acres)	11	HIGH	LOW	71%	75%	80%	93%
Parks (acres)	144.6	LOW	HIGH	3%	3%	6%	45%

Table 3.2: District Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	4,987.3	HIGH	LOW	2%	5%	16%	46%
Rail (linear miles)	16.2	HIGH	LOW	0%	0%	12%	83%
Bikeways (linear miles)	5.9	LOW	HIGH	10%	17%	34%	82%
Pathways (linear miles)	22.2	LOW	HIGH	14%	24%	43%	78%
Marine Terminals (acres)	233.4	HIGH	LOW	0%	0%	9%	69%
Buildings (count)	590	HIGH	LOW	1%	3%	8%	46%
Piers (count)	15	HIGH	LOW	0%	19%	32%	88%
Stormwater Management (count)	458	HIGH	LOW	5%	14%	30%	66%
Sewer Lifts (count)	10	HIGH	HIGH	30%	30%	50%	90%
Boat Launch Ramps (count)	3	LOW	HIGH	100%	100%	100%	100%
Beach Accessible Areas (acres)	11	HIGH	LOW	79%	83%	90%	95%
Parks (acres)	144.6	LOW	HIGH	6%	11%	25%	72%

District assets have the potential to be impacted by projected SLR-induced flooding.

Critical infrastructure such as roads, rail, and the stormwater system are particularly sensitive to potential SLR inundation or a 100-year storm event that could obstruct business operations, limit public access, and/or lead to public safety challenges including emergency response and recovery. Impacts to critical infrastructure have the potential to increase with potential inundation at 4.9 feet of projected SLR and projected temporary coastal flooding from a 100-year storm event at 2.5 feet of projected SLR.

The District contains approximately 7,500 slips or moorings for recreational, commercial fishing, sportfishing, marine services, and Harbor Police. While slips and moorings can be elevated for increased projected SLR, substantially larger storm events combined with elevated sea levels may lead to more extensive damage and longer recovery times. Although this analysis did not evaluate impacts to floating docks nor the fueling infrastructure, these assets could also be damaged with higher sea levels and 100-year storm events.

Tables 3.1 and 3.2 summarize the exposure results for each of the assets, across all scenarios for all of District Tidelands.

Coronado Ferry Landing

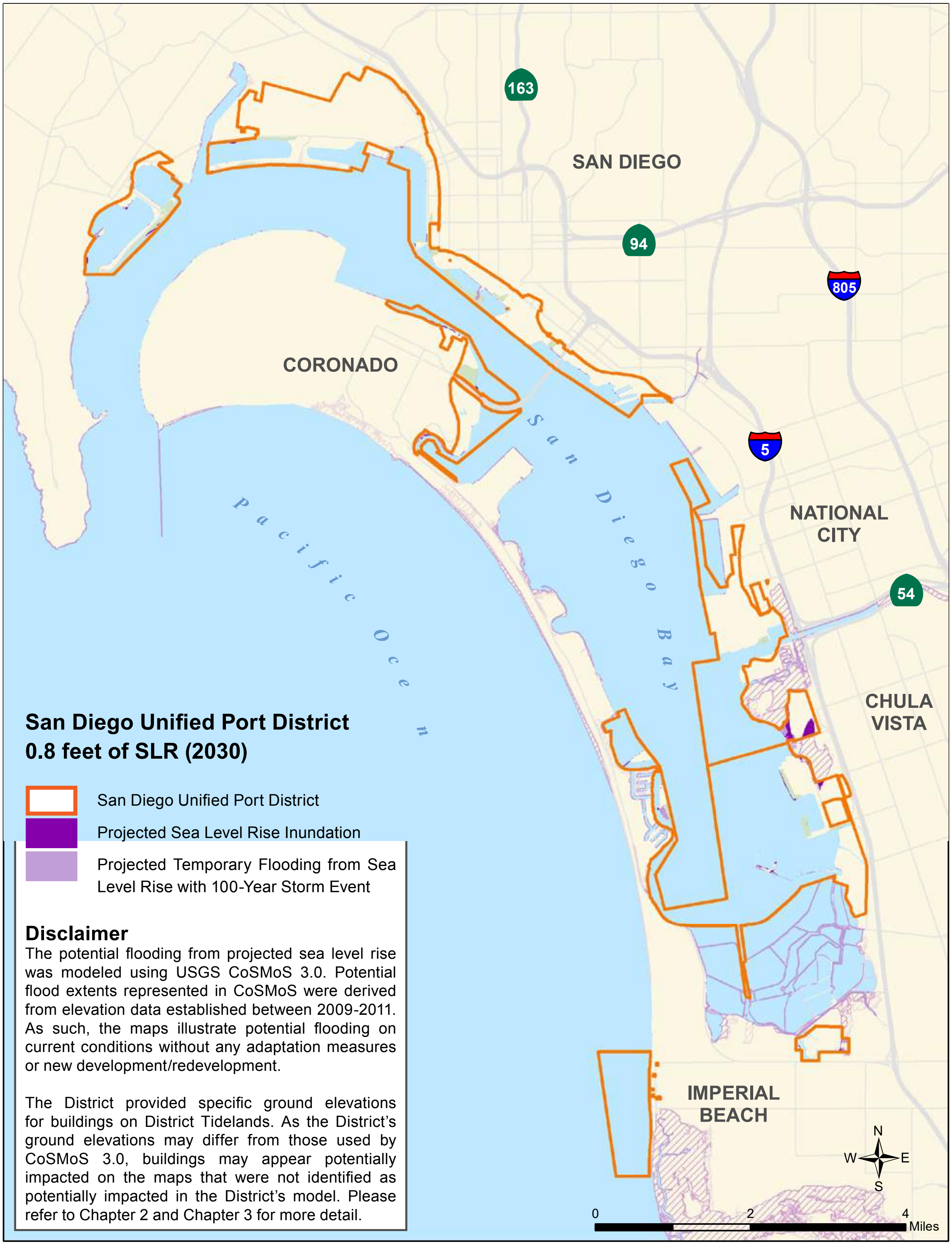


Figure 3.1: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2030

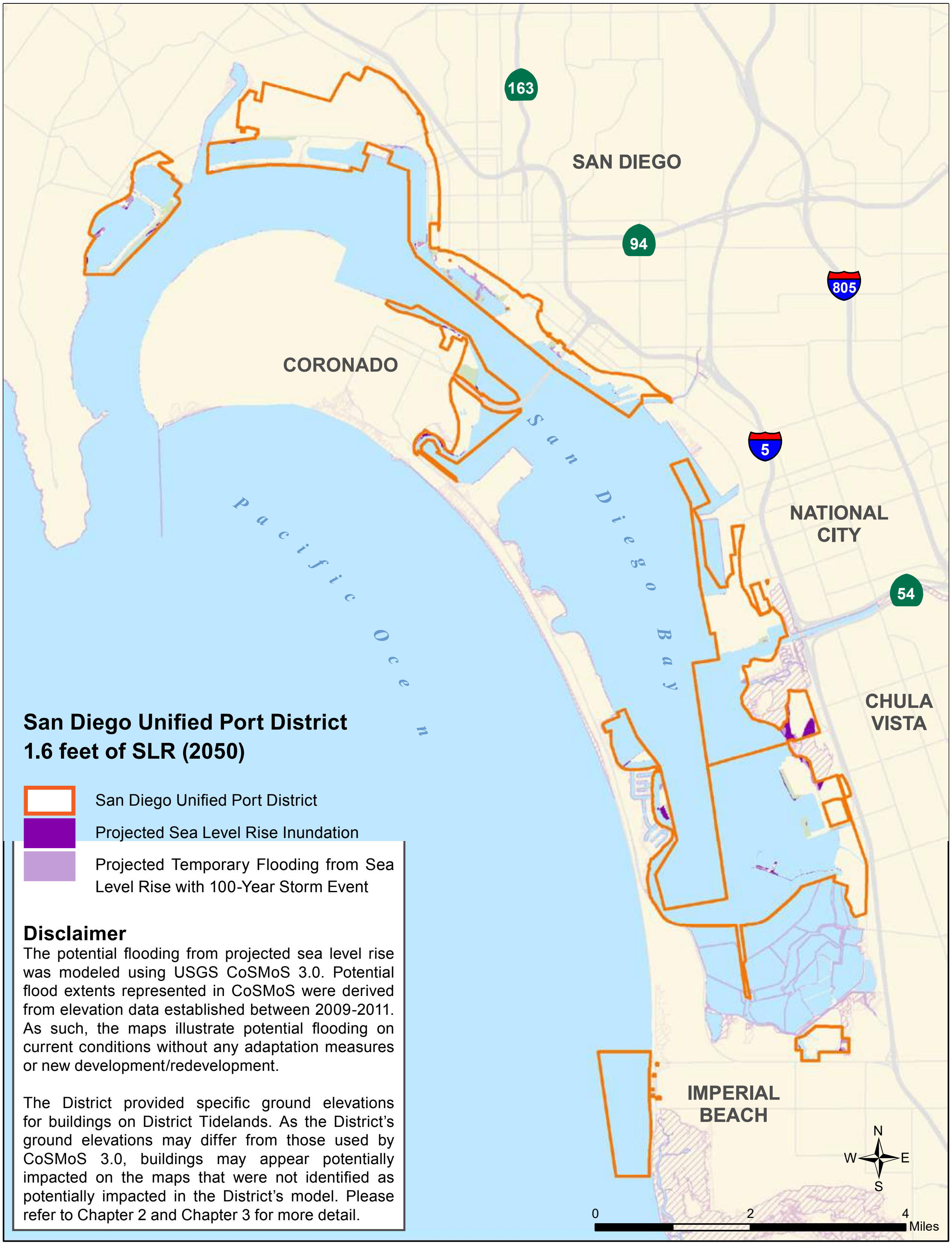


Figure 3.2: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

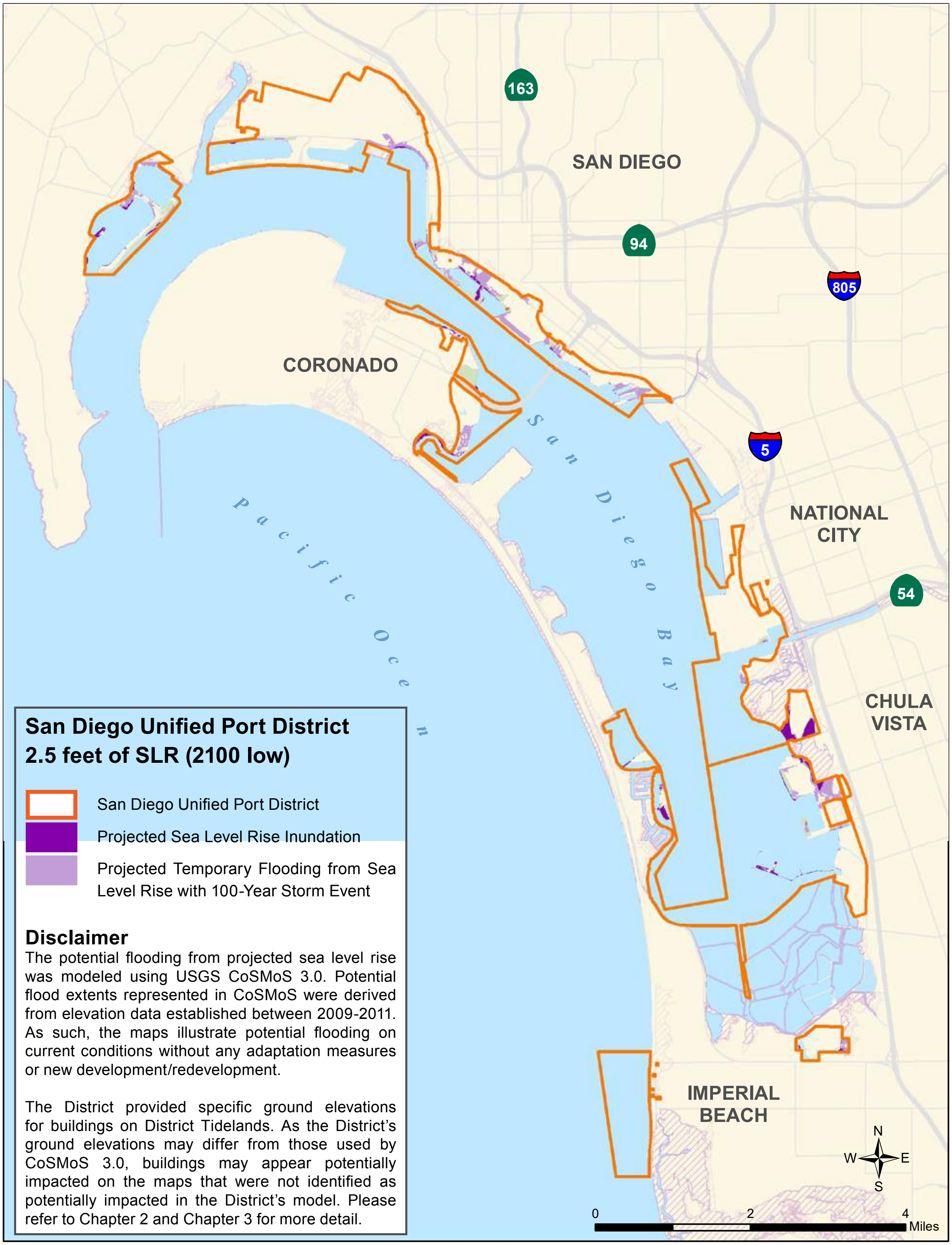


Figure 3.3: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

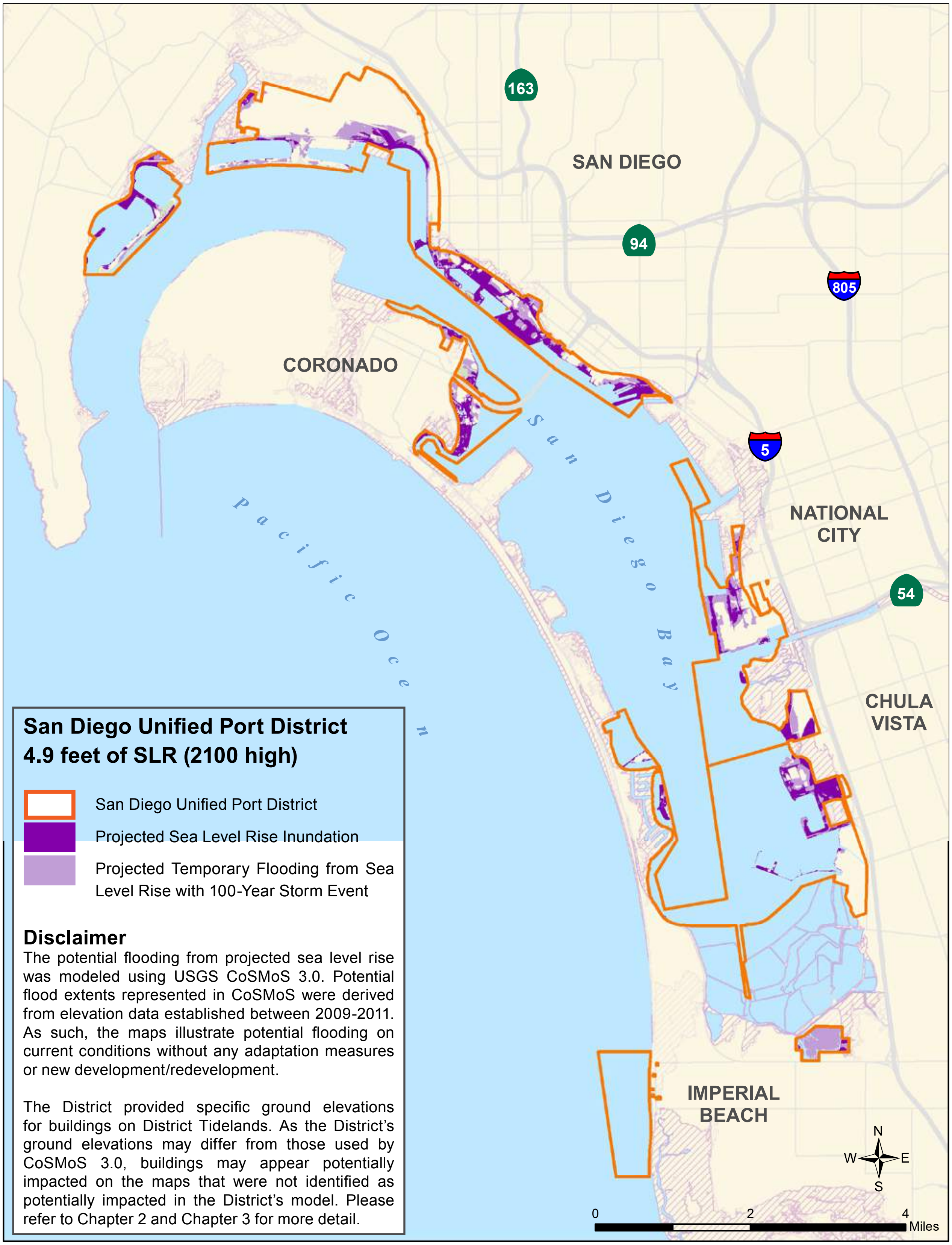


Figure 3.4: District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 High Scenario)

3.3 Planning Districts

The following sections summarize the exposure results for planning district assets across all scenarios.

3.3.1 Shelter Island Planning District

3.3.1.1 Planning District Setting

Located on the south side of the Point Loma Peninsula, the Shelter Island Planning District is adjacent to upland commercial and residential communities, military installations, and the Cabrillo National Monument. The Shelter Island Planning District includes over five miles of waterfront lined with a diverse assortment of water and land uses including commercial fishing, sportfishing, recreational berthing, marine sales and services, and commercial recreation uses. Open space and visitor-serving amenities include a linear recreational park along the Bay with a shoreline pathway and recreation areas, complemented by the La Playa Trail and Kellogg coastal access on the basin side, and the Shelter Island boat launch on the Bay side.

3.3.1.2 Shelter Island Vulnerabilities: Key Takeaways

Low lying areas in Shelter Island may experience impacts from potential inundation and temporary coastal flooding from a 100-year storm event earlier than other areas around San Diego Bay. Past 2050, public access and buildings that are at lower elevations in this Planning District are projected to be substantially impacted by temporary coastal flooding from a 100-year storm event. Shelter Island contains approximately 3,000 slips or moorings as well as fueling stations for recreational boating. While slips and moorings can be elevated for increased projected SLR, substantially larger 100-year storm events combined with elevated sea levels may lead to more extensive damage and longer recovery times. Although this analysis did not evaluate impacts to floating docks nor fueling infrastructure, these assets could also be damaged with higher sea levels and 100-year storm events.

Critical infrastructure such as roadways on or near Shelter Island are particularly sensitive to potential inundation at 4.9 feet of projected SLR as all access to the planning district may be affected. However, because of location specific impacts to Anchorage Lane and the Shelter Island Drive intersection with Scott Street, a 100-year storm event could impede access to West Shelter Island closer to 2050.

Although not predicted to be impacted by projected SLR nor a 100-year storm event, access to the Shelter Island Harbor Police Station, located at the west end Shelter Island, may be limited with 4.9 feet of projected SLR. Water and stormwater facilities could become substantially impacted by potential inundation at 4.9 feet of projected SLR and temporary affected at 2.5 feet of projected SLR with a 100-year storm event. The consequences of potential inundation combined with a 100-year storm event could potentially obstruct business operations, limit public access, and/or lead to challenges to public safety including emergency response and recovery. These consequences are projected to increase rapidly beyond 2.5 feet of projected SLR for potential inundation and temporary coastal flooding from a 100-year storm event.

3.3.1.3 Shelter Island Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

The projected exposure to projected SLR impacts in Shelter Island could transform the planning district particularly with 4.9 feet of potential inundation and with potential damage from temporary coastal flooding from a 100-year storm event starting closer to 2050. Although impacts are projected to occur at 0.8 feet and 1.6 feet due to temporary coastal flooding from a 100-year storm event, these would be to a lesser extent (assets impacted) at 4.9 feet of projected SLR.

Potential Inundation

District assets in or directly adjacent to the water at lower elevations may be impacted by potential inundation with 0.8 feet of projected SLR. These include beaches, boat launches, and walkways (see Table 3.3). The Shelter Island Boat Launch was recently reconstructed and designed to accommodate higher sea levels in the future. As the adaptive capacity of these assets is relatively high, these assets should remain operable in the at 1.6 feet and 2.5 feet.

The quantity of District assets such as roads, parks, and buildings impacted by increased SLR is projected to increase over time. At 4.9 feet of projected SLR, a majority of pathways, buildings, beach accessible areas, waste water systems, and the stormwater system are projected to be severely affected by potential inundation. Continued flooding of roadways would reduce public access, disrupt business operations, and potentially limit emergency response. Of important note, access to the Harbor

Table 3.3: Shelter Island Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	2.9	HIGH	LOW	0%	0%	4%	32%
Pathways (linear miles)	6.2	LOW	HIGH	10%	14%	22%	66%
Buildings (count)	121	HIGH	LOW	0%	0%	3%	39%
Piers (count)	1	HIGH	LOW	0%	0%	0%	0%
Stormwater Management (count)	13	HIGH	LOW	0%	0%	8%	77%
Beach Accessible Areas (acres)	5	HIGH	LOW	72%	74%	78%	85%
Parks (acres)	27.5	LOW	HIGH	2%	3%	5%	23%
Boat Launch Ramps (count)	1	LOW	HIGH	100%	100%	100%	100%

Table 3.4: Shelter Island Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	2.9	HIGH	LOW	3%	11%	24%	61%
Pathways (linear miles)	6.2	LOW	HIGH	20%	32%	52%	71%
Buildings (count)	121	HIGH	LOW	3%	9%	17%	55%
Piers (count)	1	HIGH	LOW	0%	0%	0%	0%
Stormwater Management (count)	13	HIGH	LOW	0%	23%	77%	92%
Beach Accessible Areas (acres)	5	HIGH	LOW	77%	80%	83%	87%
Parks (acres)	27.5	LOW	HIGH	4%	11%	20%	35%
Boat Launch Ramps (count)	1	LOW	HIGH	100%	100%	100%	100%

Police Shelter Island Station could be impacted as roadways become inundated. The Shelter Island Fishing Pier is not expected to be potentially inundated at the 4.9 feet SLR scenario.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

A 100-year storm event (on top of projected SLR) may lead to greater impacts from temporary coastal flooding from a 100-year storm event. For example, twice as many pathways are affected by temporary coastal flooding from a 100-year storm event as compared to potential inundation beginning at 0.8 feet of projected SLR.

While a small number of buildings may be impacted at 0.8 feet of projected SLR from a 100-year storm event, there is the potential for substantial impacts to Shelter Island structures at 4.9 feet of projected SLR. (See Table 3.4.)

Overall, beyond 2.5 feet of projected SLR, a 100-year storm event has the potential to severely impact the operations of Shelter Island.

Morning on the Bay

Figure 3.5: Shelter Island Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2030

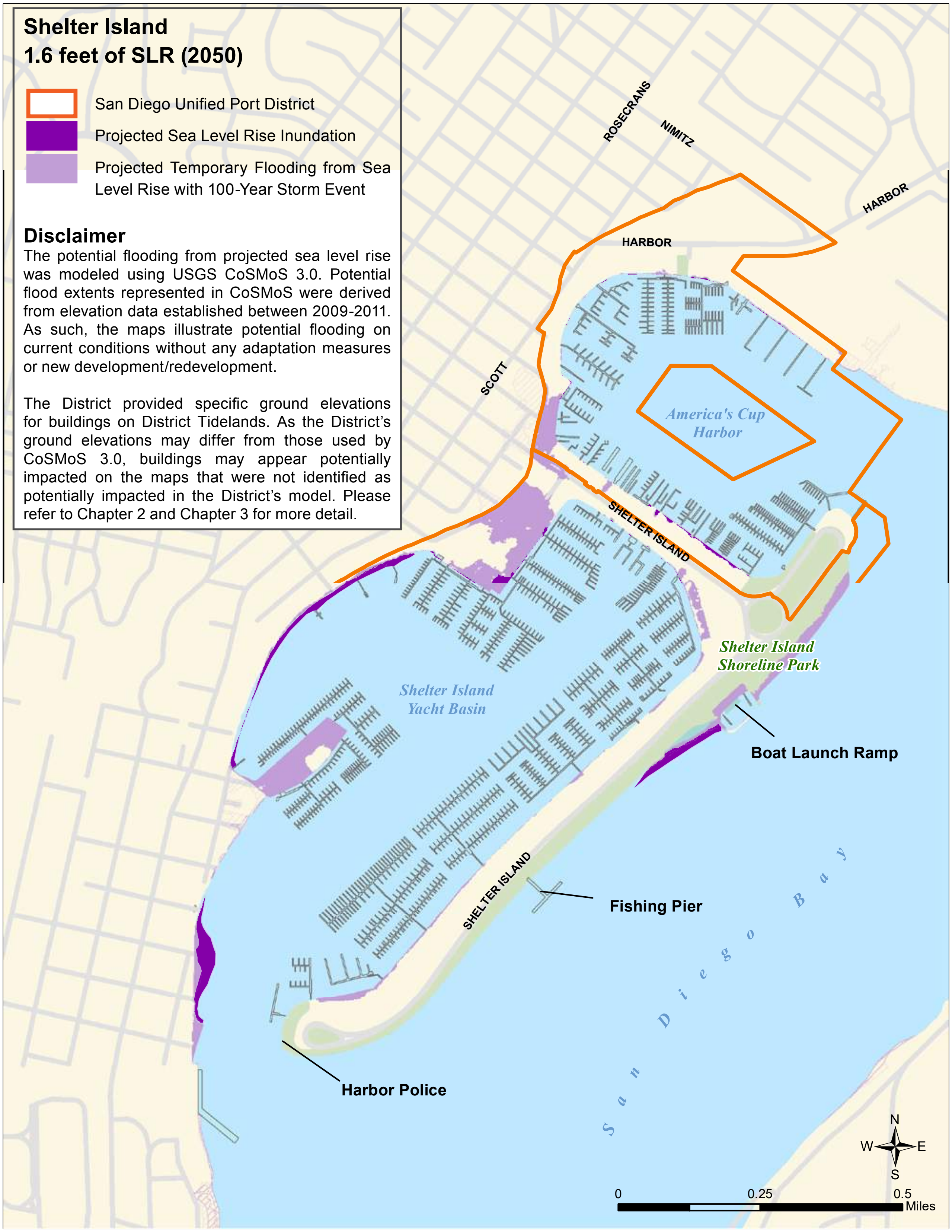


Figure 3.6: Shelter Island Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

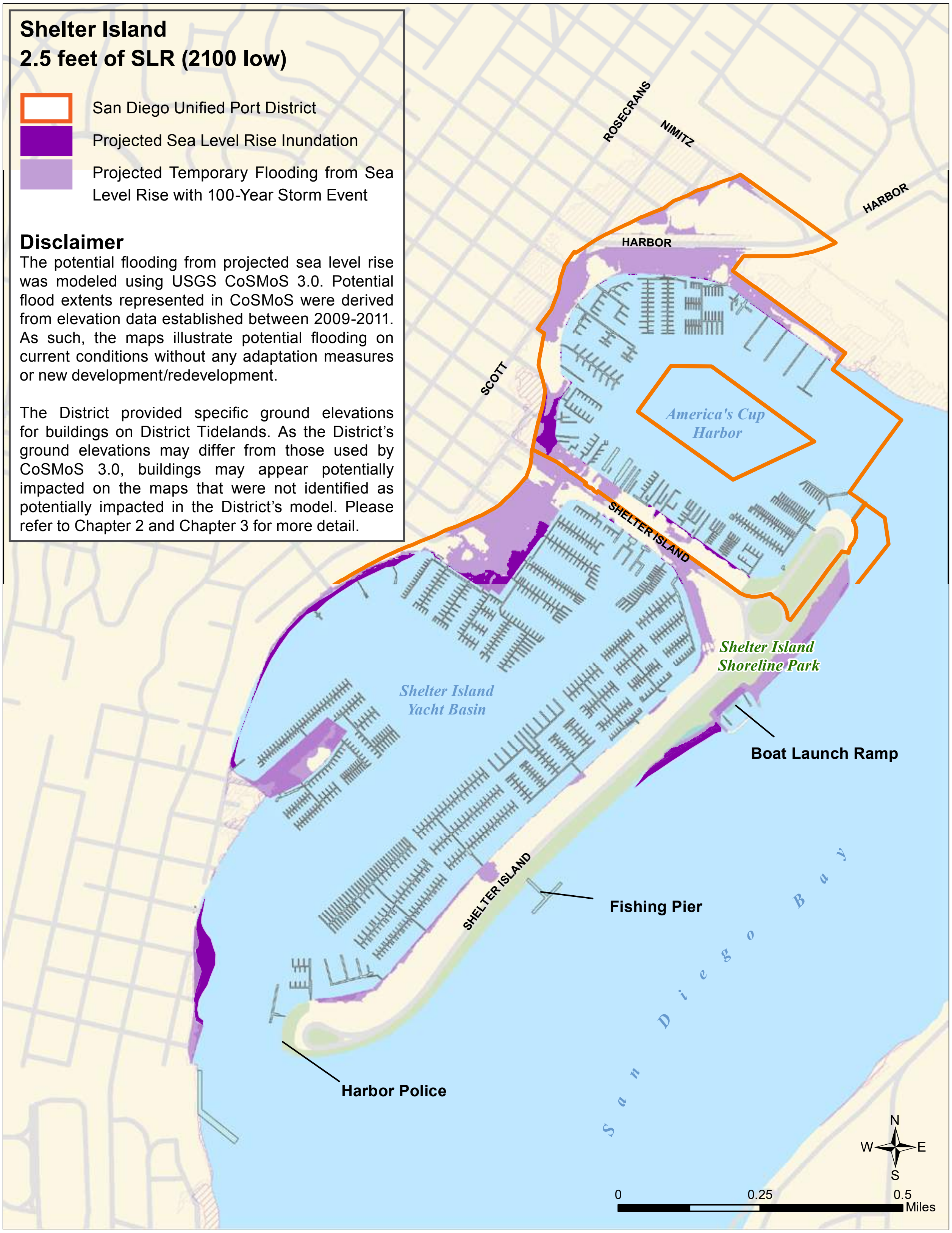


Figure 3.7: Shelter Island Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

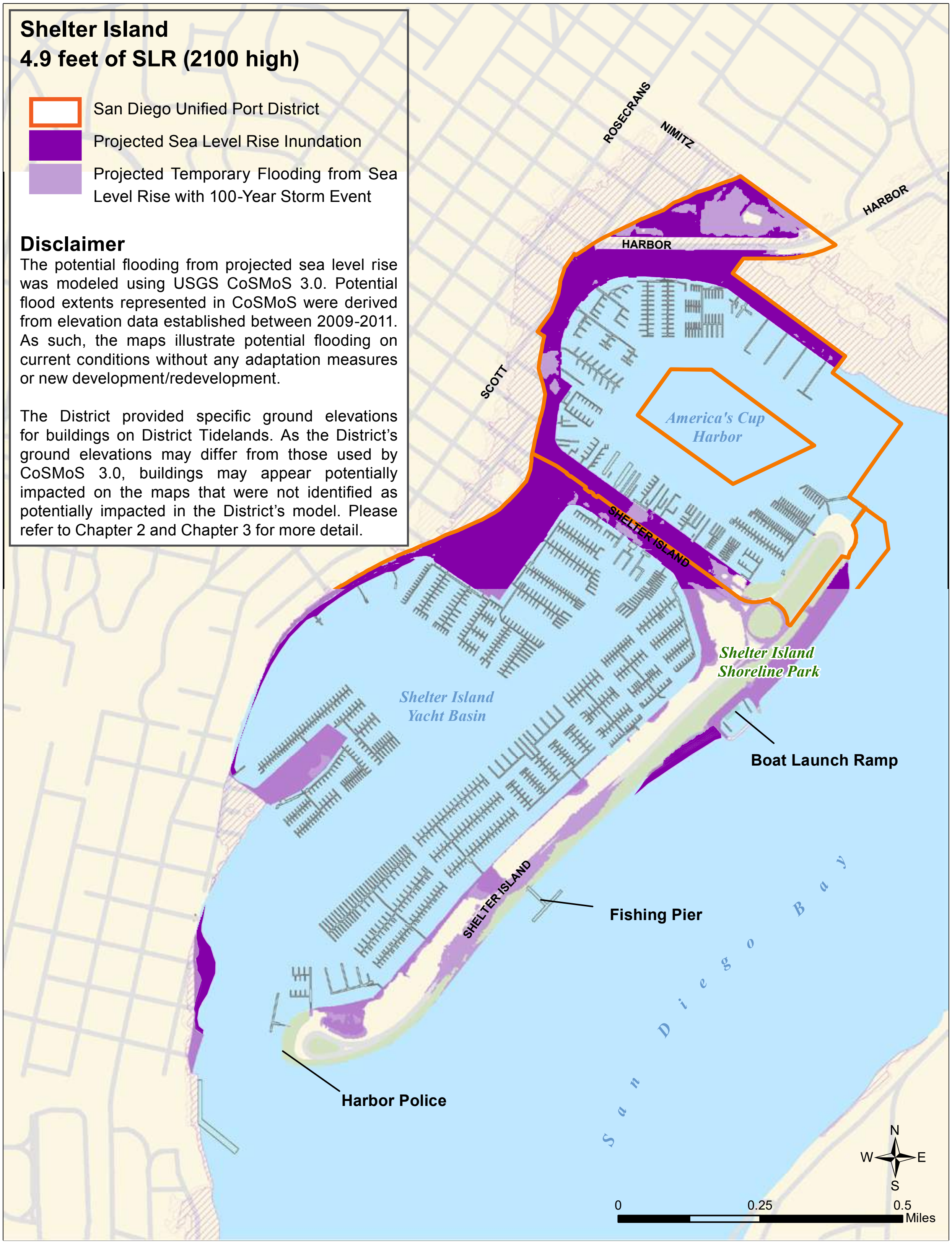


Figure 3.8: Shelter Island Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.2 Harbor Island/Lindbergh Field Planning District

3.3.2.1 Planning District Setting

Located between Downtown San Diego and the Point Loma Peninsula, the Harbor Island/Lindbergh Field Planning District is bounded by San Diego Bay and the Pacific Highway Corridor. Harbor Island Park, located on the bay side of the planning district, provides pedestrian and bicycle pathways interconnecting along the District's comprehensive open space network. Spanish Landing Park located adjacent to the Harbor Island West Marina Basin provides a variety of recreational uses including beach access. With nearly five miles of waterfront, Harbor Island is lined with an assortment of visitor-serving commercial and recreational uses. The District's Harbor Police Headquarters is located within the planning district.

The Airport Authority's assessment was performed separately from the District. Although the Airport Authority used the USGS CoSMoS model to measure impacts of projected SLR, adjustments were made to the results based on more recent ground elevation data from recent on-airport development. As such, the potential SLR inundation and temporary coastal flooding from a 100-year storm event maps shown for the Harbor Island/Lindbergh Field Planning District reflect the most recent potential inundation and flooding data.

3.3.2.2 Harbor Island/Lindbergh Field Vulnerabilities: Key Takeaways

District assets, except beach areas, are largely not projected to be impacted by potential inundation or temporary coastal flooding from a 100-year storm event until the 2100 projected SLR scenarios. The Harbor Police Headquarters may become impacted by the high-end projected SLR scenario (4.9 feet) with a 100-year storm event.

Critical infrastructure such as roads including North Harbor Drive and Harbor Island Drive are exposed to potential inundation and temporary coastal flooding from a 100-year storm event at 4.9 feet of projected SLR. The consequence of potential inundation, combined with a 100-year storm event, may affect business operations, limit public access, and/or create challenges for public safety, including emergency response and recovery. The Pacific Highway Corridor is not projected to be affected by SLR based on the four scenarios analyzed in this assessment.

3.3.2.3 Harbor Island/Lindbergh Field Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

Because of its elevation and protective shoreline structures (predominately revetment), Harbor Island is not projected to be substantially impacted by potential inundation until 4.9 feet of SLR. Exposure to temporary coastal flooding from a 100-year storm event caused by a storm surge at 4.9 feet of projected SLR may have substantial impacts in the Harbor Island/Lindbergh Field Planning District.

Although not analyzed in the AB 691 Report, recreational boating slips located at marinas in the planning district may experience damage with higher sea levels and 100-year storm events.

Potential Inundation

District assets in or directly adjacent to the water at lower elevations may be impacted by potential inundation with 0.8 feet of projected SLR. Assets include the beach and minimal areas of the park at Spanish Landing Park (see Table 3.5). The beach accessible area has higher sensitivity to erosion from wave action and adaptive capacity is high. However, as continual sand replenishment can be costly. As the majority of Spanish Landing Park exists at higher elevations, potential inundation is not expected until the 4.9 feet scenario of SLR. Harbor Island Park is not expected to experience potential inundation from projected SLR.

The quantity of District assets such as roads, parks, and buildings impacted by projected SLR is anticipated to increase

Table 3.5: Harbor Island/Lindbergh Field Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	20.4	HIGH	LOW	0%	0%	0%	7%
Pathways (linear miles)	3.7	LOW	HIGH	0%	0%	1%	30%
Buildings (count)	106	HIGH	LOW	0%	0%	0%	5%
Stormwater Management (count)	12	HIGH	LOW	0%	0%	0%	8%
Sewer Lifts (count)	3	HIGH	HIGH	0%	0%	0%	33%
Beach Accessible Areas (acres)	0.9	HIGH	LOW	46%	52%	58%	100%
Parks (acres)	18.3	LOW	HIGH	1%	1%	2%	49%

at 4.9 feet of projected SLR. Harbor Drive, an important thoroughfare, is predicted to be impacted at 4.9 feet of projected SLR and may limit access to the Harbor Island Drive and the Harbor Police Headquarters.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

With 2.5 feet of projected SLR and a 100-year storm, temporary coastal flooding from a 100-year storm event may occur in Spanish Landing Park, North Harbor Drive, and impact a small number of buildings. With the 4.9 feet of projected SLR and a 100-year storm, significant flooding may impact the planning district and disrupt businesses and challenge emergency operations. Sewer lift stations may be flooded by storm surge and represent an environmental hazard. The Harbor Police Headquarters may also experience flooding at 4.9 feet of projected SLR.

Flooding of the entryway to Harbor Island, at the intersection of North Harbor Drive and Harbor Island Drive, would obstruct access to the island, thereby limiting operations, public access, and critical infrastructure. Substantial 100-year storm events may also erode or damage beach areas, altering their use and capacity.

3.3.2.4 Airport Impacts from Exposure

Airport infrastructure and operations have been established based on historical environmental conditions and

Table 3.6: Harbor Island/Lindbergh Field Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding(100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	20.4	HIGH	LOW	0%	0%	5%	23%
Pathways (linear miles)	3.7	LOW	HIGH	0%	2%	21%	61%
Buildings (count)	106	HIGH	LOW	0%	0%	2%	11%
Stormwater Management (count)	12	HIGH	LOW	0%	0%	0%	33%
Sewer Lifts (count)	3	HIGH	HIGH	0%	0%	0%	67%
Beach Accessible Areas (acres)	0.9	HIGH	LOW	58%	66%	84%	100%
Parks (acres)	18.3	LOW	HIGH	2%	2%	24%	91%

may require adaptation to an evolving climate that could potentially bring higher sea levels, more intense rainfall, and more extreme heat.

The Airport Authority's Climate Resilience Plan (CRP) is intended to address specific issues related to enhancing the Authority's resilience to climate stressors. Development of the CRP included a comprehensive vulnerability assessment to evaluate the risks (economic, social, and environmental) posed to assets by future climate conditions as illustrated below:

Table 3.7: Airport Asset Vulnerability Profiles

Runways and Taxiways	
Description	San Diego International Airport is a single-runway airport with six main and 14 cross taxiways. Navigational aid systems are considered essential to Airport operations and ensure safe and efficient movement of aircraft during approach, departure, and taxiing maneuvers. It is critical to have all visual and navigational aid equipment working properly and maintained in good condition.
Summary	Several runway/taxiway assets are expected to first be impacted by storm surge by 1.6 feet of SLR (year 2050). Assets are not expected to be impacted by potential inundation until 4.9 feet of SLR (year 2100). The runway and taxiways are highly sensitive to flooding because they contain electrical light fixtures, which may be obstructed or damaged if exposed to floodwater for longer than designed. Standing water on the runways and taxiways could prevent aircraft from landing or departing. A loss of runway and taxiways due to flooding will cause the Airport to experience a disruption or delay of aircraft operations. Without a means to efficiently move passengers or cargo, the Airport Authority will face economic losses.

Table 3.7: Airport Asset Vulnerability Profiles (con't)

Airport Facilities	
Description	Airport facilities are divided into landside and airside facilities. Landside facilities are outside of the secure Airport operations area (AOA) and provide for the processing of passengers, cargo, freight, and ground transportation vehicles. Landside facilities include passenger terminals, administration buildings, vehicle storage areas (surface lots), and utilities. Airside facilities include security fencing/gates, aircraft aprons (tarmac), Airport support facilities (e.g., the Airport Traffic Control Tower), and Airport support infrastructure. Airside facilities are largely regulated by criteria and standards developed by the FAA to emphasize safety and efficiency while protecting federal investment in Airport transportation infrastructure.
Summary	Several airside assets are expected to first be impacted by storm surge (rare flooding) by 1.6 feet of SLR (year 2050). Airside assets are not expected to be impacted by the maximum high tide (recurring flooding) until 4.9 feet of SLR (year 2100). Several landside assets are expected to first be impacted by storm surge (rare flooding) by 2.5 feet of SLR (year 2100). Landside assets are not expected to be impacted by the maximum high tide (recurring flooding) until 4.9 feet of SLR (year 2100). Buildings have a high sensitivity to temporary flooding because they may experience widespread structural damage to even temporary exposure and have limited adaptive capacity because they are not easily elevated or relocated. Parking lots and Airport tarmac areas have low sensitivity to flooding but limited adaptive capacity. Many Airport landside and airside facilities are critical for Airport functionality, and loss of assets may result in operational delays or closures.

Table 3.7: Airport Asset Vulnerability Profiles (con't)

Airport Tenant Facilities	
Description	The Airport hosts a number of tenants that lease space from the Airport Authority. Tenants include a wide range of Airport users, such as government agencies (e.g., FAA), vendors providing aircraft and aviation services, companies handling cargo and mail, and general aviation aircraft owners. The facilities associated with the tenants vary depending on specific tenant requirements but include office buildings (and associated surface parking lots), warehouses, on-site storage, and aircraft hangars. The Airport also includes several concessions, which are not highlighted in this profile because they are located in facilities operated by the Airport Authority.
Summary	No tenant facilities are expected to be impacted by storm surge (rare flooding) or by the maximum high tide (recurring flooding) by the end of the century.
Transportation Network	
Description	The transportation network on and surrounding the Airport includes freeways, parking lots, and primary/ secondary roadways to access Airport terminals and parking lots. Roadway ownership is shared by the Airport Authority, City of San Diego, and the California Department of Transportation (Caltrans). Primary roadways consist of critical business and/or emergency access routes to Airport assets or public safety. Secondary roads provide alternative access routes to assets. Also included in Airport transportation is a trolley system operated by the Metropolitan Transit System. However, trolley stops were not included in the CRP, because they are not anticipated to be impacted and are not controlled by the Airport Authority.
Summary	Several transportation routes, including the on-airport vehicle service road, North Harbor Drive, and West Laurel Street are expected to be impacted by storm surge (rare flooding) by 1.6 feet of SLR (year 2050). Most transportation routes are not expected to be impacted by the maximum high tide (recurring flooding) until 4.9 feet of SLR (year 2100). A loss of the access roadway network will result in disruption or closure of Airport operations. Without a means for passengers and employees to access terminals or cargo facilities, the Airport Authority will face economic losses.

Table 3.7: Airport Asset Vulnerability Profiles (con't)

Least Tern Nesting Habitat	
Description	The California least tern, a federally and state-listed endangered seabird, nests from April to September in Southern California. Although least tern prefer to nest in small, scattered clusters on flat sandy areas with minimal vegetation, colonies have nested since the 1970s on sand and gravel adjacent to the runway and taxiways at the Airport. The Airport's ability to provide suitable nesting habitat, protection from predators, and access to foraging in nearby San Diego Bay makes it one of the most productive least tern nesting sites in Southern California.
Summary	Least tern habitats are not expected to be impacted by storm surge (rare flooding) or the maximum high tide (recurring flooding) until 2.5 feet or 4.9 feet of SLR (year 2100). Habitats are sensitive to increased frequency, duration, and depth of flooding. The adaptive capacity of the least terns depends on their inherent resiliency to change, ability to recover from individual events, and ability to migrate in response to climate pressures; the location of nearby habitats that can serve as refuge. Loss of least tern habitat at the Airport will limit nesting options for the migrating seabird and may cause a decline in their local populations.

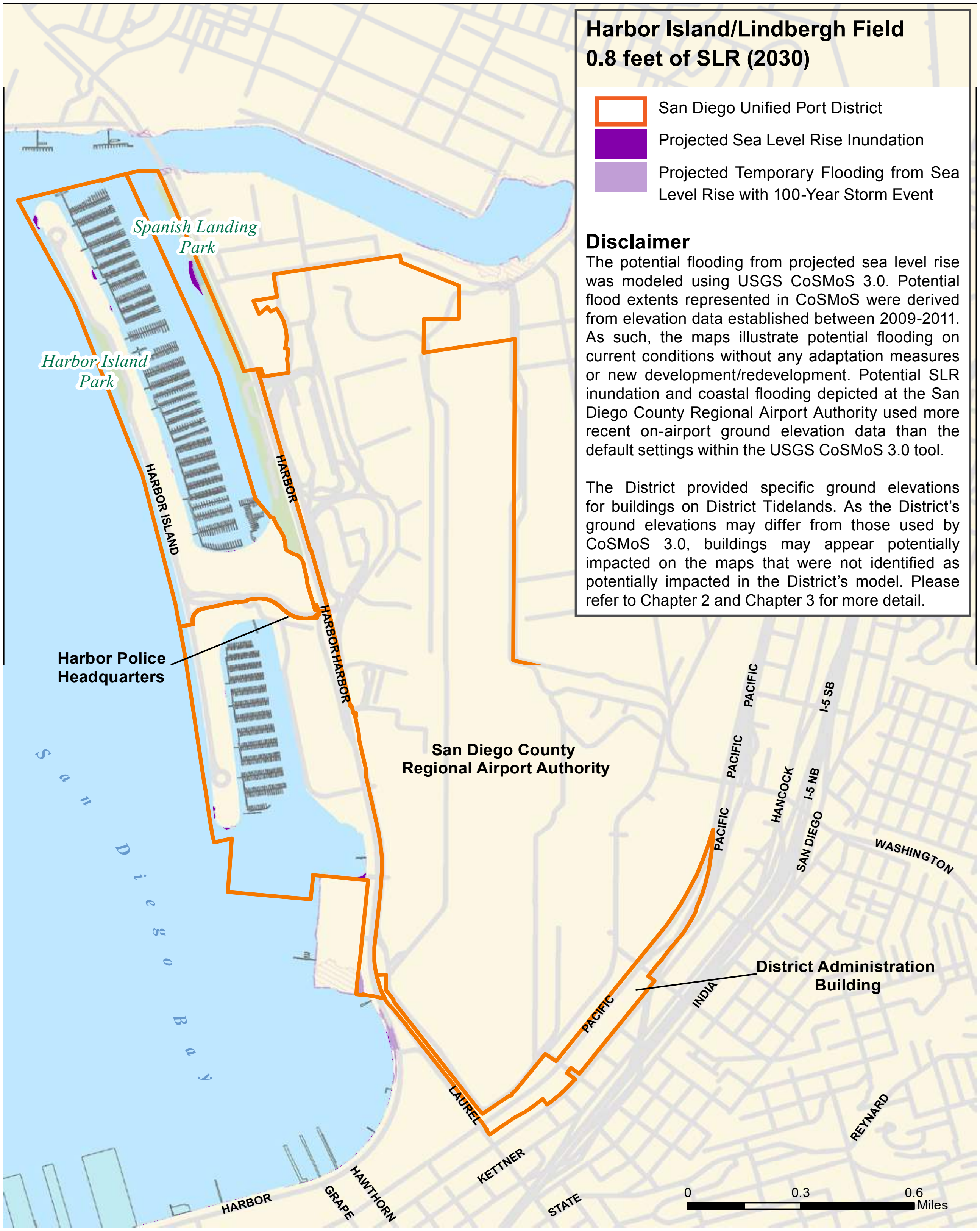


Figure 3.9: Harbor Island/Lindbergh Field Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2030

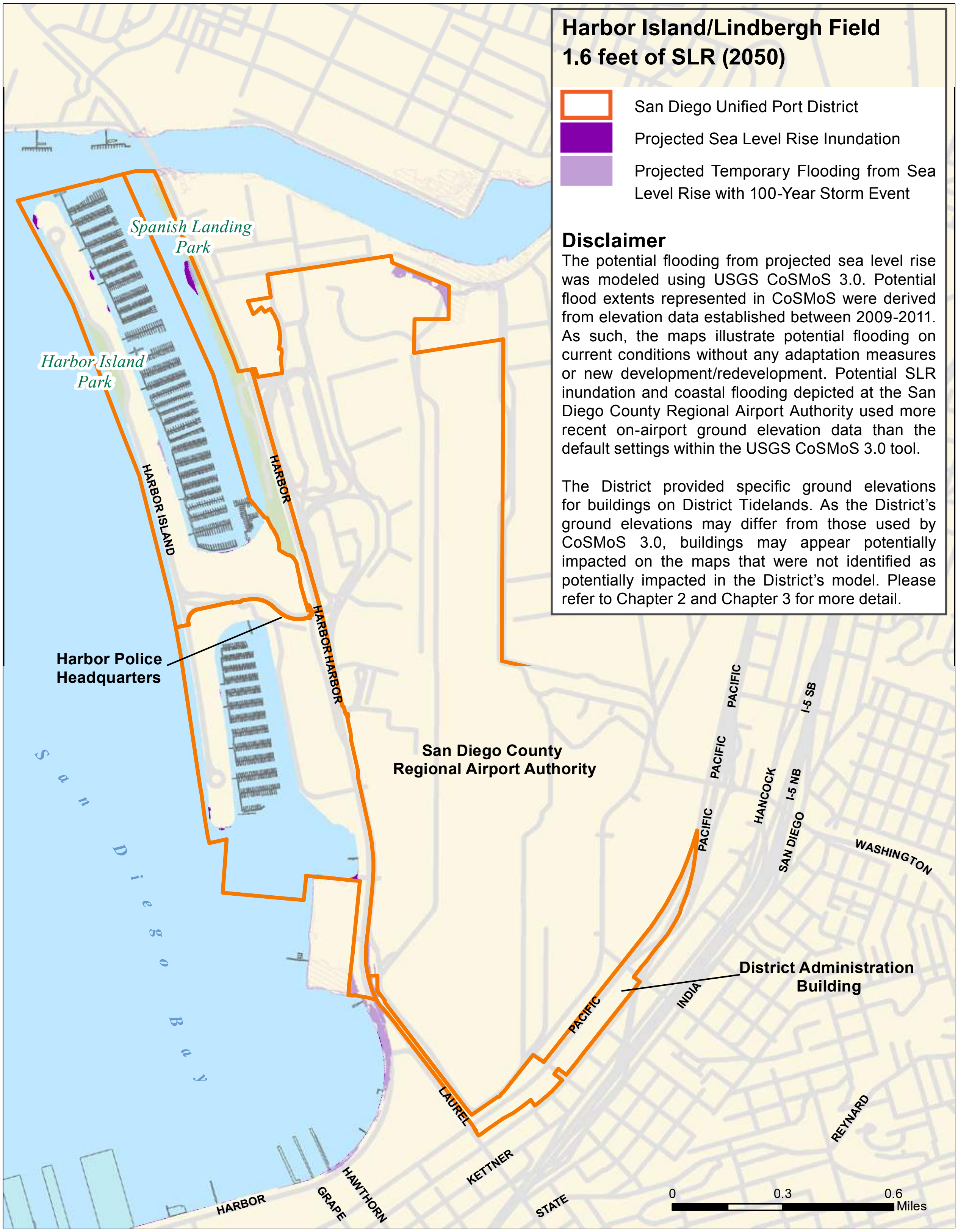


Figure 3.10: Harbor Island/Lindbergh Field Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

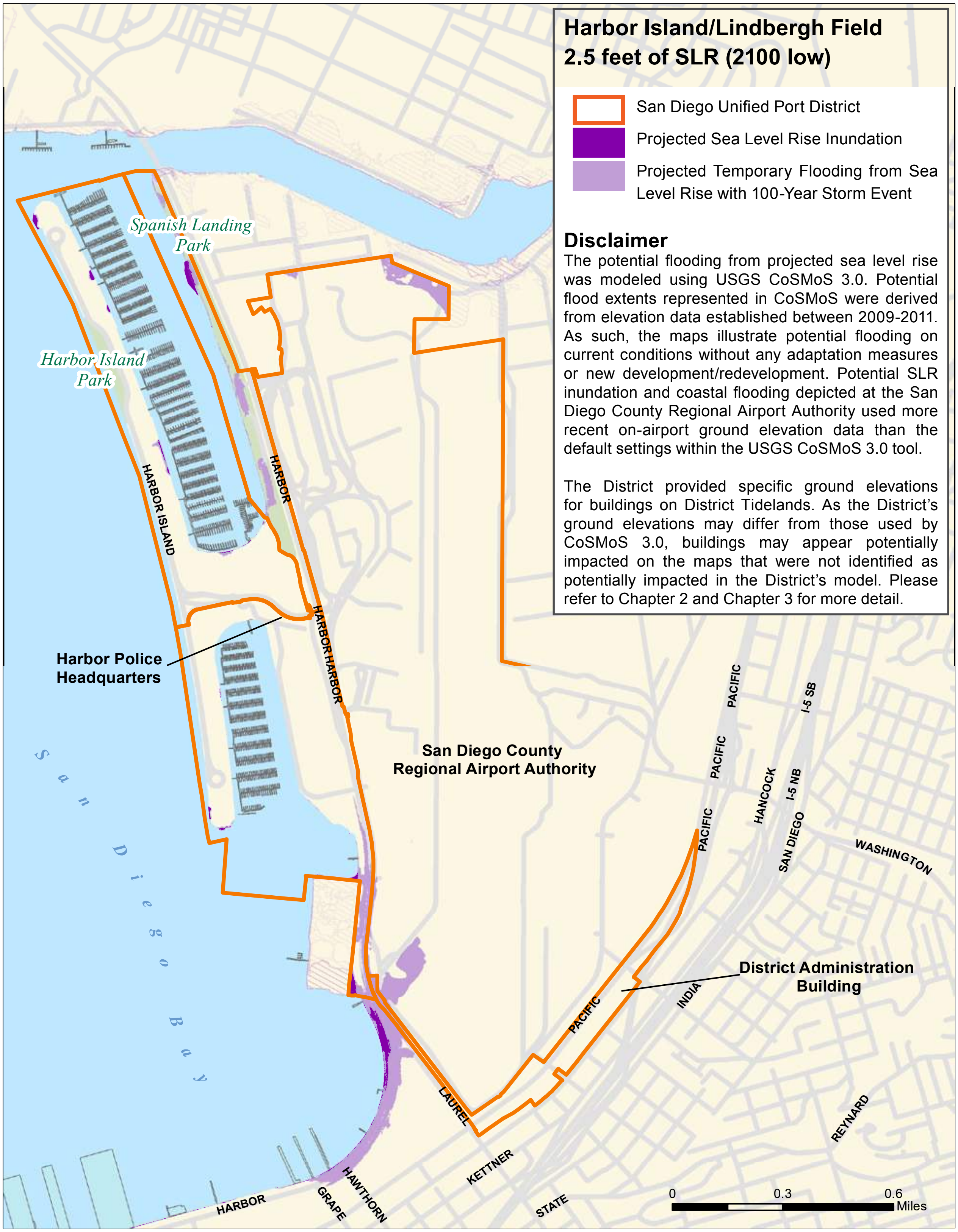


Figure 3.11: Harbor Island/Lindbergh Field Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

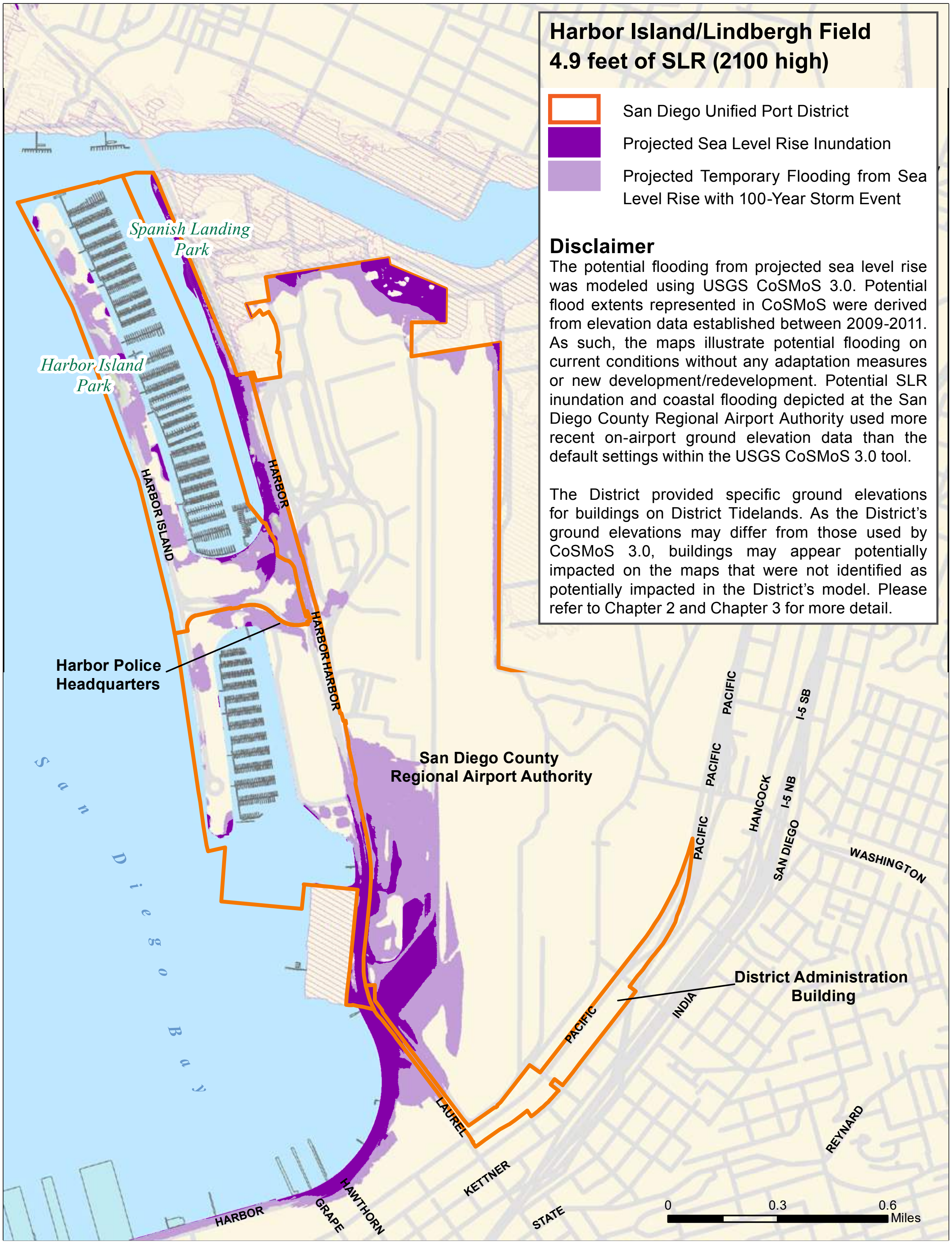


Figure 3.12: Harbor Island/Lindbergh Field Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.3 Centre City Embarcadero Planning District

3.3.3.1 Planning District Setting

Located south of the Airport and adjacent to Downtown San Diego, the Centre City Embarcadero Planning District is home to more than four miles of waterfront containing visitor- and marine-serving uses with pier-side maritime activities including commercial fishing, a cruise terminal, maritime museums, recreational boating, and recreation open space. The Embarcadero Planning District extends from Laurel Street adjacent to the Airport and continues south to the Convention Center.

3.3.3.2 Centre City Embarcadero Vulnerabilities: Key Takeaways

The North Embarcadero is protected by a continuous bulkhead that supports recreational areas and public access features. As a result, the North Embarcadero is not projected to substantially affected by potential inundation beginning with 2.5 feet of projected SLR. Under 4.9 feet projected SLR scenario, potential inundation may disrupt business operations, recreational uses including parks, piers, and pathways, and important transportation corridors throughout the planning district. With a 100-year storm event, temporary coastal flooding from a 100-year storm event may occur in low-lying areas by year 2050 under a 1.6 feet rise in sea levels. As a result, temporary coastal flooding from a 100-year storm event may impact North Harbor Drive adjacent to the United States Coast Guard and across from the Airport. The B Street Cruise Ship Terminal and Broadway Piers may be impacted with a 4.9 feet increase in sea levels combined with a 100-year storm event.

Water and stormwater facilities would become impacted by temporary coastal flooding from a 100-year storm event at all levels of modeled potential inundation projected SLR impacts exacerbated by a 100-year storm event. The consequences of potential inundation combined with a substantial storm event could potentially obstruct business operations, limit public access, and/or lead to challenges to public safety including emergency response and recovery.

3.3.3.3 Centre City Embarcadero Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

The projected exposure to projected SLR may affect public access and business operations in the planning district

Table 3.8: Centre City Embarcadero Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	6.9	HIGH	LOW	0%	0%	5%	49%
Rail (linear miles)	0.2	HIGH	LOW	0%	0%	0%	100%
Bikeways (linear miles)	1.6	LOW	HIGH	0%	1%	24%	71%
Pathways (linear miles)	5.9	LOW	HIGH	5%	5%	17%	76%
Buildings (count)	119	HIGH	LOW	0%	0%	0%	18%
Piers (count)	9	HIGH	LOW	0%	0%	0%	67%
Stormwater Management (count)	359	HIGH	LOW	5%	5%	8%	43%
Sewer Lifts (count)	3	HIGH	HIGH	33%	33%	67%	100%
Parks (acres)	32.4	LOW	HIGH	1%	1%	9%	55%

particularly with 2.5 feet and 4.9 feet of potential projected SLR inundation, but with potential damage from 100-year storm event temporary coastal flooding from a 100-year storm event scenario starting at 0.8 feet of projected SLR.

Potential Inundation

Given the elevation and existing shoreline armoring composed of bulkhead and revetment, the planning district is projected to withstand potential inundation at 4.9 feet of projected SLR. Backflow from potential inundation within the storm drain system has the potential to cause flooding during the highest tides. At 2.5 feet of projected SLR, public access may become impacted in Embarcadero Marina Park South. Of significance, potential inundation beginning with 2.5 feet of projected SLR and expanding with a 4.9 feet increase in projected SLR, may impact important roadways such as North Harbor Drive. With 4.9 feet of projected SLR, public access and recreational facilities within the planning district are expected to experience potential inundation.

Sewer lifts begin to become impacted at 0.8 feet (all three are projected to be affected at 4.9 feet of projected SLR). Piers within the planning district are not expected to be impacted by potential projected SLR inundation until 2100 under high projected SLR conditions.

Table 3.9: Centre City Embarcadero Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	6.9	LOW	HIGH	4%	16%	41%	64%
Rail (linear miles)	0.2	HIGH	LOW	0%	0%	68%	100%
Bikeways (linear miles)	1.6	LOW	HIGH	21%	33%	54%	92%
Pathways (linear miles)	5.9	LOW	HIGH	15%	33%	57%	95%
Buildings (count)	119	HIGH	LOW	0%	4%	10%	50%
Piers (count)	9	HIGH	LOW	0%	22%	33%	100%
Stormwater Management (count)	359	HIGH	LOW	5%	13%	28%	67%
Sewer Lifts (count)	3	HIGH	HIGH	67%	67%	100%	100%
Parks (acres)	32.4	LOW	HIGH	9%	21%	38%	78%

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

Public access and the circulation network are forecasted to be the most vulnerable to disruption from temporary coastal flooding from a 100-year storm event beginning at 0.8 feet of projected SLR with impacts growing at 4.9 feet of projected SLR. With 1.6 feet of projected SLR and a 100-year storm event, North Harbor Drive near Laurel Street is predicted to experience temporary coastal flooding from a 100-year storm event disrupting traffic along this important thoroughfare. These impacts may obstruct access to the waterfront, the airport, and commercial fishing operations on the G Street Mole. Embarcadero Marina Park North and South, Tuna Harbor Park, and public accessways may begin to experience temporary coastal flooding from a 100-year storm event with 1.6 feet of projected SLR and a 100-year storm event. Impacts increase throughout the planning district with 4.9 feet of projected SLR and a 100-year storm affecting several buildings and all the piers. At 4.9 feet of projected SLR with a 100-year storm event, the Embarcadero may have substantial hindrances to public access, public safety, and business operations. With a 100-year storm event, the B Street Cruise Ship Terminal, Broadway Pier, and Navy Pier are projected to experience temporary coastal flooding from a 100-year storm event with 4.9 feet of projected SLR.

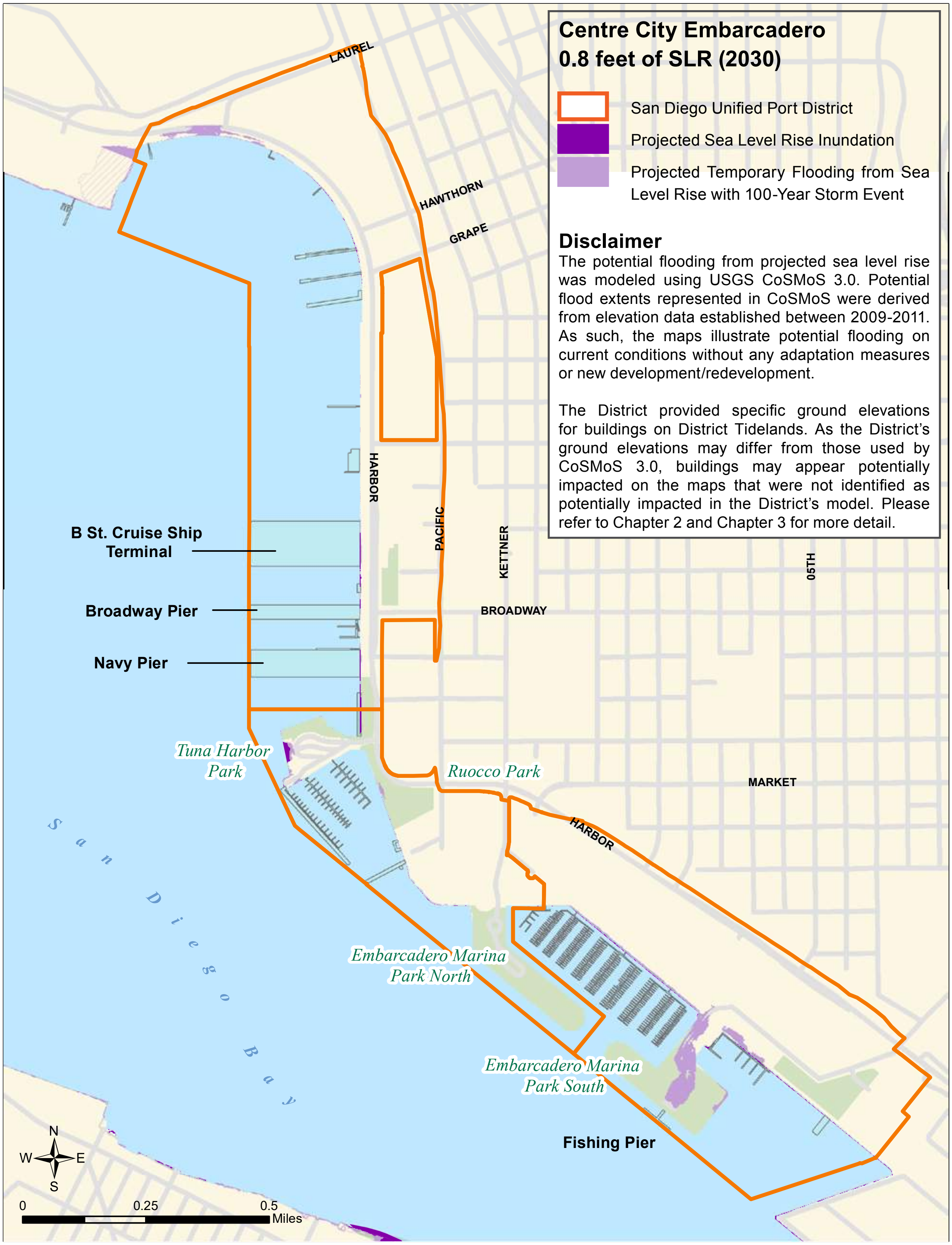


Figure 3.13: Centre City Embarcadero Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

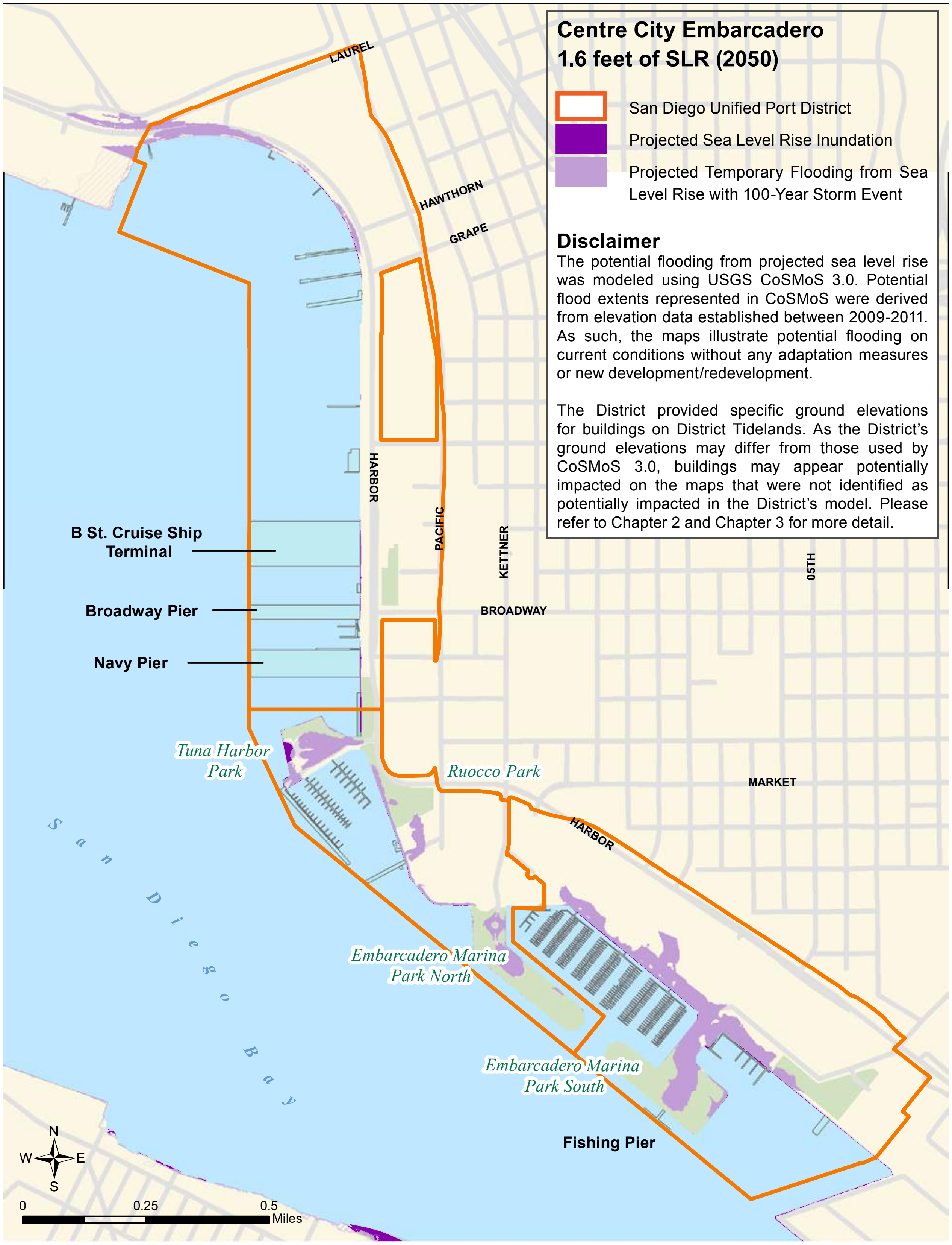


Figure 3.14: Centre City Embarcadero Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2050

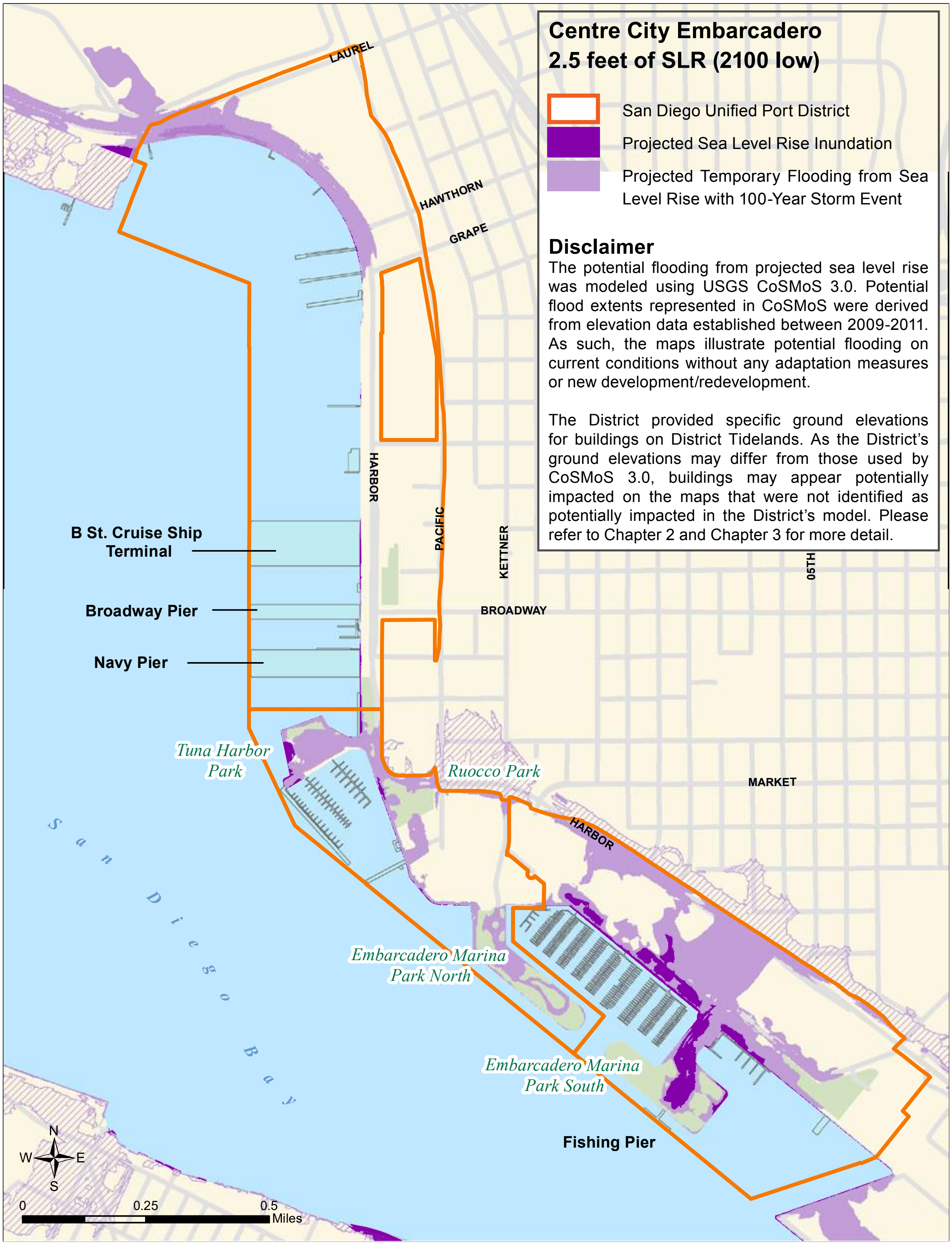


Figure 3.15: Centre City Embarcadero Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

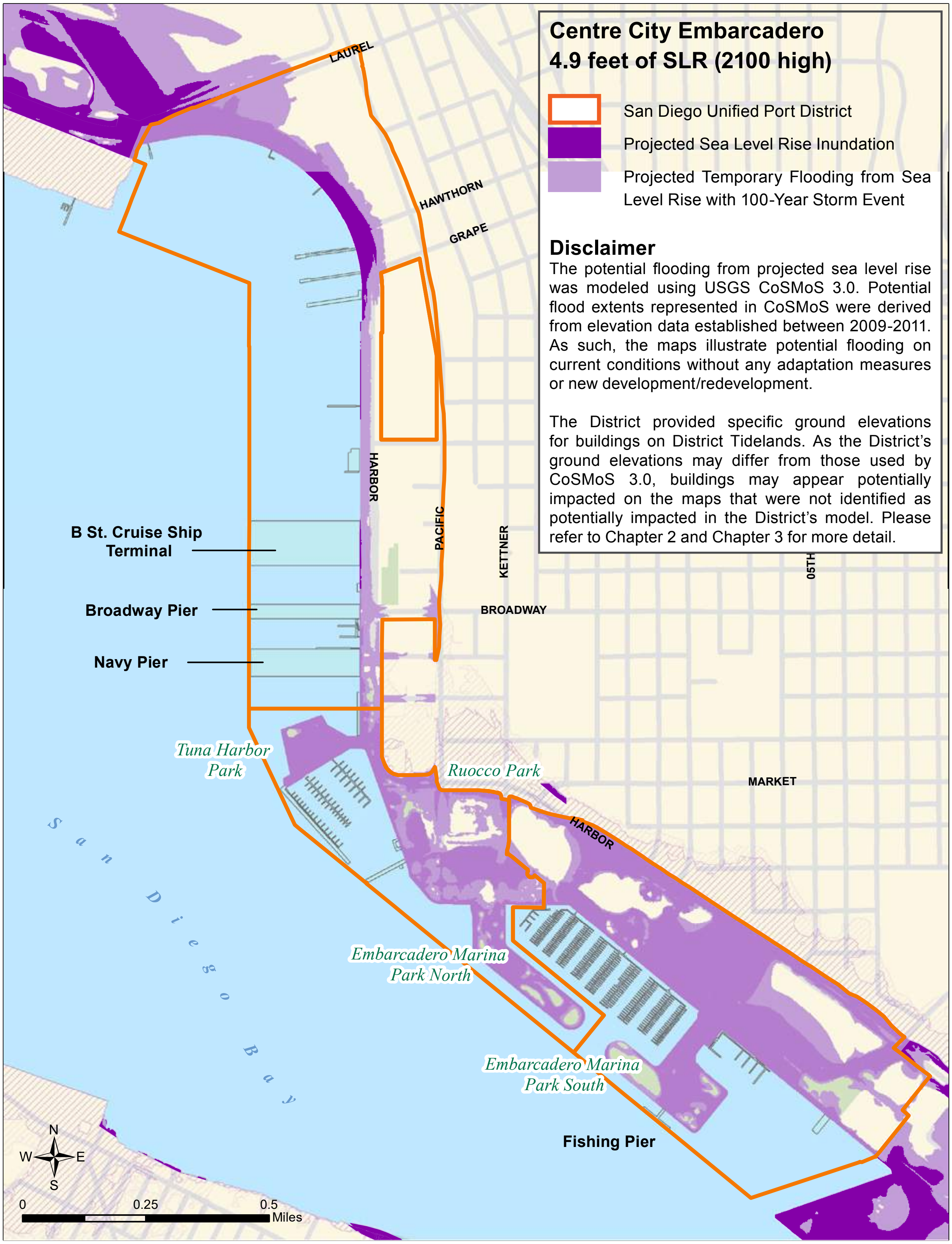


Figure 3.16: Centre City Embarcadero Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.4 Tenth Avenue Marine Terminal Planning District

3.3.4.1 Planning District Setting

Located south of downtown San Diego, the Tenth Avenue Marine Terminal Planning District largely serves as a strategic regional, state, and federal port of entry. This planning district supports maritime trade operations and water-based commerce. The Tenth Avenue Marine Terminal includes eight deep-water berths that can accommodate four large ships. Additionally, several maritime services and industrial uses that support regional commerce and the U.S. Navy, such as shipbuilding and ship repair are located along Harbor Drive south of the Tenth Avenue Marine Terminal. The District's cargo terminals are one of only 17 commercial "strategic ports," designated to support cargo and vessel operations for the U.S. military's Transportation Command and Military Sealift Command.

3.3.4.2 Tenth Avenue Marine Terminal Vulnerabilities: Key Takeaways

The higher elevation and existing shoreline armoring in the Tenth Avenue Marine Terminal Planning District are expected to protect the marine terminal and recreational areas from substantial projected SLR impacts. Past year 2050, the marine terminal (including associated structures), Cesar Chavez Park and pier, public access facilities, and industry in this planning district are projected to be impacted by temporary coastal flooding from a 100-year storm event.

Marine terminal facilities, roadways, and rail in the planning district are considered critical infrastructure and coastal dependent uses, which are particularly sensitive to potential inundation with a 4.9-feet increase in sea level. At 4.9 feet of projected SLR, access to, and operational functions of, the planning district, including the Tenth Avenue Marine Terminal, may be disrupted under the high-end projected SLR scenario. The transportation assets are highly sensitive and have low adaptive capacity due to the lack of alternate routes and large cost to elevate. These impacts are projected to occur at 4.9 feet of potential SLR inundation and potentially at lower projected SLR scenarios with a 100-year storm event.

3.3.4.3 Tenth Avenue Marine Terminal Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

The exposure to projected SLR impacts are anticipated to occur near or after year 2050 with more disruptive impacts from temporary coastal flooding from a 100-year storm event starting at 2.5 feet of projected SLR and potential inundation at 4.9 feet of projected SLR. As this planning district is largely made up of coastal dependent uses with low adaptive capacity, exposure to projected SLR and temporary coastal flooding from a 100-year storm event during a 100-year storm event pose great risks to the District.

Potential Inundation

Given the elevation and existing shoreline armoring composed of marine terminal bulkheads and revetment, this planning district is projected to withstand potential inundation at 4.9 feet of projected SLR.

Cesar Chavez Park and the observation pier are susceptible to potential inundation under the high projected SLR scenario of 4.9 feet. This park represents one of the only points of recreation and public access to the Bayfront within the planning district.

Highly sensitive transportation assets such as rail and road and terminal facilities are vital to operations of the Tenth Avenue Marine Terminal, as well as freight movement throughout the region. Projected inundation at 4.9 feet of projected SLR would disrupt the terminal operations as these assets have limited adaptive capacity to relocate. Lacking alternative routes and requiring high costs to elevate, the rail line is also

Table 3.10: Tenth Avenue Marine Terminal Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	5.1	HIGH	LOW	1%	1%	1%	54%
Rail (linear miles)	10.8	HIGH	LOW	0%	0%	0%	62%
Bikeways (linear miles)	0.5	LOW	HIGH	5%	6%	6%	32%
Pathways (linear miles)	0.3	LOW	HIGH	39%	39%	39%	85%
Marine Terminals (acres)	103	HIGH	LOW	0%	0%	1%	62%
Buildings (count)	127	HIGH	LOW	0%	0%	0%	35%
Piers (count)	1	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	15	HIGH	LOW	0%	0%	0%	53%
Sewer Lifts (count)	1	HIGH	HIGH	0%	0%	0%	100%
Parks (acres)	4.2	LOW	HIGH	0%	0%	5%	51%

highly vulnerable to projected SLR. As a Strategic Port, maintenance of operations at the terminal is critical for security purposes.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

Recreational uses and associated public access may begin to experience temporary coastal flooding from a 100-year storm event by year 2050 with 1.6 feet of projected SLR. While a small number of buildings may experience temporary coastal flooding from a 100-year storm event within the planning district with 1.6 feet of projected SLR and a 100-year storm event, greater impacts to structures occur at 4.9 feet of projected SLR. While temporary in nature, these impacts may disrupt operations of the facilities

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Access to Cesar Chavez Park may become obstructed with roads and pathways flooded by projected storm surges from 100-year storm events. The park does not showcase temporary coastal flooding from a 100-year storm event until 4.9 feet of projected SLR. The observational pier located Bay-ward of Cesar Chavez Park may also become impacted with the high end projected SLR scenario with a 100-year storm event.

Table 3.11: Tenth Avenue Marine Terminal Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	5.1	HIGH	LOW	1%	2%	22%	72%
Rail (linear miles)	10.8	HIGH	LOW	0%	0%	17%	91%
Bikeways (linear miles)	0.5	LOW	HIGH	6%	6%	6%	69%
Pathways (linear miles)	0.3	LOW	HIGH	39%	39%	53%	100%
Marine Terminals (acres)	103	HIGH	LOW	0%	0%	20%	91%
Buildings (count)	127	HIGH	LOW	0%	2%	6%	72%
Piers (count)	1	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	15	HIGH	LOW	0%	7%	40%	87%
Sewer Lifts (count)	1	HIGH	HIGH	0%	0%	0%	100%
Parks (acres)	4.2	LOW	HIGH	4%	10%	24%	100%

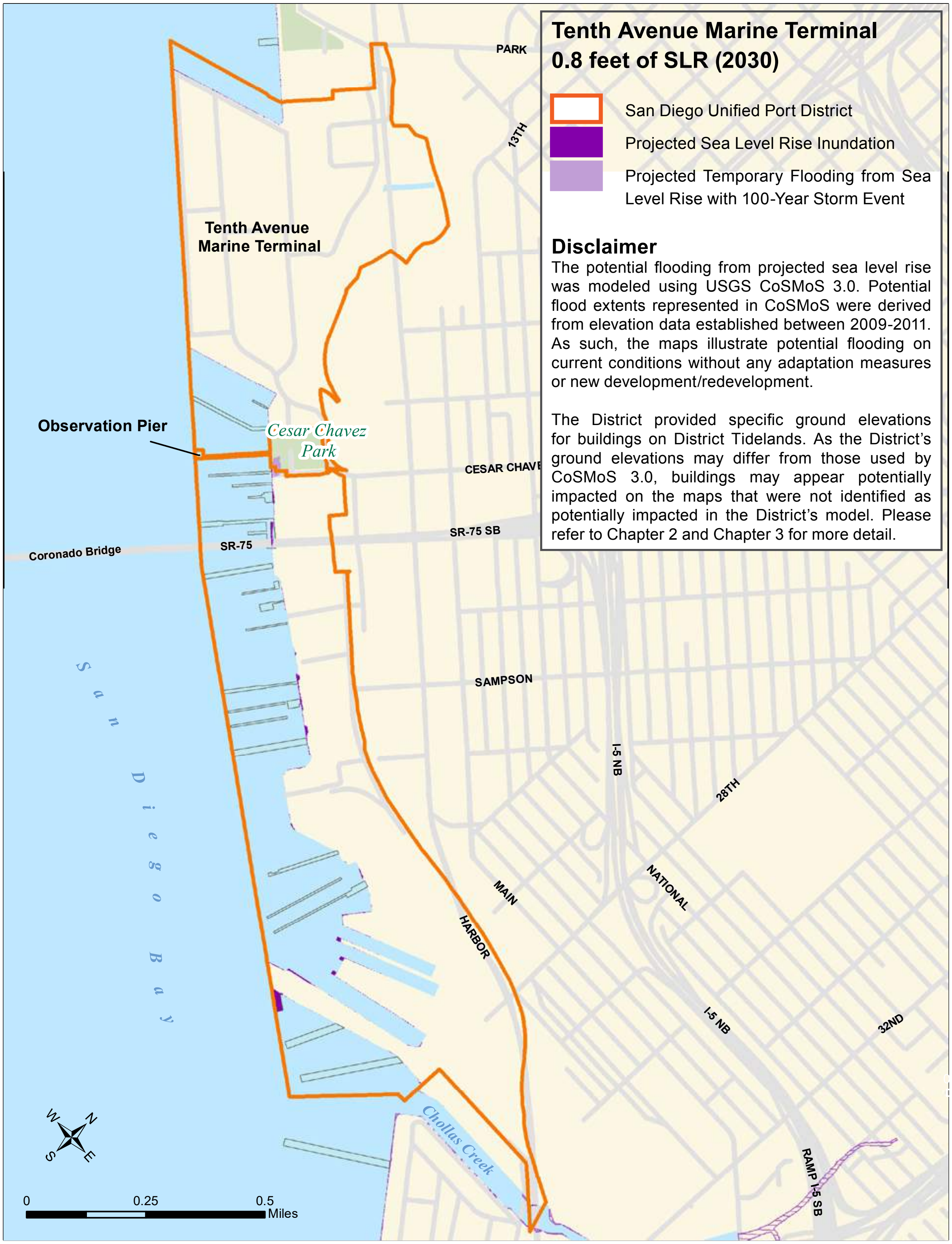

Figure 3.17: Tenth Avenue Marine Terminal Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

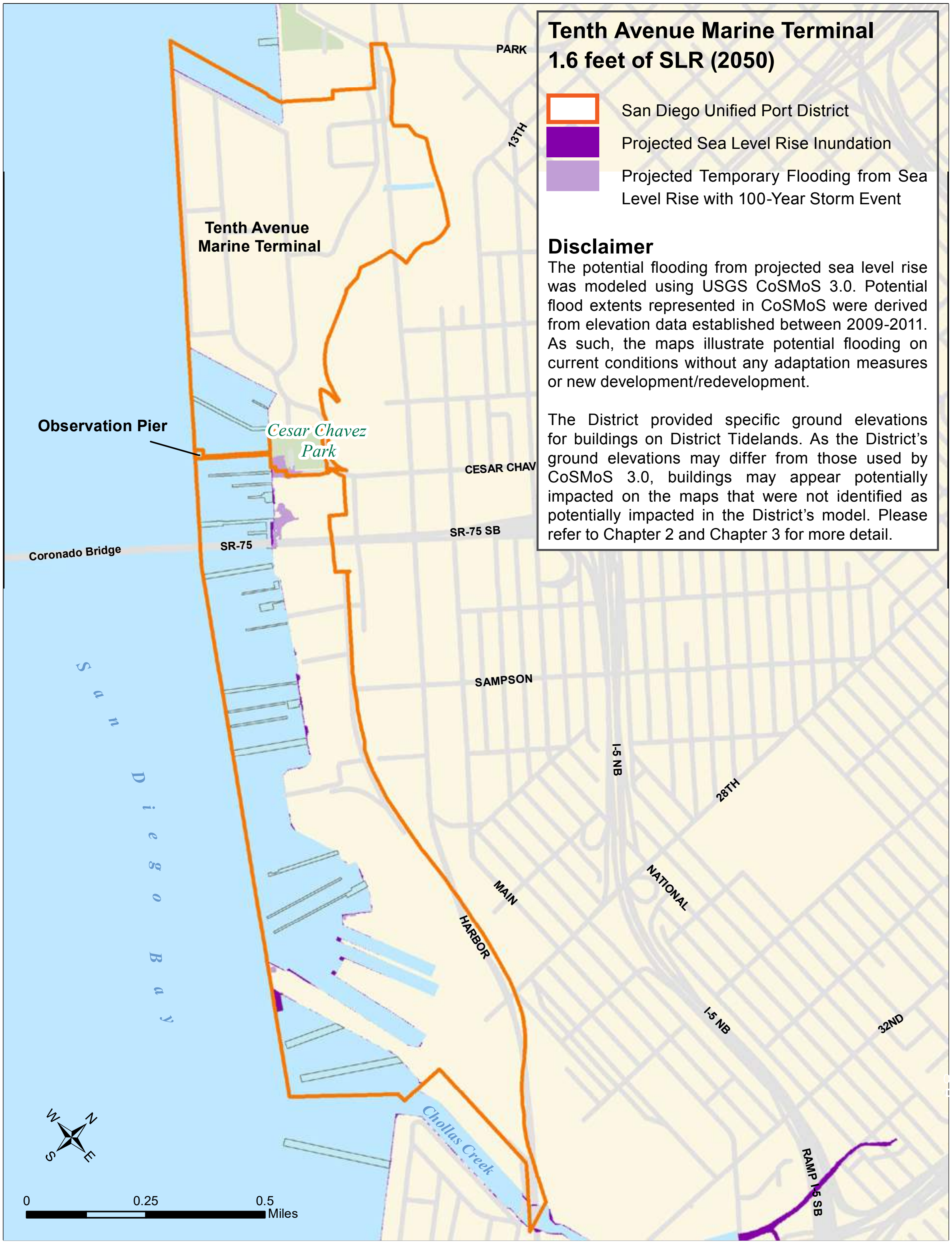

Figure 3.18: Tenth Avenue Marine Terminal Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2050

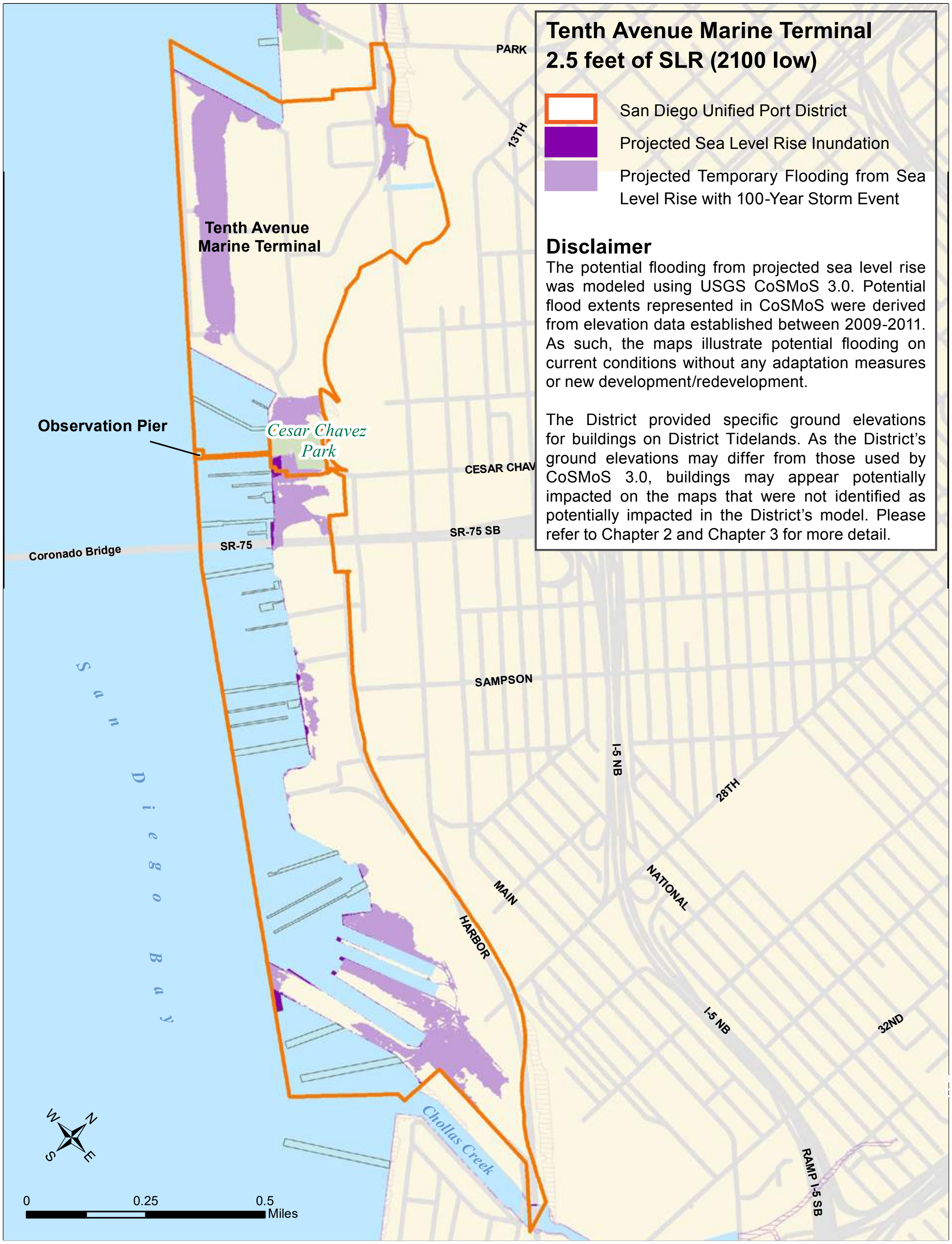

Figure 3.19: Tenth Avenue Marine Terminal Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

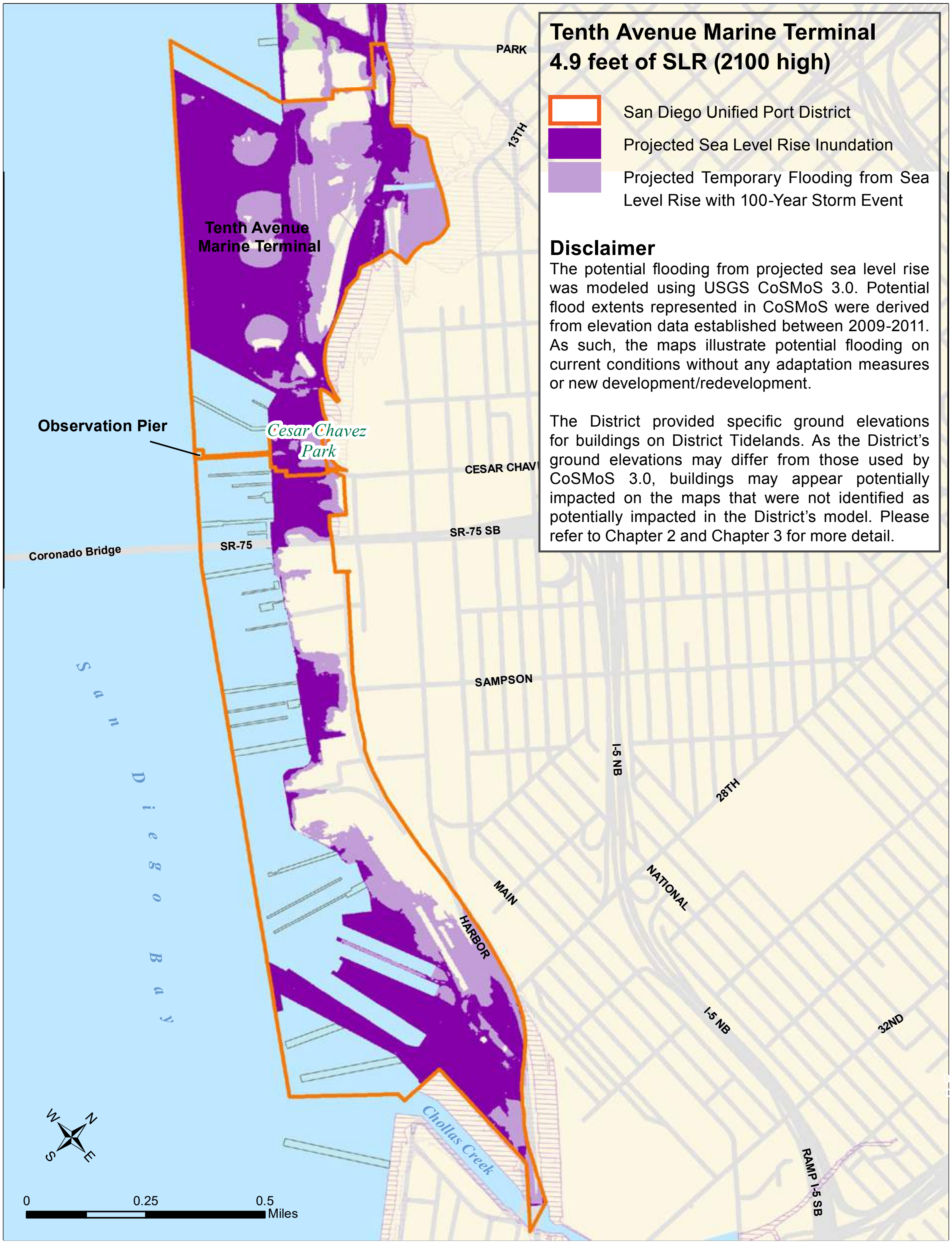

Figure 3.20: Tenth Avenue Marine Terminal Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.5 National City Bayfront Planning District

3.3.5.1 Planning District Setting

The National City Bayfront Planning District is an established and developed marine industrial area with integrated water-oriented recreational areas. Like the Working Waterfront Planning District, coastal dependent uses are prominent within this area. The planning district is made up of 273 acres of waterfront land and 167 acres of water and includes the National City Marine Terminal, Pepper Park, Pier 32 Marina, and the National City Aquatic Center. The District's General Services facility is also located along Tidelands Avenue within this planning district.

3.3.5.2 National City Bayfront Vulnerabilities: Key Takeaways

The higher tion and existing shoreline armoring in the National City Bayfront Planning District are expected to protect the marine terminal and recreational areas from substantial projected SLR impacts. At 4.9 feet of projected SLR, the marine terminal (including associated structures), Pepper Park, and adjacent open space areas at lower elevations in this planning district are projected to be impacted by temporary coastal flooding from a 100-year storm event.

Critical infrastructure such as roadways and rail in the planning district are particularly sensitive to potential inundation at 4.9 feet of projected SLR as all access to the planning district may be affected. As these assets are highly sensitive and have low adaptive capacity due to the lack of alternate routes and large cost to elevate, impact these transportation assets could severely inhibit operations of the District's General Services facility, marine terminals and commercial facilities. These impacts are projected to occur with 4.9 feet of potential inundation and potentially at lower projected SLR scenarios with a 100-year storm event.

A commercial marina is in the planning district along the Sweetwater Channel and is home to over 300 recreational boating slips. While the slips can be elevated in response to increased projected SLR, substantially larger storm events combined with elevated sea levels may lead to damage of the marina slips and boats.

3.3.5.3 National City Bayfront Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

The projected exposure to SLR impacts for the National City Bayfront are anticipated to occur with impacts from temporary coastal flooding from a 100-year storm event at 2.5 feet of projected SLR and potential inundation occurring at 4.9 feet of projected SLR. As these impacts are evenly distributed across the recreational and industrial areas, uses associated with District operations at the General Services facility, recreation, public access, or marine terminal operations may be greatly affected. As this planning district is largely made up of coastal dependent uses with low adaptive capacity, exposure to projected SLR and temporary coastal flooding from a 100-year storm event during a storm event pose great risks to the District.

Potential Inundation

Compared to other areas within the District, the National City Bayfront is not projected to be impacted from potential inundation except at the highest SLR scenario. Given the elevation and existing shoreline armoring composed of marine terminal bulkheads and revetment, this planning district is projected to better withstand potential inundation at 4.9 feet of projected SLR.

Highly sensitive transportation assets such as rail and road are vital to District operations and access to the National City Marine Terminal. Projected inundation at 4.9 feet of projected SLR would disrupt operations as these assets have limited adaptive capacity due to their coastal-dependent uses, lack of alternative routes and the high cost of elevating the assets. Potential inundation along Tideland's Avenue in the northern part of the planning District may prevent access to and from the District's General Services facility. The General Services building is not expected to be inundated with higher sea levels. Access to the National City Marine Terminal along Bay Marina Drive is also projected to be impacted. Access to the marine terminal along 32nd Street may not be inundated. With the highest projected SLR scenario, portions of the marine terminal are predicted to be inundated causing disruptions to freight movement.

Pepper Park located along the Sweetwater Channel represents the only park and public access point to the Bayfront within the planning district. Potential inundation of the park may begin 2.5 feet of projected SLR. With the highest projected SLR scenario of 4.9 feet a large portion of the park and adjoining parking area may become inundated. The Pepper Park fishing pier may also experience inundation at 4.9 feet of projected SLR.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

Recreational opportunities and associated public access are projected to be negatively impacted from temporary coastal flooding from a 100-year storm event. Almost 40 percent of pathways become affected at 0.8 feet with Pepper Park becoming increasing more flooding on a temporary basis with increased projected SLR and a 100-year storm event. The Pepper Park-related comfort stations become flooded at 2.5 feet with a 100-year storm event, whereas the Aquatic Center does not become impacted at 4.9 feet of projected SLR.

Temporary coastal flooding from a 100-year storm event along Tideland's Avenue may prevent access to and from the District's General Services facility with a 2.5 feet rise in sea levels. Although the General Services building is not expected to be flooded with higher sea levels and a 100-year storm event, portions of the parking and equipment storage areas may experience temporary coastal flooding from a 100-year storm event under the highest SLR projection. Likewise, access to the National City Marine Terminal along Bay Marina Drive is projected to be impacted with a 100-year storm event, however, access to the marine terminal along 32nd Street may not be flooded.

Table 3.12: National City Bayfront Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	2.6	HIGH	LOW	0%	0%	0%	35%
Rail (linear miles)	5.2	HIGH	LOW	0%	0%	0%	45%
Bikeways (linear miles)	0.8	LOW	HIGH	0%	0%	0%	12%
Pathways (linear miles)	1.2	LOW	HIGH	0%	0%	4%	17%
Marine Terminals (acres)	130.4	HIGH	LOW	0%	0%	1%	18%
Buildings (count)	50	HIGH	LOW	0%	0%	0%	4%
Piers (count)	1	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	3	HIGH	LOW	0%	0%	0%	33%
Sewer Lifts (count)	1	HIGH	HIGH	0%	0%	0%	0%
Boat Launch Ramps (count)	1	LOW	HIGH	100%	100%	100%	100%
Parks (acres)	5.5	LOW	HIGH	0%	0%	2%	43%

Table 3.13: National City Bayfront Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	2.6	HIGH	LOW	1%	2%	22%	72%
Rail (linear miles)	5.2	HIGH	LOW	0%	0%	17%	91%
Bikeways (linear miles)	0.8	LOW	HIGH	6%	6%	6%	69%
Pathways (linear miles)	1.2	LOW	HIGH	39%	39%	53%	100%
Marine Terminals (acres)	130.4	HIGH	LOW	0%	0%	20%	91%
Buildings (count)	50	HIGH	LOW	0%	0%	16%	20%
Piers (count)	1	HIGH	LOW	0%	0%	100%	100%
Stormwater Management (count)	3	HIGH	LOW	0%	7%	40%	87%
Sewer Lifts (count)	1	HIGH	HIGH	0%	0%	0%	100%
Boat Launch Ramps (count)	1	LOW	HIGH				
Parks (acres)	5.5	LOW	HIGH	2%	7%	23%	79%

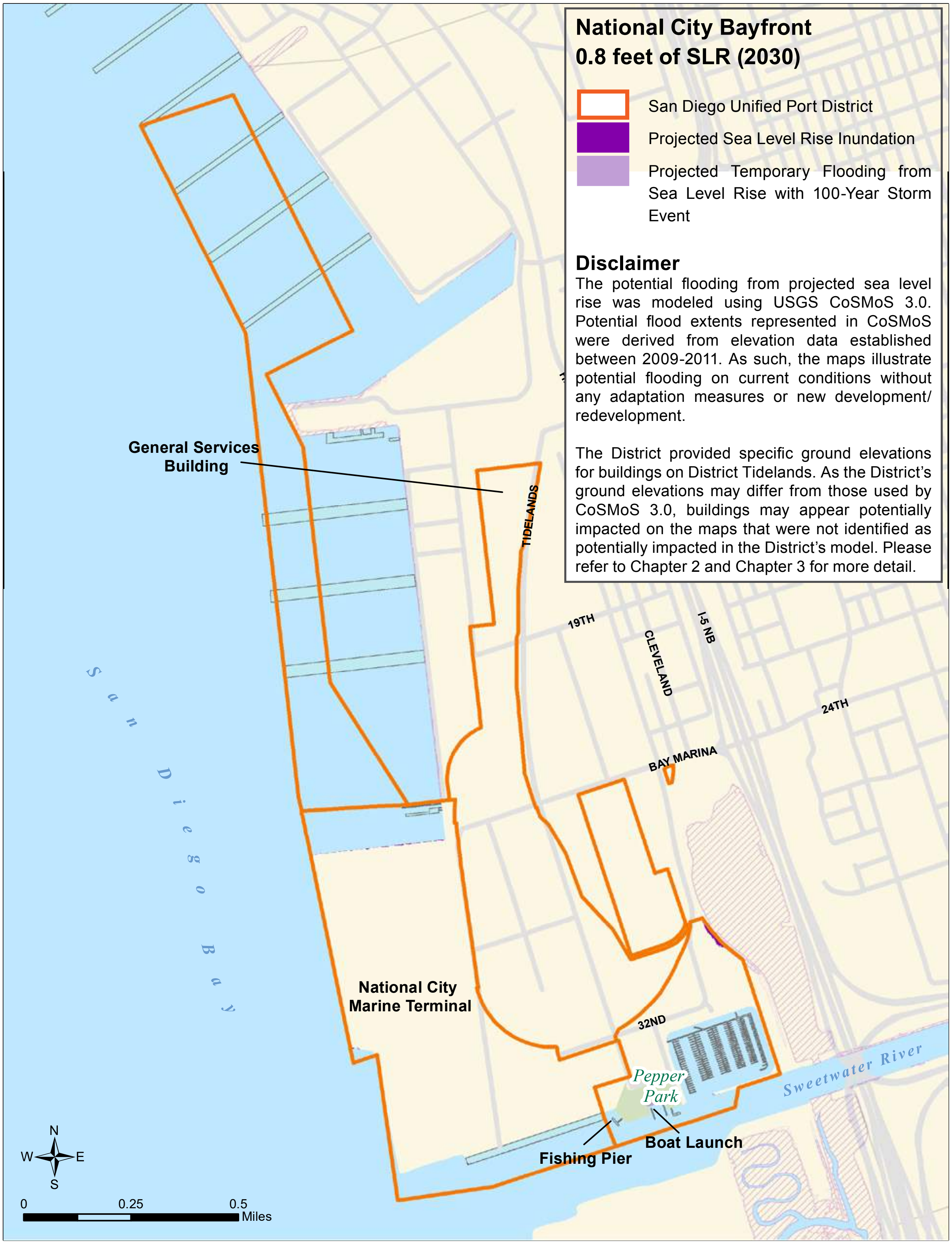

Figure 3.21: National City Bayfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

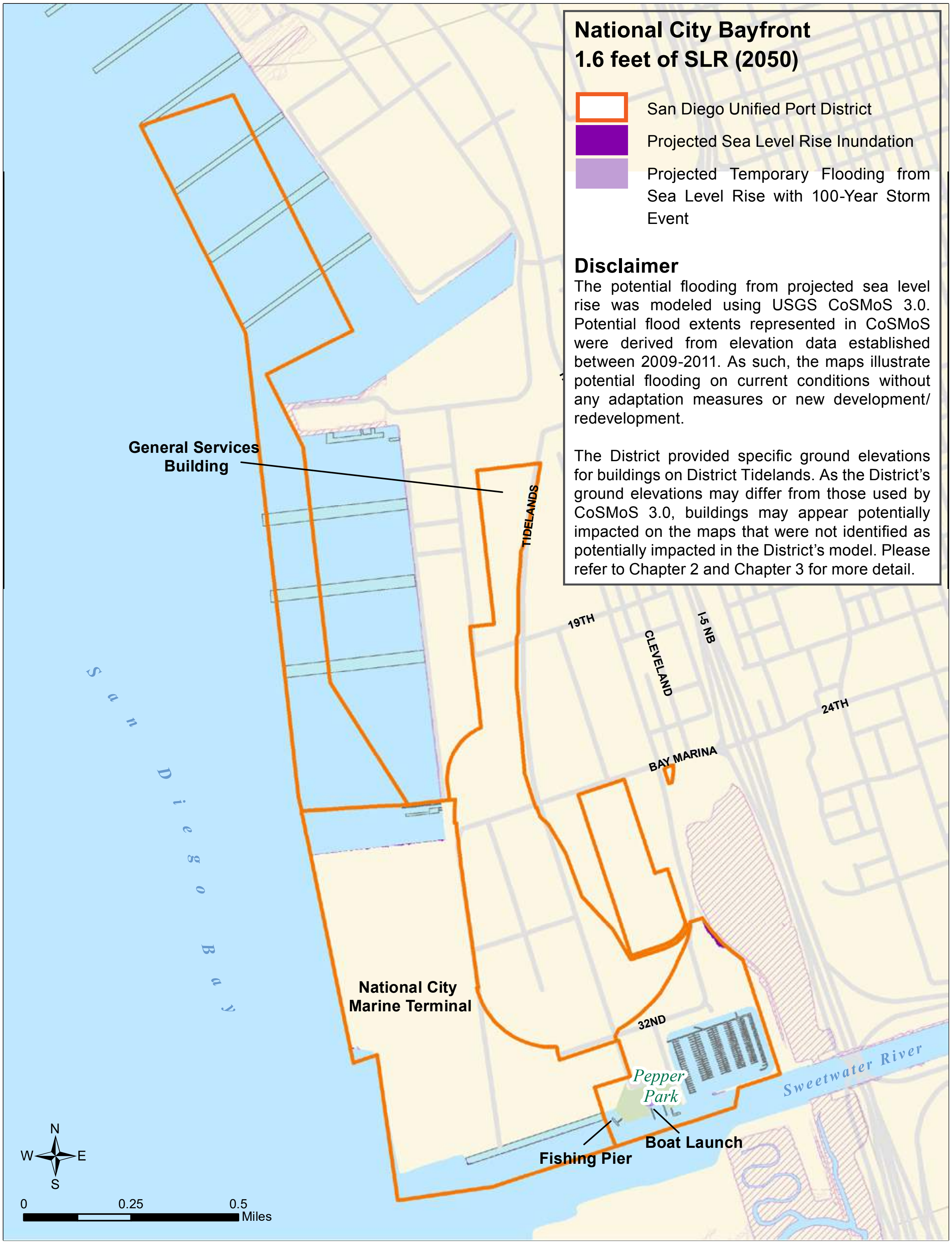

Figure 3.22: National City Bayfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2050

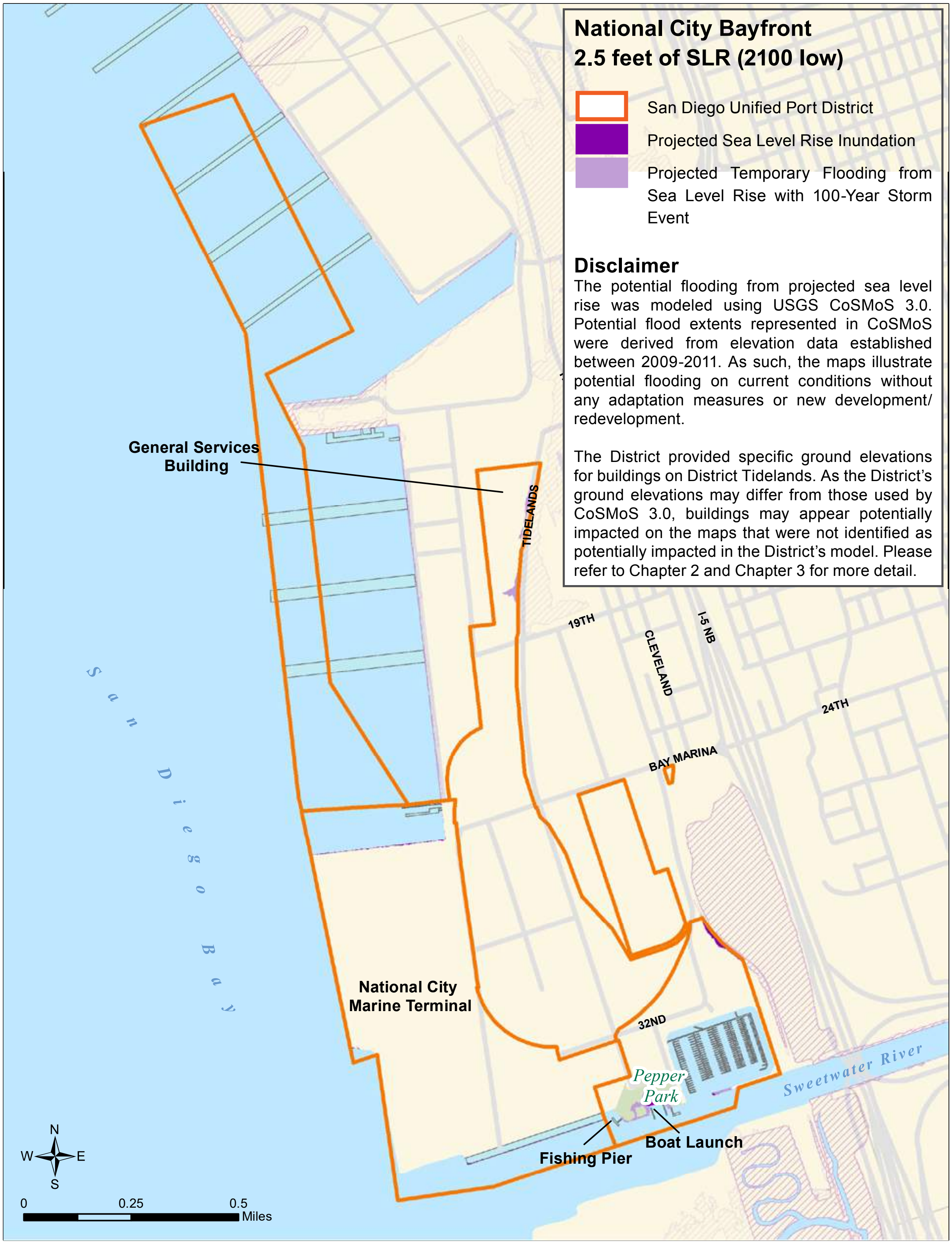

Figure 3.23: National City Bayfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

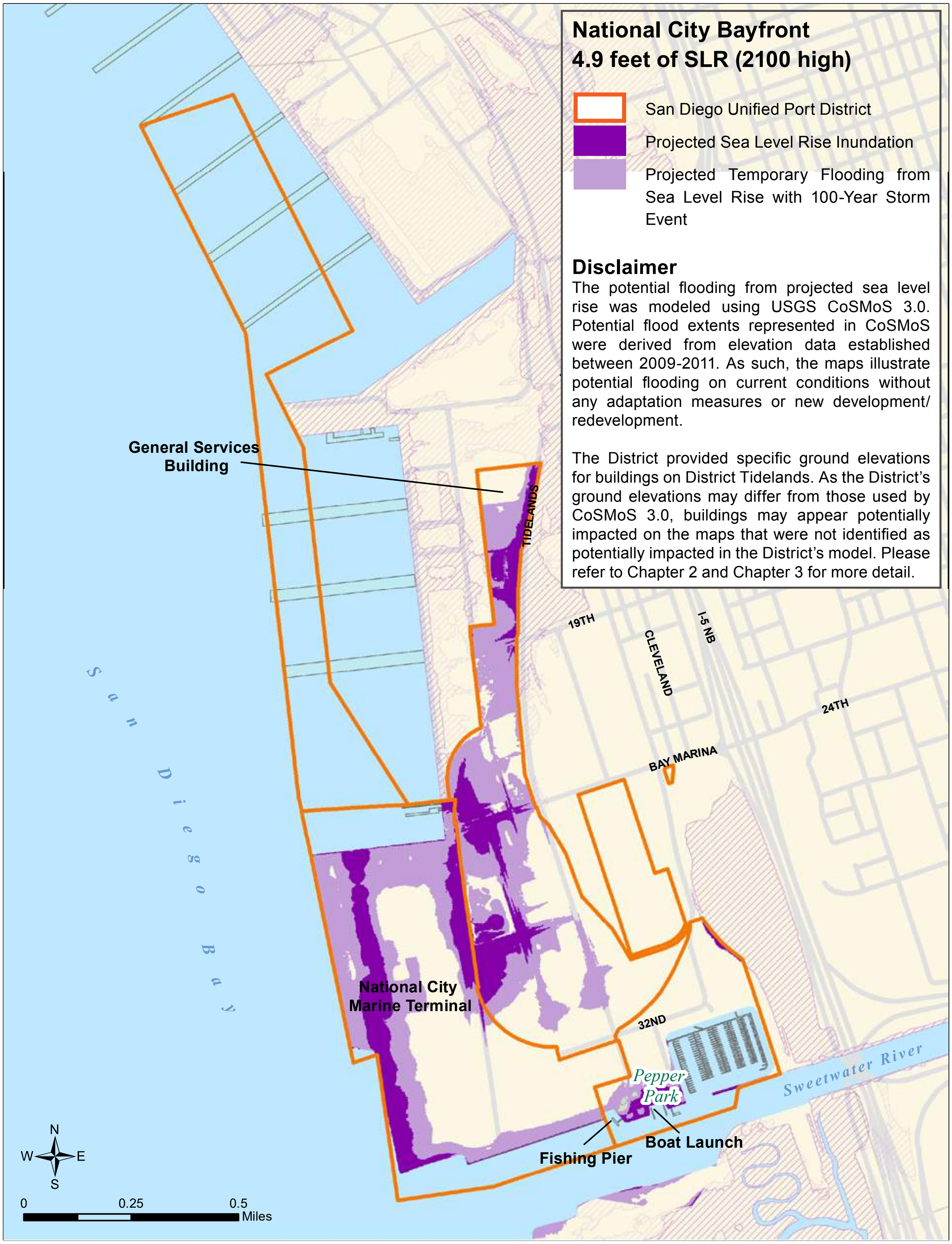

Figure 3.24: National City Bayfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.6 Chula Vista Bayfront Planning District

3.3.6.1 Planning District Setting

The Chula Vista Bayfront Planning District will be transformed in the coming years through a large-scale waterfront development, known as the Chula Vista Bayfront Project. Overall, the project will encompass approximately 535 acres and include the redevelopment of parks, open space, shoreline promenades, walking trails, RV camping, and commercial and marine-related facilities. Although the Chula Vista Bayfront Project has already been approved by the California Coastal Commission, design and construction of the project has not occurred. Therefore, the existing conditions of the planning district were included in the AB 691 analysis, i.e., it assumes no development or grade changes.

Currently, the planning district includes public parks, a boat launching ramp, an RV park, marinas, boatyards, warehouses, and a recreated wildlife habitat island. Police and emergency waterborne services are provided from the Harbor Police substation near the boat-launching ramp. Marine and biological resources are abundant throughout the entire planning district, primarily due to its proximity to San Diego Bay and the South San Diego Bay National Wildlife Refuge. The endangered California Least Tern has two nesting locations within the Planning District.

3.3.6.2 Chula Vista Bayfront Vulnerabilities: Key Takeaways

As stated above, the description of impacts hereafter caused by future projected SLR and storm surge are about current conditions and will not impact the final redevelopment of the Chula Vista Bayfront. The District has already conducted site-specific assessments of projected SLR vulnerability to the components of the Chula Vista Bayfront Project such as the proposed road network. Other site-specific assessments are planned to mitigate the effects of potential inundation and flooding caused by projected SLR.

Under existing conditions, low lying recreational areas in Chula Vista Planning District are projected to be impacted from potential future inundation and temporary coastal flooding from a 100-year storm event (from a 100-year storm event) earlier than other areas around San Diego Bay. At 4.9 feet of projected SLR, most of the planning district may be impacted by potential inundation and/or 100-year storm event temporary coastal flooding from a 100-year storm event affecting public access, recreational areas, and the transportation network. Natural resources in this planning district may also be severely impacted by potential projected SLR inundation. Important nesting habitat for the California Least Tern, which is an endangered species, may begin to become impacted with only 0.8 feet of projected SLR. With 4.9 feet of projected SLR, California least tern habitat becomes impacted at both the D Street Fill along the mouth of the Sweetwater River, and at the Chula Vista Wildlife Reserve.

Chula Vista has a fishing pier and a breakwater that are projected to be affected by projected SLR with a large storm event. Roughly 900 recreational marina slips are susceptible to damage from projected SLR and 100-year storm events that may disrupt accessibility or business operations. Critical infrastructure such as roadways and stormwater systems are particularly sensitive to potential inundation and 100-year storm events. The Harbor Police South Bay Substation, next to the boat-launching ramp in Chula Vista Bayfront Park, is not expected to experience flooding until the high end projected SLR scenario with a storm event.

3.3.6.3 Chula Vista Bayfront Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

Under existing conditions, projected impacts from potential inundation and temporary 100-year storm events are projected to occur with 0.8 feet and 1.6 feet of projected SLR. Impacts begin with public access and recreational areas (beaches). At 4.9 feet of projected SLR, a substantial portion of the planning district is projected to be impacted by potential SLR inundation. Historically, Bayside Park has been damaged from storm surge or wave run-up due to King Tides or large storm events. A 100-year storm event with increased projected SLR has the potential to substantially alter the shoreline lacking future adaptation strategies.

Potential Inundation

District assets in or directly adjacent to the water at lower elevations are projected to be impacted by potential inundation with 0.8 feet of projected SLR. These include beaches, boat launches, pathways, and the stormwater system. With the exception of the stormwater system, the adaptive capacity of these other assets, in their current state, is relatively high, and these assets should remain operable even with greater

Table 3.14: Chula Vista Bayfront Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	4.5	HIGH	LOW	0%	0%	5%	49%
Bikeways (linear miles)	1.2	LOW	HIGH	0%	1%	24%	71%
Pathways (linear miles)	2.3	LOW	HIGH	5%	5%	17%	76%
Buildings (count)	24	HIGH	LOW	0%	0%	0%	18%
Piers (count)	2	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	39	HIGH	LOW	5%	5%	8%	43%
Beach Accessible Areas (acres)	1.9	HIGH	LOW	86%	87%	89%	98%
Parks (acres)	23.6	LOW	HIGH	9%	21%	38%	78%
Boat Launch Ramps (count)	1	LOW	HIGH	1%	1%	9%	55%

Table 3.15: Chula Vista Bayfront Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	4.5	HIGH	LOW	4%	16%	41%	64%
Bikeways (linear miles)	1.2	LOW	HIGH	21%	33%	54%	92%
Pathways (linear miles)	2.3	LOW	HIGH	15%	33%	57%	95%
Buildings (count)	24	HIGH	LOW	0%	4%	10%	50%
Piers (count)	2	HIGH	LOW	0%	50%	50%	100%
Stormwater Management (count)	39	HIGH	LOW	5%	13%	28%	67%
Beach Accessible Areas (acres)	1.9	HIGH	LOW	89%	91%	94%	100%
Parks (acres)	23.6	LOW	HIGH	9%	21%	38%	78%
Boat Launch Ramps (count)	1	LOW	HIGH	9%	21%	38%	78%

increases in projected SLR. The beach areas are projected to substantially impacted and are susceptible to erosion and complete loss starting in the long-term.

With 2.5 feet of projected SLR, recreational and public access opportunities are projected to be substantially hindered. All three parks in the planning district are predicted to experience potential inundation. Overtopping of the breakwater may occur with 1.6-feet of projected SLR and a storm event. With 4.9 feet of projected SLR, a majority of parks, pathways and bikeways, the fishing pier, buildings, beach areas, roadways, and the stormwater system may be severely affected by potential inundation. Potential inundation along roadways within the planning district may severely curtail access, create challenges to emergency responses, and disrupt business operations within the area.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

A 100-year storm event in the planning district is projected to have substantial impacts to public accessibility and recreational opportunities starting at 2.5 feet of projected SLR. While a small number of buildings may be impacted at 1.6 feet of projected SLR with a 100-year storm event, half of the structures are projected to be affected by potential storm surge with 2.5 to 4.9 feet of projected SLR. Beyond 2.5 feet of projected SLR, a 100-year storm event has the potential to severely impact public access in the planning district with most roadways, pathways, bikeways, the fishing pier, and beach areas potentially becoming impacted. The Harbor Police South Bay Substation is in Chula Vista Bayfront Park next to the boat launch ramp. This facility is not expected to experience flooding until the high end projected SLR scenario with a storm event.

Important California Least Tern habitat is susceptible to temporary coastal flooding from a 100-year storm event during a storm event. Much of the nesting site located at the Chula Vista Wildlife Reserve may become flooded during a 100-year storm event with as little as 0.8 feet of projected SLR. The D Street Fill has a higher elevation and may not experience serious flooding until 4.9 feet of projected SLR coupled with a storm event.

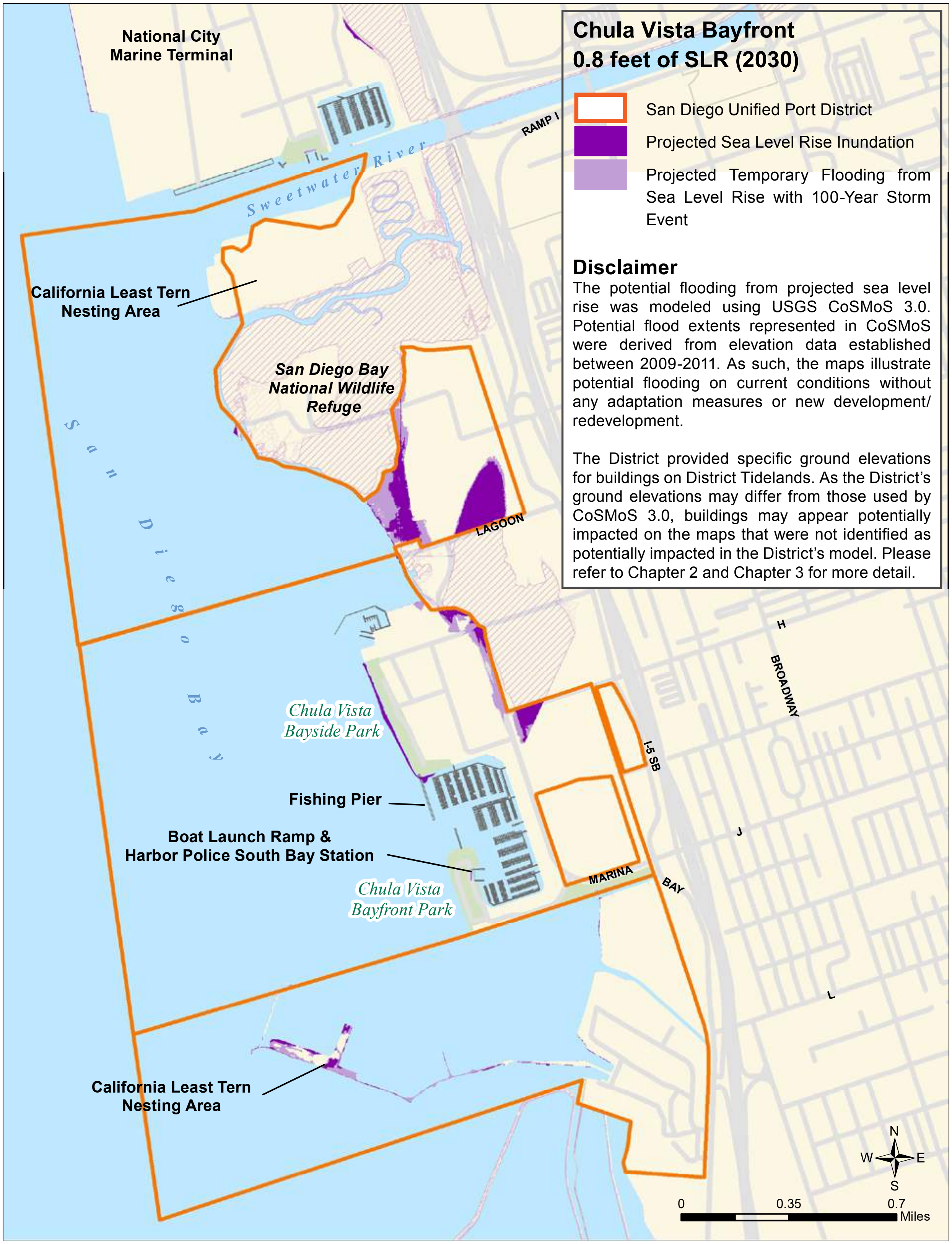

Figure 3.25: Chula Vista Bayfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

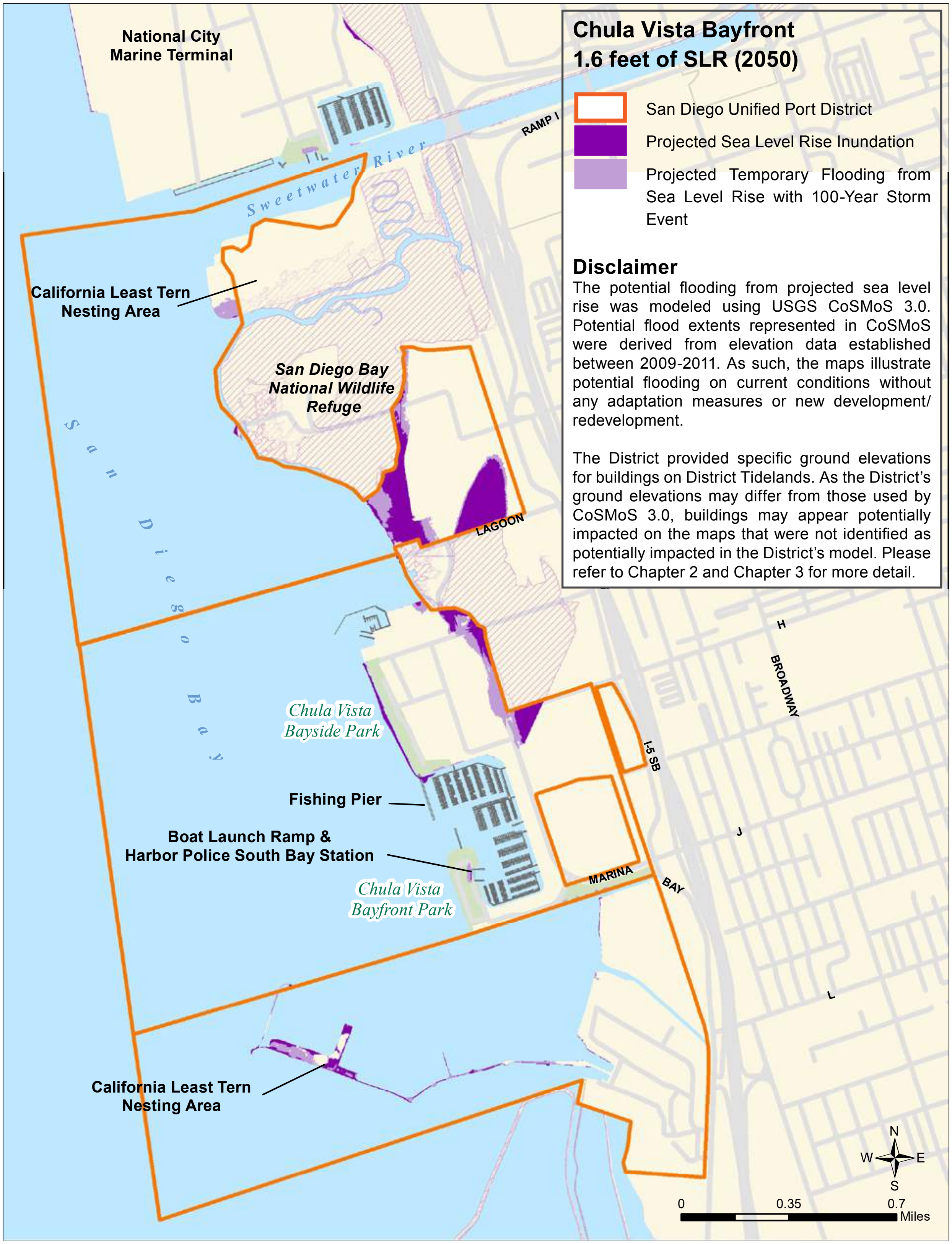

Figure 3.26: Chula Vista Bayfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2050

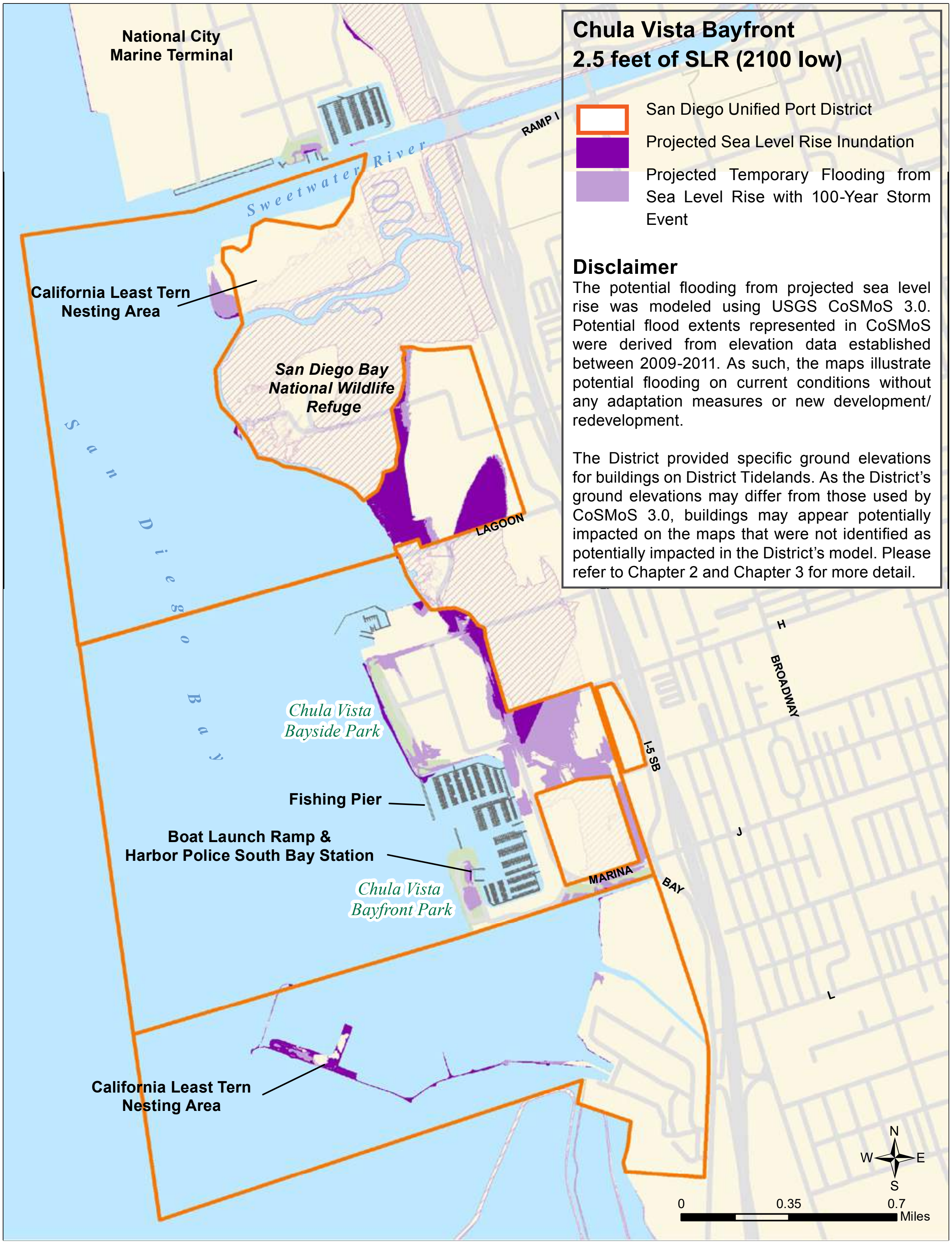

Figure 3.27: Chula Vista Bayfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

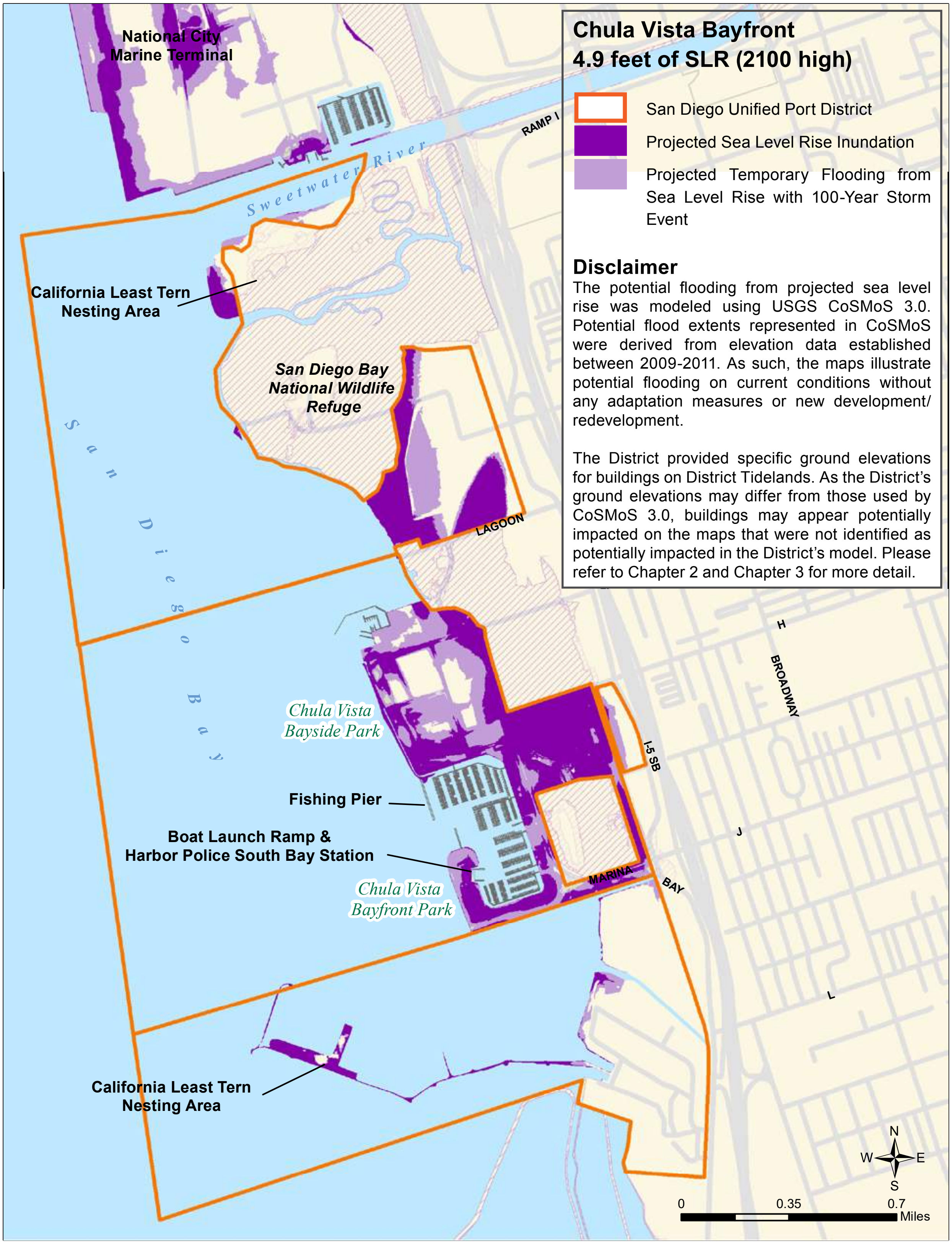

Figure 3.28: Chula Vista Bayfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.7 South Bay Salt Lands Planning District

3.3.7.1 Planning District Setting

The South Bay Salt Lands Planning District comprises the water and land areas at the southerly end of the Bay that support a diverse range of natural resources and ecosystems. A former salt pond known as Pond 20 occupies most of the planning district. The District is planning to construct a wetlands mitigation bank in Pond 20. The planning district also contains a portion of the Bayshore Bikeway and is adjacent to the National Wildlife Refuge. Otay River runs along the northern boundary of Pond 20 before emptying into San Diego Bay.

3.3.7.2 South Bay Salt Lands Vulnerabilities: Key Takeaways

The primary asset evaluated in the South Bay Salt Lands Planning District is a short section of the Bayshore Bikeway. While not projected to be impacted by potential inundation at 4.9 feet of projected SLR, impacts from temporary coastal flooding from a 100-year storm event are projected to occur at 1.6 feet of projected SLR. Adaptive capacity is high for this asset as alternative routes are available to access destinations in Coronado, Imperial Beach, and Chula Vista.

3.3.7.3 South Bay Salt Lands Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

The projected impacts to potential inundation are minimal for all projected SLR scenarios. However, storm surge will have greater impacts and potentially inhibit cyclist and pedestrian access beginning at 1.6 feet of projected SLR.

Potential Inundation

District assets in or directly adjacent to the water at lower elevations are not projected to be exposed to potential inundation until 4.9 feet of projected SLR. These impacts account for only five percent of the bikeway.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

While a very small portion of the bikeway in the planning district may be affected by temporary coastal flooding from a 100-year storm event beginning at 1.6 feet of projected SLR, all the bikeways may be fully flooded during a 100-year storm event at 4.9 feet of projected SLR.

Table 3.16: South Bay Salt Lands Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Bikeways (linear miles)	0.3	LOW	HIGH	0%	0%	0%	5%

Table 3.17: South Bay Salt Lands Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Bikeways (linear miles)	0.3	LOW	HIGH	0%	1%	40%	100%

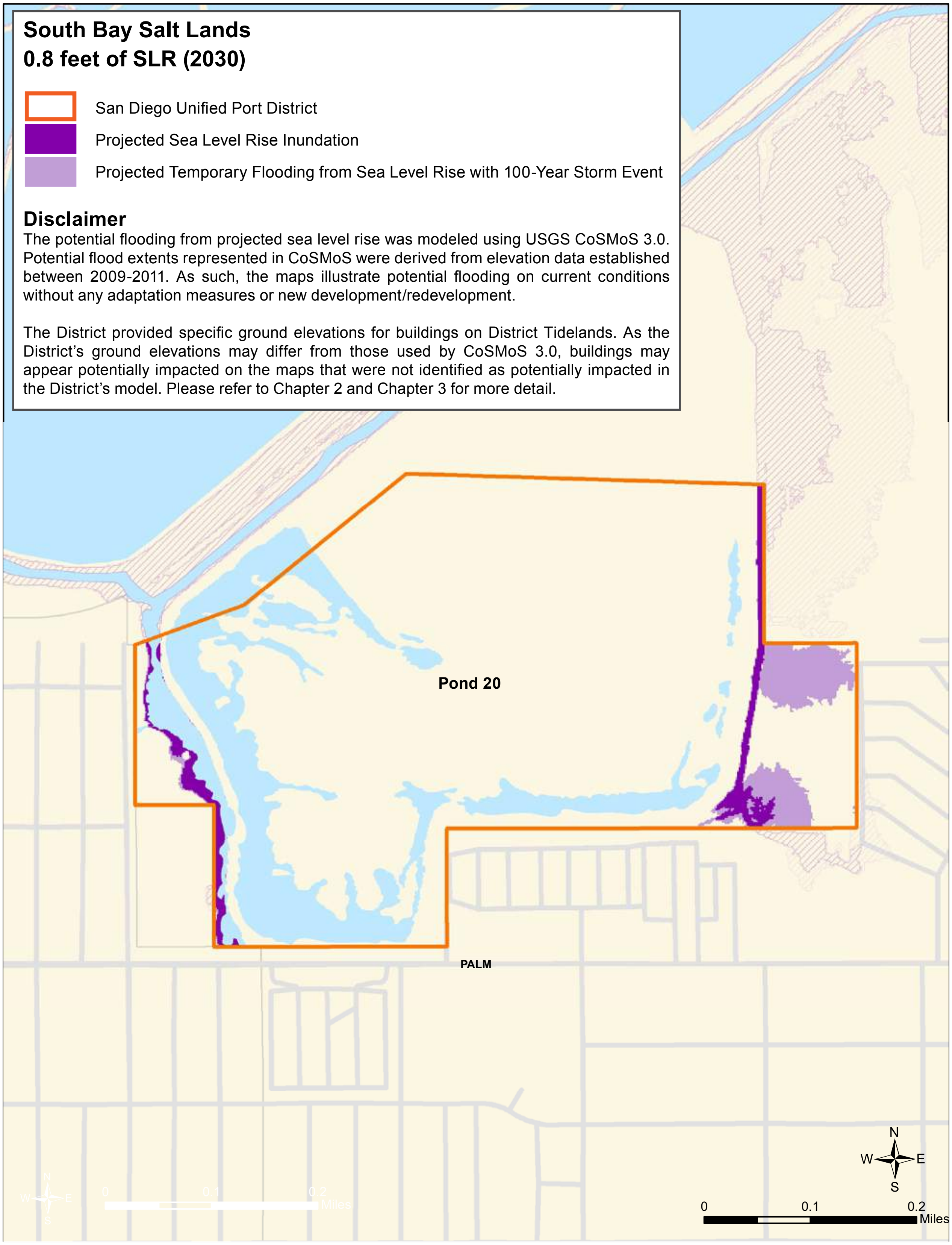

Figure 3.29: South Bay Salt Lands Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

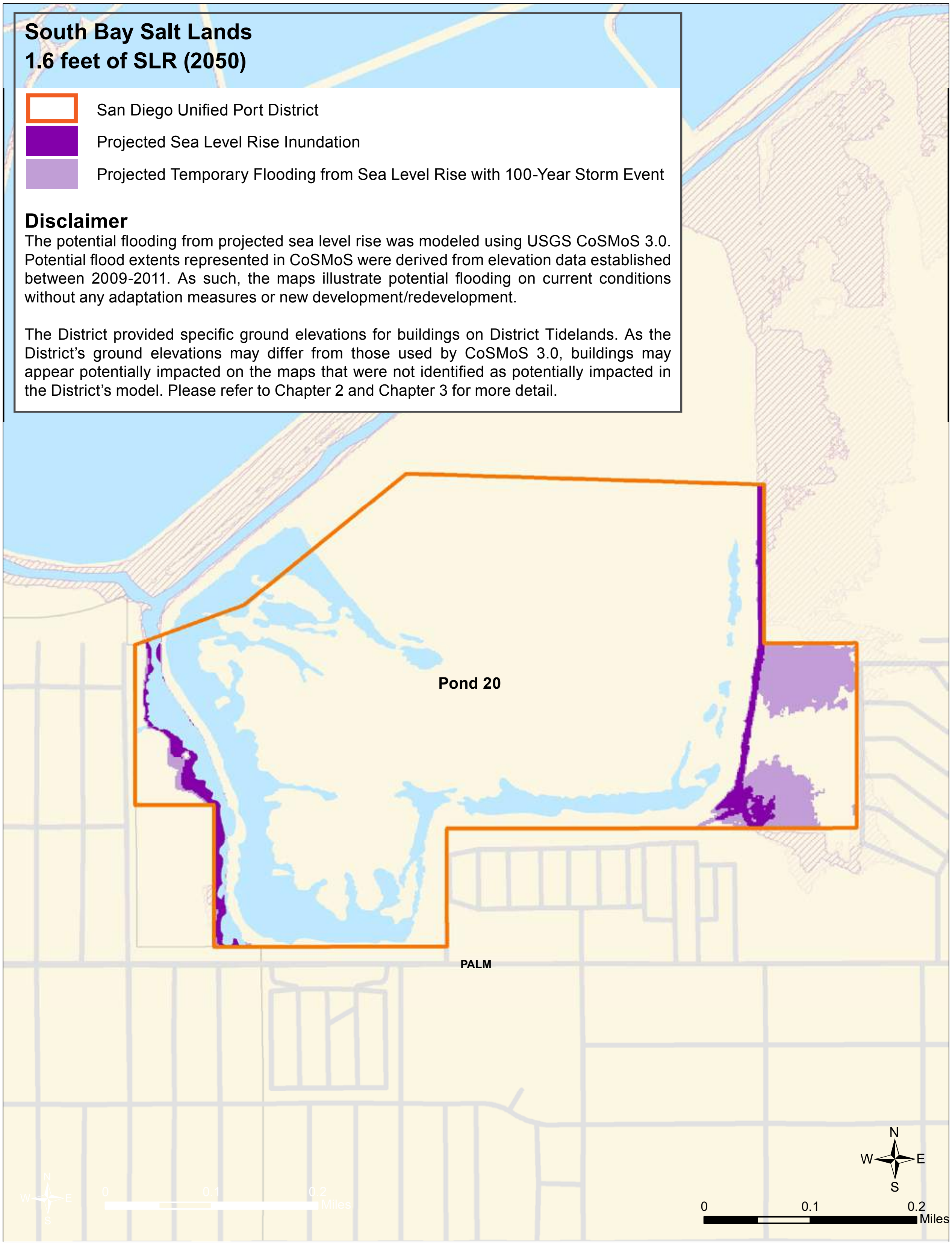

Figure 3.30: South Bay Salt Lands Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2050

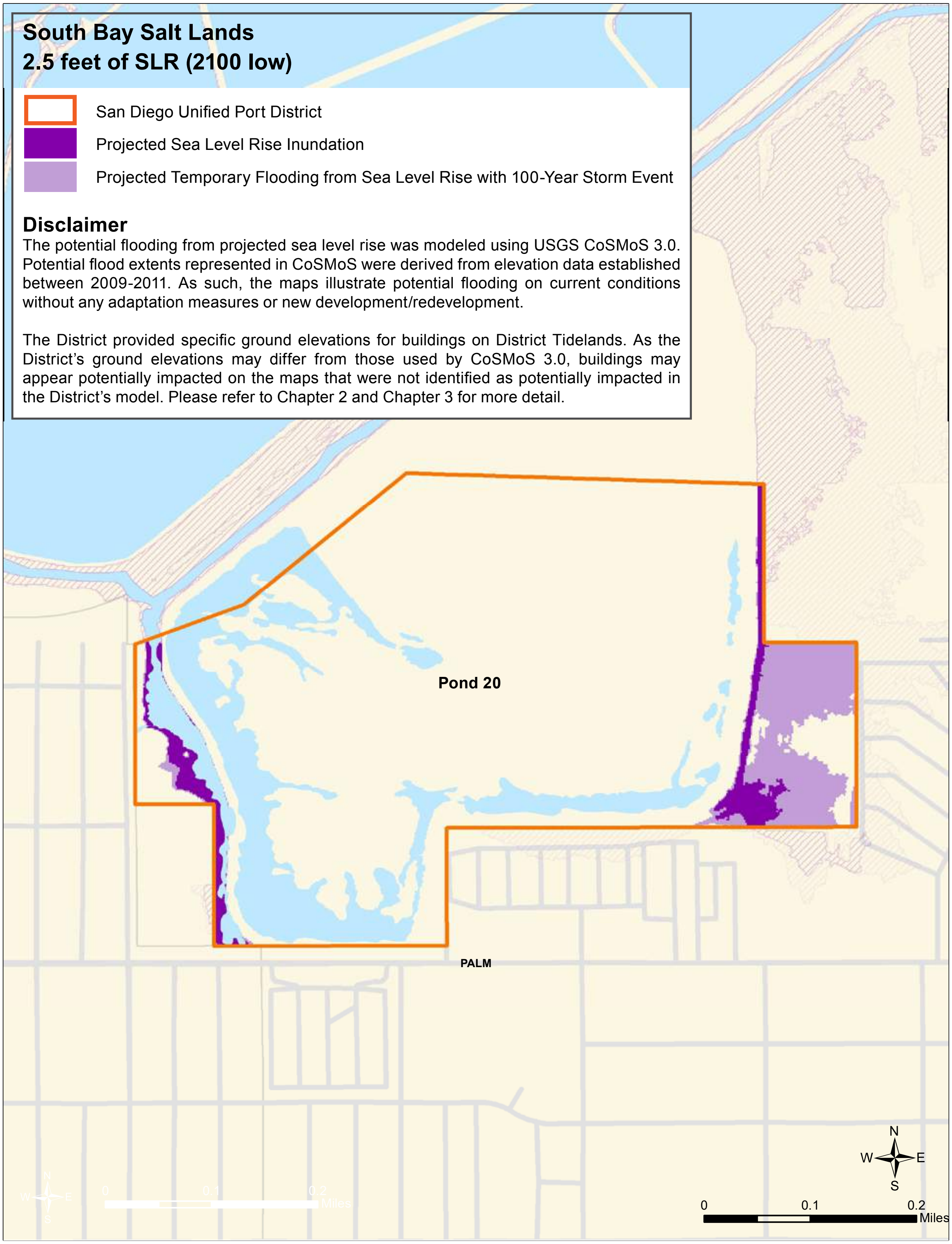

Figure 3.31: South Bay Salt Lands Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

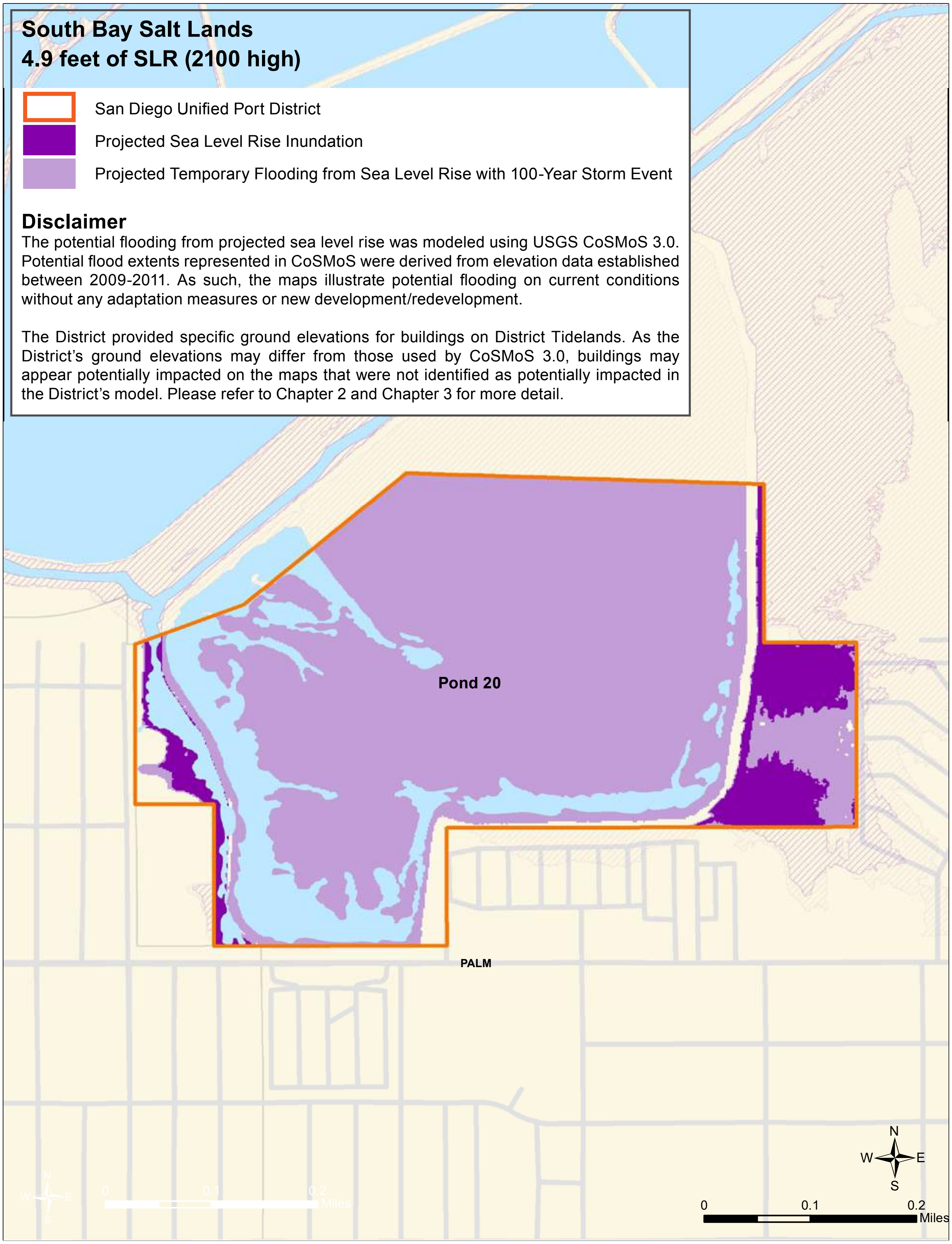

Figure 3.32: South Bay Salt Lands Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.8 Imperial Beach Oceanfront Planning District

3.3.8.1 Planning District Setting

The Imperial Beach Oceanfront Planning District includes retail, restaurant, and open space uses. Key features of the planning district include the Pacific Ocean shoreline along Imperial Beach, the Imperial Beach Municipal Pier, Dunes Park, and state granted Pacific Ocean tidelands and submerged lands. The City of Imperial Beach completed an SLR vulnerability assessment in 2016.[4] The City's assessment considered potential inundation and flooding for various future SLR scenarios and included adaptation strategies to mitigate projected SLR impacts.

3.3.8.2 Imperial Beach Oceanfront Vulnerabilities: Key Takeaways

While 100-year storm event (on top of projected SLR) may lead to greater impacts from temporary coastal flooding compared to potential inundation, the overall impacts are small. Flooded pathways may limit access to the beach and pier starting at 0.8 feet of projected SLR. Dunes Park may be affected by temporary coastal flooding from a 100-year storm event starting at 1.6 feet of projected SLR. The associated comfort station at Dunes Park is projected to be flooded at 4.9 feet of SLR with a 100-year storm event. As neither asset is considered critical infrastructure and sensitivity is low, the risk to these assets is small compared to other areas in the District. While the pier is not projected to be impacted by potential inundation, 100-year storm events may cause physical damage even if the pier is overtopped by waves.

3.3.8.3 Imperial Beach Oceanfront Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

District assets in Imperial Beach Oceanfront Planning District anticipated to be impacted by projected SLR with and without a 100-year storm event are pathways and a sewer lift. With a 100-year storm event, public access and recreational opportunities will become more limited with most pathways and parks anticipated to be temporary flooded. The beach may begin to experience potential inundation beginning with 2.5 feet of projected SLR.

[4] City of Imperial Beach Sea Level Rise Assessment (2016)

Potential Inundation

Two district assets: pathways and one sewer lift are projected to be affected by potential inundation with 0.8 feet of projected SLR. As pathways can be elevated and alternative routes exist to access beach areas and the pier, the adaptive capacity is high.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

Pathways and the single sewer lift are projected to be impacted by 100-year storm events starting in the near term. At 2.5 feet of projected SLR and beyond, a 100-year storm event has the potential to severely impact the temporary usability of park areas during storm events.

Table 3.18: Imperial Beach Oceanfront Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Pathways (linear miles)	0.2	LOW	HIGH	100%	100%	100%	100%
Buildings (count)	5	HIGH	LOW	0%	0%	0%	0%
Piers (count)	1	HIGH	LOW	0%	0%	0%	0%
Sewer Lifts (count)	1	HIGH	HIGH	100%	100%	100%	100%
Parks (acres)	0.3	LOW	HIGH	0%	0%	0%	0%

Table 3.19: Imperial Beach Oceanfront Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Pathways (linear miles)	0.2	LOW	HIGH	100%	100%	100%	100%
Buildings (count)	5	HIGH	LOW	0%	0%	0%	20%
Piers (count)	1	HIGH	LOW	0%	0%	0%	0%
Sewer Lifts (count)	1	HIGH	HIGH	100%	100%	100%	100%
Parks (acres)	0.3	LOW	HIGH	0%	76%	80%	100%

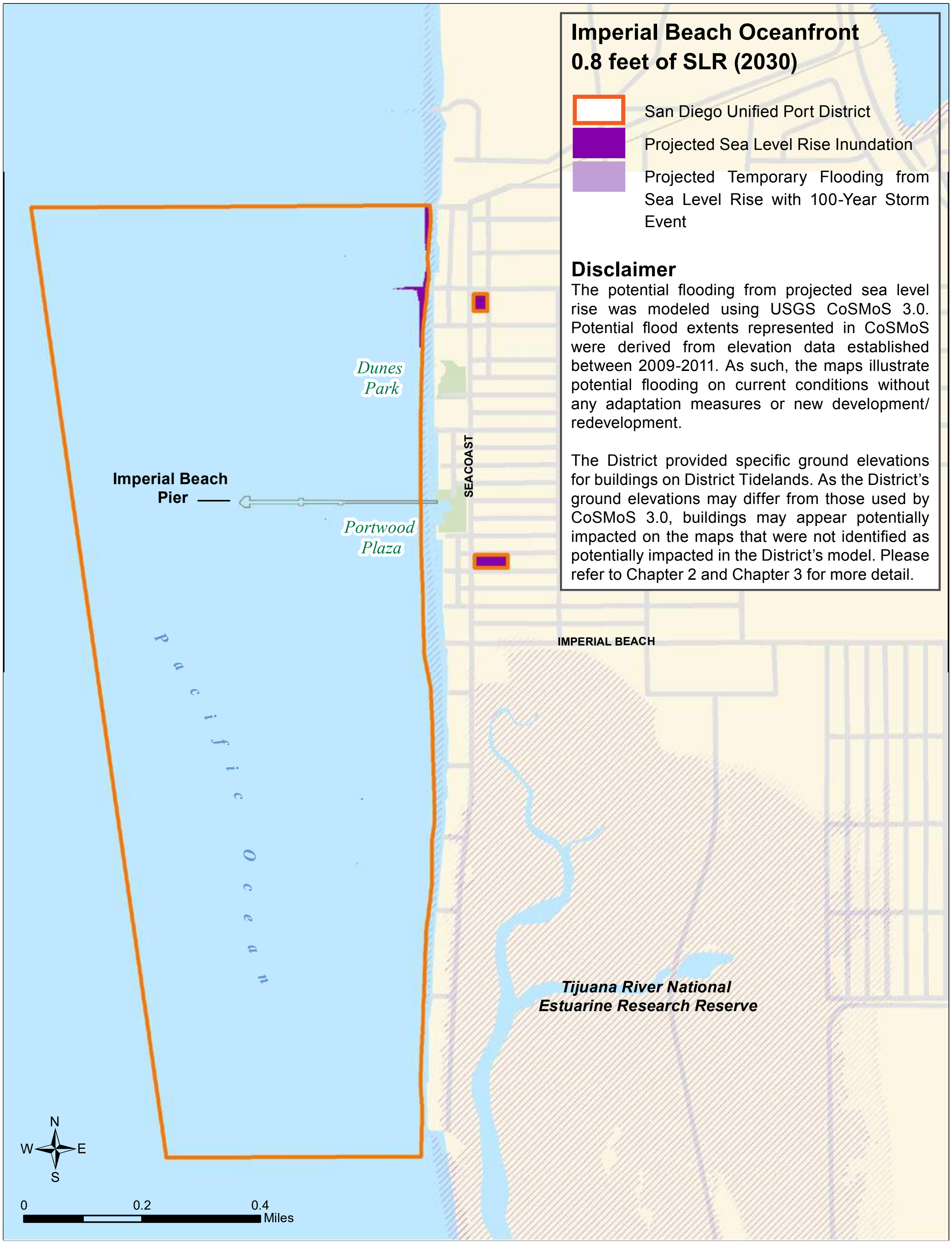

Figure 3.33: Imperial Beach Oceanfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

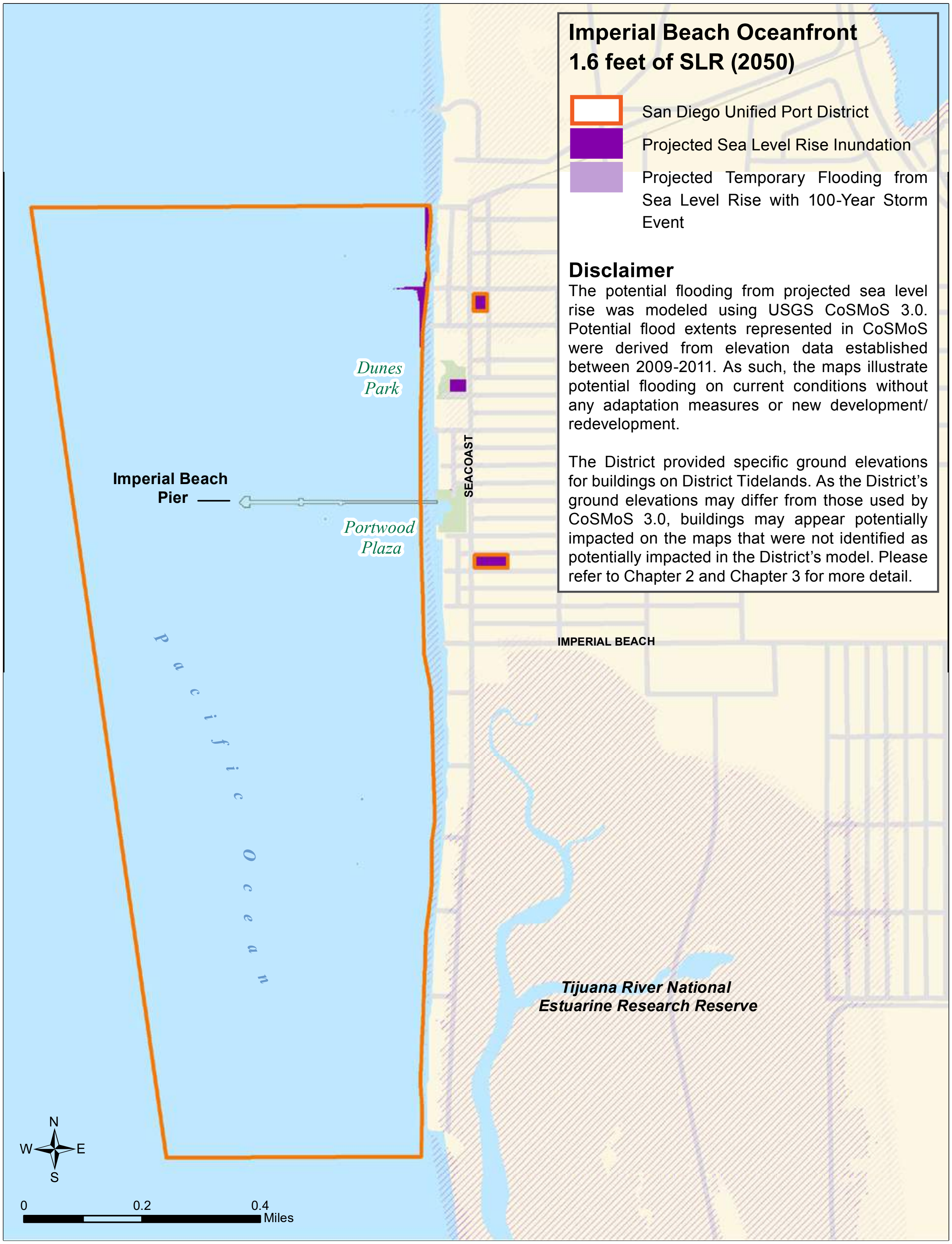

Figure 3.34: Imperial Beach Oceanfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

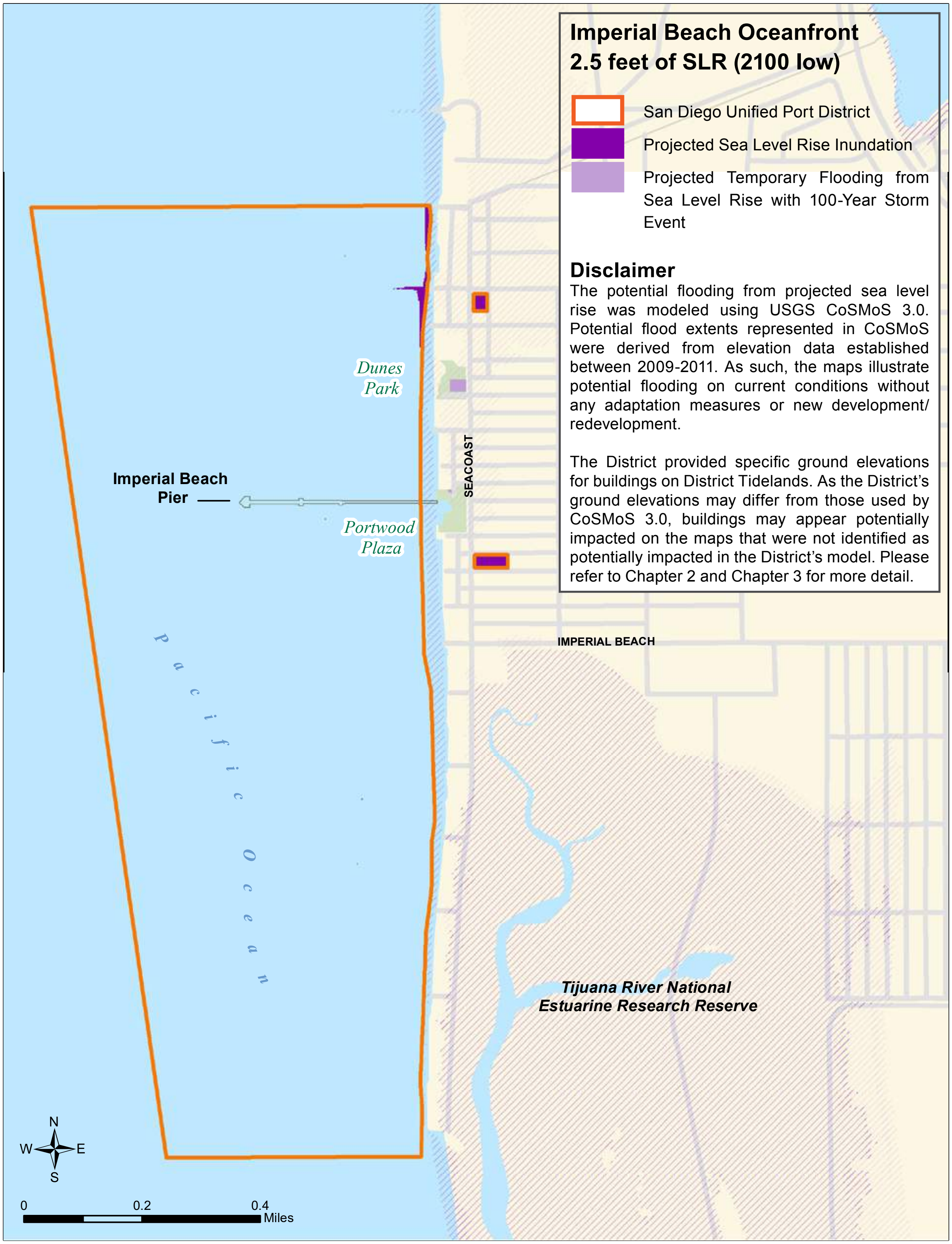

Figure 3.35: Imperial Beach Oceanfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

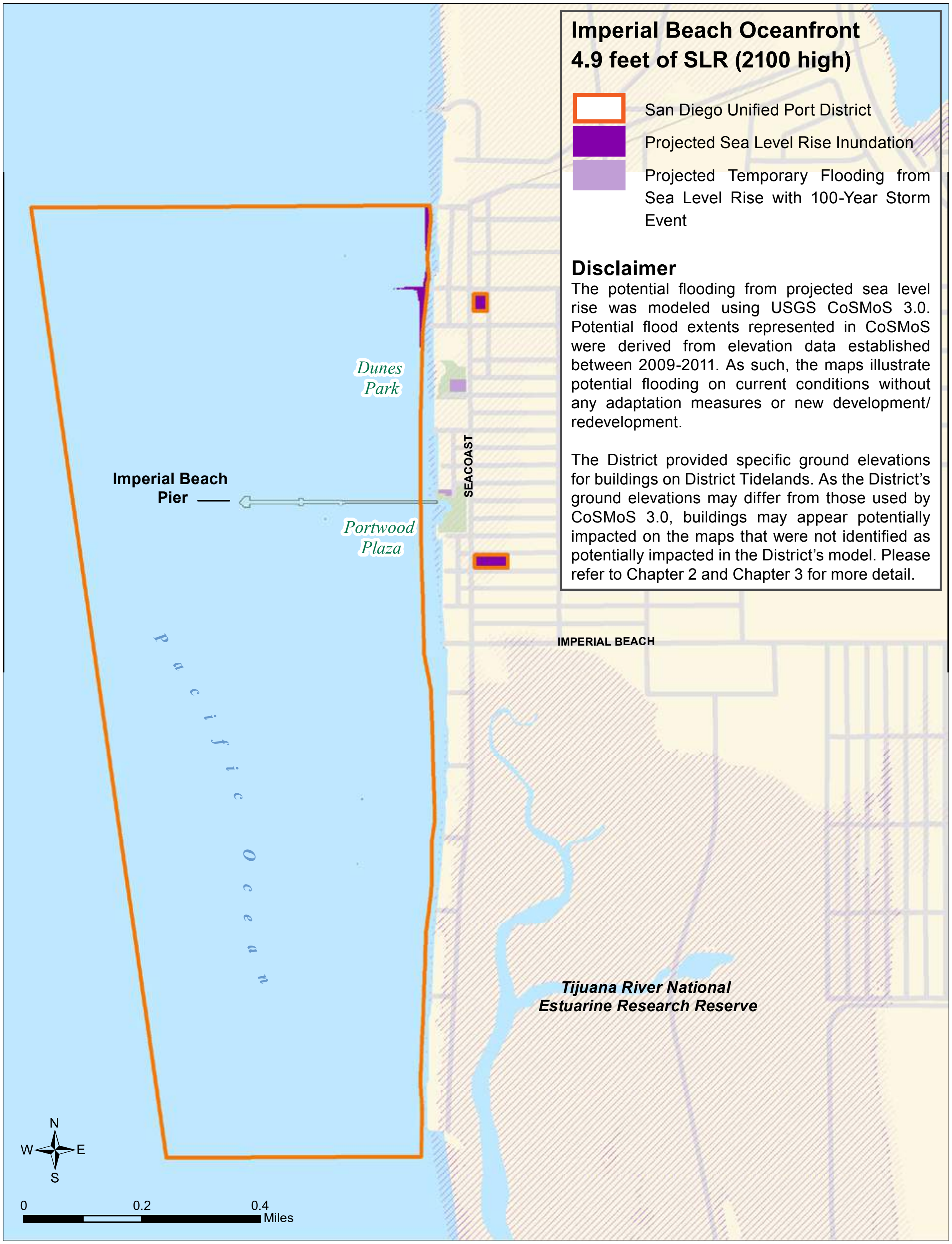

Figure 3.36: Imperial Beach Oceanfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.9 Silver Strand South Planning District

3.3.9.1 Planning District Setting

The Silver Strand South Planning District is in the southwest corner of the Bay, east of Silver Strand State Beach. It is characterized by a natural shoreline, a hotel with associated marina, a yacht club, open space, and recreational boat piers.

3.3.9.2 Silver Strand South Vulnerabilities: Key Takeaways

Public access is the primary vulnerability in Silver Strand South Planning District. These impacts, combined with a substantial storm event will limit safe, public access to the water for pedestrians. Roadways, which are critical infrastructure, are particularly sensitive to potential inundation or a temporary storm event starting at 0.8 feet of projected SLR. As there are no alternative routes to reach the islands except for Grand Caribe Causeway or Coronado Bay Road, public access, business operations, and emergency response may be substantially reduced.

There are approximately 160 boat slips in the planning district within the yacht club or recreational marinas. While slips can be elevated for increased projected SLR, substantially larger storm events combined with elevated sea levels may lead to more extensive damage from exposure to waves and storm surge.

3.3.9.3 Silver Strand South Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

Exposure from projected SLR impacts within the planning district may occur by year 2050 due to lower elevations. Potential inundation may be possible with the 2.5 feet and 4.9 feet projected SLR scenarios. This may affect public access and business operations. Potential damage from temporary coastal flooding from a 100-year storm event may occur with 0.8 feet and expand with 1.6 feet of projected SLR.

Potential Inundation

Public access areas, such as pathways and roadways, directly adjacent to the water at lower elevations are projected to be impacted by potential inundation with 0.8 feet of projected SLR.

The quantity of District assets such as roads, parks, and buildings impacted by increased projected SLR is projected to increase over time. At 4.9 feet of projected SLR, a majority of pathways and buildings are projected to be severely affected by potential inundation. Of important concern are roadways that may be inundated with 1.6 feet of projected SLR along Coronado Bay Road. Potential inundation may limit access along Grand Caribe Causeway with a 4.9-foot rise in projected SLR. Grand Caribe Park may also experience potential inundation at 4.9 feet of projected SLR. Continued flooding of roadways would reduce public access, disrupt business operations, and potentially limit emergency response.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

A 100-year storm event may begin to impact public access to the waterfront at 0.8 feet of projected SLR. Coastal access in the form of pathways are projected to be substantially impacted after year 2050 and almost completely flooded at 4.9 feet of projected SLR with a 100-year storm event. Approximately 35 percent of parks may be temporarily flooded with a 100-year storm event. However, as pathways and parks have low sensitivity and high adaptive capacity, these assets should become fully functional following a 100-year storm event assuming no substantial damage.

While one building may be impacted at 0.8 feet of projected SLR with a 100-year storm event, there is the potential for substantial impacts to all Silver Strand South buildings at 4.9 feet of projected SLR. In combination with large flooding of roadways, a 100-year storm event may have the potential to severely impact the operations of Silver Strand facilities with 2.5 feet and 4.9 feet of projected SLR.

Table 3.20: Silver Strand South Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	0.9	HIGH	LOW	7%	10%	17%	62%
Pathways (linear miles)	0.5	LOW	HIGH	12%	15%	33%	72%
Buildings (count)	10	HIGH	LOW	0%	0%	10%	30%
Parks (acres)	2.6	LOW	HIGH	0%	0%	0%	22%

Table 3.21: Silver Strand South Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	0.9	HIGH	LOW	20%	21%	25%	80%
Pathways (linear miles)	0.5	LOW	HIGH	24%	39%	51%	83%
Buildings (count)	10	HIGH	LOW	10%	10%	30%	100%
Parks (acres)	2.6	LOW	HIGH	0%	1%	1%	35%

Figure 3.37: Silver Strand South Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

Figure 3.38: Silver Strand South Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

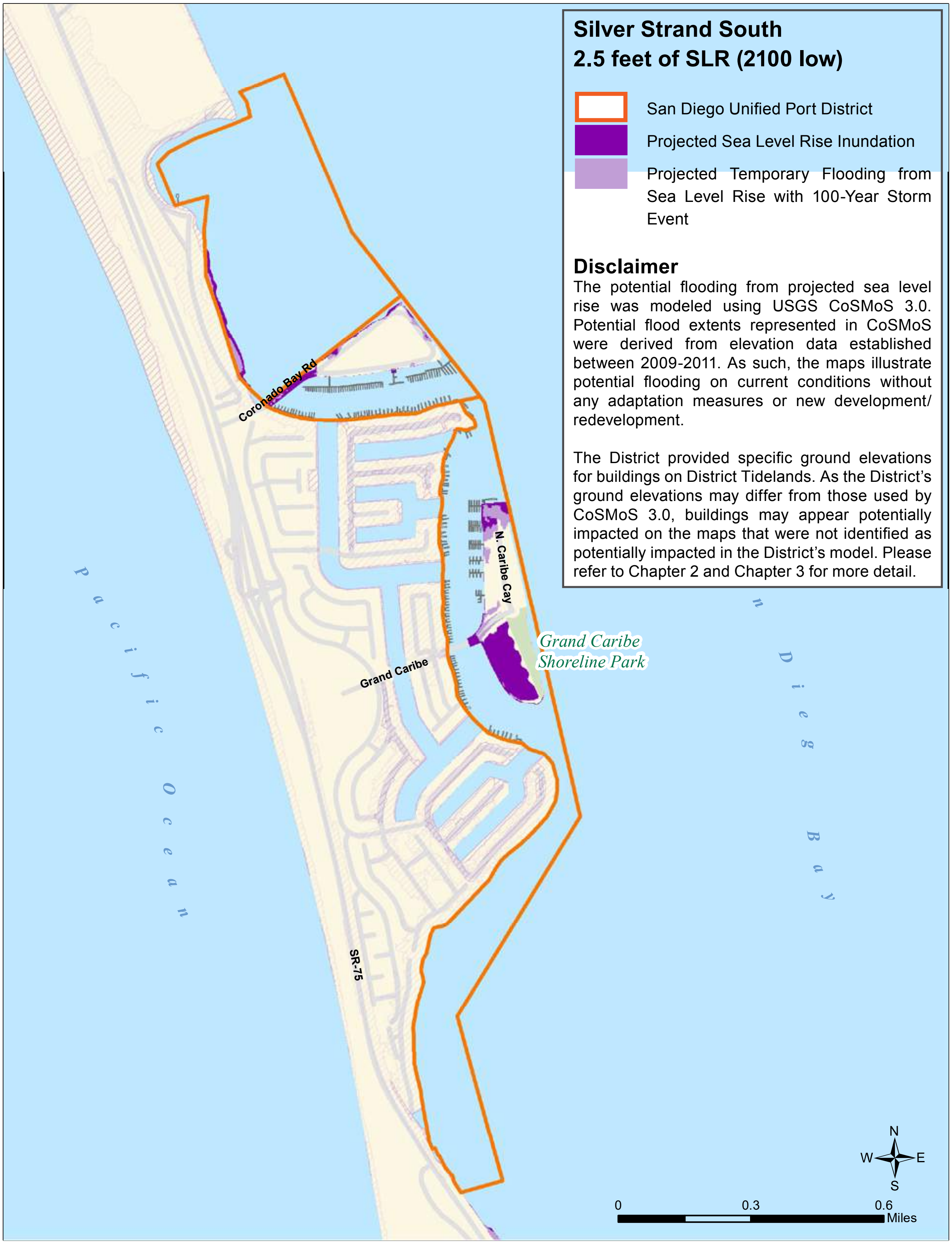

Figure 3.39: Silver Strand South Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

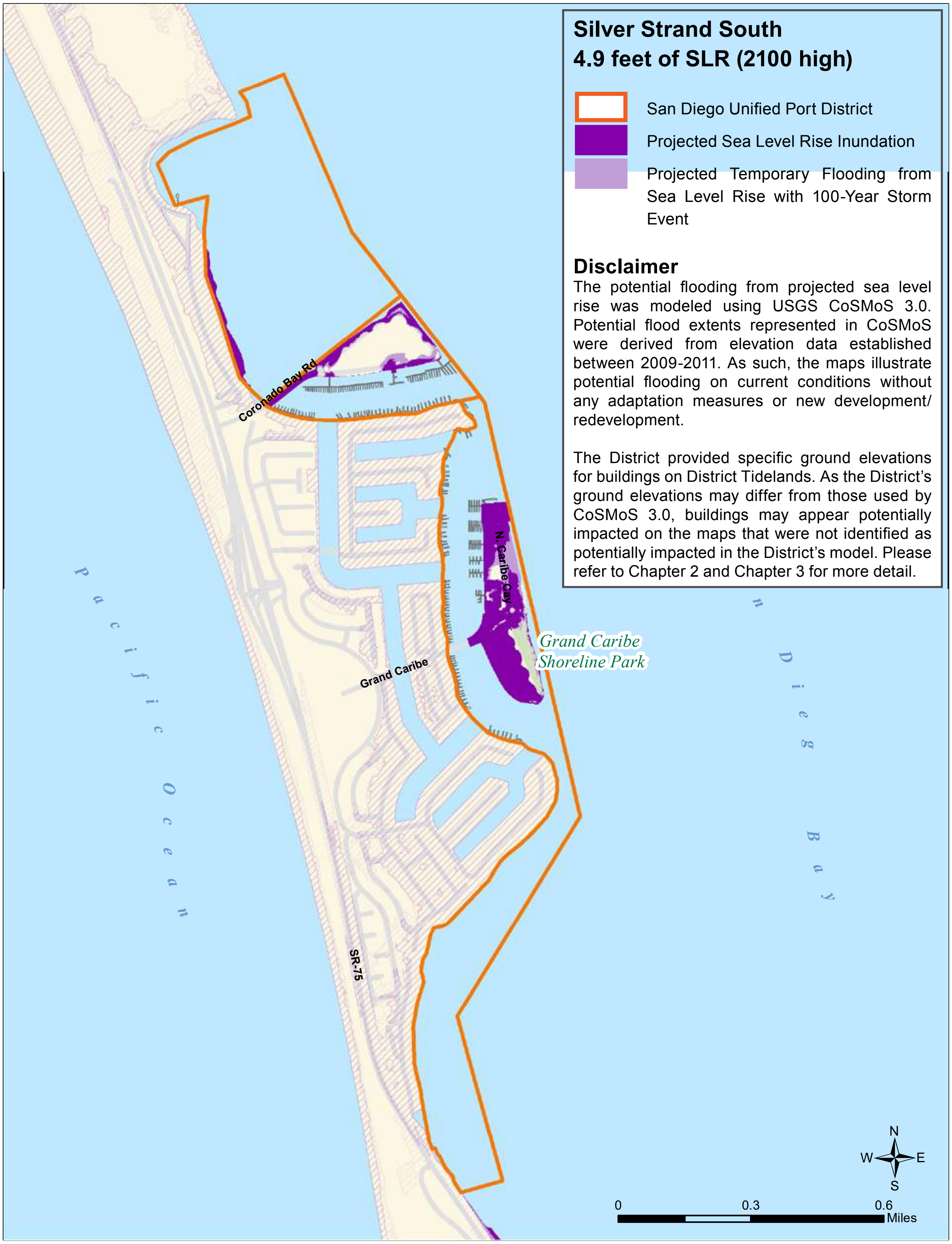

Figure 3.40: Silver Strand South Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.3.10 Coronado Bayfront Planning District

3.3.10.1 Planning District Setting

The Coronado Bayfront Planning District is characterized by visitor-serving serving recreational activities such as recreational boating, golfing, and extended promenades allowing visitors to explore and access the water. Tidelands Park provides additional opportunities for recreation including play fields, a public beach, and a skate park. The ferry landing on the east side of the planning district provides public water-based transit to and from downtown San Diego.

3.3.10.2 Coronado Bayfront Vulnerabilities: Key Takeaways

Low lying and public access areas (such as beaches) in the Coronado Bayfront Planning District are projected to experience impacts from potential inundation with 0.8 feet of SLR. These impacts combined with a 100-year storm event may limit public access to the water for pedestrians and cyclists. Critical infrastructure such as roadways, on or near, the District are particularly sensitive to potential inundation beyond 2.5 feet of projected SLR, potentially obstructing access to the District parks and recreational areas.

Glorietta Bay, located on the eastern end of the planning district, contains approximately 450 boat slips. While slips can be elevated for increased projected SLR, substantially larger storm events such as a 100-year storm, combined with elevated sea levels, may lead to more extensive damage and longer recovery times.

The only golf course within the District is in the Coronado Bayfront Planning District. As the golf course is located at an elevation already near water level, it is vulnerable to potential inundation and temporary coastal flooding from a 100-year storm event. At 2.5 feet of projected SLR, large portions of the south side of the golf course are projected to be inundated. At 4.9 feet of projected SLR, a majority golf course may be impacted by potential projected SLR inundation and temporary coastal flooding from a 100-year storm event.

3.3.10.3 Coronado Bayfront Exposure from Projected Sea Level Rise Inundation and 100-Year Storm Events

Potential Inundation

District assets directly adjacent to the water at lower elevations are projected to be impacted by potential inundation with

0.8 feet of projected SLR. These include beaches and parks (see Table 3.22). As the adaptive capacity of parks is high, these assets should remain operable even with projected SLR. Beach areas are more sensitive to projected SLR as wave run-up has greater erosional effects on the shoreline. While beaches can be augmented through beach sand replenishment, potential long-term inundation may completely erode or limit access to this asset.

The quantity of District assets affected by potential SLR inundation is projected to increase over time. Critical assets such as the stormwater system become affected with potential inundation at 2.5 feet of projected SLR. Lower elevations in the southern portion of the planning district may experience potential inundation with 1.6 feet of projected SLR. The potential for more widespread inundation may occur at 4.9 feet of projected SLR, with a majority of pathways, bikeways, roads, parks, piers, properties and the stormwater system being impacted.

Temporary coastal flooding from a 100-year storm event (100-year Storm Event)

Public access, via pathways or bikeways, would become increasingly more limited with a storm event starting at 1.6 feet of projected SLR. As these assets have low sensitivity and high adaptive capacity to temporary coastal flooding from a 100-year storm event, they should become fully functional following a storm event assuming no substantial damage.

While a less that ten percent of buildings may be impacted at 1.6 feet of projected SLR with a 100-year storm event, there is the potential for almost half of the buildings to be impacted by a 100-year storm event at 4.9 feet of projected SLR. Roadways within the planning district may experience temporary coastal flooding from a 100-year storm event with a 4.9-foot rise in sea levels.

Table 3.22: Coronado Bayfront Asset Vulnerability from Potential Inundation with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Inundation			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	4.5	HIGH	LOW	0%	0%	0%	10%
Bikeways (linear miles)	1.2	LOW	HIGH	0%	0%	9%	78%
Pathways (linear miles)	2.3	LOW	HIGH	0%	0%	8%	68%
Buildings (count)	24	HIGH	LOW	0%	0%	0%	25%
Piers (count)	1	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	39	HIGH	LOW	0%	0%	6%	75%
Beach Accessible Areas (acres)	1.9	HIGH	LOW	67%	76%	84%	100%
Parks (acres)	23.6	LOW	HIGH	8%	9%	11%	39%

Table 3.23: Coronado Bayfront Asset Vulnerability from Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise

Assets	Total Quantity in District	Sensitivity	Adaptive Capacity	Exposure to Temporary Coastal Flooding			
				0.8 ft SLR	1.6 ft SLR	2.5 ft SLR	4.9 ft SLR
Roads (linear miles)	0.8	HIGH	LOW	0%	0%	0%	59%
Bikeways (linear miles)	1.5	LOW	HIGH	10%	25%	47%	85%
Pathways (linear miles)	2.0	LOW	HIGH	11%	20%	40%	85%
Buildings (count)	28	HIGH	LOW	0%	8%	13%	42%
Piers (count)	1	HIGH	LOW	0%	0%	0%	100%
Stormwater Management (count)	16	HIGH	LOW	6%	31%	31%	81%
Beach Accessible Areas (acres)	3.4	HIGH	LOW	83%	87%	97%	100%
Parks (acres)	29.8	LOW	HIGH	10%	11%	16%	63%

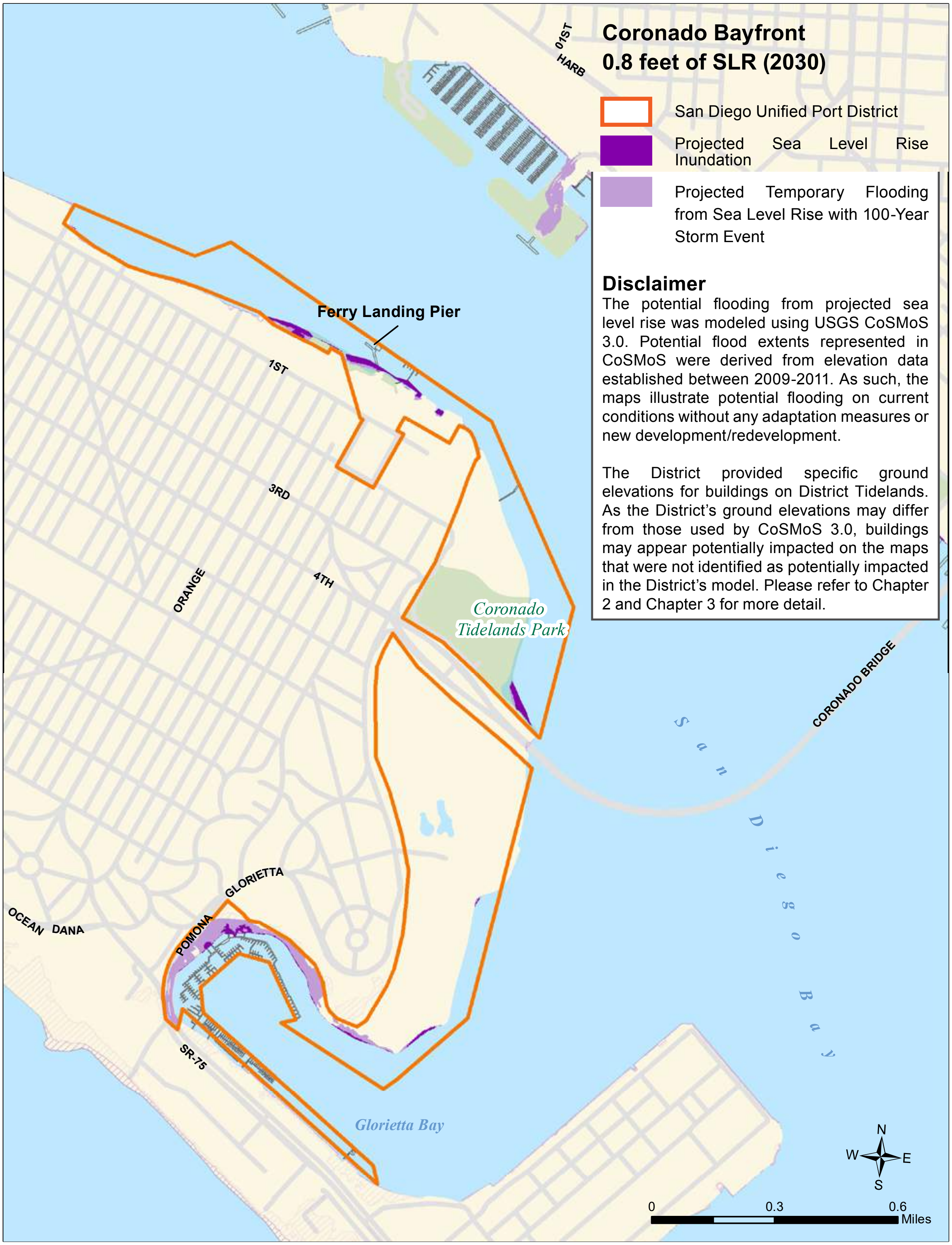

Figure 3.41: Coronado Bayfront Planning District Temporary Coastal Flooding (100-year storm event) and Inundation with Projected Sea Level Rise in 2030

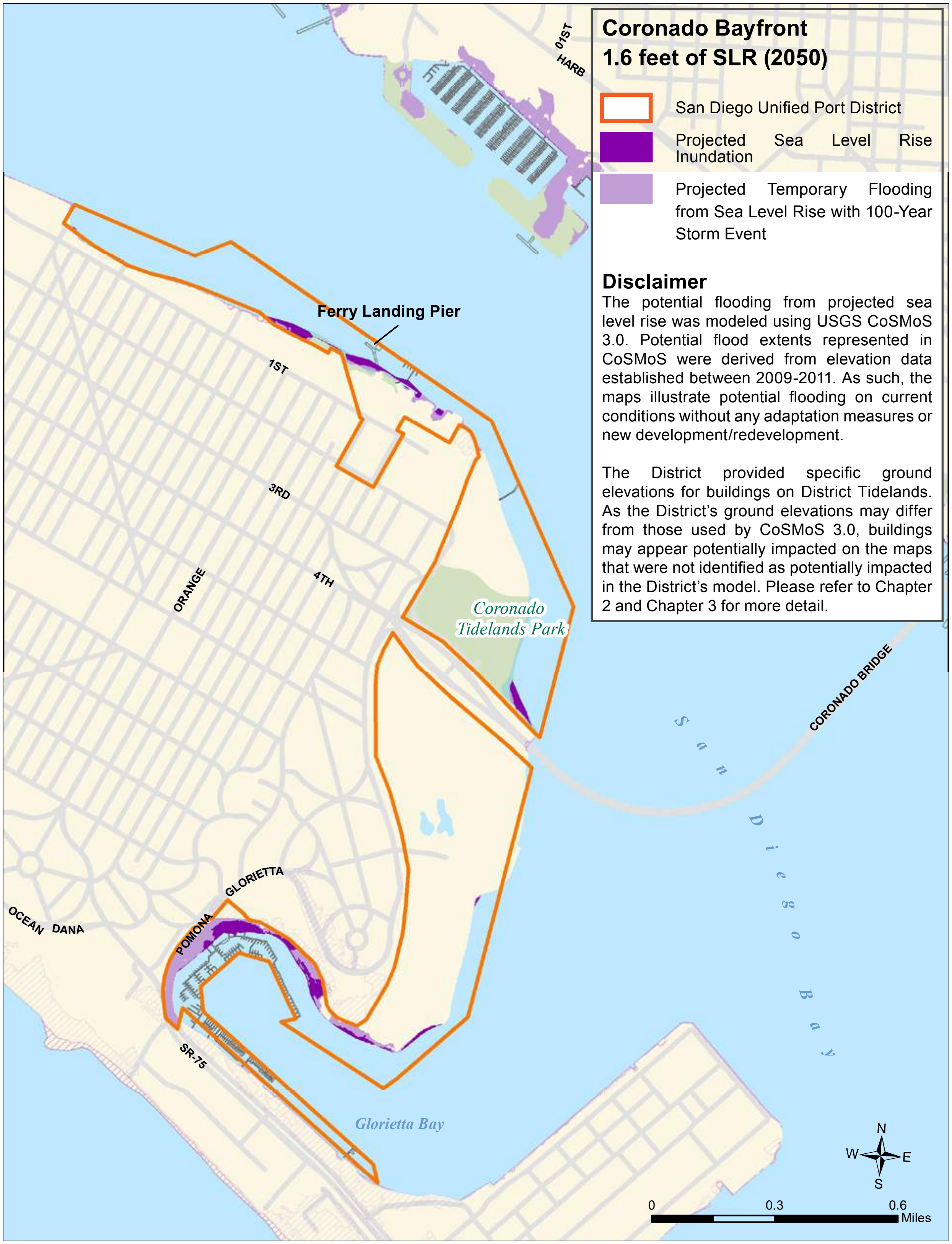

Figure 3.42: Coronado Bayfront Planning District Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2050

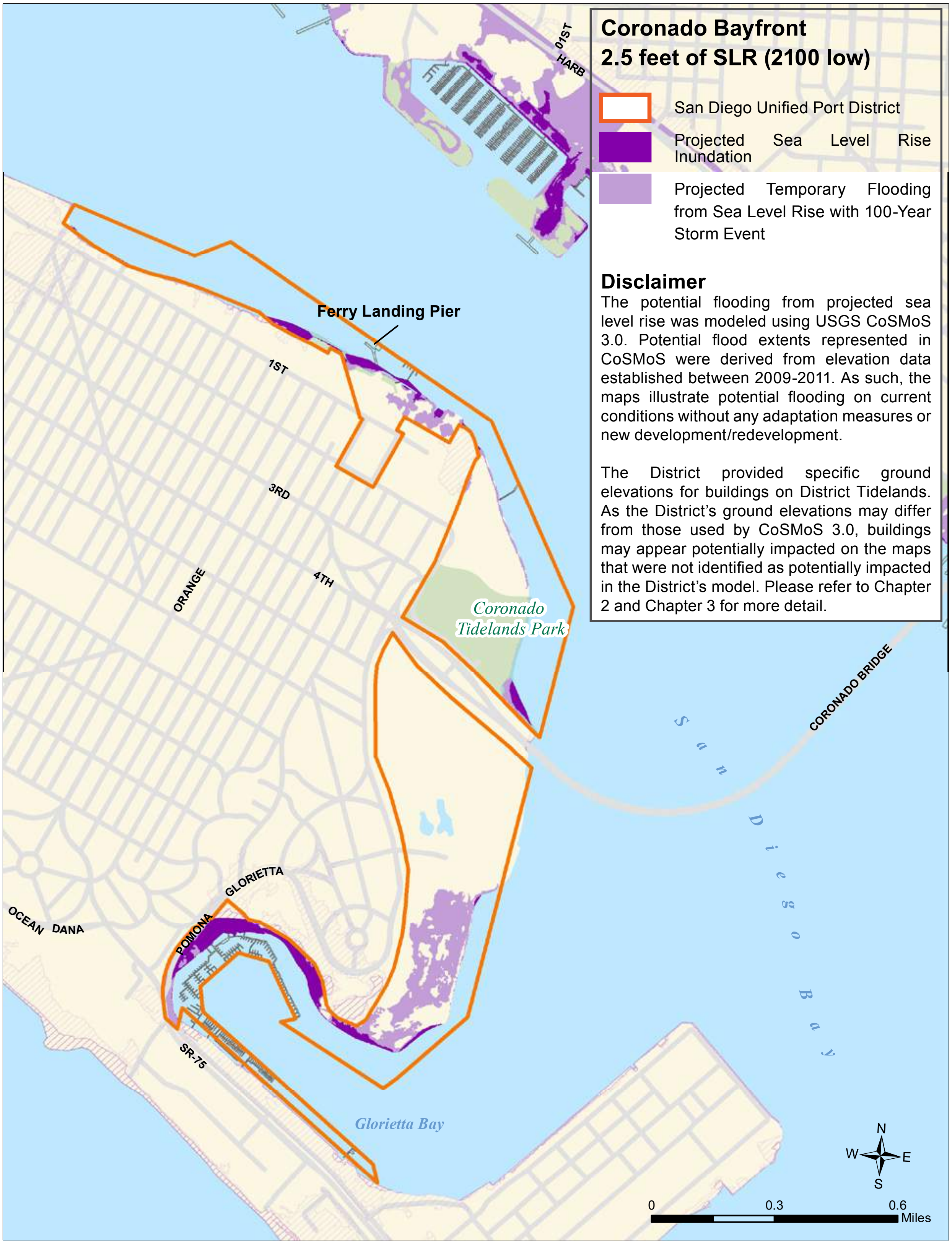

Figure 3.43: Coronado Bayfront Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (Low Scenario)

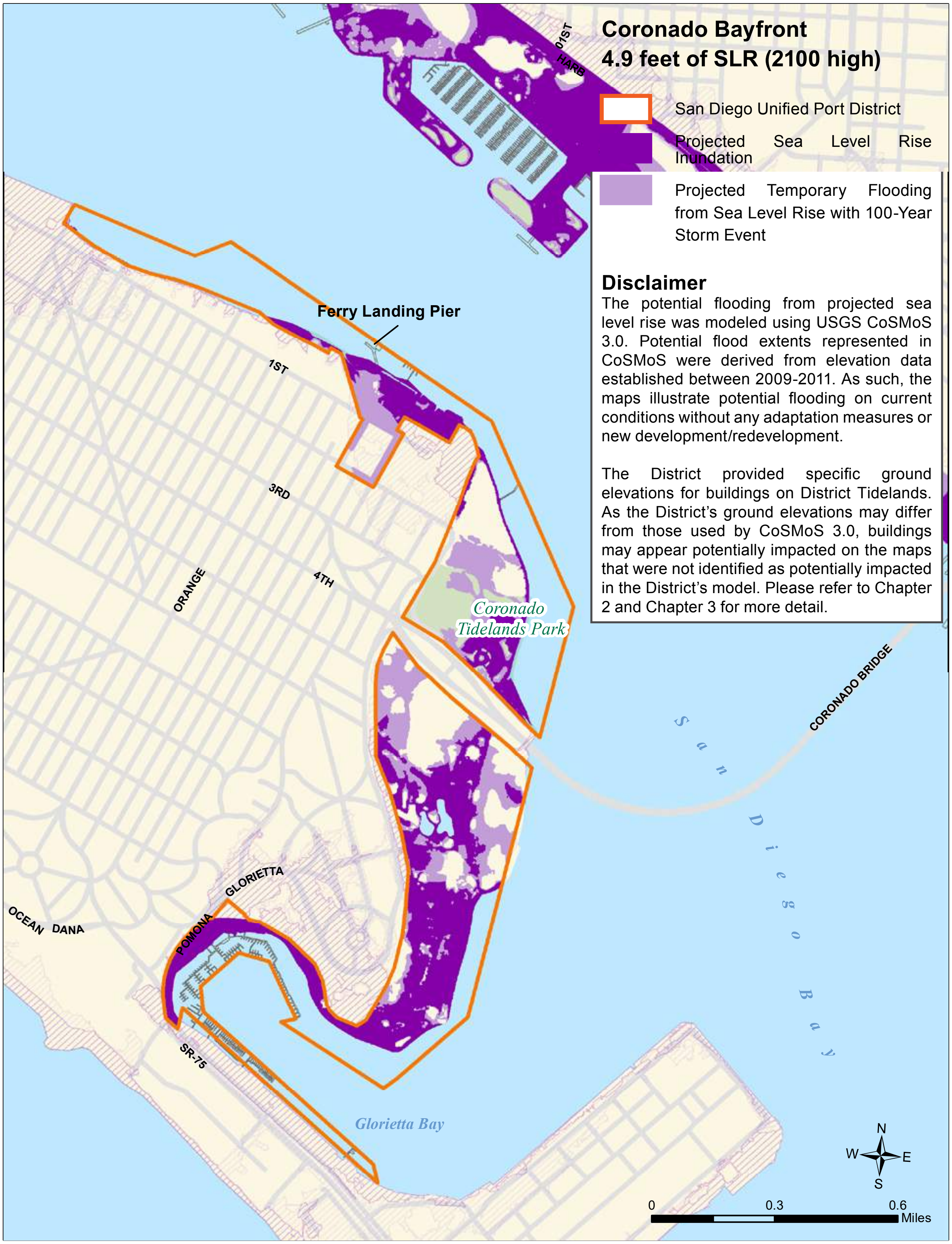

Figure 3.44: Coronado Bayfront Potential Inundation and Temporary Coastal Flooding (100-year storm event) with Projected Sea Level Rise in 2100 (High Scenario)

3.4 Natural Resources

Various natural resources including subtidal, intertidal, and upland habitats, exist in and around the Bay within the District's jurisdiction. These resources provide critical foraging, shelter, and nesting opportunities for marine life and birds. In addition, nearshore habitats help to stabilize the shoreline, collect sediment, and reduce erosion. Habitats in the Bay may be able to persist in the face of projected SLR through natural landward migration and vertical accretion, a process by which a habitat "moves" up elevation or upslope. However, due to the low elevation of these nearshore habitats, as well as constraints from adjacent urban land uses, projected SLR may pose a risk to their future existence and distribution.

The analysis of potential impacts projected SLR may cause to natural resources was conducted on a District-wide scale. As described in Section 2.5, this analysis was conducted differently than the assessment of exposure to infrastructure. Natural resources, within the marine environment, may already be exposed to sea water and varying degrees of potential inundation. The presence and depth of potential inundation are, in fact, key components of the type of natural resources that occur in and around San Diego Bay. Therefore, a typical GIS overlay analysis of potential SLR inundation was not appropriate for determining impacts to natural resources. Instead, an elevation-based analysis of nearshore habitats within the District's jurisdiction was conducted to evaluate future changes to habitat distribution as specific habitats migrate upslope with increasing projected SLR. A full report of potential impacts to nearshore habitats is included in Appendix B.

Baseline Habitat Distribution and Elevation

To assess future impacts to habitats from projected SLR, existing habitat data was obtained in a GIS format and mapped as illustrated in Figure 3.45. Habitats included eelgrass (Zostera marina L. and Z. pacifica), salt marsh including low to high marsh species, uplands representative of a variety of species including but not limited to California sagebrush (Artemisia californica), and beach/dunes. Table 3.24 provides the acreage and elevation range of each of the habitats incorporated into this analysis. Included in the table is the total available area within the District's jurisdiction that exists at a given elevation.

Figure 3.45: San Diego Unified Port District Habitats

Table 3.24: Baseline Habitat Distribution and Elevation

Habitat Type	Baseline Habitat Mapped (acres)	98% Elevation Range (feet, Analysis Range)[1]		Total Available Area (acres)	% Occupied
		Low	High		
Eelgrass	915.0	-10.7	+0.8	1,717.7	53%
Salt Marsh	81.1	+0.8	+11.5	531.6	15%
Beach/Dune[2]	13.5	0	+16.4[3]	NA[2]	NA[2]
Uplands	97.0	+6.6	+27.9[3]	425.9	23%

[1]North American Vertical Datum of 1988
[2]Beach/dune habitat is assumed to exist where those historical habitats occurred prior to development and have been maintained or allowed to remain. As both are driven by sediment and wind processes, they are considered static with no additional areas available.
[3]Maximum value mapped for those habitats.

The proportion of mapped acres to total available acres was calculated to determine percent occupied.

Future Habitat Distribution with Sea Level Rise

As sea level rises, the depth of sea water increases. Habitats may be able to keep pace with rising sea levels by migrating to appropriate elevations suitable for their existence; however, urban land uses adjacent to natural areas along the coast may hinder the movement of habitats and, therefore, reduce the area available for them to persist. Conversely, habitat may increase in area depending on whether there is more space at a higher elevation in which to move.

To understand the future distribution of habitats with increasing sea levels, the area (in acres) per 0.8 feet of elevation was calculated within the District. Only those areas that were considered natural or undisturbed were used to measure area per elevation. Those areas considered urban were used as constraints to habitat movement.

For each baseline habitat area and associated elevation (as presented in Table 3.25), the future sea levels presented in this AB 691 Report were used to assess the future distribution of each habitat with the assumption that the habitat can naturally move upslope to the next 0.8-foot elevation range. For example, eelgrass currently exists between -10.7 feet and +0.8 feet. With

Table 3.25: Future Potential Habitat Distribution

Habitat Type	Baseline[1] No Sea Level Rise		Sea Level Rise Scenarios[2] Year 2030 +0.8 feet		Year 2050 +1.6 feet		Year 2100 Low +2.5 feet		Year 2100 high +4.9 feet	
	Available	Occupied	Available	Occupied	Available	Occupied	Available	Occupied	Available	Occupied
Eelgrass	1,718	915	1,752.7	982.8	1,762.3	1,016.3	1,747.5	979.4	1,621.5	668.2
Salt Marsh	532	81	472.6	75.9	432.7	74.4	415.1	75.2	370.5	78.3
Beach/ Dune[3]	13	-	-	12.7	-	11.6	-	10.7	-	8.6
Uplands	426	97	394.5	90.1	360.0	82.2	322.1	73.4	222.6	50.8

[1]Baseline values are based on the current vegetation map and elevation data.
[2]All sea level rise scenarios acreages are predictions based on the mapped baseline conditions and the resulting elevation ranges and mapped percent occupancy.
[3]Beach/dune habitats are driven primarily by sediment and wind processes; they are considered static with no additional areas available.

0.8 feet of projected SLR, which may occur by year 2030, eelgrass that exists at lower elevations may not be able to persist as the depth of water increases. However, eelgrass may be able to move upslope and occupy available area between 0.8 and 1.6 feet. If the higher elevation to which eelgrass can move is greater in area compared to the area lost at the lowest elevations (between -10.7 and -9.9 feet), then eelgrass can increase its distribution.

Table 3.25 provides an overview of the available area (in acres) for each habitat type under each of the four projected SLR scenarios based on the analysis range. In addition, the acres of predicted occupied habitat are shown for each habitat based on the baseline occupancy rates. Overall the terrestrial habitats (salt marsh, beach/dune, and upland) decline with the higher projected SLR scenarios. This declining trend is consistent with existing research but likely underestimates the decline due to a variety of assumptions required for this analysis, assuming there is adequate time for habitat to respond in advance of rising seas. Eelgrass has a unique trend, with increasing acreage in the moderate projected SLR scenarios, but then a sharp decline in the 4.9 feet projected SLR scenario. With 4.9 feet of projected

SLR, a loss of acres for eelgrass is driven by a reduction in available area coupled with a larger reduction in the preferred range, with more of the available habitat occurring in the deeper range where occupancy rates are lower.

Available acres of salt marsh habitat decline as projected SLR increases. However, the occupied rate is relatively stable as there may be available uplands to which salt marsh can migrate. It should be noted, however, that upland habitats which support environmental management objectives such as preservation of nesting sites for California least terns may limit transition of salt marsh. Such management objectives will need to be discussed among natural resource managers as projected SLR increases.

Lastly, beach/dune and upland habitats both decline with rising sea levels. These habitats are specifically constrained as sea water encroaches and urban land uses prevent their movement.

The analysis conducted for this AB 691 Report was a general evaluation to assess whether area of land increases or decreases at elevations where habitats are found in the District's jurisdiction. There are many factors that contribute to the presence and absence of specific habitats beyond simply elevation and projected SLR. Therefore, further analysis will need to be considered to better manage natural resources in and around the Bay in the face of projected SLR and 100-year storm events. As a variety of agencies and stakeholders manage natural resources adjacent to the District's jurisdiction, including the U.S. Fish and Wildlife Service and the U.S. Navy, continued coordination is necessary to align management priorities and objectives.

3.5 Financial Impacts

Tables 3.26 and 3.27 on the following pages, shows the estimated financial impacts for the projected SLR scenarios. Table 3.26 shows the predicted sea level heights without a 100-year storm and Table 3.27. shows predicted sea level heights with a 100-year storm.

Tables 3.26 and 3.27 show potential primary and secondary impacts from projected SLR. The District selected properties and infrastructures likely to be damaged from projected SLR, whether due to potential projected SLR inundation, or temporary coastal flooding from a 100-year storm event. The secondary impact categories represent the indirect impacts that would be caused by the primary impacts, such as loss of District business revenue or storm cleanup, traffic control, and emergency responses. Some impacts, such as the potential loss of business revenue are discussed qualitatively elsewhere in this report.

3.5.1 Sea Level Rise Without a 100-Year Storm Event

The estimated damages without a 100-year storm event represent damages that would result from potential inundation under the "no action" (no adaptation strategies) conditions. That is, potential damages would be caused by increased projected SLR that could permanently flood assets if no adaptation strategies were enacted to mitigate or prevent damages. Potential inundation could lead to a loss of District revenue due to a potential loss of land. (Please see Appendix C for the methodology and more information about how estimates were calculated and what was included in each category.)

For all projected SLR scenarios without a 100-year storm event, the greatest financial impacts would be due to the potential loss of transportation and other infrastructure (Table 3.26). For the 0.8 feet and 1.6 feet scenarios, transportation and other infrastructure combined damages are estimated to be over $45 million; and for the 2.5 feet and 4.9 feet scenarios, damages are estimated to be over $95 million, and for the 4.9 feet scenario, infrastructure damages are estimated to be over $600 million.

Sea level rise impacts are also projected for property throughout the District. For the 0.8 feet and 1.6 feet scenarios, property damages are estimated to be approximately $1.2 million each. Damages for the 2.5 feet scenario are estimated to be over $1 million, and for the 4.9 feet scenarios, damages are estimated to be over $267 million.

Total financial damages, which also include the District's loss of revenue, for 0.8 feet and 1.6 feet are estimated to be $63 and $69 million, respectively. Financial damages for 2.5 feet and 4.9 feet are estimated to range from approximately $127 million to $922 million.

It is important to note that land value is not included in property estimates due to the differing methodology for identifying land and structure impacts. As discussed more in the methodology section in Appendix C, the District

Table 3.26: Estimated Financial Impacts: Potential Inundation with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet	2030 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2030.	**Primary Damage:** Property (structures, parking lots)[1] Transportation infrastructure Other infrastructure **Secondary Damage:** Loss of Port Business Revenue[2] Total	 $1,200,000 $18,400,000 $27,300,000 $16,100,000 $62,900,000
1.6 feet	2050 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2050.	**Primary Damage:** Property (structures, parking lots)[1] Transportation infrastructure Other infrastructure **Secondary Damage:** Loss of Port Business Revenue[2] Total	 $1,200,000 $23,900,000 $27,300,000 $16,100,000 $68,500,000
2.5 feet	2100 SLR with no storm event under 50% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:** Property (structures, parking lots)[1] Transportation infrastructure Other infrastructure **Secondary Damage:** Loss of Port Business Revenue[2] Total	 $6,300,000 $61,400,000 $34,700,000 $24,800,000 $127,100,000
4.9 feet	2100 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:** Property (structures, parking lots)[1] Transportation infrastructure Other infrastructure **Secondary Damage:** Loss of Port Business Revenue[2] Total	 $266,900,000 $551,700,000 $64,300,000 $39,200,000 $922,100,000

Table 3.27: Estimated Financial Impacts: Potential Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet + water increase from 100-yr storm event	2030 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2030.[3] Estimating per storm event the potential coastal flooding damages in the year 2030.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$1,500,000 $1,500,000
1.6 feet + water increase from 100-yr storm event	2050 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2050.[3] Estimating per storm event the potential coastal flooding damages in the year 2050.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$6,300,000 $6,300,000
2.5 feet + water increase from 100-yr storm event	2100 SLR under 50% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$12,100,000 $12,100,000
4.9 feet + water increase from 100-yr storm event	2100 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial) **Secondary Damage:** Storm Cleanup, Traffic Control, Emergency Response.[4] Total	$152,400,000 $152,400,000[5]

Note: Sea level rise estimated damages that occur without a storm event (inundation) are not included in the 100-yr storm estimates. 100-year storm flooding damages represent only those potential damages that would occur in addition to the loss due to sea level rise without a storm event.

[1]Impacted buildings were identified by the District and may not be consistent with the CoSMoS inundation and coastal flooding boundaries. Impacted parking lots were determined from CoSMoS boundaries. Therefore, parking lot and building impacts may not be consistent.

[2]Following the NOAA *What Will Adaptation Cost? Impact Assessment* methodology, this estimate only represents the annual loss for the corresponding scenario year in 2018 dollars. The Impact Assessment methodology estimates damages based on water height and one point in time. However, if the property were lost, the revenue loss would occur for subsequent years as well.

[3]Estimates represent the financial impact from temporary coastal flooding from a 100-year storm event with the corresponding projected SLR elevations.

[4]Cleanup, traffic control, and emergency response are included in annual operating budgets of the District staff. These potential impacts are discussed qualitatively in the report.

[5]Because inundation damages are expected to be substantially greater under the 4.9 feet scenario, 100-year storm event coastal flooding damages are less than previous scenarios.

identified structure impacts using their own model with local data, while parcel land impacts were based upon CoSMoS identified potential projected SLR inundation boundaries. In some areas, the impacts identified by the two models were not consistent. The value of property typically would be estimated from the value of both land and structures; however, due to the inconsistent methodology, this analysis deemed it inappropriate to combine the output of both models to estimate one property value of parcels with both structures and land. Therefore, only structure estimates are included in the analysis, and not land.

3.5.2 Sea Level Rise with a 100-year Storm Event

The estimated damages for the 100-year storm event represent additional damages that would occur on top of the potential inundation damages for the corresponding projected SLR water height (the assessment's SLR projections are associated with water heights before a storm event (i.e., 0.8 feet, 1.6 feet, 2.5 feet, and 4.9 feet). A 100-year storm event would result in an additional temporary coastal flooding from a 100-year storm event. On average, a 100-year storm event could result in further flooding of up to approximately 3.77 feet depending upon the scenario and land elevation (OCOF, 2019). Thus, 100-year storm event flooding could result in added damages. For example, at 0.8 feet, it is estimated that $62.9 million in damages would result from potential inundation plus an additional $1.5 million is estimated if there were 100-year storm flooding event. Again, these estimates assume damages that would transpire without implementing additional adaptation strategies.

It is important to point out that a 100-year storm event is a storm that is predicted to occur once every 100 years. Thus, it is highly unlikely that a 100-year storm event would occur in 2030, 2050, and 2100. The predicted scenarios in Table 3.27 are not meant to suggest that 100-year storm damages would transpire at all three points in time. Rather, the table provides an estimate of the potential damages for a 100-year storm occurring with a projected SLR scenario (e.g., 1.6 feet).

Coastal flooding damages are estimated to result in damages to structures under this analysis. Storm event flooding, including during a 100-year storm event, is temporary and is not projected to damage the land. While it is foreseeable that temporary storm flooding could require cleanup, and/or traffic control and emergency response for transportation and other infrastructure (e.g., storm drains), these events were not analyzed.

As shown in Table 3.27, damage to structures would have the greatest financial impacts. Storm event damages, in addition to the previously discussed potential inundation damages, could result in almost $1.5 million in structural damages under the 0.8 feet scenario, and more than $6 million under the 1.6 feet scenario. Estimated flooding damages from a 100-year storm event are $12.1 million under the 2.5 feet scenario, and $152.4 million for the 4.9 feet scenario. The storm flooding analysis accounts for structures that are impacted by potential inundation so that they are not double-counted in the financial estimates.

3.5.3 Natural Resource Valuation

Examining the ecosystem services provided by habitats within the Tidelands will help to better understand the value (monetary and non-monetary) of those habitats. Ecosystem services represent the benefits people obtain from the ecosystem and, through the Millennium Ecosystem Assessment, are organized into four broad categories: provisioning, regulating, cultural, and supporting (Table 3.28; MA, 2005).

Ecosystem services identified for each of these categories document some type of value provided to direct and indirect users of habitats within the District. Shifts in habitat size and type can affect, both positively and negatively, the overall well-being of those users.

Five general valuation methods were identified that can be used to monetize natural resources. While a framework was developed to best analyze the District's natural resources, the time and data constraints associated with these methods are prohibitive. An alternate, preferred approach was developed using a benefit transfer method.

Benefit transfer methodology is the preferred valuation method as it is mostly used in instances where resources (e.g., time and money) are limited. However, caution must be taken to ensure that values are transferred between comparable goods and/or services. If characteristics differ enough between them, the values may not be accurate and could significantly over or underestimate the natural resource in question. Figure 3.29 identifies the

Table 3.28: Primary Ecosystem Services for Port Tideland Habitats

Provisioning	Regulating
• Fisheries support • Animal harvesting • Direct food production • Mineral extraction	• Carbon sequestration • Shoreline stability and erosion control • Flood and storm protection • Water purification and waste treatment
Cultural	**Supporting**
• Cultural activities • Recreation • Education • Tourism • Aesthetics	• Refugia habitat • Habitat provision and food web support • Nutrient cycling

Table 3.29: Advantages and Disadvantages of Benefit Transfer Method

Advantages	Disadvantages
• Avoids the cost and time associated with conducting a primary study • Least data intense of all methods	• Must find studies with comparable natural resources • Values may not reflect actual conditions of resources being evaluated • May require "adjusting" of values • Variations in methods from original studies may not be comparable

resources within the District is estimated to decrease to a range of $29 million to $45 million.

For more information regarding the Resource Valuation Methods, please see Appendix D.

3.6 Cascading Impacts

Cascading impacts can be defined as a series of secondary impacts that are triggered by the primary loss of an asset, a specific function, or a service (County of San Mateo 2018). These impacts could occur when an asset is affected by flooding, and its impacts primary advantages and disadvantages associated with benefit transfer valuation methods.

Table 3.30 presents the total value ($/year) of each habitat and for those services valued for the whole system under baseline conditions and four projected SLR scenarios (0.8 feet, 1.6 feet, 2.5 feet, and 4.9 feet). Results were found by multiplying the estimated acreage by the total dollar per acre ($/acre) for each habitat. Data provided in Table 3.30 indicate the low and high estimated values ($/acre/yr.) for each case study. Values are differentiated by habitat type and the respective ecosystem service. In some instances, values were collected that represent the system and are not allocated to an individual habitat.

Current value services provided by natural resources within the District range from $40 million to $61 million per year. The ecosystem services identified for each of the habitats were combined to estimate the total value of the District's natural resources. With projected SLR, the extent of different habitats may change, leading to changes in the predicted value of these resources. Under the most extreme projected SLR scenario (4.9 feet), the value of natural

View of Downtown San Diego

Table 3.30: Total Habitat Values

SLR	Acres	Low Estimate ($/yr)	High Estimate ($/yr)
Eelgrass			
Baseline	915	$11,339,205	$11,456,219
0.8 feet	983	$12,178,846	$12,304,524
1.6 feet	1,016	$12,593,963	$12,723,924
2.5 feet	979	$12,137,569	$12,262,821
4.9 feet	668	$8,279,930	$8,365,374
Salt Marsh			
Baseline	81	$676,091	$809,447
0.8 feet	76	$632,848	$757,675
1.6 feet	74	$620,939	$743,417
2.5 feet	75	$627,548	$751,330
4.9 feet	78	$653,392	$782,272
Beach/Dune			
Baseline	13	$41,459	$41,836
0.8 feet	13	$39,002	$39,356
1.6 feet	12	$35,616	$35,939
2.5 feet	11	$32,919	$33,218
4.9 feet	9	$26,559	$26,800
Uplands			
Baseline	97	$228,100	$228,100
0.8 feet	90	$211,871	$211,871
1.6 feet	82	$193,262	$193,262
2.5 feet	73	$172,781	$172,781
4.9 feet	51	$119,404	$119,404
Whole System			
Baseline	1,107	$28,029,798	$48,946,184
0.8 feet	1,161	$29,419,821	$51,373,470
1.6 feet	1,184	$30,003,952	$52,393,492
2.5 feet	1,139	$28,848,345	$50,375,547
4.9 feet	806	$20,414,163	$35,647,614

generate additional adverse effects. Cascading impacts, which are most typically associated with networked infrastructure, cause the effect of a flood to reach beyond the geographic extent of the flood. Roads, rail, and stormwater systems are particularly susceptible to failures and interruptions as disruption in one component can affect the entire system. Cascading impacts should be considered when evaluate vulnerabilities to projected SLR and when planning for adaptation.

Nesting terns in South Bay Salt Lands

Chapter 4 Adaptation Planning and Strategy Implementation

4.1 An Adaptive Management Framework

Given the level of uncertainty in projections of SLR, the District's ability to be flexible in adapting to SLR is crucial. For this reason, the District is proposing an *adaptive management approach* to address projected SLR, defined as "a process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change" (IPCC 2014). Adaptive management is not a new scientific concept and the District already utilizes it for many of its environmental management programs.

Extending the adaptive management approach to coastal resiliency will allow the District to adjust policies and/or strategies that help to reduce the risks associated with projected SLR inundation and temporary coastal flooding from a 100-year storm event as new information regarding climate science and/or techniques to address coastal hazards emerge.

The Adaptive Management Framework (Framework) shown in Figure 4.1 is composed of three stages:

(1) A Vulnerability Assessment
(2) Adaptation Planning
(3) Strategy Implementation.

This Framework promotes an iterative, cyclical process whereby each stage can be continually improved as new information is collected and integrated.

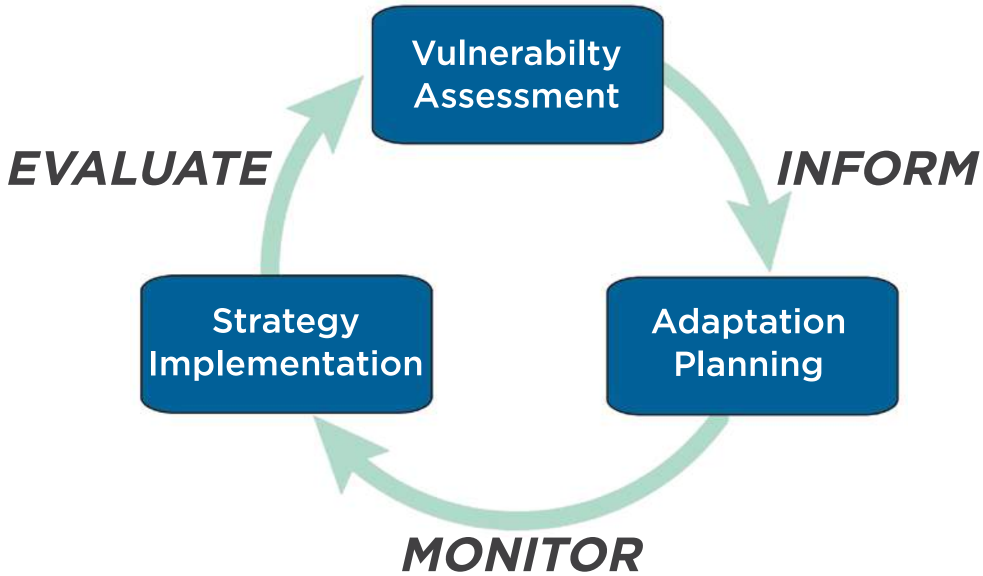

Figure 4.1: Sea Level Rise Adaptive Management Framework

The first stage of the Adaptive Management Framework is the Vulnerability Assessment. The process of conducting a vulnerability assessment is necessary to understand risks of exposure to SLR. This was described in detail in Chapters 2 and 3 of this report. A vulnerability assessment should be conducted regularly to assess progress to reduce risks.

The term "Adaptation" is commonly used when planning for projected SLR because of the inherent uncertainty of predicting future sea level changes. Therefore, the strategies used to reduce risks of projected SLR inundation and coastal flooding from a 100-year storm event need to be proactively planned, and require flexibility in their implementation to adjust to changing conditions over time. A strategy may be adaptive if it can be enhanced in the future to higher sea levels due to proactive planning when first implemented.

4.2 Adaptation Planning

The second stage of the projected SLR Framework, Adaptation Planning, is intended to provide *guidance* for the selection and implementation of suitable projected SLR adaptation strategies. Informed by the Vulnerability Assessment, this stage involves evaluating the exposure, sensitivity, adaptive capacity, and other associated impacts (e.g., financial) to identify projected SLR adaptation strategies are suitable. This step also includes the develop of a monitoring program that informs *when* to implement the selected strategies.

For this AB 691 Report, the District is not providing specific adaptation strategies for each potentially vulnerable asset or area (as described in Chapter 3). Due to the diversity and unique characteristics of the Public Trust lands managed by the District, a "one-size-fits-all" strategy is not conducive as adaptation strategies would need to be applied based on site-specific characteristics and vulnerabilities.

4.2.1 Adaptation Strategies

The suite of options available for adapting to projected SLR comprises three basic types (protection, accommodation, adjustment) or a hybrid of two or more options.

Protect

Protection strategies typically use natural or man-made infrastructure to defend existing structures or areas in their current location.

Accommodate

Rather than protecting an asset from flooding or erosion, accommodation strategies enable the asset to continue functioning in its exposed environment by making adaptive changes to the asset itself.

Adjust

Adjust strategies focus on removing or relocating existing development out of hazard-prone areas and limiting new development in vulnerable areas.

Furthermore, the District has organized adaptation strategies according to policy change, natural structural approaches, shoreline solutions, or changes to existing buildings. Each of these categories is described below:

- Policy considerations for projected SLR include strategies to reduce flood damage through design guidelines, checklists, setbacks, or operational changes.
- Natural or nature-based solutions include natural features such as wetlands, reefs, living shorelines, and coastal dunes to dissipate wave action and safeguard a shoreline from erosion.

- Shoreline solutions are predominantly used to repel and alter the flow of floodwater. These solutions include sea walls, bulkheads, levees, and breakwaters.
- Building/infrastructure approaches include design and engineering techniques to reduce or prevent damages from potential flooding and inundation. An example of an infrastructure-related approach may be to floodproof electrical equipment in a building or move sensitive equipment from a basement to an upper-level floor.

Tables 4.1 through 4.4 provide a list of adaptation strategies, per the categorizes outlined above. Included in the tables are costs to implement the strategy. It should be noted that the tables represent a non-comprehensive list of strategies, and the District may pursue others.

This AB 691 Report provides an adaptation planning process that can be used by the District and relevant stakeholders to plan for, and respond to, projected SLR. Developing a process, rather than select strategies to be applied in the future when conditions may drastically change, provides greater flexibility and potential

Table 4.1: Examples of Policy Adaptation Strategies

Strategy	Type	Description	Cost
Protect District Mission-Driven Uses	Protect	Coastal-dependent uses, critical infrastructure, and public accessways should employ shoreline adaptation strategies that protect against, then accommodate, temporary coastal flooding or inundation.	N/A
Limit redevelopment in at-risk locations	Protect	Prohibit redevelopment of storm- or flood-damaged structures in highly vulnerable areas or prohibit redevelopment of repetitive loss structures.	N/A
Design standards	Accommodate	Could include minimum elevation requirements for structures and/or utilities.	N/A
Provide Adequate Setbacks	Adjust	Prescribes a distance to waterfront from which all or certain kinds of development are prohibited.	N/A

cost-effectiveness. The U.S. Navy has developed a handbook that provides a framework and methodology to help their planners consider potential inundation and temporary coastal flooding from a 100-year storm event when implementing projects and infrastructure (NAVFAC 2017). The handbook describes a process to properly select adaptation strategies based on several criteria using a step-wise decision-making formula. The District has elected to use a modified version of the Navy's decision-making process as it presents a defensible way to compare appropriate strategies and implement solutions.

Table 4.2: Examples of Natural or Nature-Based Adaptation Strategies

Strategy	Type	Description	Cost
Living Shoreline (wave attenuation)	Protect	Buffer estuaries, bays, and other sheltered shorelines from wave action. May stabilize the shoreline, reduce erosion and provide habitat.	$1,000/linear ft
Living Breakwaters (Oyster Reef/ Floating Reef)	Protect	Intended to protect against storm surge and coastal erosion, a living breakwater is intentionally designed to incorporate natural habitat components.	$500,000/acre
Bioenhancing Concrete	Protect	Bio-enhancing concrete admixtures, complex surface textures and science-based design. The structures are tailored to encourage growth of flora and fauna, which can provide protection in coastal zones.	$2,750/unit
Beach Nourishment	Accommodate	The practice of adding large quantities of sand or sediment to beaches to combat erosion and increase beach width.	$19/cubic yard
Wetland terraces	Accommodate	A wetland-restoration technique used to convert shallow subtidal bottom to marsh. Uses existing bottom sediments to form terraces or ridges at marsh elevation.	$6,500/linear ft
Sediment augmentation	Accommodate	Artificially increasing sediment onto marsh surfaces or elevating eelgrass beds.	$700,000/inch per acre
Restoration	Accommodate	Restoring salt marsh or eelgrass natural hydrology or extensive excavation with revegetation.	$16,000-$45,000/acre

Table 4.3: Examples of Shoreline Strategies

Strategy	Type	Description	Cost
Revetment (Dynamic/ Geotextile)	Protect	Sloping structures placed on banks or cliffs in such a way as to absorb the energy of incoming water. Made from a variety of materials including geotextiles filled with sand or slurry; stone; grouted or cemented stone or gravel; and asphalt.	$325/linear ft
Breakwater (Branch Box/ Floating/ Submerged)	Protect	A breakwater is a coastal structure (usually a rock and rubble mound structure) projecting into the sea that shelters vessels from waves and currents and protects a shore area.	$200/sq. ft Or $16,000/linear ft
Bulkhead	Protect	Vertical shoreline stabilization structures that only retain surcharge loads and soil behind the load.	$13,500/linear ft
Seawall	Protect	Protect the shoreline from wave loads, and to retain surcharge loads and soil behind the wall.	$4,200/ linear ft
Groins	Protect	A shoreline protection structure built perpendicular to the shoreline of the coast to reduce longshore drift and trap sediments.	$5,100/ linear ft
Floating Sector Gate	Protect	Navigable storm surge barriers that move or rotate horizontally to close off a waterway to an incoming storm surge.	$5 million/ gate

Table 4.4: Examples of Building and Infrastructure Strategies

Strategy	Type	Description	Cost
Embankment	Protect	A wall or bank of earth or stone with sloping sides, built to prevent a water body from flooding a land area.	$3,400/ linear ft
Retractable Barriers/ Aquafence	Protect	Temporary barriers used to protect an asset from possible flooding.	$325/ linear ft
Elevate	Accommodate	Increase the ground floor height of an asset or facility.	$44/ sq. ft
Floodable Park	Accommodate	Designed to have areas of lower grade that can accept and hold excess water from nearby areas that would experience damage from flooding.	$750,000/ acre

Figure 4.1 illustrates five steps:

1. Set the Adaption Goal: Articulating the desired outcome of adaptation will help guide the selection of suitable strategies.
2. Identify Potential Strategies: Depending on exposure, sensitivity, adaptive capacity, financial impact, or cascading impacts of a vulnerable asset (e.g. land-based versus water-based, critical infrastructure, coastal-dependency, etc.) potential strategies can be identified.
3. Describe Benefits and Limitations: For each strategy identified, a description of benefits, limitations allows for comparison of strategies.
4. Evaluate Feasibility: The feasibility of each strategy should be assessed to ascertain its capability to be deployed and perform. Feasibility may include, but is not limited to, an evaluation of technical capability, financial viability, or legal consistency.
5. Assess Appropriateness: Each strategy should aim to align with and social, political, environmental, and economic objectives. An evaluation of consistency with existing plans, policies, and standards should be included. Furthermore, a strategy should support the desired outcome.

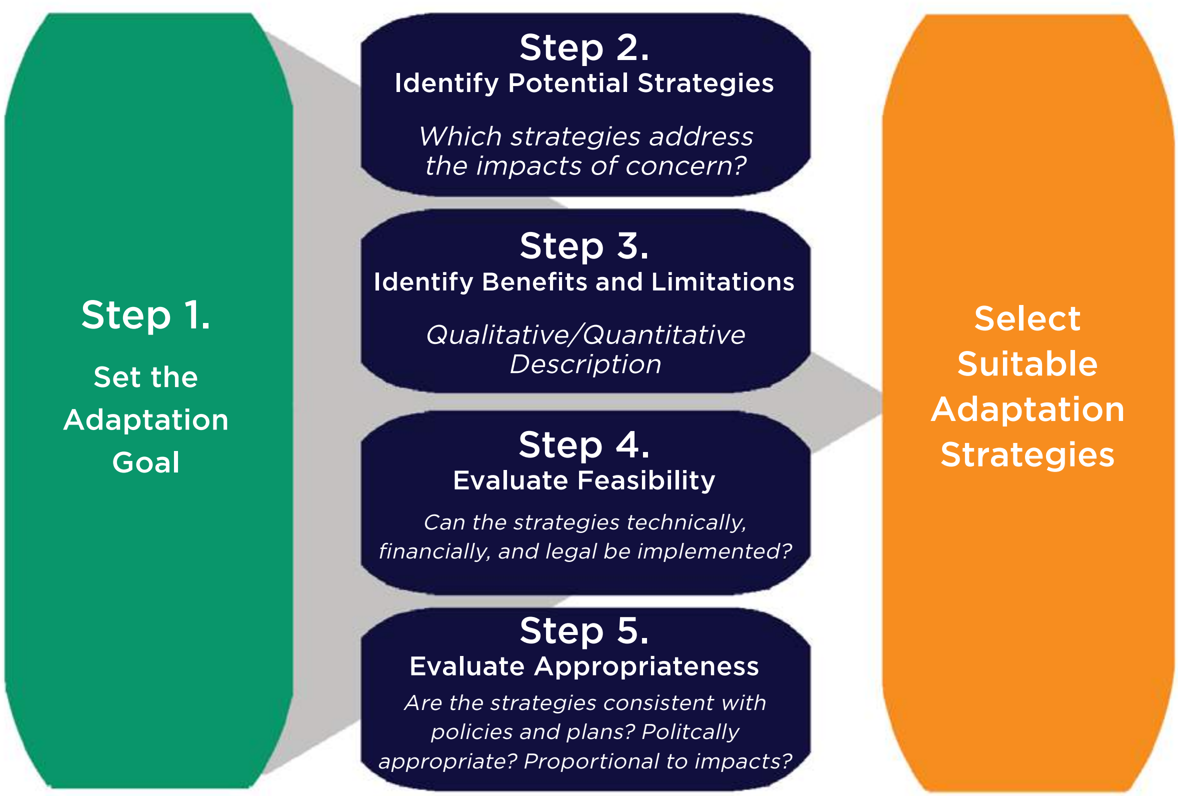

Figure 4.1: Proposed Adaptation Selection Process

The intent of the process described is to select a suitable strategy or strategies to reduce the risk of potential inundation and/or temporary coastal flooding from a 100-year storm event for a specific asset or area.

4.2.2 Develop and Implement a Monitoring Program

Planning and implementation of adaptation strategies occur as part of the District's general course of management of natural resources, maintenance of infrastructure, negotiations of lease terms, or redevelopment of properties. However, the implementation of future adaptation strategies must be flexible to environmental conditions, both physical and financial. By monitoring changing conditions, the District can better understand their evolution, and when to implement adaptation strategies.

The District already implements monitoring programs in and around the Bay. These programs include but are not limited to the of monitoring changes to the physical characteristics of the Bay, water and sediment quality, or habitat migration. Used in conjunction with projections of projected SLR, frequency of storm events, or future costs of damage, the District can better understand the potential trajectory of climate conditions to inform adaptation planning.

Table 4.5 illustrates potential indicators the District could use to monitor conditions in and around San Diego Bay. Where feasible, the District would utilize existing programs, tools, and resources to collect information. Moreover, the District will continue to work with external agencies and stakeholders to collaborate on projected SLR monitoring.

4.3 Strategy Implementation

The third stage of the Adaptive Management projected SLR Framework is Strategy Implementation. As discussed, the implementation of strategies may be precipitated by risk or observed changes through monitoring. The need for strategies may also occur during the regular course of District operations such as performing habitat restoration, installing new infrastructure, or developing new waterfront businesses and coastal dependent uses.

As District projects are located within the coastal zone, projects are subject to California Coastal Act permitting. The District's approach to implementation is largely consistent with the Coastal

Table 4.5: Proposed Sea Level Rise Monitoring Indicators

Indicator	Description
Physical Indicators	
Water levels	Measurement of still water elevations in San Diego Bay
Wave Activity	Measurement of maximum water elevations associated with storm surge and wave activity
Tide Levels	Do tides surpass a defined threshold
Frequency of Storms	Measurement of number of annual storm events
Biological Indicators	
Habitat Extent and Migration	Mapping of habitat acreages and extents in and around San Diego Bay
Habitat Health	Assessment of the diversity of habitat types to support healthy ecosystems
Operational Indicators	
Flooding frequency	Count of flooding events which occur in the built environment
Performance of Flood Defense Infrastructure	Measurement of how existing devices respond to inundation and temporary coastal flooding
Cost of Response	Estimation of the cost to respond to and replace assets damaged by flooding events

Commission's Guidance. As CoSMoS is not developed to be used for design of a project to reduce risks of potential projected SLR-caused inundation and temporary coastal flooding from a 100-year storm event, the District recommends a site-specific projected SLR assessment. This more refined assessment could account for site-specific topographical conditions not captured at a Baywide scale. A site-specific vulnerability assessment also would allow planners the opportunity to adjust design of the intended project and measure impacts given various scenarios of projected SLR.

Choosing appropriate adaptation strategies for specific projects is an important consideration. Selecting the appropriate adaptation strategy or combination of strategies should follow a decision-making process as outlined in this chapter. Following this process will allow District staff and decision-makers to make informed, defensible decisions to reduce risk to the project as well as the Public Trust uses.

It is important to note, that proactively planning for projected SLR does not mean that strategies need to be designed to reduce the impacts of SLR at the highest range of SLR projections. Strategies can be designed and implemented in the near-term to protect against projected SLR conditions that may be likely to occur, but strategies should have the capacity to be enhanced to protect against changes in projected SLR that are less probable. For example, a project with a 60-year lifespan could be designed to reduce impacts of projected SLR-caused inundation and temporary coastal flooding from a 100-year storm event considering a 2.5-foot rise in sea levels, but have the capacity to adapt to higher levels of projected SLR if conditions are warranted.

Because the future is uncertain, and the Public Trust uses should be protected for future generations, projects administered by the District should include an implementation plan detailing the types of strategies that will be deployed. The plan should include opportunities for monitoring coastal hazards to adapt strategies as necessary to changing conditions.

4.4 Cross-Jurisdictional Collaboration

Fundamental to the District's success in implementing the Framework will be collaboration with other relevant jurisdictions. As potentially vulnerable assets such as roads and storm management systems are linked with adjacent jurisdictions, implementation of specific adaptation strategies may require cross-jurisdictional collaboration and agreements.

An example of an existing collaboration is the District's partnership with the U.S. Navy Southwest Region -two major agencies with management responsibility for the San Diego waterfront. In 2018, the two agencies entered into a Memorandum of Agreement to coordinate on SLR adaptation planning for a period of six years. Future collaborations such as this can increase the effectiveness and efficiency of adaptation strategy planning and implementation.

Chapter 5 Conclusion

Protecting and preserving the Public Trust Uses is an important obligation for the District. As demonstrated throughout this AB 691 Report, projected SLR inundation and temporary coastal flooding from a 100-year storm event may potentially impact District operations if action is not taken to reduce the risks of coastal hazards. Managing the Tideland areas of San Diego Bay represents unique challenges in the face of projected SLR as the District's jurisdiction is in an urban environment where space-dependent strategies may not always be feasible.

As discussed in this report, rather than specifying precise adaptation strategies to mitigate potential projected SLR inundation and coastal flooding, the District has developed an adaptive management planning framework to assess risk and appropriately plan for projected SLR.

The District believes that a process with a menu of options will best serve the diversity of uses along San Diego Bay.

Application of the adaptive management approach will allow the District to plan and implement adaptation strategies in the near-term while remaining flexible enough to adjust future strategies in the face of uncertain conditions. Following an iterative process informed by best available climate science, monitoring data in San Diego Bay, and performance effectiveness of strategies, the Framework can be continually improved to reduce the risks associated with projected SLR inundation and temporary coastal flooding from a 100-year storm event.

The District has been collaborating with federal, state, regional, and local agencies regarding projected SLR. Of significance, the District and Navy

Regional Southwest recently entered into a Memorandum of Agreement to align their planning initiatives related to projected SLR and coastal flooding. As the two largest land managers along San Diego Bay, a continued partnership between the District and the Navy is crucial to protecting coastal dependent uses. Likewise, working with academia is important for the District to identify and fill research gaps. Continued research in San Diego Bay will help to refine future models of projected SLR and coastal flooding that can be used to inform the proper implementation of adaptation strategies. As a result, the District and academic institutions such as Scripps Institution of Oceanography will continue their long-standing relationship of research in San Diego Bay.

Through this AB 691 Report, the District acknowledges that planning for projected SLR is a long-term process. The ability to prepare and collaborate across the San Diego Region should help protect the Public Trust. This AB 691 Report meets the requirements of AB 691 or Section 6311.5 and sets the foundation for the District to become more resilient in the future.

Embarcadero Marina Park North

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Appendices

APPENDIX A

District Assets

The following section describes in more detail the District assets and their sensitivity and adaptive capacity to potential inundation and temporary coastal flooding from a 100-year storm event resulting from projected SLR. The descriptions are intended to be general in nature. Specific assets will have varying degrees of sensitivity and adaptive capacity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR considering factors such as location, economic life cycle, size, condition, and design. Therefore, the discussion should be considered a broad view of the asset type.

Table AP.A1: Summary of Asset Sensitivity and Adaptive Capacity to Sea Level Rise

Asset	Sensitivity	Adaptive Capacity
Roads	HIGH	LOW
Rails	HIGH	LOW
Bikeways	LOW	HIGH
Pathways	LOW	HIGH
Marine Terminals	HIGH	LOW
Piers	HIGH	LOW
Stormwater Management	HIGH	LOW
Wastewater Management	HIGH	LOW
Sewer Lifts	HIGH	HIGH
Sanitary Pump Outs	LOW	HIGH
Buildings	HIGH	LOW
Beach Accessible Areas	HIGH	LOW
Parks	LOW	HIGH
Boating Facilities	LOW	HIGH
Fuel Docks	HIGH	HIGH
Boat Launch Ramps	LOW	HIGH

Transportation

The transportation system throughout the District has two distinct objectives: the movement of people and the movement of goods. To facilitate these objectives, the District collaborates with adjacent jurisdictions to maintain a roadway network that provides vehicular connections to, from, and through the District. The network within the District consists of roads, rail, bikeways, and pathways. While the transportation system connects to adjacent jurisdictions, this vulnerability assessment only considers transportation assets on Tidelands.

A. Roads:

A road is an accessway solely dedicated for the use of vehicular traffic. Examples of roadways include, but are not limited to, general lanes and dedicated transit lanes. There are approximately 44.3 linear miles of roads on Tidelands consisting of two-lane and multi-lane routes supporting people and cargo movement.

Sensitivity

Roads generally have high sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR because exposure could force road closures, although alternate routes allow for detours. However, based on the District's geographic location directly adjacent to water, many areas of the District have single access points that limit alternate routes. Temporary coastal flooding from a 100-year storm event with projected SLR (that does not cause structural damage to roads), may limit public access, goods movement, and/or emergency responders. Inundation of roads could render them unusable and with potential cascading effects that disrupt business operations and permanently limit public access.

Adaptive Capacity

Roads may continue to facilitate mobility in the aftermath of temporary coastal flooding from a 100-year storm event with projected SLR assuming no structural damage. Alternate routes may be available for some roadways, and once water drains from the roads, roads are typically usable again without requiring significant repair. Sections of road could be elevated (relocation is more difficult), although at substantial cost; therefore, the adaptive capacity is very low for potential inundation.

B. Rail:

Rail lines refer to the continuous lines of bars laid to form rail infrastructure. Rail lines located in the District move freight to and from the marine terminals. There are approximately 16.1 linear miles of rail lines located on Tidelands.

Sensitivity

Rail lines are highly sensitive to even small amounts of standing water on the tracks (Adapting to Rising Tides, 2011). If a portion of track is affected by potential inundation, it may result in the closure of that immediate section with potential for larger disruptions in service if alternative routes are not available.

Adaptive Capacity

The high sensitivity of rail operations resulting from potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR combined with the limited ability to relocate or elevate rail infrastructure make the adaptive capacity of rail very low. The adaptive capacity to withstand impacts to rail infrastructure is further hampered by the lack of alternative rail lines in the region.

C. Bikeways:

Bikeways are paths or lanes for the use of bicycles. Bikeways provide alternative mobility options for visitors and workers to access Tidelands. Bikeways consist of dedicated bike paths or multi-use paths. There are approximately 5.9 linear miles (31,297 linear feet) of bikeways on Tidelands, including but not limited to the Bayshore Bikeway.

Sensitivity

Assuming storm events do not cause permanent damage, bikeways have low sensitivity to temporary coastal flooding from a 100-year storm event with projected SLR. The same bikeways have higher sensitivity to potential inundation with projected SLR if they become inaccessible and/or unsafe for public use and no alternative routes exist.

Adaptive Capacity

The adaptive capacity of bikeways on Tidelands is high. Bikeways could be reconfigured or relocated to avoid potentially flooded areas or elevated in place. Like roads, once the floodwaters recede, and assuming no substantial structural damage, the bikeways are usable.

D. Pathways:

Pathways provide pedestrian and/or bicycle access to the waterfront for visitors and workers to Tidelands. Pathways take the form of walkways, which include promenades (waterside), sidewalks, or nature trails. There are approximately 22.2 linear miles (117,034 linear feet) of pathways on District tidelands.

Sensitivity

Pathways have low sensitivity to potential temporary coastal flooding from a 100-year storm event with projected SLR although it limits public access and potentially reduces public safety. Pathways are more highly sensitive to potential inundation from projected SLR as it may render pathways unusable. Compared to hardened surfaces, nature trails, such as in La Playa or South Bay, are more prone to erosion and damage resulting from potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR.

Adaptive Capacity

The adaptive capacity of pathways to temporary coastal flooding from a 100-year storm event with projected SLR on Tidelands is high. Assuming not a major storm event, pathways, except for nature trails, may be able to withstand temporary coastal flooding from a 100-year storm event with projected SLR and should become usable with receding floodwaters and cleanup. Nature trails may have limited adaptive capacity if substantial erosion occurs and the trail cannot be rebuilt or relocated.

The adaptive capacity of pathways to potential inundation from projected SLR is generally high, depending on geographic constraints. Many pathways can be reconfigured or relocated to avoid areas projected to be impacted by inundation from SLR. While waterside promenades or nature trails may be constrained by adjacent structures or natural resource areas and relocation or reconfiguration is not possible, there is the potential to elevate in place.

Marine Terminals

The District operates two marine transport terminals and two cruise ship terminals. The Tenth Avenue and National City marine terminals are part of the Port's working waterfront. Tenth Avenue provides break-bulk and refrigerated container distribution facilities while the National City location provides vehicle import/export operations. The District also has two cruise ship terminals, located at B Street and at Broadway Pier. These terminals include a 30,000-square-foot main cruise ship terminal building, two supplemental structures for passenger reception and baggage handling and two warehouse areas (SDUPD, 2019).

Sensitivity

Terminal and maritime operations are highly sensitive to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR, potentially prompting temporary closures of operations. Closure of the terminals or maritime industrial activities would disrupt the delivery of goods and services and could have broader regional economic impacts. The Tenth Avenue Marine Terminal is designated as a Strategic Port, which is utilized be the United States military for the deployments around the world. In addition, marine terminals may be utilized as important conduits of goods and services in the aftermath of an emergency.

Adaptive Capacity

The adaptive capacity of marine terminals and maritime industrial uses is low. The coastal-dependent nature combined with heavy industrial infrastructure limits relocation of facilities or structures. Even small increases in SLR may render piers unusable if bumper systems are not modified.

Piers

A pier is platform supported on pillars or girders leading out from the shore into a body of water. On Tidelands, the piers provide docking points for a variety of vessels, such as commercial fishing or excursion vessels, as well as recreational opportunities including fishing. Piers on Tidelands also offer opportunities for physical and visual public access.

Sensitivity

Piers are highly sensitive to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR that may limit the ability of vessels to dock or prevent visitors from accessing the pier.

Adaptive Capacity

The adaptive capacity of fixed piers is low, as few alternatives may exist for vessel berthing. In addition, raising piers requires substantial over-water work and costs.

Stormwater management

The stormwater management system includes storm drains and pipes that connect to flood control infrastructure to the bay. The vulnerability of storm drains to SLR depends on their current storage and flow capacity as well as the elevation of catch basins and outfalls.

Sensitivity

Stormwater infrastructure has high sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR and may cause backflows upstream. The infrastructure is more sensitive to temporary coastal flooding from a 100-year storm event with projected SLR with the addition of onshore precipitation.

Adaptive Capacity

The adaptive capacity of stormwater infrastructure is low in the long-term. Stormwater pumps may assist water flows in the near-term but have limited effectiveness in the long-term. The adaptive capacity of the stormwater infrastructure system is very low in the long-term because of the cost, logistics, and cross-jurisdictional collaboration necessary to plan and implement adaptation strategies (e.g., elevate or relocate).

Wastewater

Wastewater infrastructure includes sewer lifts, along with sanitary pump outs used in marinas. There are ten sewer lifts located on Tidelands. There are 14 sanitary pump outs located on Tidelands.

A. Sewer lifts:

Sensitivity

Sewer lifts, which help pump wastewater from lower to higher point elevations, have high sensitivity to temporary coastal flooding from a 100-year storm event with projected SLR. The lifts have also higher sensitivity to inundation as they may become unusable, compromising the larger system's operational capacity.

Adaptive capacity

Adaptive capacity of sewer lifts is high as these facilities can be elevated upon replacement at the end of the service life.

B. Sanitary Pump-outs:

Sensitivity

Sanitary pump outs have high sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR as they could become temporary unusable, compromising their capacity to operate.

Adaptive Capacity

Sanitary pump-outs at marinas can be modified or elevated to address rising sea levels. Adaptive capacity of sanitary pump-outs is high.

Buildings

There are approximately 590 buildings including District and tenant buildings located on Tidelands, providing or support a diverse array of commercial, recreational, industrial, or government services.

Sensitivity

Buildings have high sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR as damage to the structure as well as associated electrical or water infrastructure may render the facility unusable following an event.

Adaptive Capacity

Buildings have low adaptive capacity to potential inundation because they are not easily elevated or relocated. Buildings have a higher adaptive capacity to temporary coastal flooding potential from a 100-year storm event with projected SLR as structures cab be protected by sandbags, temporary flood barriers, and pump systems can assist to remove water.

Park & Beach Areas

The District manages 22 Parks and recreation areas on tidelands spread across 144 acres, which provide free or low-cost recreational opportunities for visitors. Parks and beach areas across District tideland also provide important environmental, economic, and public health benefits.

A. Beach areas:

Sensitivity

Beach accessible areas have high sensitivity to temporary coastal flooding from a 100-year storm event with projected SLR because of their direct exposure to wave impacts that can cause widespread erosion.

Adaptive Capacity

Adaptive capacity for beach areas is high in the near-term with the application of beach sand replenishment actions. Adaptive capacity is low in the long-term as potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR will most likely scour the sand and erode the beach areas and in areas backed by coastal development.

B. Parks:

Sensitivity

Temporary coastal flooding and inundation will affect the ability for visitors to access and enjoy the parks. Parks have low sensitivity to temporary coastal flooding from a 100-year storm event with projected SLR as the parks become usable when flood waters recede (and assuming no substantial physical damage). Parks have higher sensitivity to inundation as they become unsafe and unusable to the public.

Adaptive Capacity

Adaptive capacity of park areas is high to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR. Park areas may be able be elevated through soil augmentation or infrastructure can be enhanced to expedite water runoff from temporary coastal flooding from a 100-year storm event with projected SLR. In addition, alternative park options are available in the region.

Boating facilities

A boating facility supports vessel operations. Boating facilities on Tidelands include fuel docks and boat launches.

A. Fuel Docks

Fuel docks provide fuel access to recreational vessels and Harbor Police on San Diego Bay.

Sensitivity

Fuel docks on Tidelands are located on floating structures and may become temporarily unavailable during storm events or elevated water levels. As a result, they have high sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR.

Adaptive Capacity

Fuel docks can be modified to withstand higher sea levels. The adaptive capacity of fuel docks assets is high.

B. Boat Launches

Boat launches a ramp on the shore by which vessels can be moved to and from the water. The District has three public boat launch facilities located in Chula Vista, National City, and Shelter Island.

Sensitivity

Boat launches have low sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR (depending on mean sea level in relation to the ramp elevation).

Adaptive Capacity

The adaptive capacity of boat launch ramps is high depending on the ability to expand the ramp inland.

Marinas Slips

A boat slip is the portion of a pier or float where a vessel is berthed or moored. There are approximately 7,500 slips (and moorings) on District Tidelands; almost 75 percent of these in recreational marinas. The remainder are used for commercial fishing, sportfishing, marine service, or within yacht clubs. The District maintains almost 40 slips across the Bay for Harbor Police.

Sensitivity

Marina slips are located on floating structures and may become damaged during storm events. As they can float, they have low sensitivity to potential inundation and temporary coastal flooding from a 100-year storm event with projected SLR.

Adaptive Capacity

Marina slips may be modified to withstand higher sea levels. The adaptive capacity of fuel docks assets is high.

APPENDIX B

Nearshore Habitat Mapping and Resiliency Evaluation for the San Diego Unified Port District Jurisdiction

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Acronyms and Abbreviations

Acronym	Definition
°F	degrees Fahrenheit
AB	Assembly Bill
CEMP	California Eelgrass Mitigation Policy
cm	centimeters
CoSMoS	Coastal Storm Modeling System
District	Unified Port District of San Diego
GIS	geographic information system
NOAA	National Oceanic and Atmospheric Administration
ROW	right-of-way
SANDAG	San Diego Association of Governments
SLR	sea level rise
USGS	United States Geological Survey
WMA	Watershed Management Area

Section 1
Introduction

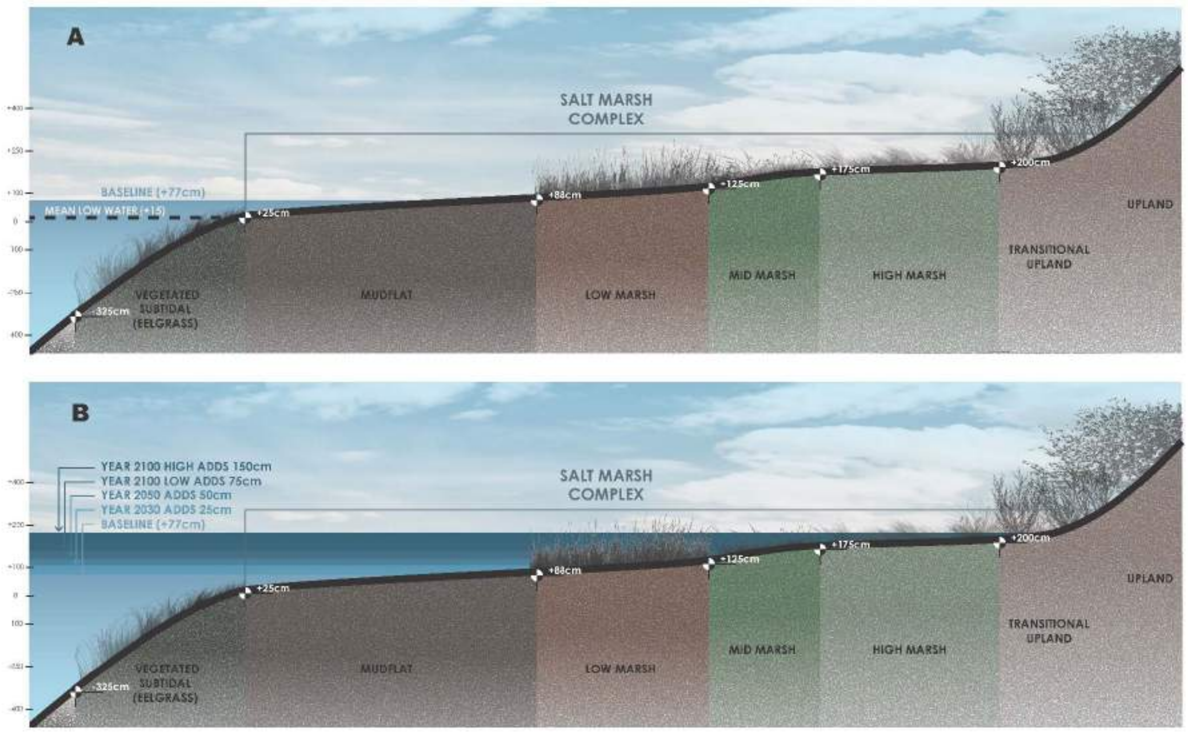
Pursuant to Assembly Bill 691, the San Diego Unified Port District (hereafter referred to as "District") as a trustee of public trust lands, is required to assess its vulnerabilities to future sea level rise. The law requires the District to analyze the impacts coastal flooding and inundation exacerbated future scenarios of sea level rise and extreme storms may have on its natural and manmade resources and facilities. Included in the assessment shall be an evaluation of the financial impacts to these resources as well as a description of how the District proposes to protect and preserve them. A final report must be submitted to the State Lands Commission no later than July 1, 2019.

This study is intended to support the District's AB 691 submittal by evaluating potential impacts to nearshore habitats with increasing levels of sea level throughout the District's jurisdiction. Nearshore habitats capable of supporting biodiversity, including salt marsh and eelgrass, can persist in the face of sea- level rise through natural landward migration and vertical accretion, a process by which the habitat "moves" up elevation or upslope. In San Diego Bay, landward (horizontal) marsh migration into adjacent, low-lying uplands is largely constrained by coastal development. Furthermore, sediment inputs from the ocean and connecting waterways are minimal in San Diego Bay and therefore natural accretion is slow to nonexistent (Thorne et al. 2018). Illustration 1 provides an example cross-section depicting salt marsh complex and eelgrass (two tidally influenced habitat types) under baseline conditions and evaluated sea level rise scenarios.

This evaluation uses the USGS Coastal Storm Modeling System (CoSMoS) elevation data on 4 selected scenarios with corresponding years: 25 cm (2030), 50cm (2050), 75 cm (2100 LOW), and 150 cm (2100 HIGH) based on the 2018 California Ocean Protection Council Sea Level Rise Guidance (Illustration 1B). CoSMoS makes detailed predictions (meter-scale, as used in this analysis) over large geographic scales (100s of kilometers) of storm-induced coastal flooding and erosion for both current and future sea-level rise (SLR) scenarios. CoSMoS v3.0 for Southern California shows projections for future climate scenarios (sea-level rise and storms) to provide emergency responders and coastal planners with information that can be used to increase public safety, mitigate physical damages, and more effectively manage and allocate resources within complex coastal settings (Barnard et al, 2018).

Both, a qualitative and quantitative analysis of existing nearshore habitats within District jurisdiction was completed, along with a prediction of future habitat distribution, analysis of trends over time, implications of modeled change, and recommended management and monitoring strategies for future planning. It is important to note that this analysis examines future sea level rise scenarios on current natural resources, land uses, and management practices. This work will help the District to analyze a range of potential changes to the habitats of San Diego Bay, and to develop effective adaptive management strategies to maintain the maximum practicable diversity in habitat capable of supporting species and other ecosystem services.

Illustration 1. Illustration 1 provides an example cross-section depicting salt marsh complex and eelgrass (two tidally influenced habitat types) under baseline conditions (A) and under the four evaluated sea level rise scenarios (B). The illustration keeps the surface contour and habitat constant for both A and B while showing the added water depth for each scenario in B. Note that without landward migration or changes to surface elevations (i.e. accretion) the habitat becomes deeper and deeper relative to sea level.



Section 2
Existing Conditions

2.1 Climate

San Diego Bay is located along Southern California's Pacific Coast just north of the Tijuana River and U.S./Mexico border (see Figure 1). This geographic region is dominated by a semiarid Mediterranean climate and is characterized by warm to hot dry summers and mild to cool wet winters. The Mediterranean climate results in relatively long periods of low flow dry conditions with modest runoff into San Diego Bay. These dry conditions are punctuated by brief, seasonal episodes of heavy rainfall and higher volume runoff. Daytime temperatures rarely exceed 95 degrees Fahrenheit (°F) and nighttime temperatures usually remain above freezing in the winter. Seasonal rainfall along the coast averages from 10 to 14 inches per year, with approximately 75% of the precipitation falling from November through March.

2.2 Watershed

The San Diego Bay Watershed Management Area (WMA) encompasses over 415 square miles (668 square kilometers), and is the largest within the boundaries of San Diego County (Figure 2). There are three contributing hydrologic units: the smaller but heavily populated Pueblo Hydrologic Unit to the north, Sweetwater Hydrologic Unit in the middle, and the Otay Hydrologic Unit to the south. The San Diego Bay WMA is heavily developed in many areas and supports over 50% of the county's working and/or residential population (Project Clean Water 2019).

The Sweetwater Hydrologic Unit is the largest of the three San Diego Bay hydrologic units, encompassing over 145,000 acres half undeveloped and open space lands (60%) with the remaining areas heavily developed, with the population concentrated in the lower watershed estimated at 340,000 (Project Clean Water 2019).

The Otay Hydrologic Unit is the second largest in the county, comprising nearly 98,500 acres of land and be further broken down into three distinct hydrologic areas, each with unique geological and environmental features: Coronado, Otay Valley, and Dulzura. The Otay River is the central creek that collects and conveys most of the watershed's water. The watershed is composed primarily of undeveloped and open spaces, which make up roughly 68% of the watershed with high density uses occurring at the downstream end and low density and natural space occurring in the upper end. (Project Clean Water 2019).

The smallest of the contributing hydrologic units is the Pueblo Hydrologic Unit, covering about 38,000 acres (approximately 14%) of the San Diego Bay WMA. Unlike the Sweetwater and Otay hydrologic units, Pueblo has no central stream system and instead consists primarily of a group of relatively small local creeks and pipe conveyances, many of which are concrete-lined and drain directly into San Diego Bay. (Project Clean Water 2019).

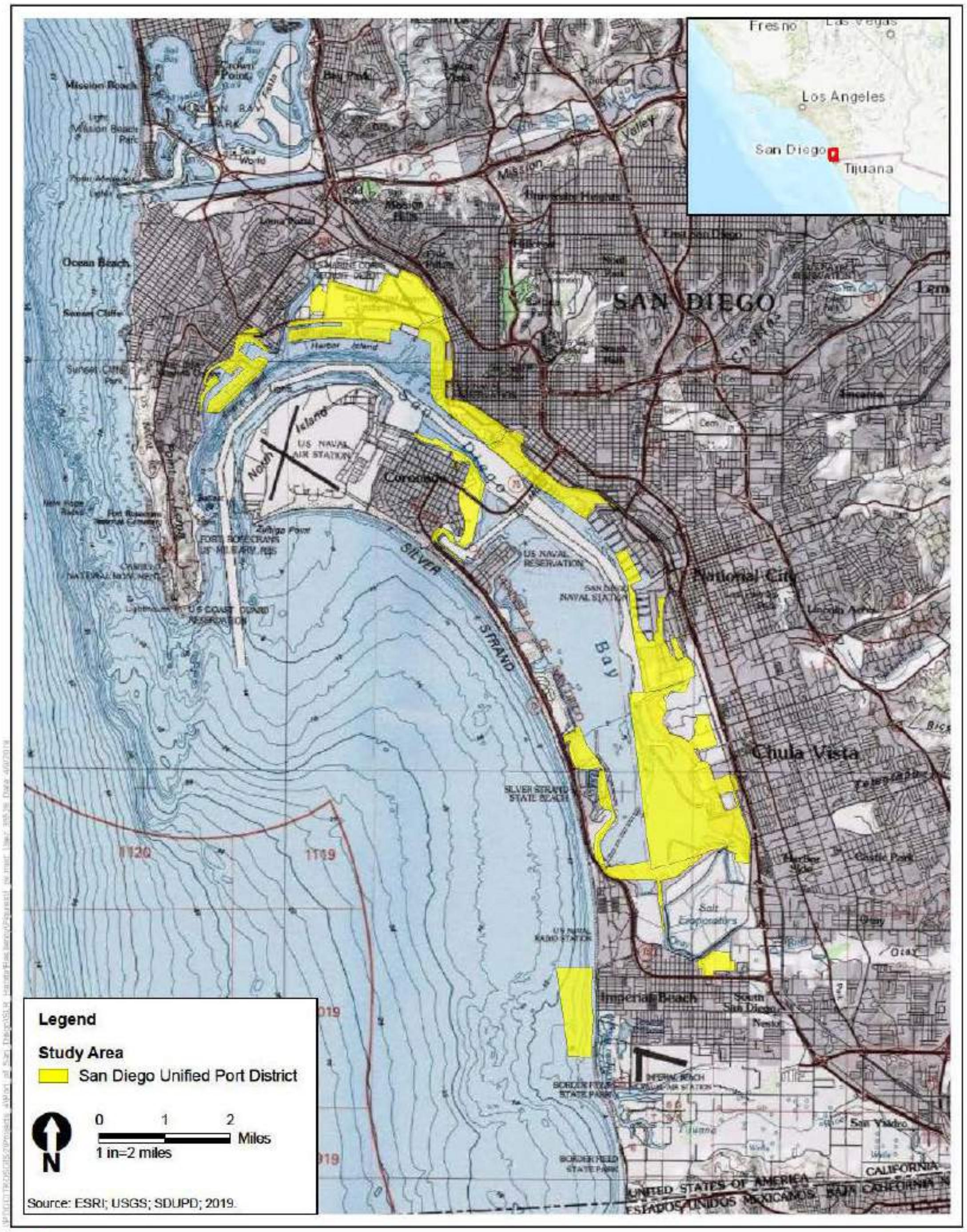


Figure 1
Regional Location

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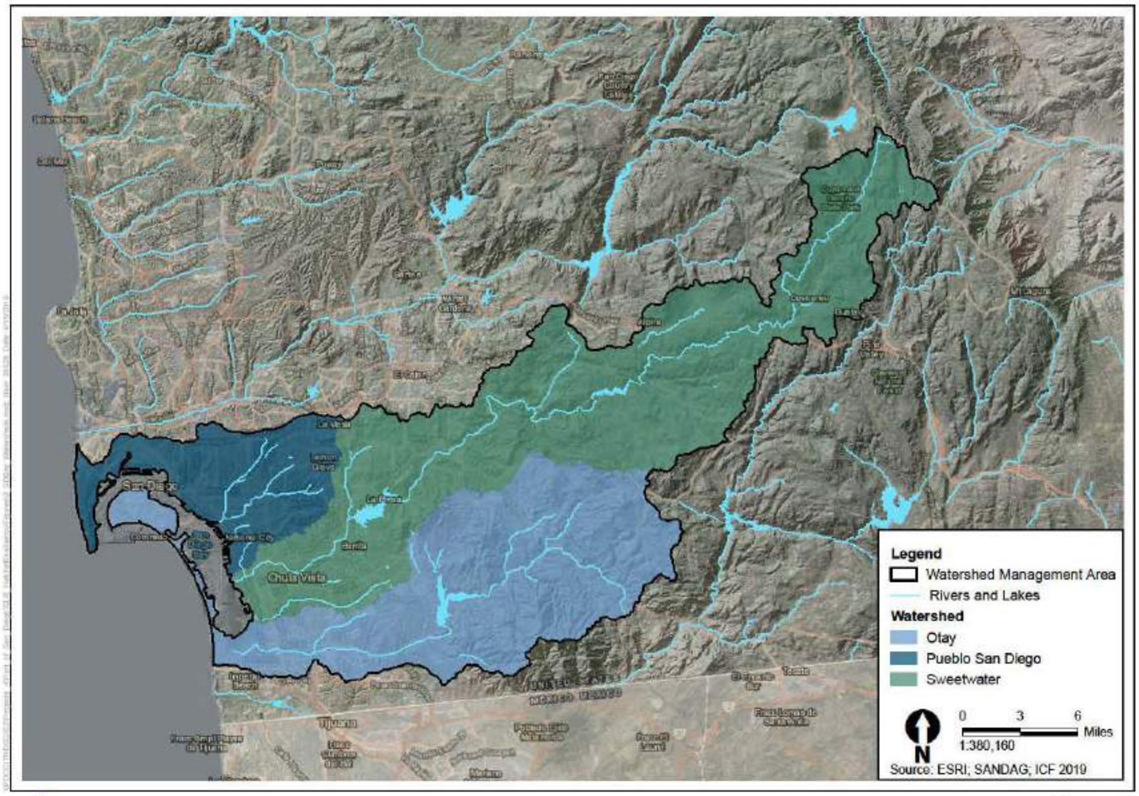

Figure 2
San Diego Bay Watersheds

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2.3 Habitats

The following is a summary of the key habitat types found within San Diego Bay.

2.3.1 Eelgrass (Subtidal)

Eelgrass (*Zostera marina* L. and *Z. pacifica*) is a native marine plant indigenous to the soft-bottom bays and estuaries of the northern hemisphere. Eelgrass can be found along the west coast of North America, ranging from Baja California and the Sea of Cortez to Alaska. It is associated with healthy shallow bays and estuaries and is a highly productive species. It is one of the only physical structures (biotic or other) along these shallow subtidal shorelines and embayments and as such is a *foundation* or *habitat forming* species. Eelgrass is protected under the Clean Water Act and locally managed under the California Eelgrass Mitigation Policy (CEMP), which was developed and amended by National Oceanic and Atmospheric Administration (NOAA) Fisheries (NAVFAC 2013 and NOAA 2014).

Eelgrass plays many roles within coastal bays and estuary ecosystems and contributes to ecosystem functions at multiple levels as a primary and secondary producer, habitat structuring element, substrate for epiphytes and epifauna, and sediment stabilizer and nutrient cycling facilitator. Eelgrass provides important nursery habitat for young fish and invertebrates, acting as foraging areas and shelter. It is also a food source for migratory waterfowl and sea turtles, and provides spawning surfaces for invertebrates and commercially important fish such as the Pacific herring and many bass species (NAVFAC 2013 and NOAA 2014)

2.3.2 Salt Marsh Complex

Salt marsh complexes are an association of herbaceous and suffrutescent, salt-tolerant hydrophytes that form a moderate to dense cover and can reach a height of 1 meter (3 feet). Most species are active in summer and dormant in winter (Holland 1986). Coastal salt marsh plants are distributed along distinct zones depending upon such environmental factors as frequency and length of tidal inundation, salinity levels, and nutrient status (MacDonald 1977). In the higher littoral zone, there is much less tidal inflow, resulting in lower salinity levels, while soil salinity in the lower littoral zone is fairly constant due to everyday annual tidal flow (Adam 1990).

Salt marsh species often segregate along elevation bands due to different exposures to the tides, resulting in varied tidal inundation and other stratified environmental variables. The lowest elevations support mudflats, an important habitat characterized by a lack of vegetation, exposure during daily low tides, and complex benthic invertebrate populations. Around San Diego Bay, the first terrestrial plant species, at the lowest elevation, is California cordgrass (*Spartina foliosa*) also referred to as low marsh. The next vegetation band is mid marsh, generally dominated by Pacific pickleweed (*Sarcocornia pacifica*) and saltwort (*Batis maritima*), which then transitions to high marsh, including alkali-heath (*Cressa truxillensis*) and Parish's pickleweed (*Arthrocnemum subterminale*). Other characteristic species include saltgrass (*Distichlis spicata*) and salty Susan (*Jaumea carnosa*). There is also an upland transitional area often associated with the outer limits of salt marsh complexes that is not directly affected by the tide but still supports a unique mix of salt tolerant perennial species including bladderpod (*Peritoma arborea*), coast goldenbush (Isocoma menziesii) and arrowweed (*Pluchea sericea*).

San Diego Bay also supports saltpans which are unvegetated to sparsely vegetated flat, alkaline areas near the coast that are subject to tidal influence. In coastal areas, saltpans are most often associated with salt marsh habitat. While saltpans can cover relatively large areas, they often occur in a mosaic pattern with more densely vegetated areas within the salt marsh. Vegetation is limited to non-existent in saltpans due to seasonally high soil salinity levels that prevent colonization by perennial salt marsh species (Ferren et al. 1987).

2.3.3 Uplands

A variety of upland habitats existing around San Diego Bay. The primary native community is Diegan coastal sage scrub which may be dominated by a variety of species depending upon site-specific topographic, geographic, and edaphic conditions. California sagebrush (*Artemisia californica*) is more dominant in coastal forms (Oberbauer 2008), but it often occurs with various codominant species. There are several recognized subassociations of Diegan coastal sage scrub based upon the dominant species. Typical Diegan coastal sage scrub dominants include California sagebrush, California buckwheat (*Eriogonum fasciculatum*), laurel sumac (*Malosma laurina*), black sage (*Salvia mellifera*), lemonadeberry (*Rhus integrifolia*), and California encelia (*Encelia californica*).

Another common upland community is nonnative grassland which is characterized by a dense to sparse cover of annual grasses, often with native and nonnative annual forbs (Holland 1986). Typical grasses within the region include ripgut grass (*Bromus diandrus*), red brome (*Bromus madritensis* ssp. *rubens*), soft chess (*Bromus hordeaceus*), wild oats (*Avena* spp.), and fescue (*Vulpia myuros*). Disturbance-related annuals, such as non-native red stem filaree (*Erodium cicutarium*) and horseweed (*Conyza canadensis*), are common to this community. Though named as a nonnative community, nonnative grassland often has significant biological value because it provides foraging habitat for raptors; can support native grassland species; and often supports sensitive wildlife species.

Disturbed habitat is any land that has been permanently altered by previous human activity, including grading, repeated clearing, intensive agriculture, vehicular damage, or dirt roads. Disturbed land is typically characterized by large amounts of bare ground and an absence of remnant native vegetation with little to no biological value without active restoration. Disturbed habitat in San Diego Nay includes dirt roads, berms, and areas of bare ground.

Photo showing typical disturbed areas including large areas of compacted bare ground and nonnative ruderal species.

2.3.4 Beach/Dune

Beach habitat is the flat, sandy area along the immediate coastline that occurs between mean tide and the foredune, or to the farthest inland reach of storm waves. This habitat is characterized by high exposure to salt spray and sand blast, and sandy substrate with a low organic content and water-holding capacity (Barbour and Major 1977). The lower portions of beaches are unvegetated, while the upper beach can transition to dunes. Dunes are an area of loose to partially stabilized sand that forms near the shore above the high tide line. The plants found in this community can tolerate harsh conditions, such as high winds, salt, and a low nutrient supply. Many of the plants in this community have deep taproots and/or a prostrate growth form to help stabilize them in the loose sand. Dominant native plants within the coastal strand community include beach-bur (*Ambrosia chamissonis*), beach evening-primrose (*Camissonia cheiranthifolia* ssp. *suffruticosa*), sand-verbena (*Abronia maritima, A. umbellata* var. *umbellata),* lotus (*Acmispon heermannii, A. prostratus*), and salt bush (*Atriplex watsonii, A. leucophylla*).

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Section 3
Study Overview

The following section provides an overview of the evaluation process; including data, assumptions, general methods, and analysis. The resiliency analysis of each sea level rise scenario identifies areas open to horizontal expansion of eelgrass and salt marsh habitat as well as development and other barriers that will impede habitat horizontal expansion. This is a predictive analysis scaled to a bay-wide extent using existing regional data and is intended for general planning purposes. Focused management actions would require additional studies to provide site-specific details and greater resolution.

3.1 Data Compilation

It was determined that existing datasets would be used to set baseline extent of habitats and barriers to habitat expansion. The habitat data used in this analysis is consistent with the datasets that have been used in previous District planning documents such as the *Integrated Natural Resource Management Plan for San Diego Bay*. The following datasets were consulted to complete this evaluation (no supplemental data was collected at this time):

- United States Geological Survey (USGS) topobathymetry raster surface was the source of baseline current conditions elevation across the analysis. **Coastal Storm Modeling System (CoSMoS) Raster** elevation data was chosen as the baseline to match other District reports analyzing sea level rise (USGS CoSMoS 2016).
- Habitats were provided by the District as geographic information system (GIS), file geodatabasepolygons with feature classes named **Eelgrass, Salt Marsh, Beach/Dune, and Uplands**. The eelgrass data is from 2017 and other resources are slightly older. The salt marsh polygons are generalized and broken down by elevation using literature from ESA's Pond 20 report (District 2017, data not publicly available).
- **Current Land Use** published by the San Diego Association of Governments (SANDAG) was downloaded via the SanGIS data portal to filter down to developed lands as barriers to habitat expansion (SanGIS2018).
- **Pavement** is District data representing maintained paved areas included in the Barriers to Habitat Expansion layer (District 2017, data not publicly available).
- **Docks & Wharfs** is District data included in development of the Barriers to Habitat Expansion layer (District 2017, data not publicly available).
- **Open Water, San Diego Bay Shoreline** polygon from USGS was used in development of Barriers to Habitat Expansion layer (USGS 2017).

3.2 Assumptions

Prior to conducting the analysis, a series of assumptions were developed as described below. Assumptions were broken into two groups, those that applied to the entire model (i.e., *model-wide*) versus habitat-specific decisions (i.e., *habitat-specific*). These are described below.

3.2.1 Model-Wide Assumptions

The following assumptions apply to the entire model:

- The model is intended for general understanding of how future sea levels may affect nearshore habitats found within District jurisdiction. As the District jurisdiction does not encompass all of San Diego Bay, additional evaluation would be needed to address all habitats within the larger bay limits.
- This is not a hydrodynamic model and is, intended for estimating trends and identifying future analysis and monitoring needs. Additional studies and modeling efforts are required for finer scale interpretation as well as project-level and site-specific analysis.
- There are many Sea Level Rise predictions available. This analysis uses the same sea level rise scenarios utilized in the District's *Sea Level Rise Vulnerability Assessment and Coastal Resiliency Report* (District, in prep). Future sea level rise projections are obtained from the California Ocean Protection Council Sea Level Rise Guidance projections for San Diego Bay and then converted to the nearest available scenario using the USGS CoSMoS model. This includes:
  - Use of the USGS CoSMoS for baseline elevation data; and
  - Evaluation of the following selected scenarios:
    - Year 2030, +25 centimeters (cm)
    - Year 2050, +50 cm;
    - Year 2100 Low Estimate, +75 cm; and
    - Year 2100 High Estimate, +150 cm.
- This analysis did not couple future sea level rise scenarios with a 100-year storm event. Storm event data was determined to be inappropriate for the District level analysis and calculations. Hydrodynamic modeling of project specific locations are recommended if accurate storm event predictions are desired.
- The habitat categories chosen for this analysis were based on past comments from resource agencies and stakeholders, each habitat's capacity to support listed species including regionally significant or rare, the ability to provide high ecological services/functions, and adequate data for evaluation. In addition, each of the habitat categories has a unique relationship to elevation and the corresponding frequency of tidal inundation. Four distinct habitat categories were chosen, including:
  - Uplands
  - Salt Marsh (estuary)
  - Beach/Dune
  - Eelgrass

- The analysis intentionally disregards all other possible environmental variables and assumes the primary driver to habitat persistence is water depth and inundation frequency, and the primary mechanism for habitat persistence is upwards landward migration (i.e., to move to higher elevations horizontally up slope) to keep pace with sea level elevation changes and remain in their preferred habitat range.
- The analysis assumes that existing (2019) land uses and shoreline conditions remain and no management actions are taken to assist in habitat migration.
- Each habitat was assigned a minimum and maximum elevation (referenced to the North American Vertical Datum of 1988) based on the most current habitat mapping data available. This elevation range was then assumed to be the "analysis range" for each habitat relative to current sea level. It can then be used to predict total available acres for each habitat category under the future sea level rise scenarios.
- The elevation range and percent occupancy (cover) for each habitat type is held constant for all sea level rise scenarios and does not account/quantify any changes that may result from other environmental variables that may also change with sea level.
- Landward migration rates differ by habitat due to various environmental conditions as well as the dispersal and/or growth mechanism for the dominant plants of that community (Borchert et al. 2018). This analysis assumes that adequate time would be available under every sea level rise scenario to allow each habitat to move (i.e., we assume that every habitat can keep up with sea level rise if provided the space to do so).
- Due to current land uses in the San Diego Bay watersheds it is assumed that little to no significant accretion (sediment and organic material build up) will occur (Thorne et al. 2018). A recent study measured low accretion rates for San Diego Bay and south San Diego County watersheds, with middle bay Sweetwater River contributing 0.15 cm per year. (Thorne et al. 2018).
- The following tidal datum was used for all analysis in this report. Note that the NOAA datum is displayed as Mean Lower Low Water (MLLW). Any use in the document were converted to NAVD88.

Station ID: 9410170 **PUBLICATION DATE:** 09/20/2017
Name: San Diego, San Diego Bay, CA
NOAA Chart: 18772 **Latitude:** 32° 42.9' N (32.71419)
USGS Quad: Point Loma **Longitude:** 117° 10.4' W (-117.17358)

T I D A L D A T U M S*
LENGTH OF SERIES: 19 YEARS
TIME PERIOD: January 1983 - December 2001
TIDAL EPOCH: 1983-2001

HIGHEST OBSERVED WATER LEVEL (11/25/2015)	= 2.511
MEAN HIGHER HIGH WATER	MHHW = 1.745
MEAN HIGH WATER	MHW = 1.519
MEAN TIDE LEVEL	MTL = 0.902
MEAN SEA LEVEL	MSL = 0.896
MEAN LOW WATER	MLW = 0.285
North American Vertical Datum	NAVD88 = 0.132
MEAN LOWER LOW WATER	MLLW = 0.000
LOWEST OBSERVED WATER LEVEL (12/17/1937)	= -0.942

*Tidal datums at SAN DIEGO, SAN DIEGO BAY based on elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

3.2.2 Habitat-Specific Assumptions

The following assumptions apply to specific habitats:

- The following elevation ranges (NAVD88) were used for each of the habitats based on existing literature and current San Diego Bay vegetation mapping, details on the methodology to determine the elevation range are included in Section 3.3.
  - Eelgrass: -325 cm to +25 cm
  - Salt Marsh: +25 cm to +350 cm
  - Beach/Dune: > 0 cm
  - Uplands: > 200 cm
- As it is difficult to determine the exact elevation of the interface between beach and mudflats habitats and subtidal habitats, any area below +25 cm is considered subtidal habitat for this analysis, which could include eelgrass and unvegetated areas.

- Uplands were defined as occurring above +200 cm, which corresponds to the low end of upland transitional habitat range calculated for other reference wetlands in southern California including the preliminary design for the Pond 20 restoration project (ESA 2018). Habitat above this elevation is outside the higher high water limit and should not receive tidal inundation although it may still be influenced by subsurface saline conditions.
- For the primary evaluation salt marsh was evaluated as a single habitat type. However, it is important to acknowledge that a series of sub-habitat types can occur ranging from mudflat on the lowest end and high marsh and transitional uplands on the high end. Each of these sub-habitats represents a different inundation band and supports different vegetation and wildlife. High functioning salt marshes support a mix of these sub-habitat types at varying levels of diversity. Additional analysis was completed to look closer at these sub-habitat types to allow for the District to better understand the changes over time. Due to the resolution in the data, caution should be taken when viewing these results for anything other than future data needs and long-term monitoring.

3.3 Determining Existing Habitat Suitability

Key terminology are *italicized* and <u>underlined</u> below with select terms visually depicted in Illustration 2.

Step 1: All available habitat datasets for San Diego Bay were combined to create a District baseline habitat map, as shown on Figure 3.

Step 2: Habitat data that originated as GIS polygons were rasterized and projected to UTM zone 11NAD83 horizontal and NAVD88 vertical datums to match the 1-meter cells of USGS CoSMoS topobathymetric surface. Then the topobathymetric data and each of the habitat rasters were clipped to the District jurisdiction and reclassified into 25 cm classes (*<u>elevation class</u>*) of vertical distribution. The reclassification included 78, 25 cm elevation classes (a range of 1,950 cm) ranging from -475 cm to +1,475 cm NAVD88. The output gives an attribute table with total number of 1-meter raster cells at each elevation and the number of 1-meter cells that are occupied by a specific habitat (*<u>existing habitat or occupied cells</u>*) at each elevation. These 1-meter cells are compiled to calculate aerial extent within any given limits. Note that all calculations were done using square meters and then converted to acres for discussion as this is a common large scale unit of measure for the general public to understand.

Step 3: Habitat rasters and topobathymetric datasets were combined and compared to the map of existing habitats to determine the *<u>maximum vertical distribution range</u>* (low and high elevation) of each habitat under baseline conditions.

Step 4: The maximum vertical distribution range was then compared to the data to determine where the majority of each habitat occurs and to identify outliers. The outliers were removed from the analysis to avoid artificially expanding the suitable range and diluting the ability to detect change under future sea level rise scenarios. These outliers may exist due to differing methods of data collections as well as errors in the dataset and mapping. The lower and upper 1% of the data for eelgrass and salt marsh habitat was removed and the analysis focused on the remaining 98% of the data and the corresponding range. Removal of the lower and upper 1% range accounts for possible errors in the data that over estimates its extent, which may result in an inaccurate portrayal of the elevation where the habitat is found. This refined 98% range is referred to as the *analysis range* and was used in all future steps.

Step 5: Once the analysis range was finalized for each habitat type, the *total available area* for each habitat type was calculated for the analysis range as well as for each 25 cm elevation class within any given analysis range. In addition, the *absolute occupancy* of each habitat within their corresponding analysis range was calculated by dividing the existing habitat by the total available area. Furthermore, *relative occupancy* within each 25 cm elevation class was calculated by dividing occupied cells in each 25 cm elevation class by the total number of occupied cells in the analysis range.

This information was used to determine baseline cover for each habitat, including absolute percent cover across District lands and the relative distribution of each habitat within the elevation classes. As stated in the assumptions, it is assumed that these cover values remain consistent across all sea level rise scenarios.

Step 6: The relative occupancy was used to define a *preferred range* (i.e. the range where the majority of mapped habitat occurs) for each habitat type as follows:

- ***Eelgrass and salt marsh—*** habitat communities have a strong relationship to environmental variables tied to sea level, inundation frequency, and other corresponding environmental variables such as light, temperature, and sediment. This often results in changes in density, cover, and species types at the extreme ends of their ranges. As such, the preferred range is the elevation increment(s) where the largest percentage of mapped habitat occurs. Each 25 cm elevation increment that supported 10% or more of the total mapped habitat contributed to the preferred range.
- ***Beaches and dunes*** are not an actual vegetation community but rather a topographic feature driven by wind and sediment processes as well as tidal action that may or may not support vegetation. As such, no preferred range was identified. Any responses to sea level rise from these communities such as migration upslope would require functional wind and sediment processes, which are severely altered in San Diego Bay. In addition, these habitats are severely constrained by existing land uses on the upper edge. Due to land use constraints and the lack of adequate physical processes, it is assumed that the potential for these two habitats to migrate is limited to non-existent. Therefore, the upper edge of the current elevation distribution is considered to remain static in all sea level rise scenarios while the lower edge of the distribution would be affected.
- ***Upland*** habitats have the potential to occur across all available areas above tidal influence. Any variances in the current vertical distribution and associated upland cover is likely the result of other variables—including slope, soil, freshwater availability, and disturbance—as well as other variables not associated with sea level. As such upland is not considered to have a preferred range.
- Figure 3. Baseline Mapped Habitat, Current Conditions

Figure 3
Baseline Mapped Habitat
Current Conditions

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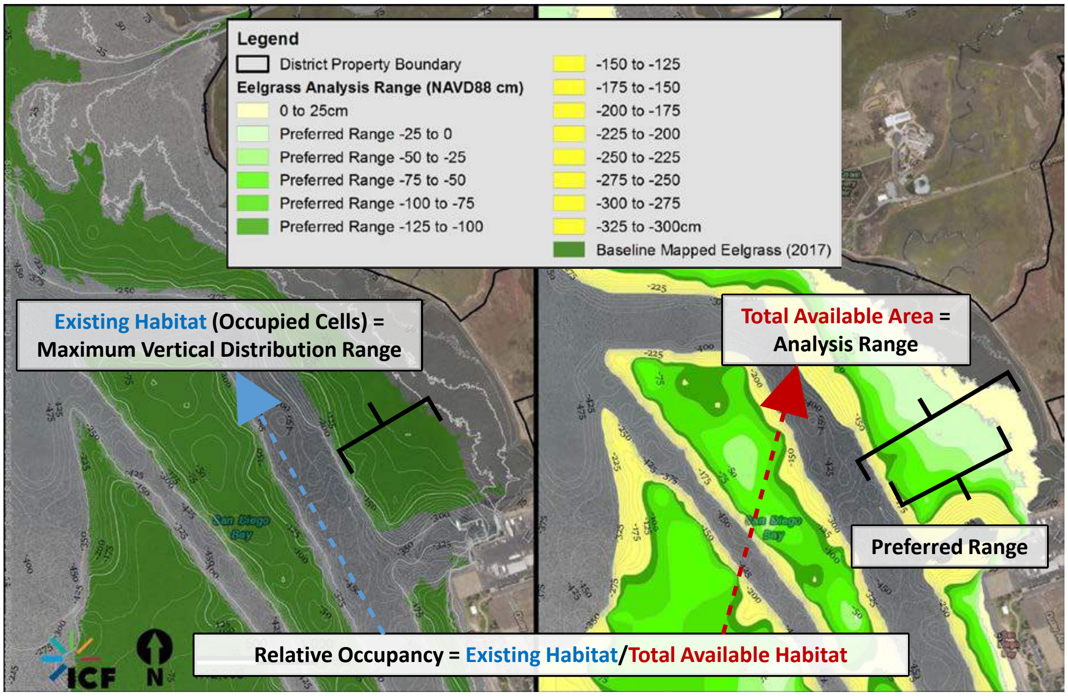
Illustration 2. Depiction of Select Key Terminology Used in Section 3.3



3.4 Predicting Future Conditions

Each habitat category was evaluated against each of the four sea level rise scenarios to understand how the total available area, absolute occupancy (total vegetated area), and relative occupancy (overall distribution) may change. The analysis range was applied to each scenario to calculate the total available area and preferred range of each habitat using current absolute and relative occupancy across total available area within District jurisdiction. Tables including these numbers are included in the appendix.

Step 1: A habitat barrier map was compiled identifying any area currently supporting development that would preclude or inhibit habitat from growing. The barriers data was created using a combination of existing data layers as well as a few manual edits. The habitat barrier map can be used, modified, or built upon for future sea level rise monitoring and planning efforts.

- SANDAG's Land Use data was initially filtered to remove all lands suitable to support habitat including *Water, Undevelopable Natural Area, Vacant and Undeveloped Land, Open Space Park or Preserve, Other Recreation – Low, Other Recreation – High, Landscape Open Space, Beach – Passive, Beach – Active, Bay or Lagoon,* and *Extractive Industry (SanGIS 2018)*. During this process a few errors were noted and corrected to the extent possible, including natural and developed lands not included or incorrectly identified.
    - Some natural areas were erroneously included in the land use filter, and some developed areas were not included.

- Other data layers were added to improve the accuracy of barriers layer, including:
  - A high-resolution shoreline polygon from USGS was incorporated to remove the open water out of the marinas as it was included in the barriers data. The existing land use data grouped both the land side and water side for each marina as developed; however, eelgrass is known to occur in many of the marinas within San Diego Bay. This same exercise removed the Coronado Bridge right-of-way (ROW) as a barrier to habitat as softbottom areas occur under the ROW.
  - Pavement extent data provided by the District was added as a barrier to habitat expansion.
  - The docks and wharfs data provided by the District was used to add major industrial wharfs as additional barriers to expansion, although narrow floating docks and small marinas were not included as barriers to habitat.
  - Select manual edits were also applied to improve the barrier layer, including filling in a paved parking area on Grand Caribe in the Coronado Cays, part of the San Diego International Airport, as well as parts of the National City Marine Terminal. These manual changes were based on input from District staff and on the team's site understanding.

Step 2: To calculate the areas suitable to support habitat (any type) the final barriers GIS layer was extracted from the District jurisdiction lands yielding a raster with only suitable areas. As with the baseline analysis a table of 1-meter cell counts available (total available area) for habitat within each of the same 25 cm elevation classes was generated. During this process it was discovered that the USGS CoSMoS topobathymetry data appears to have areas with scarce bathymetry data and as a result force an average slope up to known terrestrial elevations. For example, it was noted that a slope was artificially added to the data on the water side of a deep bulkhead in the National City Marine Terminal where habitat suitable elevations do not presently exist. This area was manually corrected and other data errors along the terrestrial/bathymetric data interface persist as a known issue with this dataset. It is recommended that future studies create a better topobathymetric surface specifically for San Diego Bay.

Step 3: Once the GIS mapping exercise of barriers and suitable areas for habitat was complete, increments of 25 cm of sea level were added to the original elevation increments to achieve each of the various sea level rise scenarios (i.e., 25 cm, 50 cm, 75 cm, and 150 cm). As the elevation range suitable for each habitat is always relevant to sea level and topography is considered constant, a new map of suitable areas for each habitat based on their analysis range was generated. From this map, total available area was calculated as well as a new total acreage of habitat assuming the relative occupancy for each elevation class remains constant.

Section 4
Results

4.1 Baseline Conditions

The following provides a summary of the baseline conditions used for this analysis including baseline acres from existing habitat maps, total available area (acres) for each habitat within the analysis range and a calculated percent occupancy for each habitat.

Table 4-1. Summary of Mapped Habitat, Mapped Elevation Range, and Modeled Suitable Habitat

Habitat Type	Baseline Habitat Mapped (acres)	Analysis Range (cm, 98% Elevation Ran)* Low	Analysis Range (cm, 98% Elevation Ran)* High	Total Available Area (acres)	% Occupied (Absolute Occupancy)
Eelgrass	915.0	-325	+25	1,717.7	53%
Salt Marsh	81.1	+25	+350	531.6	15%
Beach/Dune**	13.5	0	+500***	NA**	NA**
Uplands	97.0	+200	+850***	425.9	23%

*NAVD88 cm

** Beach/dune habitat is assumed to exist where those historical habitats occurred prior to development and have been allowed to remain. As both are driven by sediment and wind processes, they are considered static with no additional areas available.

*** Maximum value mapped for those habitats.

4.1.1 Eelgrass

According to 2017 mapping, 98% of the eelgrass within District jurisdiction was found from -325 cm to 25 cm NAVD88. The preferred range (highest density) includes 78% of the population and ranges from -125 to 0 cm. Current conditions suitable for eelgrass habitat is shown on Figure 4a. The purpose of the exhibit is to display all areas within the District that have the potential to support eelgrass, falling within the existing range of mapped eelgrass. In addition, Figure 4a shows the area identified as preferred habitat based on the elevation range where the highest density of eelgrass occurs. Out of the 1,717 acres of total district waters at this elevation, currently 53% (915 acres) of the area is occupied. The remaining 47% of the available area that is unoccupied is a result of a wide variety of environmental variables not evaluated in this document, many of which may be site specific. These variables could include temperature, light, salinity, sediment, water quality in addition to land use and disturbances.

Table 4-2. Eelgrass Habitat Analysis Elevation Range and Preferred Elevation Range

Analysis Range (98% Elevation Range)	-325 cm to +25 cm
Baseline Acres	915 acres
Preferred Range	-125 cm to 0 cm
Acreage within Preferred	715 acres

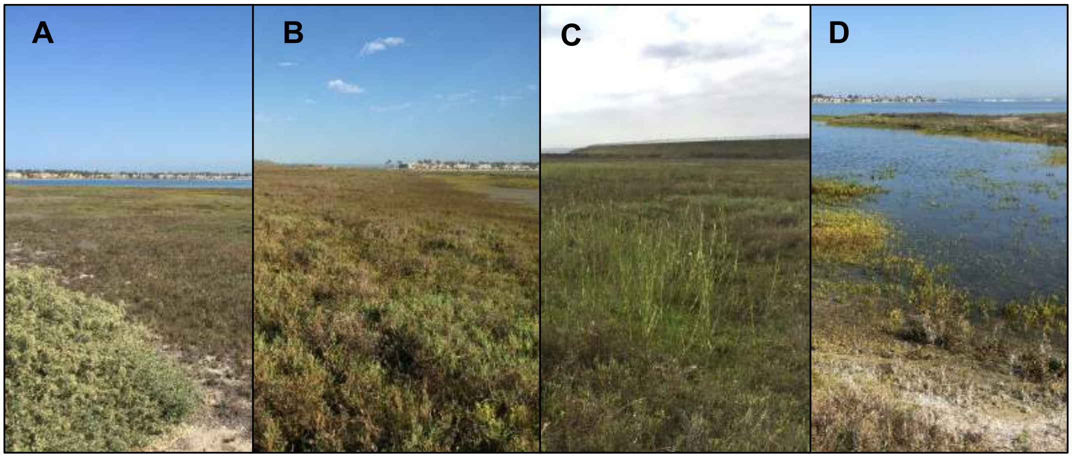
Photo showing eelgrass in San Diego Bay and a juvenile fish. Note the bare ground and spare tall shoots typical of deeper areas within the analysis range. Photo credit, Marine Taxonomic Services.

4.1.2 Salt Marsh

Based on existing salt marsh mapping 98% of this habitat type occurs from 25 cm to 350 cm NAVD88; with more than 75% of salt marsh currently occurring between a more narrow band (the preferred range) of 100 cm and 200 cm. Figure 4b displays the total area within the District that is suitable for salt marsh as well as the area that falls within the preferred range. Of the area that has the potential to support salt marsh, currently only 15 percent (81 acres) is occupied. The remaining areas may be unoccupied for a variety of reasons including environmental variables as well as land use differences and possible disturbances. This analysis was not designed to explain the drivers behind unoccupied areas.

Table 4-3. Salt Marsh Eelgrass Habitat Analysis Elevation Range and Preferred Elevation Range

Analysis Range (98% Elevation Range)	+25 cm to +350 cm
Baseline Acres	81 acres
Preferred Range	+100 cm to +200 cm
Acreage within Preferred	60 acres



Photos of Salt Marsh Complex in San Diego Bay, Emory Cove. Each photo shows a different subhabitat along elevation and tidal inundation gradients, note changing vegetation**.** **A.** Upland to high marsh transition, **B.** High Marsh to Mid Marsh, **C.** Mid Marsh to Low Marsh, and **D.** Low Marsh to Mudflat and Subtidal.

4.1.3 Uplands

Overall topography in the District is limited with subtidal areas reaching -13.5 meters in depth near the shipyards just north of the Coronado Bridge and the highest elevation of habitat mapped within the District at +9.75 meters. This coupled with the high intensity of land uses and developed land surrounding San Diego Bay trap upland habitats between rising sea levels and the development of a busy port district. According to baseline mapping, uplands currently occupy 22.8% of 97 acres of available area. Uplands can be found at any elevation above 200 cm and do not have a preferred elevation range as the only limit is the lower limit and sea level interaction. Figure 4c displays the current suitable areas for uplands, based on any available area above 200 cm without permanent development.

4.1.4 Beach and Dunes

Beaches and dunes are not expected to regenerate or migrate with sea level rise as the natural processes of sediment and wind are substantially manipulated. This analysis assumes beaches and dunes currently occur in the areas where they can be supported. The currently mapped beach and dune habitat is shown on Figure 3, totaling 13.5 acres ranging from 125 cm to 500 cm.

Photo showing Tidelands Park with Coronado Bridge in the background, riprap in the foreground, and a recreational park at the back.

Source: ICF; Port of San Diego; USGS; SanGIS; ESRI; CoSMoS Elevations NAVD88 cm (2019)

Figure 4a
Mapped Suitable Areas for Eelgrass
Current Conditions

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Figure 4b
Mapped Suitable Areas for Salt Marsh
Current Conditions

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Source: ICF; Port of San Diego; USGS; SanGIS; ESRI; CoSMoS Elevations NAVD88 cm (2019)

0 1 2 Mile(s)
1 inch equals 1 mile(s)

Figure 4c
Mapped Suitable Areas for Uplands
Current Conditions

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4.2 Future Conditions, Sea Level Rise Scenarios

The following table provides an overview of the available area (in acres) for each habitat type under each of the four sea level rise scenarios based on the analysis range. In addition, the acres of predicted occupied habitat are shown for each habitat based on the baseline absolute and relative occupancy rates. Overall the terrestrial habitats (salt marsh, beach/dune, and upland) decline with increasing sea level rise scenarios. The decreasing trend is consistent with existing research but likely underestimates the decline due to a variety of assumptions required for this analysis, in particular assuming there is adequate time for habitat to respond in advance of rising seas. The subtidal habitat (eelgrass) has a unique trend, with increasing acreage in the moderate sea level rise scenarios but a sharp decline in the 2100 High scenario. The 2100 High eelgrass trend is driven by a reduction in available area coupled with a larger reduction in the preferred range, with more of the available habitat occurring in the deeper range where occupancy rates are lower. The trends for each habitat are discussed further below.

Table 4-4. Existing and Predicted Acreage Available for Each Habitat Type and Percent Occupied

	Baseline* No Sea Level Rise		Sea Level Rise Scenarios** Year 2030 +25 cm		Sea Level Rise Scenarios** Year 2050 +50 cm		Sea Level Rise Scenarios** Year 2100 Low +75 cm		Sea Level Rise Scenarios** Year 2100 High +150 cm	
Habitat Type	**Available**	**Occupied**	**Available**	**Occupied**	**Available**	**Occupied**	**Available**	**Occupied**	**Available**	**Occupied**
Eelgrass	1,718	915	1,752.7	982.8	1,762.3	1,016.3	1,747.5	979.4	1,621.5	668.2
Salt Marsh	532	81	472.6	75.9	432.7	74.4	415.1	75.2	370.5	78.3
Beach/ Dune***	13	-	-	12.7	-	11.6	-	10.7	-	8.6
Uplands	426	97	394.5	90.1	360.0	82.2	322.1	73.4	222.6	50.8

* Baseline values are based on the current vegetation map and elevation data.

** All sea level rise scenarios acreages are predictions based on the mapped baseline conditions and the resulting elevation ranges and mapped percent occupancy.

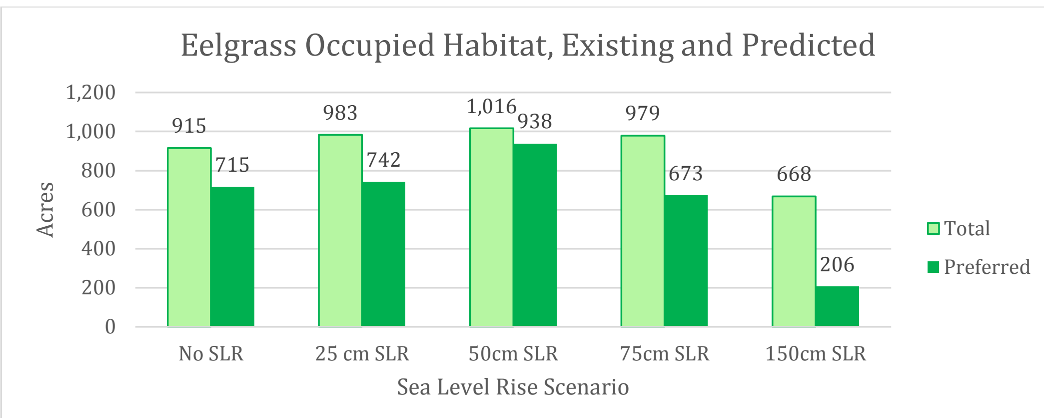
*** Beach/dune habitats are driven primarily by sediment and wind processes, they are considered static with no additional areas available.

4.2.1 Eelgrass

Based on existing eelgrass mapping this habitat type occurs from -325 to +25 cm NAVD88; with 78% of current mapping occurring between -125 and 0 cm, i.e. the preferred range. Figure 4a displays the current suitable habitat and the elevation for eelgrass throughout the District. The graph below summarizes current and predicted eelgrass habitat under future sea level rise scenarios. As seen in Graph 1, the overall availability for eelgrass increases for the first three sea level rise scenarios as a result of increased acres of area within the preferred range (-125 cm to 0 cm) where eelgrass relative cover is higher. However, the availability for eelgrass takes a sharp decline (27 percent decrease) in the Year 2100 High scenario that assumes +150 cm. Figure 5a shows predicted suitable habitat for the Year 2100 High Scenario, after +150 cm sea level rise. The sharp decline in availability for eelgrass occurs as the slopes increase and a larger percentage of the suitable habitat occurs deeper than the preferred range where eelgrass occurs at much lower densities.

A similar trend is observed when looking closer at the preferred elevation range, with eelgrass habitat increasing 31% in the 50 cm SLR scenario. However, the preferred area begins a declining trend in both 2100 scenarios with a 6% decline in the +75 scenario and a 73% decline in the +150 scenario. Under 2100 High scenario, 73% of the current eelgrass populations will be deeper than the preferred elevation range. Unlike other habitats, eelgrass is a single species habitat that responds to changing environmental conditions with varying densities and heights. The loss of the preferred range in the 2100 scenarios has implications on habitat structure and corresponding functions, as eelgrass structure changes along an elevation gradient. At the deeper end of the range eelgrass is often sparse and tall while at the shallow end of the range eelgrass is often very dense and short.

Graph 1. Eelgrass Occupied Habitat in District, Existing and Predicted

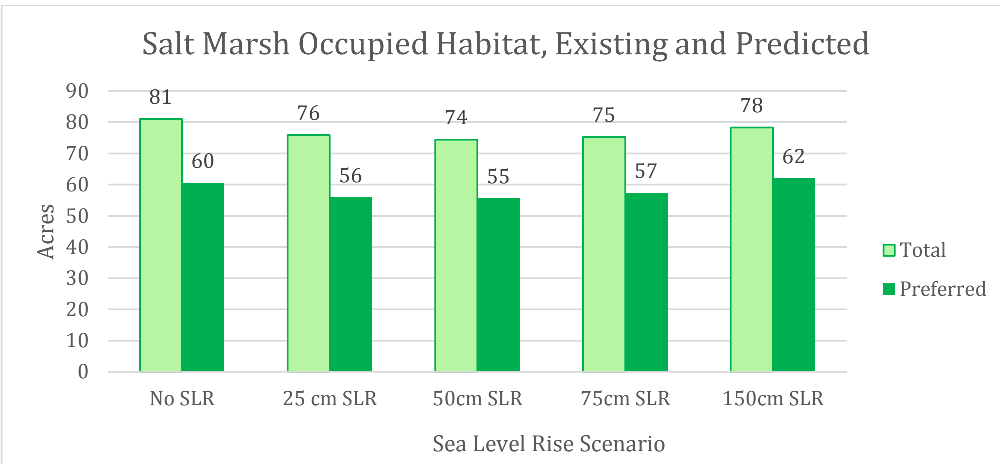


4.2.2 Salt Marsh Complex

Based on existing salt marsh mapping this habitat type occurs from +25 cm to +350 cm NAVD88; with 75% of current mapping occurring between 100 cm and 200 cm. Figure 4b displays the current suitable habitat and the elevation for salt marsh throughout the District. Figure 5b shows predicted suitable habitat for the Year 2100 High Scenario, after +150 cm sea level rise. The chart below summarizes current and predicted salt marsh habitat under future sea level rise scenarios. As seen in Graph 2, there is an overall reduction in total occupied habitat for all for scenarios, with a loss of 7 to 3 acres relative to the existing 81 acres of mapped salt marsh. When looking closer at the preferred range, which was determined to be between +100 and +200 cm, it appears that acreage decreases slightly with the first three scenarios but increases slightly under the 2100 High scenario, with 2 additional acres in the preferred range. For all scenarios, it appears there is space for existing salt marsh habitat to occupy if lateral migration occurs. Many of these areas are currently being occupied by upland habitats. Understanding the current conditions of the new salt marsh areas including existing habitats, soils, compaction, sensitive species management and other environmental variables, would help to understand the likelihood of habitat migrating and whether additional management actions would be required. Under each sea level rise scenario salt marsh habitat would move upslope into existing upland areas, while the lower range of salt marsh would be encroached upon by eelgrass.

It is important to remember that unlike eelgrass (a monoculture), salt marsh habitat is comprised of multiple sub-habitat types ranging from mudflat at the lowest elevation, to low marsh, mid marsh, high marsh, and transitional uplands as the high end. As these sub-habitats align themselves along an inundation gradient, an additional analysis looking the preferred elevation range of the complex may in fact hide some of the story. For example an analysis of the preferred range of the salt marsh complex may overemphasize the “center” (high and mid marsh) and not a good mix of salt marsh sub-habitats. In order to look closer at this trend, an analysis of the sub-habitats was completed.

Graph 2. Salt Marsh Occupied Habitat in District, Existing and Predicted



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Source: ICF; Port of San Diego; USGS; SanGIS; ESRI; CoSMoS (2019)

ICF N 0 1 2 Miles 1:63,360

Figure 5a
Potentially Suitable Areas for Eelgrass
Year 2100 High Scenario, +150cm

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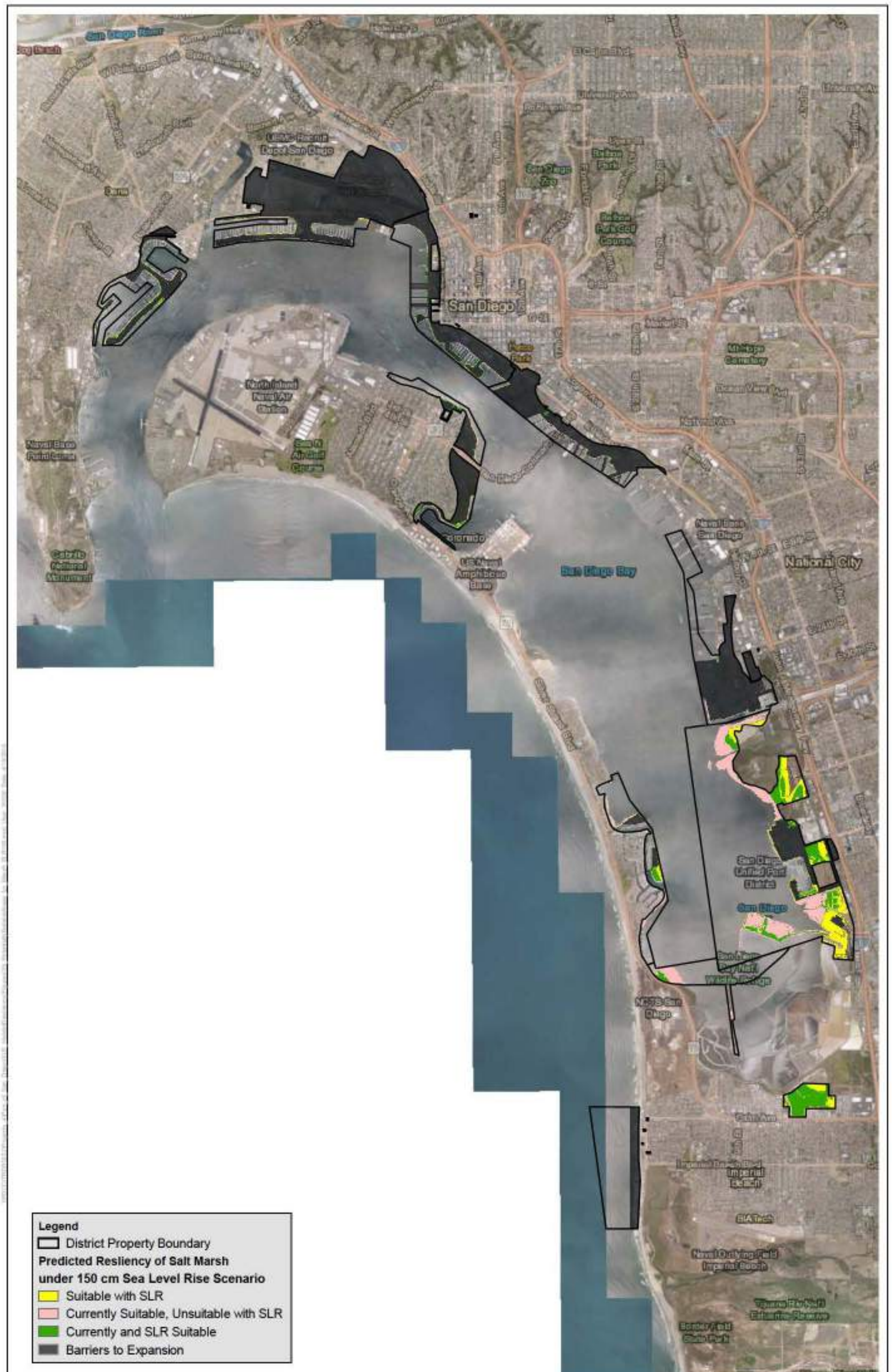

Source: ICF; Port of San Diego; USGS; SanGIS; ESRI; CoSMoS (2019)

0 1 2 Miles
1:63,360

Figure 5b
Potentially Suitable Areas for Salt Marsh
Year 2100 High Scenario, +150cm

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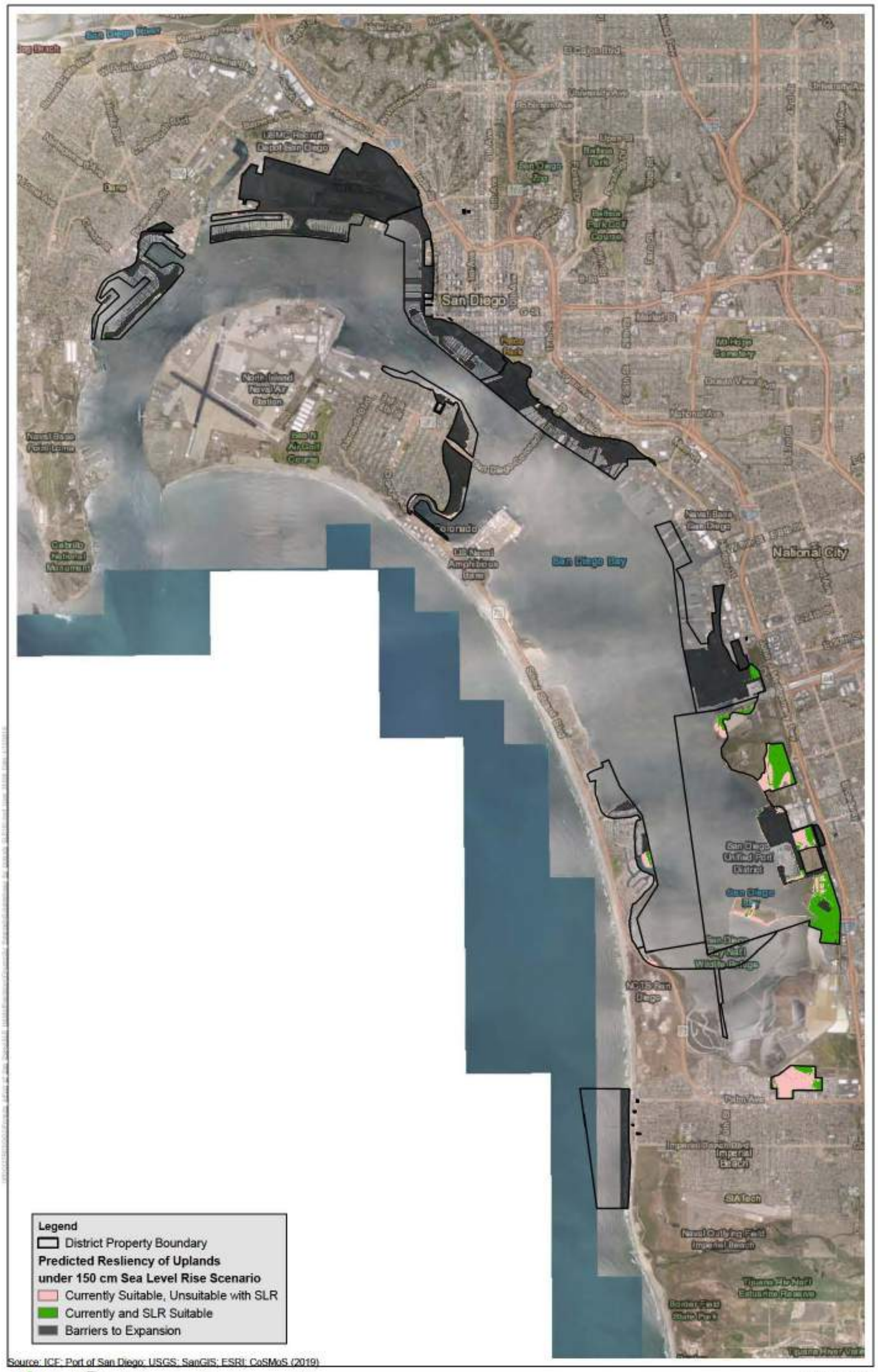

ICF N 0 1 2 Miles 1:63,360

Figure 5c
Potentially Suitable Areas for Uplands
Year 2100 High Scenario, +150cm

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Figure 5d
Potentially Suitable Areas for Beach and Dune
Year 2100 High Scenario, +150cm

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Salt Marsh Sub-Habitats Analysis

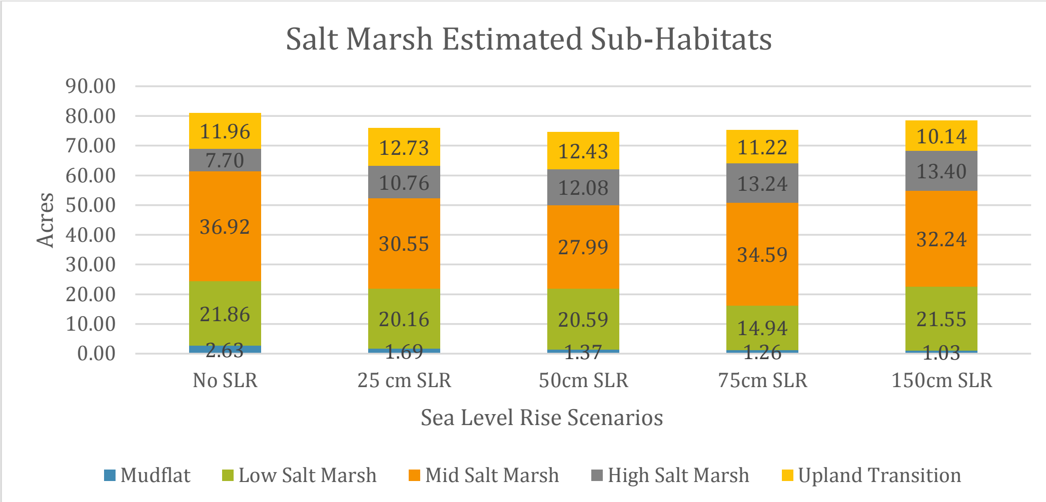
As stated above and further illustrated in Table 5, salt marsh can be divided into 5 sub-habitats including mudflat, low coastal salt marsh, mid coastal salt marsh, high coastal salt marsh, and upland transition. Elevations for the salt marsh components were defined using existing elevation information in San Diego Bay, no vegetation mapping to this resolution was available. The unique elevation bands for each salt marsh sub-habitat is being applied to the existing salt marsh complex mapping (ESA 2017 and NAVFAC 2013). As no formal mapping or field verification of these sub-habitats has been completed, this analysis should be used for conversation purposes and to advise future monitoring and data needs.

Table 4-5. Salt Marsh Habitats, Elevation Range, Associated Floral Species

Target Habitat	Elevation NAVD88 (cm)	Associated Floral Species
Subtidal (unvegetated)	Below -325	unvegetated
Subtidal (eelgrass)	+325 to +25	eelgrass (*Zostera marina*) or non-vegetated
Mudflat	+25 to +125	non-vegetated
Low Coastal Salt Marsh	+88 to +125	California cordgrass (*Spartina foliosa*) or non-vegetated
Mid Coastal Salt Marsh	+125 to +175	dwarf saltwort (*Salicornia bigelovii*), Pacific swampfire (*Salicornia virginica*), *Jaumea carnosa, Batis maritime,* Parish's glasswort (*Arthrocnemum subterminale*)
High Coastal Salt Marsh	+175 to +200	*Salicornia virginica,* Parish's glasswort (*Arthrocnemum subterminale), Monanthochloe littoralis, Distichlis spicata, Frankenia salina, Limonium californicum, Suaeda taxifolia*
Upland Transition	above +200 AND immediately adjacent to salt marsh and tidal exchange	California buckwheat (*Eriogonum fasciculatum*), wild rye (*Leymus condensatus* and *L. triticoides*), western ragweed (*Ambrosia psilostachya*), California poppy (*Eschscholzia californica*), purple needlegrass (*Nasella pulchra*), coast goldenbush (*Isocoma menziesii*), black sage (*Salvia mellifera*), coyote brush (*Baccharis pilularus*), bladderpod (*Cleome isomeris*), coast sunflower (*Encelia californica*), deerweed (*Lotus scoparius*), arrow weed (*Pluchea sericea*)

Graph 3 depicts the overall mix of sub-habitats and any changes in the diversity of those sub-habitats by sea level rise scenario. Each of the salt marsh sub-habitats are estimated from the existing habitat, predicted habitat, and topography ranges as described above. In all cases mudflat is the lowest relative cover representing less than 2 percent of the total salt marsh habitat with the most significant drop occurring in the +150 cm scenario. Mid marsh habitat consistently makes up the largest percentage of each scenario ranging from 28 percent to 37 percent. Low marsh is the second largest group, representing 20 percent of each scenario other than in the +75 scenario where there is a decline of 15 percent. Low marsh is often considered a regionally significant habitat, further emphasizing the need to map this habitat properly.

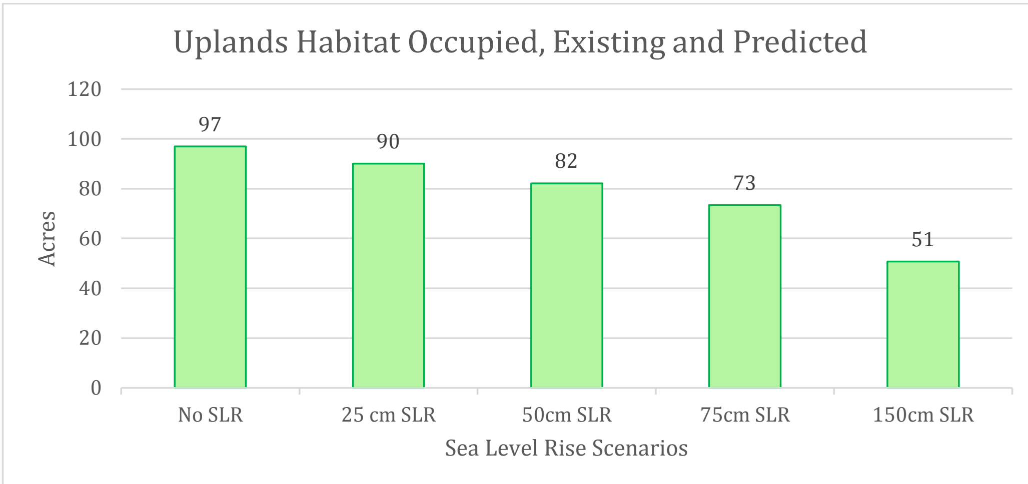
Graph 3. Salt Marsh Estimated Sub-Habitats in District



4.2.3 Uplands

Upland habitats within the District are bound by the rising ocean on the low end and urban development on the high end in addition to occupying area that may be used by retreating salt marsh habitat. As shown in the graph below, with limited space to migrate this habitat could potentially lose nearly a third of its footprint after 150 cm of sea level rise. According to baseline mapping, uplands currently occupies 22.8% of available area, and that same rate was applied to available area after each sea level rise increment was calculated. As a result, upland habitat area declines roughly 47 percent by the end of the century under the +150 cm scenario. Figure 4c displays the current suitable areas for uplands, based on any available area above 200 cm without permanent development. Figure 5c shows predicted suitability of the same area after 150 cm sea level rise.

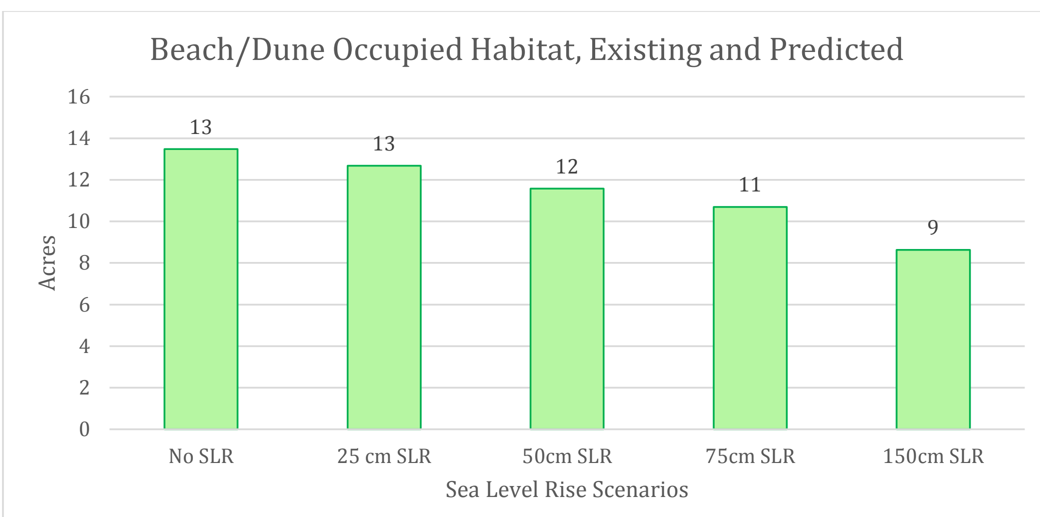
Graph 4. Uplands Occupied Habitat in District, Existing and Predicted



4.2.4 Beach and Dunes

Beaches and dunes are not expected to regenerate or migrate with sea level rise as the natural processes of sediment and wind are substantially manipulated. This analysis assumes beaches and dunes currently occur in the areas where they can be supported. Beaches and dunes are not expected to regenerate or migrate with sea level rise. This analysis predicts that beach and dune will be lost to inundation from the current 13 acres to potentially around 9 acres. Current conditions and predicted loss are displayed on Figure 4d, which includes a detailed image of Coronado, as a typical example of the small beaches scattered around the District jurisdiction.

Graph 5. Beach/Dune Occupied Habitat in District Acres, Existing and Predicted



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Section 5
Recommendations

The purpose of this evaluation was to compile mapping of nearshore habitats and evaluate their resiliency to sea level rise pursuant to AB 691 on behalf of the District using 4 selected scenarios: 2030 (25 cm), 2050 (50cm), 2100 (75 cm), and 2100 (150 cm). This work is intended to help the District to analyze a range of potential changes to the habitat of San Diego Bay, and to develop effective adaptive management strategies to maintain the maximum practicable diversity in habitat capable of supporting species and other habitat services. Please be aware that this is a predictive analysis scaled to a bay-wide extent using existing regional data and is intended for general planning purposes. In addition, it is important to remember that sea level rise predictions contain an inherent amount of error in addition to the datasets used to complete this evaluation. The following recommendations are put forward for consideration in future planning and evaluation exercises.

5.1.1 Recommendations

- Implement policies and plan for ecosystem-based engineering solutions for shorelines and wetland restoration and enhancement.
- Consider nature-based solutions where hard infrastructure and steep natural topography limit migration.
- Dredge sediments to be used to increase wetland elevations to outpace SLR.
- Continue partnerships and collaboration with key agencies and stakeholders to monitor the health of habitats and ecosystems in and around San Diego Bay.

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Section 6
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Appendix A
Data Summary Tables

Table 1. Data summary of each elevation class, total area (square meters and acres) of habitat suitability, and acres of occupied habitat.

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitability Within District Sq. Meters	Habitat Suitability Within District Acres	Occupied Habitat in District (acres)** Eelgrass	Occupied Habitat in District (acres)** Salt Marsh	Occupied Habitat in District (acres)** Beach/Dune	Occupied Habitat in District (acres)** Uplands
1	-475	-450	257465	63.6	0.08	-	-	-
2	-450	-425	220175	54.4	0.15	-	-	-
3	-425	-400	235568	58.2	0.57	-	-	-
4	-400	-375	282425	69.8	4.62	-	-	-
5	-375	-350	253158	62.6	3.26	-	-	-
6	-350	-325	241148	59.6	3.85	-	-	-
7	-325	-300	251207	62.1	5.13	-	-	-
8	-300	-275	213665	52.8	6.08	-	-	-
9	-275	-250	221134	54.6	7.70	-	-	-
10	-250	-225	241431	59.7	10.29	-	-	0.03
11	-225	-200	337231	83.3	18.27	-	-	5.91
12	-200	-175	364168	90.0	36.62	-	-	1.53
13	-175	-150	314712	77.8	43.84	-	0.00	1.02
14	-150	-125	383402	94.7	63.40	-	0.00	0.77
15	-125	-100	577704	142.8	113.70	-	0.02	0.69
16	-100	-75	646122	159.7	133.83	-	0.06	0.66
17	-75	-50	571738	141.3	118.02	-	0.13	0.62
18	-50	-25	1100250	271.9	179.75	-	0.20	0.60
19	-25	0	1260418	311.5	169.55	0.04	0.36	1.24
20	0	25	468218	115.7	8.86	0.44	0.80	1.66
21	25	50	392925	97.1	1.49	1.04	1.10	1.63
22	50	75	252128	62.3	0.49	1.60	0.88	1.98
23	75	100	161533	39.9	0.32	6.06	0.87	2.41
24	100	125	149267	36.9	0.16	15.79	0.59	2.36

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitability Within District Sq. Meters	Habitat Suitability Within District Acres	Occupied Habitat in District (acres)** Eelgrass	Occupied Habitat in District (acres)** Salt Marsh	Occupied Habitat in District (acres)** Beach/Dune	Occupied Habitat in District (acres)** Uplands
25	125	150	137595	34.0	0.06	17.69	0.60	3.23
26	150	175	145814	36.0	0.01	19.22	0.77	2.49
27	175	200	89498	22.1	0.01	7.70	0.95	3.56
28	200	225	124979	30.9	0.00	4.33	1.68	7.74
29	225	250	140404	34.7	-	2.94	1.22	7.86
30	250	275	153840	38.0	-	1.69	1.32	5.87
31	275	300	131168	32.4	-	1.00	1.16	6.40
32	300	325	116591	28.8	-	0.97	0.75	6.97
33	325	350	155670	38.5	-	1.03	0.66	10.87
34	350	375	154038	38.1	-	0.42	0.11	11.11
35	375	400	90550	22.4	-	0.22	0.02	10.37
36	400	425	90258	22.3	-	0.03	0.03	6.46
37	425	450	105943	26.2	-	0.03	0.01	4.27
38	450	475	80465	19.9	-	0.03	0.03	3.78
39	475	500	65846	16.3	-	0.03	0.00	2.04
40	500	525	49996	12.4	-	0.02	-	0.93
41	525	550	39166	9.7	-	0.01	-	1.39
42	550	575	33302	8.2	-	0.01	-	1.80
43	575	600	31360	7.7	-	0.01	-	2.38
44	600	625	32836	8.1	-	0.01	-	2.21
45	625	650	29212	7.2	-	0.01	-	1.74
46	650	675	21590	5.3	-	0.01	-	0.75
47	675	700	20244	5.0	-	0.00	-	0.54
48	700	725	16050	4.0	-	0.00	-	0.46
49	725	750	10711	2.6	-	-	-	0.36
50	750	775	10969	2.7	-	-	-	0.63

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitability Within District Sq. Meters	Habitat Suitability Within District Acres	Occupied Habitat in District (acres)** Eelgrass	Occupied Habitat in District (acres)** Salt Marsh	Occupied Habitat in District (acres)** Beach/Dune	Occupied Habitat in District (acres)** Uplands
51	775	800	8173	2.0	-	-	-	0.01
52	800	825	4736	1.2	-	-	-	0.01
53	825	850	2170	0.5	-	-	-	0.00
54	850	875	1006	0.2	-	-	-	-
55	875	900	874	0.2	-	-	-	-
56	900	925	720	0.2	-	-	-	-
57	925	950	472	0.1	-	-	-	-
58	950	975	221	0.1	-	-	-	-
59	975	1000	4	0.0	-	-	-	-
60	1000	1025	-	-	-	-	-	-
61	1025	1050	-	-	-	-	-	-
62	1050	1075	-	-	-	-	-	-
63	1075	1100	-	-	-	-	-	-
64	1100	1125	-	-	-	-	-	-
65	1125	1150	-	-	-	-	-	-
66	1150	1175	-	-	-	-	-	-
67	1175	1200	-	-	-	-	-	-
68	1200	1225	-	-	-	-	-	-
69	1225	1250	-	-	-	-	-	-
70	1250	1275	-	-	-	-	-	-
71	1275	1300	-	-	-	-	-	-
72	1300	1325	-	-	-	-	-	-
73	1325	1350	-	-	-	-	-	-
74	1350	1375	-	-	-	-	-	-
75	1375	1400	-	-	-	-	-	-
76	1400	1425	-	-	-	-	-	-

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitability Within District Sq. Meters	Habitat Suitability Within District Acres	Occupied Habitat in District (acres)** Eelgrass	Occupied Habitat in District (acres)** Salt Marsh	Occupied Habitat in District (acres)** Beach/Dune	Occupied Habitat in District (acres)** Uplands
77	1425	1450	-	-	-	-	-	-
78	1450	1475	-	-	-	-	-	-

* Value in this table represents the GIS code for a 25cm elevation range of CoSMoS elevation data in NAVD88
** The counts in this table represent 1sq m cells of occupied habitat

Table 2. Summary of data used for eelgrass habitat evaluation for each SLR scenario.

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
Baseline Current Conditions							
1	-475	-450	-	-	-	-	Outside Analysis Range
2	-450	-425	-	-	-	-	Outside Analysis Range
3	-425	-400	-	-	-	-	Outside Analysis Range
4	-400	-375	-	-	-	-	Outside Analysis Range
5	-375	-350	-	-	-	-	Outside Analysis Range
6	-350	-325	-	-	-	-	Outside Analysis Range
7	-325	-300	62.1	5.1	8%	1%	Analysis Range, including 98% of current habitat
8	-300	-275	52.8	6.1	12%	1%	Analysis Range, including 98% of current habitat
9	-275	-250	54.6	7.7	14%	1%	Analysis Range, including 98% of current habitat
10	-250	-225	59.7	10.3	17%	1%	Analysis Range, including 98% of current habitat
11	-225	-200	83.3	18.3	22%	2%	Analysis Range, including 98% of current habitat
12	-200	-175	90.0	36.6	41%	4%	Analysis Range, including 98% of current habitat
13	-175	-150	77.8	43.8	56%	5%	Analysis Range, including 98% of current habitat
14	-150	-125	94.7	63.4	67%	7%	Analysis Range, including 98% of current habitat
15	-125	-100	142.8	113.7	80%	12%	Preferred elevation range of habitat
16	-100	-75	159.7	133.8	84%	15%	Preferred elevation range of habitat
17	-75	-50	141.3	118.0	84%	13%	Preferred elevation range of habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
18	-50	-25	271.9	179.8	66%	20%	Preferred elevation range of habitat
19	-25	0	311.5	169.6	54%	19%	Preferred elevation range of habitat
20	0	25	115.7	8.9	8%	1%	
21	25	50	97.1	-	-	-	Outside Analysis Range
22	50	75	62.3	-	-	-	Outside Analysis Range
23	75	100	39.9	-	-	-	Outside Analysis Range
24	100	125	36.9	-	-	-	Outside Analysis Range
25	125	150	34.0	-	-	-	Outside Analysis Range
26	150	175	36.0	-	-	-	Outside Analysis Range
27	175	200	22.1	-	-	-	Outside Analysis Range
28	200	225	30.9	-	-	-	Outside Analysis Range
2030 SLR Scenario (+25 cm)							
1	-500	-475	-	-	-	-	Outside Analysis Range
2	-475	-450	-	-	-	-	Outside Analysis Range
3	-450	-425	-	-	-	-	Outside Analysis Range
4	-425	-400	-	-	-	-	Outside Analysis Range
5	-400	-375	-	-	-	-	Outside Analysis Range
6	-375	-350	-	-	-	-	Outside Analysis Range
7	-350	-325	62.1	-	-	-	Outside Analysis Range
8	-325	-300	52.8	4.4	8%	0%	Analysis Range, including 98% of current habitat
9	-300	-275	54.6	6.3	12%	1%	Analysis Range, including 98% of current habitat
10	-275	-250	59.7	8.4	14%	1%	Analysis Range, including 98% of current habitat
11	-250	-225	83.3	14.4	17%	1%	Analysis Range, including 98% of current habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
12	-225	-200	90.0	19.7	22%	2%	Analysis Range, including 98% of current habitat
13	-200	-175	77.8	31.6	41%	3%	Analysis Range, including 98% of current habitat
14	-175	-150	94.7	53.4	56%	5%	Analysis Range, including 98% of current habitat
15	-150	-125	142.8	95.5	67%	10%	Analysis Range, including 98% of current habitat
16	-125	-100	159.7	127.2	80%	13%	Preferred elevation range of habitat
17	-100	-75	141.3	118.4	84%	12%	Preferred elevation range of habitat
18	-75	-50	271.9	227.1	84%	23%	Preferred elevation range of habitat
19	-50	-25	311.5	205.9	66%	21%	Preferred elevation range of habitat
20	-25	0	115.7	63.0	54%	6%	
21	0	25	97.1	7.4	8%	1%	
22	25	50	62.3	-	-	-	
23	50	75	39.9	-	-	-	
24	75	100	36.9	-	-	-	
25	100	125	34.0	-	-	-	Outside Analysis Range
26	125	150	36.0	-	-	-	
27	150	175	22.1	-	-	-	
28	175	200	30.9	-	-	-	
2050 SLR Scenario (+50 cm)							
1	-525	-500	-	-	-	-	
2	-500	-475	-	-	-	-	
3	-475	-450	-	-	-	-	
4	-450	-425	-	-	-	-	

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
5	-425	-400	-	-	-	-	Outside Analysis Range
6	-400	-375	-	-	-	-	
7	-375	-350	62.1	-	-	-	
8	-350	-325	52.8	-	-	-	
9	-325	-300	54.6	4.5	8%	0%	Analysis Range, including 98% of current habitat
10	-300	-275	59.7	6.9	12%	1%	Analysis Range, including 98% of current habitat
11	-275	-250	83.3	11.7	14%	1%	Analysis Range, including 98% of current habitat
12	-250	-225	90.0	15.5	17%	2%	Analysis Range, including 98% of current habitat
13	-225	-200	77.8	17.0	22%	2%	Analysis Range, including 98% of current habitat
14	-200	-175	94.7	38.6	41%	4%	Analysis Range, including 98% of current habitat
15	-175	-150	142.8	80.5	56%	8%	Analysis Range, including 98% of current habitat
16	-150	-125	159.7	106.8	67%	11%	
17	-125	-100	141.3	112.5	80%	11%	Preferred elevation range of habitat
18	-100	-75	271.9	227.9	84%	22%	Preferred elevation range of habitat
19	-75	-50	311.5	260.2	84%	26%	Preferred elevation range of habitat
20	-50	-25	115.7	76.5	66%	8%	Preferred elevation range of habitat
21	-25	0	97.1	52.9	54%	5%	Preferred elevation range of habitat
22	0	25	62.3	4.8	8%	0%	
23	25	50	39.9	-	-	-	

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
24	50	75	36.9	-	-	-	Outside Analysis Range
25	75	100	34.0	-	-	-	
26	100	125	36.0	-	-	-	
27	125	150	22.1	-	-	-	
28	150	175	30.9	-	-	-	
2100 Low SLR Scenario (+75 cm)							
1	-550	-525	-	-	-	-	Outside Analysis Range
2	-525	-500	-	-	-	-	
3	-500	-475	-	-	-	-	
4	-475	-450	-	-	-	-	
5	-450	-425	-	-	-	-	
6	-425	-400	-	-	-	-	
7	-400	-375	62.1	-	-	-	
8	-375	-350	52.8	-	-	-	
9	-350	-325	54.6	-	-	-	
10	-325	-300	59.7	4.9	8%	1%	Analysis Range, including 98% of current habitat
11	-300	-275	83.3	9.6	12%	1%	Analysis Range, including 98% of current habitat
12	-275	-250	90.0	12.7	14%	1%	Analysis Range, including 98% of current habitat
13	-250	-225	77.8	13.4	17%	1%	Analysis Range, including 98% of current habitat
14	-225	-200	94.7	20.8	22%	2%	Analysis Range, including 98% of current habitat
15	-200	-175	142.8	58.1	41%	6%	Analysis Range, including 98% of current habitat
16	-175	-150	159.7	90.0	56%	9%	Analysis Range, including 98% of current habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
17	-150	-125	141.3	94.5	67%	10%	Analysis Range, including 98% of current habitat
18	-125	-100	271.9	216.5	80%	22%	Preferred elevation range of habitat
19	-100	-75	311.5	261.1	84%	27%	Preferred elevation range of habitat
20	-75	-50	115.7	96.6	84%	10%	Preferred elevation range of habitat
21	-50	-25	97.1	64.2	66%	7%	Preferred elevation range of habitat
22	-25	0	62.3	33.9	54%	3%	Preferred elevation range of habitat
23	0	25	39.9	3.1	8%	0%	
24	25	50	36.9	-	-	-	
25	50	75	34.0	-	-	-	
26	75	100	36.0	-	-	-	Outside Analysis Range
27	100	125	22.1	-	-	-	
28	125	150	30.9	-	-	-	
2100 High SLR Scenario (+150 cm)							
1	-625	-600	-	-	-	-	
2	-600	-575	-	-	-	-	
3	-575	-550	-	-	-	-	Outside Analysis Range
4	-550	-525	-	-	-	-	
5	-525	-500	-	-	-	-	
6	-500	-475	-	-	-	-	
7	-475	-450	62.1	-	-	-	
8	-450	-425	52.8	-	-	-	
9	-425	-400	54.6	-	-	-	
10	-400	-375	59.7	-	-	-	

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Eelgrass in District (acres)	% Occupied**	Relative %	Comments
11	-375	-350	83.3	-	-	-	
12	-350	-325	90.0	-	-	-	
13	-325	-300	77.8	6.4	8%	1%	Analysis Range, including 98% of current habitat
14	-300	-275	94.7	10.9	12%	2%	Analysis Range, including 98% of current habitat
15	-275	-250	142.8	20.1	14%	3%	Analysis Range, including 98% of current habitat
16	-250	-225	159.7	27.5	17%	4%	Analysis Range, including 98% of current habitat
17	-225	-200	141.3	31.0	22%	5%	Analysis Range, including 98% of current habitat
18	-200	-175	271.9	110.6	41%	17%	
19	-175	-150	311.5	175.6	56%	26%	
20	-150	-125	115.7	77.4	67%	12%	
21	-125	-100	97.1	77.3	80%	12%	
22	-100	-75	62.3	52.2	84%	8%	Preferred elevation range of habitat
23	-75	-50	39.9	33.3	84%	5%	Preferred elevation range of habitat
24	-50	-25	36.9	24.4	66%	4%	Preferred elevation range of habitat
25	-25	0	34.0	18.5	54%	3%	Preferred elevation range of habitat
26	0	25	36.0	2.8	8%	0%	
27	25	50	22.1	-	-	-	Outside Analysis Range
28	50	75	30.9	-	-	-	

Table 3. Summary of data used for saltmarsh habitat evaluation for each SLR scenario.

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
Baseline Current Conditions							
21	25	50	97.1	1.0	1%	1%	Analysis Range, including 98% of current habitat
22	50	75	62.3	1.6	3%	2%	Analysis Range, including 98% of current habitat
23	75	100	39.9	6.1	15%	7%	Analysis Range, including 98% of current habitat
24	100	125	36.9	15.8	43%	19%	Preferred elevation range of habitat
25	125	150	34.0	17.7	52%	22%	Preferred elevation range of habitat
26	150	175	36.0	19.2	53%	24%	Preferred elevation range of habitat
27	175	200	22.1	7.7	35%	10%	Preferred elevation range of habitat
28	200	225	30.9	4.3	14%	5%	Analysis Range, including 98% of current habitat
29	225	250	34.7	2.9	8%	4%	Analysis Range, including 98% of current habitat
30	250	275	38.0	1.7	4%	2%	Analysis Range, including 98% of current habitat
31	275	300	32.4	1.0	3%	1%	Analysis Range, including 98% of current habitat
32	300	325	28.8	1.0	3%	1%	Analysis Range, including 98% of current habitat
33	325	350	38.5	1.0	3%	1%	Analysis Range, including 98% of current habitat
34	350	375	38.1	0.4	-	-	Outside Analysis Range
35	375	400	22.4	0.2	-	-	Outside Analysis Range
36	400	425	22.3	0.0	-	-	Outside Analysis Range

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
37	425	450	26.2	0.0	-	-	Outside Analysis Range
38	450	475	19.9	0.0	-	-	Outside Analysis Range
39	475	500	16.3	0.0	-	-	Outside Analysis Range
2030 SLR Scenario (+25 cm)							
21	0	25	97.1	-	0%	0%	
22	25	50	62.3	0.7	1%	1%	Analysis Range, including 98% of current habitat
23	50	75	39.9	1.0	3%	1%	Analysis Range, including 98% of current habitat
24	75	100	36.9	5.6	15%	7%	Analysis Range, including 98% of current habitat
25	100	125	34.0	14.6	43%	19%	Preferred elevation range of habitat
26	125	150	36.0	18.7	52%	25%	Preferred elevation range of habitat
27	150	175	22.1	11.8	53%	16%	Preferred elevation range of habitat
28	175	200	30.9	10.8	35%	14%	Preferred elevation range of habitat
29	200	225	34.7	4.9	14%	6%	Analysis Range, including 98% of current habitat
30	225	250	38.0	3.2	8%	4%	Analysis Range, including 98% of current habitat
31	250	275	32.4	1.4	4%	2%	Analysis Range, including 98% of current habitat
32	275	300	28.8	0.9	3%	1%	Analysis Range, including 98% of current habitat
33	300	325	38.5	1.3	3%	2%	Analysis Range, including 98% of current habitat
34	325	350	38.1	1.0	3%	1%	Analysis Range, including 98% of current habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
35	350	375	22.4	0.2	-	-	
36	375	400	22.3	0.0	-	-	
37	400	425	26.2	0.0	-	-	
38	425	450	19.9	0.0	-	-	
39	450	475	16.3	0.0	-	-	
2050 SLR Scenario (+50 cm)							
21	-25	0	97.1	0.0	-	0%	
22	0	25	62.3	0.0	-	0%	
23	25	50	39.9	0.4	1%	1%	Analysis Range, including 98% of current habitat
24	50	75	36.9	0.9	3%	1%	Analysis Range, including 98% of current habitat
25	75	100	34.0	5.2	15%	7%	Analysis Range, including 98% of current habitat
26	100	125	36.0	15.4	43%	21%	Preferred elevation range of habitat
27	125	150	22.1	11.5	52%	15%	Preferred elevation range of habitat
28	150	175	30.9	16.5	53%	22%	Preferred elevation range of habitat
29	175	200	34.7	12.1	35%	16%	Preferred elevation range of habitat
30	200	225	38.0	5.3	14%	7%	Analysis Range, including 98% of current habitat
31	225	250	32.4	2.7	8%	4%	Analysis Range, including 98% of current habitat
32	250	275	28.8	1.3	4%	2%	Analysis Range, including 98% of current habitat
33	275	300	38.5	1.2	3%	2%	Analysis Range, including 98% of current habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
34	300	325	38.1	1.3	3%	2%	Analysis Range, including 98% of current habitat
35	325	350	22.4	0.6	3%	1%	Analysis Range, including 98% of current habitat
36	350	375	22.3	0.0	-	-	
37	375	400	26.2	0.0	-	-	
38	400	425	19.9	0.0	-	-	
39	425	450	16.3	0.0	-	-	
2100 Low SLR Scenario (+75 cm)							
21	-50	-25	97.1	0.0		0%	
22	-25	0	62.3	0.0		0%	
23	0	25	39.9	0.0		0%	
24	25	50	36.9	0.4	1%	1%	Analysis Range, including 98% of current habitat
25	50	75	34.0	0.9	3%	1%	Analysis Range, including 98% of current habitat
26	75	100	36.0	5.5	15%	7%	Analysis Range, including 98% of current habitat
27	100	125	22.1	9.5	43%	13%	Preferred elevation range of habitat
28	125	150	30.9	16.1	52%	21%	Preferred elevation range of habitat
29	150	175	34.7	18.5	53%	25%	Preferred elevation range of habitat
30	175	200	38.0	13.2	35%	18%	Preferred elevation range of habitat
31	200	225	32.4	4.5	14%	6%	Analysis Range, including 98% of current habitat
32	225	250	28.8	2.4	8%	3%	Analysis Range, including 98% of current habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
33	250	275	38.5	1.7	4%	2%	Analysis Range, including 98% of current habitat
34	275	300	38.1	1.2	3%	2%	Analysis Range, including 98% of current habitat
35	300	325	22.4	0.8	3%	1%	Analysis Range, including 98% of current habitat
36	325	350	22.3	0.6	3%	1%	Analysis Range, including 98% of current habitat
37	350	375	26.2	0.0	-	-	
38	375	400	19.9	0.0	-	-	
39	400	425	16.3	0.0	-	-	
2100 High SLR Scenario (+150 cm)							
21	-125	-100	97.1	0.0	-	0%	
22	-100	-75	62.3	0.0	-	0%	
23	-75	-50	39.9	0.0	-	0%	
24	-50	-25	36.9	0.0	-	0%	
25	-25	0	34.0	0.0	-	0%	
26	0	25	36.0	0.0	-	0%	
27	25	50	22.1	0.2	1%	0%	Analysis Range, including 98% of current habitat
28	50	75	30.9	0.8	3%	1%	Analysis Range, including 98% of current habitat
29	75	100	34.7	5.3	15%	7%	Analysis Range, including 98% of current habitat
30	100	125	38.0	16.3	43%	21%	Preferred elevation range of habitat
31	125	150	32.4	16.9	52%	22%	Preferred elevation range of habitat
32	150	175	28.8	15.4	53%	20%	Preferred elevation range of habitat

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Habitat Suitable Jurisdiction (acres)	Saltmarsh in District (acres)	% Occupied**	Relative %	Comment
33	175	200	38.5	13.4	35%	17%	Preferred elevation range of habitat
34	200	225	38.1	5.3	14%	7%	Analysis Range, including 98% of current habitat
35	225	250	22.4	1.9	8%	2%	Analysis Range, including 98% of current habitat
36	250	275	22.3	1.0	4%	1%	Analysis Range, including 98% of current habitat
37	275	300	26.2	0.8	3%	1%	Analysis Range, including 98% of current habitat
38	300	325	19.9	0.7	3%	1%	Analysis Range, including 98% of current habitat
39	325	350	16.3	0.4	3%	1%	Analysis Range, including 98% of current habitat

Table 4. Summary of data used for beach/dune habitat evaluation for each SLR scenario.

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Beach/Dune Existing and Predicted (acres) Baseline Beach/Dune	Beach/Dune Existing and Predicted (acres) SLR Scenario 2030 (+25cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2050 (+50cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2100 (+75cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2100 (+150cm)	
20	0	25	0.8	0.8	0.8	0.8	0.8	Lost to inundation, possible eelgrass or open water
21	25	50	1.1	1.1	1.1	1.1	1.1	Lost to inundation, possible eelgrass or open water
22	50	75	0.9	0.9	0.9	0.9	0.9	Lost to inundation, possible eelgrass or open water
23	75	100	0.9	0.9	0.9	0.9	0.9	Lost to inundation, possible eelgrass or open water
24	100	125	0.6	0.6	0.6	0.6	0.6	Lost to inundation, possible eelgrass or open water
25	125	150	0.6	0.6	0.6	0.6	0.6	Lost to inundation, possible eelgrass or open water
26	150	175	0.8	0.8	0.8	0.8	0.8	Analysis range
27	175	200	0.9	0.9	0.9	0.9	0.9	Analysis range
28	200	225	1.7	1.7	1.7	1.7	1.7	Analysis range
29	225	250	1.2	1.2	1.2	1.2	1.2	Analysis range
30	250	275	1.3	1.3	1.3	1.3	1.3	Analysis range
31	275	300	1.2	1.2	1.2	1.2	1.2	Analysis range
32	300	325	0.8	0.8	0.8	0.8	0.8	Analysis range
33	325	350	0.7	0.7	0.7	0.7	0.7	Analysis range
34	350	375	0.1	0.1	0.1	0.1	0.1	Analysis range

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Beach/Dune Existing and Predicted (acres) Baseline Beach/Dune	Beach/Dune Existing and Predicted (acres) SLR Scenario 2030 (+25cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2050 (+50cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2100 (+75cm)	Beach/Dune Existing and Predicted (acres) SLR Scenario 2100 (+150cm)	
35	375	400	0.0	0.0	0.0	0.0	0.0	Analysis range
36	400	425	0.0	0.0	0.0	0.0	0.0	Analysis range
37	425	450	0.0	0.0	0.0	0.0	0.0	Analysis range
38	450	475	0.0	0.0	0.0	0.0	0.0	Analysis range
39	475	500	0.0	0.0	0.0	0.0	0.0	Analysis range
40	500	525	0	0	0	0	0	Analysis range

Table 5. Summary of data used for upland habitat evaluation for each SLR scenario.

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Uplands Existing and Predicted (acres) Hab Suitable Jurisdiction	Uplands Existing and Predicted (acres) Baseline Uplands	Uplands Existing and Predicted (acres) SLR Scenario 2030 (+25cm)	Uplands Existing and Predicted (acres) SLR Scenario 2050 (+50cm)	Uplands Existing and Predicted (acres) SLR Scenario 2100 (+75cm)	Uplands Existing and Predicted (acres) SLR Scenario 2100 (+150cm)	
28	200	225	30.9	7.7	7.7	7.7	7.7	7.7	Lost to innundation, possible eelgrass or open water
29	225	250	34.7	7.9	7.9	7.9	7.9	7.9	Lost to innundation, possible eelgrass or open water
30	250	275	38.0	5.9	8.7	8.7	8.7	8.7	Lost to innundation, possible eelgrass or open water
31	275	300	32.4	6.4	7.4	7.4	7.4	7.4	Lost to innundation, possible eelgrass or open water
32	300	325	28.8	7.0	6.6	6.6	6.6	6.6	Lost to innundation, possible eelgrass or open water
33	325	350	38.5	10.9	8.8	8.8	8.8	8.8	Lost to innundation, possible eelgrass or open water
34	350	375	38.1	11.1	8.7	8.7	8.7	8.7	Analysis range
35	375	400	22.4	10.4	5.1	5.1	5.1	5.1	Analysis range
36	400	425	22.3	6.5	5.1	5.1	5.1	5.1	Analysis range
37	425	450	26.2	4.3	6.0	6.0	6.0	6.0	Analysis range
38	450	475	19.9	3.8	4.5	4.5	4.5	4.5	Analysis range
39	475	500	16.3	2.0	3.7	3.7	3.7	3.7	Analysis range
40	500	525	12.4	0.9	2.8	2.8	2.8	2.8	Analysis range
41	525	550	9.7	1.4	2.2	2.2	2.2	2.2	Analysis range
42	550	575	8.2	1.8	1.9	1.9	1.9	1.9	Analysis range
43	575	600	7.7	2.4	1.8	1.8	1.8	1.8	Analysis range
44	600	625	8.1	2.2	1.8	1.8	1.8	1.8	Analysis range

Class*	Elevation Range (NAVD88 cm) Low	Elevation Range (NAVD88 cm) High	Uplands Existing and Predicted (acres) Hab Suitable Jurisdiction	Uplands Existing and Predicted (acres) Baseline Uplands	Uplands Existing and Predicted (acres) SLR Scenario 2030 (+25cm)	Uplands Existing and Predicted (acres) SLR Scenario 2050 (+50cm)	Uplands Existing and Predicted (acres) SLR Scenario 2100 (+75cm)	Uplands Existing and Predicted (acres) SLR Scenario 2100 (+150cm)	
45	625	650	7.2	1.7	1.6	1.6	1.6	1.6	Analysis range
46	650	675	5.3	0.7	1.2	1.2	1.2	1.2	Analysis range
47	675	700	5.0	0.5	1.1	1.1	1.1	1.1	Analysis range
48	700	725	4.0	0.5	0.9	0.9	0.9	0.9	Analysis range
49	725	750	2.6	0.4	0.6	0.6	0.6	0.6	Analysis range
50	750	775	2.7	0.6	0.6	0.6	0.6	0.6	Analysis range
51	775	800	2.0	0.0	0.5	0.5	0.5	0.5	Analysis range
52	800	825	1.2	0.0	0.3	0.3	0.3	0.3	Analysis range
53	825	850	0.5	0.0	0.1	0.1	0.1	0.1	Analysis range
54	850	875	0.2	0.0	0.1	0.1	0.1	0.1	Analysis range
55	875	900	0.2	0.0	0.0	0.0	0.0	0.0	Analysis range
56	900	925	0.2	0.0	0.0	0.0	0.0	0.0	Analysis range
57	925	950	0.1	0.0	0.0	0.0	0.0	0.0	Analysis range
58	950	975	0.1	0.0	0.0	0.0	0.0	0.0	Analysis range
59	975	1000	0.0	0.0	0.0	0.0	0.0	0.0	Analysis range

Notes: This data is derived from CoSMoS Elevation data clipped to the District jurisdiction and then filtered to remove barriers to habitat expansion. Then the data was reclassified into the same blocks used across this analysis. The field for value in the table represents the GIS code for a 25cm elevation block, as specified in the Range Low and Range High columns. The Hab Suitable Jurisdiction field represents how many 1sq m cells of that elevation block are available in the District jurisdiction. The light green shading includes the analysis range and quantity of 1sq m cells within the 98% relative total. Uplands in District under current conditions are occupied based on latest available mapping. Darker green indicates Preferred range of habitat. The Uplands in District is the predicted occupied count of 1sq m cells based on available area at the same percent occupied as current. Uplands run out of available habitat in District jurisdiction at 850cm NAVD88. Uplands currently occupies about 22% of total area based on vertical distribution. This analysis is assuming 22% cover remains consistent with SLR and habitat can migrate but is also lost to inundation.

APPENDIX C

NEXUS Planning & Research

Financial Analysis

As part of the analysis for AB691, the Port of San Diego (District) was required to provide "an estimate of the financial cost of the impact of sea level on granted public trust lands." While the AB691 mandate does not require a benefit-cost analysis, the cost of adaptation strategies to mitigate potential sea level rise damages were also estimated. This report summarizes the results of this financial analysis and details how the costs were estimated.

Summary of Estimated Financial Impacts

The tables, on the next pages, show the estimated financial impacts for the projected sea level rise scenarios. The table shows the predicted water heights without a 100-year storm and with a 100-year storm. The District chose these water heights by first reviewing the California Ocean Protection Council probabilistic projections (OPC, 2018), and then aligning them to CoSMoS v3.0. The OPC projections were aligned to CoSMoS because CoSMoS provides GIS layers that show the extent and depth of flooding for multiple scenarios, including those with and without a 100-year storm. These GIS layers were used to identify specific property and infrastructure, with the exception of structures, that could be impacted by sea level rise with and without a 100-year storm.

Tables AP.C1 and AP.C2 show potential primary and secondary impacts from projected sea level rise. The District selected the primary categories (e.g., buildings, etc.) that represent property and infrastructure likely to be damaged from sea level rise, whether due to potential inundation or temporary coastal flooding from a 100-year storm event with projected SLR. The secondary impact categories represent the indirect impacts that would be caused by the primary impacts, such as loss of District business revenue or storm cleanup, traffic control, and emergency response. Some impacts, such as loss of tenant business revenue are discussed qualitatively elsewhere in this report.

The water heights shown in Table AP.C1 and AP.C2 represent projected sea level rise for 2030 (0.8 feet), 2050 (1.6 feet), and 2100 (4.9 feet) with a 5 percent probability of occurring. Additionally, impacts were estimated for 2100 (2.5 feet) with a 50 percent probability of occurring. By including

Table AP.C1: Estimated Financial Impacts: Potential Inundation with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet	2030 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2030.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$1,200,000
		Transportation infrastructure	$18,400,000
		Other infrastructure	$27,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$16,100,000
		Total	**$62,900,000**
1.6 feet	2050 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2050.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$1,200,000
		Transportation infrastructure	$23,900,000
		Other infrastructure	$27,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$16,100,000
		Total	**$68,500,000**
2.5 feet	2100 SLR with no storm event under 50% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$6,300,000
		Transportation infrastructure	$61,400,000
		Other infrastructure	$34,700,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$24,800,000
		Total	**$127,100,000**
4.9 feet	2100 SLR with no storm event under 5% likelihood of occurring. Estimate of potential inundation loss in the year 2100.	**Primary Damage:**	
		Property (structures, parking lots)[1]	$266,900,000
		Transportation infrastructure	$551,700,000
		Other infrastructure	$64,300,000
		Secondary Damage:	
		Loss of Port Business Revenue[2]	$39,200,000
		Total	**$922,100,000**

Table AP.C2: Estimated Financial Impacts: Potential Temporary Coastal Flooding (100-Year Storm Event) with Projected Sea Level Rise

Water Height	Predicted Scenario	No Action Scenario Estimated Damages (2018$ rounded to nearest $100,000)	
0.8 feet + water increase from 100-yr storm event	2030 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2030.[3] Estimating per storm event the potential coastal flooding damages in the year 2030.	**Primary Damage:** Structures (commercial, industrial)	$1,500,000
		Secondary Damage: Storm Cleanup, Traffic Control, Emergency Response.[4]	
		Total	$1,500,000
1.6 feet + water increase from 100-yr storm event	2050 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2050.[3] Estimating per storm event the potential coastal flooding damages in the year 2050.	**Primary Damage:** Structures (commercial, industrial)	$6,300,000
		Secondary Damage: Storm Cleanup, Traffic Control, Emergency Response.[4]	
		Total	$6,300,000
2.5 feet + water increase from 100-yr storm event	2100 SLR under 50% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial)	$12,100,000
		Secondary Damage Storm Cleanup, Traffic Control, Emergency Response.[4]	
		Total	$12,100,000
4.9 feet + water increase from 100-yr storm event	2100 SLR under 5% likelihood of occurring, with 100-year storm event occurring in the year 2100.[3] Estimating per storm event the potential coastal flooding damages in the year 2100.	**Primary Damage:** Structures (commercial, industrial)	$152,400,000
		Secondary Damage: Storm Cleanup, Traffic Control, Emergency Response.[4]	
		Total	$152,400,000[5]

Note: Sea level rise estimated damages that occur without a storm event (inundation) are not included in the 100-yr storm estimates. 100-year storm flooding damages represent only those potential damages that would occur **in addition** to the loss due to sea level rise without a storm event.

[1]Impacted buildings were identified by the District and may not be consistent with the CoSMoS inundation and coastal flooding boundaries. Impacted parking lots were determined from CoSMoS boundaries. Therefore, parking lot and building impacts may not be consistent.

[2]Following the NOAA *What Will Adaptation Cost? Impact Assessment* methodology, this estimate only represents the annual loss for the corresponding scenario year in 2018 dollars. The Impact Assessment methodology estimates damages based on water height and one point in time. However, if the property were lost, the revenue loss would occur for subsequent years as well.

[3]Estimates represent the financial impact from temporary coastal flooding from a 100-year storm event with the corresponding projected SLR elevations.

[4]Cleanup, traffic control, and emergency response are included in annual operating budgets of the District staff. These potential impacts are discussed qualitatively in the report.

[5]Because inundation damages are expected to be substantially greater under the 4.9 feet scenario, 100-year storm event coastal flooding damages are less than previous scenarios.

this additional scenario, the analysis presents a range for a 2100 impacts with a lower and higher probability of transpiring.

The financial estimates were developed following the impact assessment methodology option found in the NOAA report entitled, *What Will Adaptation Cost?* (NOAA, 2013). Although each water height represents a predicted scenario associated with a particular year (i.e., 2030, 2050, and 2100), the estimates were not tied to planning horizons for specific years. Rather, these estimates signify the potential damages for each water height regardless of when they occur. Furthermore, the estimates are independent of one another. Each scenario's estimate only represents potential damages – in 2018 dollars – for the corresponding water height. The estimates do not account for previous damages that may have occurred.

Sea Level Rise without a Storm Event

¬The estimated damages without a storm event represent the cost of potential damages that could result from potential inundation under the "no action" conditions. That is, estimated damages could be caused by increased sea level rise that could permanently flood land, structures, parking lots, and transportation and other infrastructure if no adaptation strategies were enacted to mitigate damages. This permanent flooding from sea level rise is referred to as inundation throughout this chapter. Inundation could lead to a loss of District revenue due to a loss of land that could affect park events, parking, and leases. Please see the methodology section for more information about how these estimates were calculated and what was included in each category.

For all sea level rise water height scenarios without a storm event, the greatest financial impacts would be due to loss of transportation and other infrastructure (Table AP.C1). For the 0.8 and 1.6 feet scenarios, transportation and other infrastructure combined damages are estimated to be over $45 million. Combined damages for the 2.5 feet scenario are estimated to be over $95 million, and for the 4.9 feet scenario, infrastructure damages are estimated to be over $600 million.

Sea level rise impacts are also projected for property throughout the District. For the 0.8 feet and 1.6 feet scenarios, property damages are estimated to be approximately $1.2 million each. Damages for the 2.5 feet scenario are estimated to be over $1 million, and for the 4.9 feet scenarios, damages are estimated to be over $267 million.

Total financial damages, which also include the District's loss of revenue, for 0.8 feet and 1.6 feet are estimated to be $63 and $69 million, respectively. Financial damages for 2.5 feet and 4.9 feet are estimated to range from approximately $127 million to $922 million.

It is important to note that land value is not included in property estimates due to the differing methodology for identifying land and structure impacts. As discussed more in the methodology section, the District identified structure impacts using their own model with local data, while parcel land impacts were based upon CoSMoS identified inundation boundaries. In some areas, the impacts identified by the two models were not consistent. The value of property typically would be estimated from the value of both land and structures; however, due to the inconsistent methodology, this analysis deemed it inappropriate to combine the output of both models to estimate one property value of parcels with both structures and land. Therefore, only structure estimates are included in the analysis, and not land.

Sea Level Rise with a 100-year Storm Event

The estimated damages for the 100-year storm event represent *additional* damages that could occur on top of the potential inundation damages for the corresponding sea level rise water height. This study's sea level rise projections are associated with water heights before a storm event (i.e., 0.8, 1.6, 2.5, and 4.9 feet). A storm event w\could result in additional temporary coastal flooding from a 100-year storm event. On average, a 100-year storm event could result in further coastal flooding of up to approximately 1.15 meters (3.77 ft.) depending upon the scenario and land elevation (OCOF, 2019). Thus, storm event flooding could result in added damages. For example, at 0.8 feet, it is estimated that $62,900,00 in damages could result from potential inundation and an additional $1,500,000 could occur if there were a 100-year storm flooding event. Again, these estimates assume damages that could transpire without implementing additional adaptation strategies.

It is important to point out that a 100-year storm event is a storm that is predicted to occur once every 100 years. Thus, it is highly unlikely that a 100-year storm event would occur in 2030, 2050, and 2100. The predicted scenarios in Table AP.C2 are not meant to suggest that 100-year storm damages would transpire at all three points in time. Rather, the table estimates what the damages *could* be if a 100-year storm corresponded with a particular sea level rise water height (e.g., 1.6 feet).

Coastal flooding damages are only assumed to result in damages to the District structures under this analysis. Storm event flooding is temporary and is not assumed to damage the land or parking lots. While it is foreseeable that temporary coastal flooding could require cleanup, and/or traffic control and emergency response for transportation and other infrastructure (e.g., storm drains), these financials cost fall within the normal operating budget of the District.

As shown in Table AP.C2, damage to structures would have the greatest financial impacts. Storm event damages, in addition to the previously discussed potential inundation damages, could result in almost $1.5 million in structural damages under the 0.8 feet scenario, and more than $6 million under the 1.6 feet scenario. Estimated flooding damages from a 100-year storm event are $12.1 million under the 2.5 feet scenario, and $152.4 million for the 4.9 feet scenario. The storm flooding analysis accounts for structures that are impacted by potential inundation so that they are not double-counted in the financial estimates.

Methodology

Financial estimates were calculated by primarily following the methodology found in the NOAA report *What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure* (NOAA, 2013). The report provides a framework for comparing the cost and benefits of adaptation strategies that could lessen the coastal flooding impacts of current and future sea level rise. Because AB691 only required an estimate of financial impacts and the cost of adaptation strategies without conducting a more comprehensive comparative benefit-cost analysis, this study only utilizes the relevant NOAA methodology for estimating the financial impacts rather than the full benefit-cost estimates.

The District selected water height scenarios from the probabilistic projections for the height of sea level rise for the La Jolla tide gauge (OPC, 2018). They selected four scenarios as shown in Table AP.C3 below. The table also shows the corresponding GIS layers from CoSMoS v3.0 that were used to determine both the extent of chronic inundation due to sea level rise and temporary flooding caused by a 100-year storm for all assets except structures. The District developed their own model for identifying building impacts, which is discussed more in this section.

While the water heights are predicted to occur in particular future timeframes (i.e., 2030, 2050, 2100), the NOAA impact assessment methodology bases Estimated damages on water height instead of a planning horizon. This means that all monetized impacts are shown in present value (2018$), and do not account for previous damages that may occur. For example, estimated damages at 1.6 feet are independent from estimated damages at 0.8 feet.

Table AP.C3: Selected Sea Level Rise Scenarios

Ft. Above the Average Relative Sea Level Over 1991 – 2009	Represents	Corresponding CoSMoS Layer
0.7 feet	5% probability sea level rise meets or exceeds height under high emissions in 2030.	0.25 meter (0.82 ft.)
1.4 feet	5% probability sea level rise meets or exceeds height under high emissions in 2050.	0.50 meter (1.64 ft.)
2.6 feet	50% probability sea level rise meets or exceeds height under high emissions in 2100.	0.75 meter (2.46 ft.)
4.6 feet	5% probability sea level rise meets or exceeds height under high emissions in 2100.	1.50 meter (4.92 ft.)

The analysis was based upon these projected increases in sea level rise following the NOAA impact assessment option in their report. Impacts were assessed for each of the water heights without and with a 100-year storm event. These estimates represent potential damages under a "no action" scenario without adaptation strategies being applied. This analysis had three broad steps:

1. Identify potential impacts by overlaying CoSMoS files over parcels, transportation, and other infrastructure in the District. The District provided data that identified impacted buildings and depth of flooding from their own local model.
2. Monetize the impacts. The next section details how these financial estimates were calculated.
3. Sum the estimated monetary impacts for each water height scenario, shown in Tables AP.C1 and AP.C2 to calculate an overall estimate of potential damages.

For the most part, potential impacts were identified by overlaying the CoSMoS GIS files and intersecting them with the asset GIS layers in ArcMap, either as part of the District initial vulnerability assessment that identified District assets at risk for sea level rise damages or this specific cost analysis that also utilized GIS to identify impacts. When available, this cost analysis used the identified impacts from the vulnerability assessment to be consistent. Additionally, the District developed their own model for identifying impacts to structures based on their local ground elevation data. Table AP.C4 shows the assets that were included in this analysis as either a primary or secondary impact. Primary impacts are those damages to property and infrastructure that are directly caused by chronic inundation and/or flooding. Secondary impacts result from the damages caused to the primary impacts. For example, a loss of the District's parking lots could result in a loss of parking revenue for the District.

The potential impacts of sea level rise could differ depending upon whether impacts were due to potential inundation or temporary coastal flooding. For example, temporary coastal flooding is unlikely to result in the loss of land, parking lots, or certain infrastructure. Therefore, this analysis assumed no temporary coastal flooding damages for these assets.

Table AP.C4 also shows the approach for valuing each category depending upon whether the estimated damage was due to potential inundation (sea level rise with permanent water increase) or due to temporary coastal flooding from a 100-year storm event. (The next section explains these estimation procedures in more detail.)

The value of impacted parcel lands is not included in this analysis because of the differing methodology between structures and land. Typically, inundation estimates would be based upon the value of the structure and the land combined because both could be permanently lost. However, the District developed their own model for estimating structure impacts that was not consistent with the CoSMoS model's inundation and flooding boundaries in some areas. Therefore, it was deemed inappropriate to combine the output from both models to develop one property estimate that represented both land and structures. Alternatively, the District decided to use the structure estimates only. Furthermore, it should also be noted that structure impacts may not be consistent with other asset impacts, such as roads, due to the differing models.

Estimating Primary and Secondary Impacts

This section describes how the primary and secondary impacts were calculated for each asset category, including any assumptions and business rules. As shown in Table AP.C4, most of the estimates for primary impacts were calculated using the replacement cost method. The replacement cost method uses the cost of a similar new item as an estimate of its replacement value, which is then its estimated value (USACE, 1995). Estimates are shown in 2018 dollars. When necessary, estimates for earlier years were inflated to 2018 using the San Diego Region Consumer Price Index (CPI).

Table AP.C4: Methods for Valuing Primary and Secondary Impacts

Asset Category/Impact Type **Primary Impacts**	Methods(s) for Valuing	Data Source(s)
Structures (inundation)	Replacement cost to rebuild the structure in 2018$	District AMP building file with ground elevation; RSMeans (2018)
Structures (100-year storm flooding)	Replacement costs in 2018$. USACE depth damage functions for structure damage only (not contents).	USACE depth damage functions for commercial/industrial property; District AMP building file with ground elevation; RSMeans (2018)
Parking lots[1] (inundation)	Replacement cost to rebuild the parking lot in 2018$	District GIS pavement layer; Cost per square foot from private paving company.
Transportation infrastructure: Roads, rail, bikeways, promenades (inundation)	Replacement costs in 2018$.	NEXUS (2017) Table B-1; Federal Railroad Administration Cost Worksheet; City of San Diego Bicycle Master Plan (2013); District asset inventory
Other infrastructure: Sewer lifts, fuel docks (inundation)	Replacement costs in 2018$	Port of Olympia (2012); Oceanside (2018); District Asset Inventory
Asset Category/Impact Type **Secondary Impacts[2]**	Methods(s) for Valuing	Data Source(s)
Loss of Port revenue due to tenant leases, parking revenue, and park special event permit fees (inundation)	Estimated loss of annual revenue in $2018	District lease data; District parking revenue; District monthly park permits

[1]Only includes tenant parking lots that were included in the District GIS pavement layer.

[2]Cleanup, traffic control, and emergency response are considered secondary impacts, and are included in annual operating budgets of the District staff. These potential impacts are discussed qualitatively in the report.

Structures (inundation)

Structures are at risk for potential inundation when they are located on land where sea level rise is projected to expand the shoreline. When that land is permanently inundated, it is assumed that the land and structure are lost. The resulting financial consequence is the total loss to the land and structure owner. While the District owns the underlying land, tenants lease the building residing on top of it. Thus, both the District and tenants are impacted by potential inundation.

There are no residential structures in the District, only District- and tenant-leased operations, commercial, and industrial structures. Because the District owns the underlying land and it is all public lands, the analysis was unable to consider comparable properties to estimate the sale of similar commercial and industrial properties. Instead, the structures were valued using the replacement cost method of what it would cost to build the structure today. The costs were estimated using the District Asset Management Program (AMP) structure inventory that provided area and perimeter data. Then, the cost to rebuild was calculated using the RSMeans square foot model estimator (RSMeans Online, 2018). RSMeans is construction cost database that provides information that can be used to estimate residential and commercial construction project costs. Their square foot model combines material, labor, and equipment costs into square foot unit costs.

It is also important to note that the District AMP structure inventory and GIS layer only provided the footprint of the building. Thus, even though it was unknown whether higher floors had the same square footage, they were assumed to have the same. This could result in an overestimate, especially for hotel towers that have a much larger first floor than subsequent floors. The structure inventory was also incomplete for the purposes of RSMeans estimation. The number of stories was added by visual inspection on Google Earth, and the District staff provided structure framing/material by commercial and industrial use type. In a few cases, the value of structures could not be estimated due to missing data that could not be obtained.

The District developed their own model for identifying structures that were impacted by sea level rise. Using their local data, they subtracted each building's ground elevation from the mean projected water elevation for each CoSMoS scenario. If the resulting value was negative, the building was not considered impacted; if it were positive, it was deemed impacted. It is important to note that these identified structure impacts differed from those that were identified by overlaying the CoSMoS GIS layers on top of the District's GIS building file. This is likely due to CoSMoS taking into account the topography of the land, and thus, unlike the District's methodology, where individual building ground levels were applied. This difference in methodology essentially resulted in differing inundation and flood boundaries, and associated impacts, for each model.

Structures (100-year storm event flooding)

Flooding is temporary and is not assumed to damage the land. However, it may damage the structure. The analysis estimated coastal flooding damages using the District's AMP structure inventory, District-provided depth files, and USACE depth-damage functions (USACE, 2006). Depth-damage functions or curves predict the percentage of damage that is caused to a structure. The percentage of damage to a structure is determined from the depth of flooding that is projected. This depth is typically based upon the first-floor elevation; however, those data were unavailable, and depth was measured from the ground elevation.

The depth of flooding was based on District depth files developed from their own model, as explained in the previous section. Using the square footage of the structure, and the cost per square foot to build a comparable structure from RS Means (RSMeans Online, 2018), this study first estimated the replacement cost of the structure. Then, the percentage of damage was determined from the depth-damage function curve and multiplied by the estimated replacement cost of the structure to arrive at a monetary estimate of damages.

Because the USACE commercial depth-damage curves are based on 2-story structures, the analysis only considered the estimated cost of the structure's first two floors. For example, a 10-story hotel would not expect to have the percentage (e.g., 66%) applied to all 10 stories. This would overestimate the damages. Therefore, the analysis calculated the replacement cost using the square footage from each structure's first two floors. In cases where the number of stories was missing from the District AMP structure file and the structure could not be viewed on Google Earth, the analysis assumed a 1-story building

Structures that were already shown to be potentially impacted by inundation were not included in the corresponding scenario's storm event coastal flooding damage estimates. It was assumed that once a structure was impacted by inundation, it would not have additional flooding impacts.

Parking lots (Inundation)

Inundation would result in the loss of parking lots because the land underneath them would be permanently underwater. The parking lots were identified by District staff of from the District's pavement GIS file by overlaying CoSMoS layers. Parking structures were not included in this analysis because they were not identified on the pavement GIS file.

The total square feet of each parking lot was calculated in GIS, and was multiplied by $3.56 square foot. While some sources provide an estimate of cost per parking space, it was more efficient to use the square foot method because it did not require site surveys to count parking spaces. The cost per square was estimated from the Ohio Paving & Construction and adjusted to San Diego region using the RSMeans regional indexes.

This analysis utilized the following business rules because chronic inundation that only impacted part of the lot would not be estimated to result in a total loss.

- When less than 50% of the parking lot's total square feet were impacted, the analysis estimated a corresponding proportional loss.
- When 50% or more of the parking lot's total square feet were impacted, the analysis assumed 100% loss of the parking lot's square feet.

Transportation infrastructure (Inundation)

Like land and parking lots, it was assumed that temporary storm flooding would not damage roads, rail, bikeways, and promenades. Potential inundation, however, could result in the loss of these infrastructures. Replacement costs were used to estimate the value of these assets. The District provided the estimates of the total linear feet impacted in its asset inventory table. The estimates were developed by overlaying CoSMoS files and intersecting with each asset's GIS layer.

Roadways: The District's asset inventory provided the total linear feet affected by each scenario. These values were multiplied by the estimated cost to build in linear feet. Because the asset inventory did not breakdown the total linear feet by classification of roads, the cost per linear feet was based on a roadway similar to Pacific Highway since it is the primary highway running through the District. This figure, $7,362 per linear foot, was the road replacement cost sourced from another San Diego region study and inflated to 2018 dollars (Nexus, 2017, Table B-1).

Rail: The District's asset inventory provided the total linear feet impacted for each scenario. These values were converted in linear miles, and multiplied by the estimated cost to build a rail line in miles. Again, the asset inventory did not breakdown the rail classification. It was assumed that the rail represented a commuter rail, rather than light rail, since the COASTER and Amtrak are the primary rail running through the District; however, a more detailed asset inventory could be conducted to break apart the light rail costs. The costs were calculated from the Federal Railroad Administration (FRA) capital projects estimation worksheet. The estimated cost per linear mile was $1,879.798, after inflating to 2018$. This estimate represents the cost to replace the track, and does not include stations and support facilities (e.g., rail yards).

Bikeways: The District asset inventory provided an estimate of the total linear feet impacted for each scenario. These values were converted into miles, and multiplied by the estimated cost to build a bikeway per linear mile. Again, the bikeway impacts were not broken down by classification. It was assumed that the impacted bikeways were bike paths (Class I). The costs to replace these bike paths were estimated at $755,533 a linear mile (2018$) using estimates from the 2013 City of San Diego Bicycle Master Plan (City of San Diego, 2013).

Walkways: The District asset inventory also provided an estimate of the total linear feet impacted for each scenario. Walkways impacts were not categorized, and were assumed to be paved pedestrian paths, such as those typically found along the District's waterfront. The total linear feet impacted was multiplied by the estimated cost to build a walkway per linear foot. The cost per linear foot of $1,071 (2018$) was the replacement cost sourced from another San Diego region study and inflated to 2018 dollars (Nexus, 2017, Table B-1). This estimate includes walkway lighting, benches, and garbage cans.

Other infrastructure (Inundation)

In addition to transportation infrastructure, it is anticipated that other operational infrastructure would be impacted by potential inundation. Inundation could result in these infrastructures being permanently underwater, and thus unusable. It was assumed that temporary coastal storm flooding could not damage these infrastructures. This analysis quantified impacts to sewer lifts and fuel docks. Due to the complexity of estimating storm drain replacement costs, these impacts are discussed qualitatively elsewhere in this report.

Sewer lifts: The asset inventory identified the number of sewer lifts impacted by each scenario. The estimated cost to replace each sewer lift station was $7,400,000 (2018$) based on the estimated cost to replace their Oceanside Boulevard Sewer Lift station (City of Oceanside, 2018).

Fuel dock: The District's asset inventory identified the number of fuel docks affected by each scenario.

The cost to replace each fuel dock was based on another study's estimated construction costs to build a marine fueling station (Port of Olympia, 2012). The estimated cost per fueling station was $4,153,614 (2018$).

Secondary Impacts

In addition to the primary impacts already discussed, this study also considered secondary impacts, such as loss of use or revenue, and clean up and emergency response. The District decided to quantify the financial impacts related to loss of revenue resulting from the loss of tenant leases, parking revenue, and special event permit fees in their parks.

The loss of revenue estimates included here are the result of inundation. Again, it was assumed that temporary coastal flooding caused by a 100-year storm with projected SLR would not affect revenue because the flooding would be temporary and recede. In actuality, storms could result in a temporary loss of use of park and parking lot facilities; however, it was unknown how long this temporary loss would last. For the sake of simplicity, the District decided to estimate permanent revenue loss rather than both permanent and temporary. Furthermore, in some cases, inundation would pre-empt 100-year storm flooding losses because the land would already be lost.

Lease revenue loss (Inundation)

The District leases land to tenants and collects revenue from these leases. Many of these tenants operate commercial or industrial business on these lands. The District may offer an annual flat lease amount, and in some cases, require an additional minimum rent based on the business's annual revenue.

Lease revenue data were joined to the District's parcel inventory using the lease-out number. (The parcel inventory was previously intersected by CoSMoS layers and identified impacted parcels for each scenario.) The District's parcel inventory includes split parcels, which are identified in this analysis as parcel objects. Because a lease may span multiple parcel objects, the amount of the lease was distributed based on the percentage of square feet for each parcel object. In most cases, only land leases were assumed to permanently lose revenue because water leases, such as marinas, were assumed to continue operating under sea level rise conditions. However, there was one exception: Shelter Island lost all road access beginning with the 0.8 feet sea level rise scenario. Therefore, it was assumed that businesses operating on the island, including water-based businesses, may not be able to continue operations because they would be inaccessible.[1]

The annual revenue loss was calculated using the following business rules:

- For those leases on Shelter Island, 100% loss of the annual lease amount for both land and water parcel leases.
- For non-Shelter Island leases:
  - o Water leases are not impacted
  - o When less than 50% of the parcel object's square feet were impacted, the analysis estimated a corresponding proportional loss of parcel object's annual lease amount.
  - o When more than 50% of the parcel object's square feet were impacted, the analysis assumed 100% loss of the parcel object's annual lease amount.

Parking Revenue Loss (Inundation)

The District operates parking lots and structures around Tidelands. The loss of parking lots due to potential inundation would result in the loss of parking revenue as well. This analysis only includes District owned and operated parking lots and structures. The impacted lots were identified from CoSMoS and the GIS pavement layer. District staff identified two impacted parking structures, both of which were underground structures. The loss of revenue was estimated from the District's parking revenue spreadsheet that displayed the annual revenue by lots and garages.

The annual revenue loss was calculated using the following business rules:

- For parking lots on Shelter Island, 100% loss of the annual parking lot revenue due to the loss of island accessibility in all scenarios.
- For non-Shelter Island *parking lots*:
  - o When less than 50% of the parking lot's square feet were impacted, the analysis estimated a corresponding proportional loss of annual revenue.
  - o When more than 50% of the parking lot's square feet were impacted, the analysis assumed 100% loss of annual revenue.
- For non-Shelter Island underground *parking structures*:
  - o When the inundation layer intersected the structure, the analysis assumed 100% loss of annual revenue due to the structure being underground.

[1]The financial impacts related to Shelter Island's inaccessibility only apply to revenue, and not property loss. This is because the secondary impact of lease revenue loss is due to the tenants' loss of use, while the primary impacts of land and structure are valued for the overall loss of the tangible assets for the District, not the loss of its use.

Park Special Event Permit Revenue (Inundation)

The District provides parks throughout the district for public use and enjoyment. Residents and businesses can rent these facilities for special events. The District collects revenue from these events. The impacted parks were identified from CoSMoS and the District parks GIS layer. The District provided the monthly park permit revenue by park.

The annual revenue loss was calculated using the following business rules:

- For parks on Shelter Island, 100% loss of the annual special event revenue due to the loss of island accessibility in all scenarios.
- For non-Shelter Island parks:
  - When less than 50% of the park's square feet were impacted, the analysis estimated a corresponding proportional loss of annual special event revenue.
  - When more than 50% of the park's square feet were impacted, the analysis assumed 100% loss of annual special event revenue.

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APPENDIX D

Port of San Diego
Natural Resource Valuation Methods

May 2019

Prepared for the Port of San Diego

Prepared by the Energy Policy Initiatives Center

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About EPIC

The Energy Policy Initiatives Center (EPIC) is a non-profit research center of the USD School of Law that studies energy policy issues affecting California and the San Diego region. EPIC's mission is to increase awareness and understanding of energy- and climate-related policy issues by conducting research and analysis to inform decision makers and educating law students.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report summarizes the methods available to value natural resources within the Port of San Diego and establishes a framework to determine a range in values for four habitats, based on ecosystem services provided by each, using a benefit transfer method.

Key Findings

Habitats within the Port Tidelands provide four types of ecosystem services. Of the habitats identified for valuation, four different categories of ecosystem services are considered to assist in determining monetary values for the natural resources. These categories include: provisioning, regulating, cultural, and supporting services.

Benefit transfer methodology is the preferred valuation method. Five general valuation methods were identified that can be used to monetize natural resources. While a framework was developed to best analyze the Port's natural resources, the time and data constraints associated with these methods are prohibitive. An alternate, preferred approach was developed using a benefit transfer method. Here, values from case studies were applied to the Port's natural resources.

Current value services provided by natural resources within Port Tidelands range from a low estimate of $40 million - $61 million per year. The ecosystem services identified for each of the habitats were combined to estimate the total value of the Port's natural resources. With sea level rise, the extant of different habitats is projected to change, leading to changes in the predicted value of these resources. Under the most extreme sea level rise scenario (150cm), the value of Port Tidelands natural resources is projected to decrease to a range of $29 million to $45 million.

1 | Introduction

Assembly Bill 691 (AB 691) was approved by the California legislature in 2013 and mandates the financial costs of sea level rise be considered for lands held in the Public Trust. As part of the Port of San Diego's (Port) sea level rise analysis, natural resources within Port Tidelands must be evaluated to understand their economic value.

This analysis identifies the natural resources with Port Tidelands to be evaluated and their accompanying ecosystem services. It provides a discussion on the types of goods and services that can be evaluated and presents an overview of each of the valuation methods currently available. After assessing the advantages and disadvantages of each, a framework for valuing the Port's natural resources was established and, using a benefit transfer approach, a literature review was conducted to estimate a range in values for the four primary habitats.

2 | Natural Resources within Port Tidelands

This section first documents the type and size of habitats found within Port Tidelands, and then identifies those relevant ecosystem services provided by these coastal habitats.

2.1 Habitats within the San Diego Bay

Habitats and their extant within the San Diego Bay were identified by ICF consultants on behalf of the Port as part of the Port's seal level rise planning efforts.[1] Table 1 identifies the current and predicted future acreage for four main habitat groups within the Port Tidelands – Eelgrass, Salt Marsh, Beach/Dune, and Uplands.[2] These habitats are considered the natural resources with which a valuation method must be determined.

Table 1. Extant of Habitats within the San Diego Bay

Habitat	Current (Baseline Acres)	SLR 25cm (acres)	SLR 50cm (acres)	SLR 75cm (acres)	SLR 150cm (acres)
Eelgrass	915	983	1016	979	668
Salt Marsh	81	76	74	75	78
Beach/Dune	13	13	12	11	9
Uplands	97	90	82	73	51
Total Acres	**1,107**	**1,161**	**1,184**	**1,139**	**806**

2.2 Ecosystem Services Provided by Habitats in the Port Tidelands

Examining the ecosystem services provided by habitats within the Port Tidelands will help to better understand the value (monetary and non-monetary) of those habitats. Ecosystem services represent the benefits people obtain from the ecosystem and, through the Millennium Ecosystem Assessment, are organized into four broad categories: provisioning, regulating, cultural, and supporting (Figure 1; MA, 2005). Ecosystem services identified for each of these categories document some type of value provided to direct and indirect users of habitats within the Port Tidelands. Shifts in habitat size and type can affect, both positively and negatively, the overall well-being of those users.

[1] ICF findings have not yet been released in a report. Data were provided by ICF to EPIC.
[2] Once published, refer to ICF report for further discussion on habitat characteristics and traits.

Ecosystem Services of Coastal Habitats	
Provisioning	**Regulating**
• Fisheries support • Animal harvesting • Direct food production • Mineral extraction	• Carbon sequestration • Shoreline stability and erosion control • Flood and storm protection • Water purification and waste treatment
Cultural	**Supporting**
• Cultural activities • Recreation • Education • Tourism • Aesthetics	• Refugia habitat • Habitat provision and food web support • Nutrient cycling

Figure 1. Primary Ecosystem Services for Port Tideland Habitats

2.2.1 Provisioning Ecosystem Services

Provisioning services include material products directly obtained from the habitat. These services are often traded through conventional markets and can, consequently, be valued more easily than other types of ecosystem services. The primary provisioning services identified here include: fisheries support, animal harvesting, direct food production, and mineral (e.g., salt) extraction.

2.2.2 Regulating Ecosystem Services

Regulating services provide benefits to users through the regulation of ecosystem services and are rarely given a value in conventional markets. Generally, users derive an indirect use from these services in some physical or material capacity. The primary regulating services identified here include: carbon sequestration, shoreline stability and erosion control, flood and storm protection, and water purification and waste treatment.

2.2.3 Cultural Ecosystem Services

Unlike the first two types of services, cultural ecosystem services provide non-material benefits to individuals. Generally, these services do not involve the extraction of resource(s) and the use by one individual does not preclude the use of another. The primary cultural services identified here include: cultural activities, recreation, education, tourism, and general aesthetic provisions.

2.2.4 Supporting Ecosystem Services

Supporting ecosystem services provide benefits that support the other services identified above. With these services, there are no direct uses by individuals; however, the presence of these services can increase the productivity of habitats and, consequently, increase the benefits received by users of other ecosystem services. Additionally, the elimination of some of these services could result in the loss of other ecosystem services. The primary supporting services identified here include: refuge habitat, habitat provision and food web support, and nutrient cycling.

3 | Valuation Methods

This section provides a discussion on how goods and services can be classified and documents those methods that can be used to determine a monetary value for natural resources via the ecosystem services identified in the previous section. In addition, it evaluates a potential framework for the Port to value its natural resources within the Port Tidelands.

3.1 Types of Goods and Services

The economic value of goods and services provided by natural resources can have either market or non-market based values (Figure 2). Determining the value of market based goods and services uses explicit data from the market in which it is sold. Non-market based goods and services, however, require an indirect analysis of how the resource is used (use value) or preserved (non-use value).

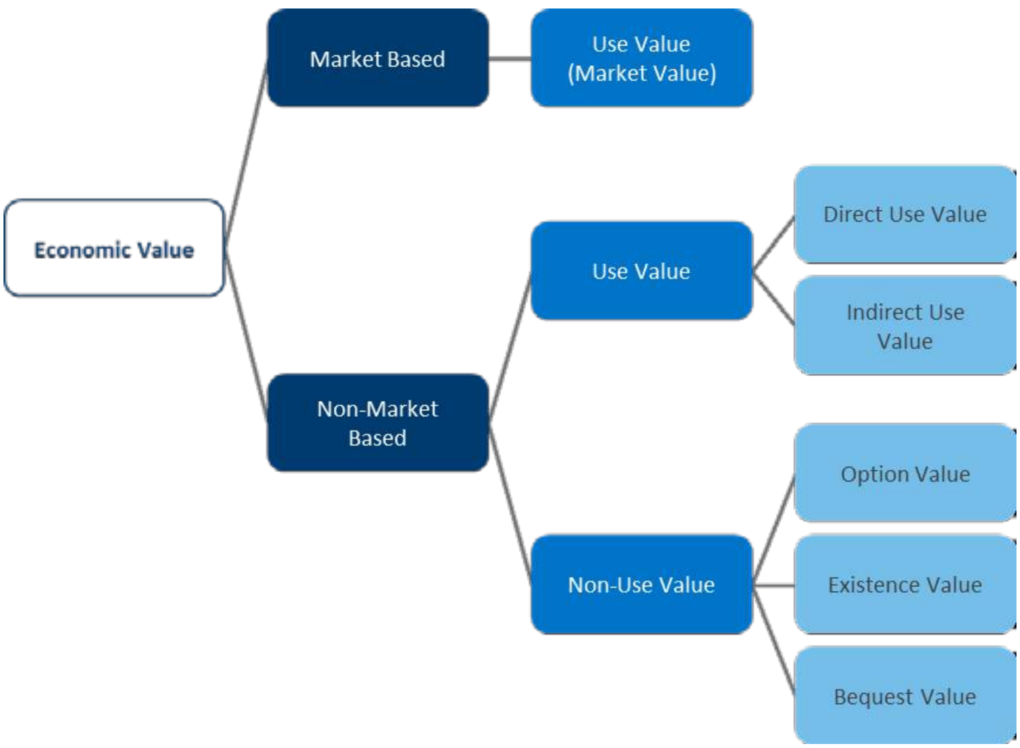

Figure 2. Classification of Economic Values for Non-Market Goods and Services

3.1.1 Market Goods and Services

Market goods and services include those that are currently bought or sold in the marketplace. The value of these goods and services is a use value and can be inferred from their associated supply and demand curves (e.g., at what price are sellers willing to sell and at what price are buyers willing to buy?). There are three ways to value market goods and services according to market conditions. The first, and easiest, is to assign the good or service a value equal to the market price – the price at which the good or service is sold within any market (Figure 2, a).[3] The second way is to estimate the producer surplus associated with the service (Figure 2, b), and the third the consumer surplus (Figure 2, c). To estimate both the producer and consumer surplus, more detailed knowledge of the supply and demand curves must be known.

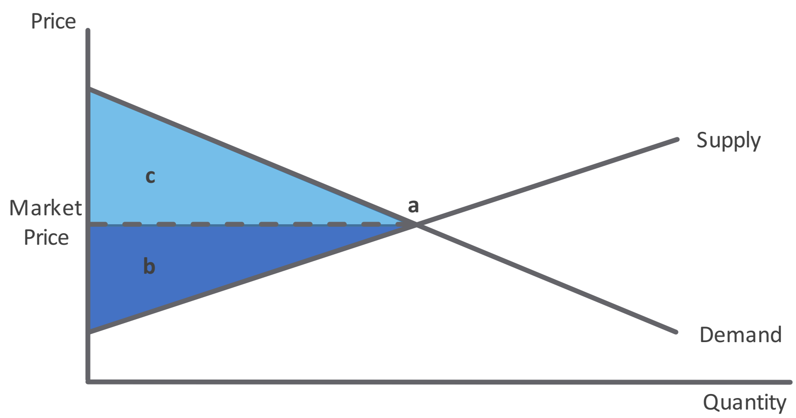

Figure 3. Illustrative Supply and Demand Curves

Market goods and services in a coastal context include the use of natural resources for a profit, such as through aquaculture, fishing, or the extraction of minerals (e.g., salt).

3.1.2 Non-market Goods and Services

Non-market goods and services are not bought or sold in a market and the value is thus not revealed in market pricing. There are five categories of non-market goods and services that are classified as either having a use or non-use value (Figure 2). Together, use and non-use represent the total value of a (natural) resource.

Use Value. A natural resource has use value when a consumer actively uses the resource and it can be categorized as either a direct or indirect use value (Figure 4). Direct use value is derived from the direct consumption or use of the resource without paying for it. For coastal systems, examples of direct use values include recreation, aquaculture[4], and fishing. Indirect use value is derived from the indirect use of a resource for some form of economic gain. Examples of indirect use include flood protection, shoreline stabilization, and water purification.

[3] Market value and market price are considered equal when the market is in equilibrium. Deviations from equilibrium can result in a market price that over- or under-values a good or service, although typically only marginally.
[4] Although, aquaculture projects can have operational costs associated with the use of a natural resource (e.g., water rights permitting or leasing rights).

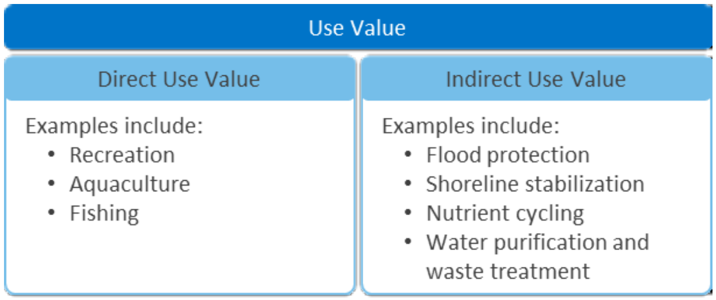

Figure 4. Use Value Categories for Non-Market Goods and Services

Non-Use Value. Non-use value relates to benefits provided to society when there is no active use of the resources being evaluated. Types of non-use value include: option, existence, and bequest (Figure 5). Option value refers to the value of a resource for future use even if that future use is unlikely. Existence value refers to value of knowing a particular natural resource exists even though the person valuing the resource has no intention to use or experience the resource. Bequest value refers to the value someone would be willing to pay to preserve a natural resource for future generations.

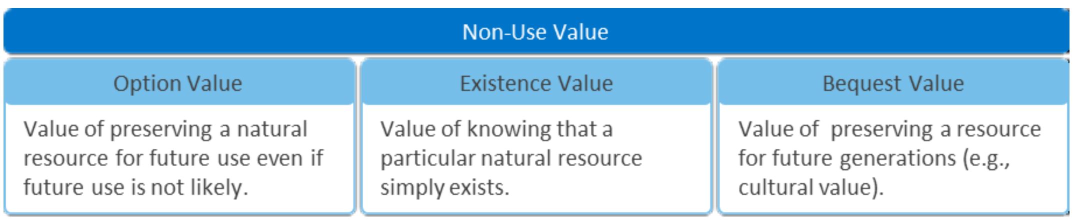

Figure 5. Non-Use Value Categories for Non-Market Goods and Services

3.2 Applicable Valuation Methods

Five general methods have been identified that can be used to determine a monetary value for natural resources (Figure 6). Of these methods, two – stated and revealed preference – have multiple ways to determine a value. The preferred method for valuing specific ecosystem services provided by natural resources are discussed further in Section 4.

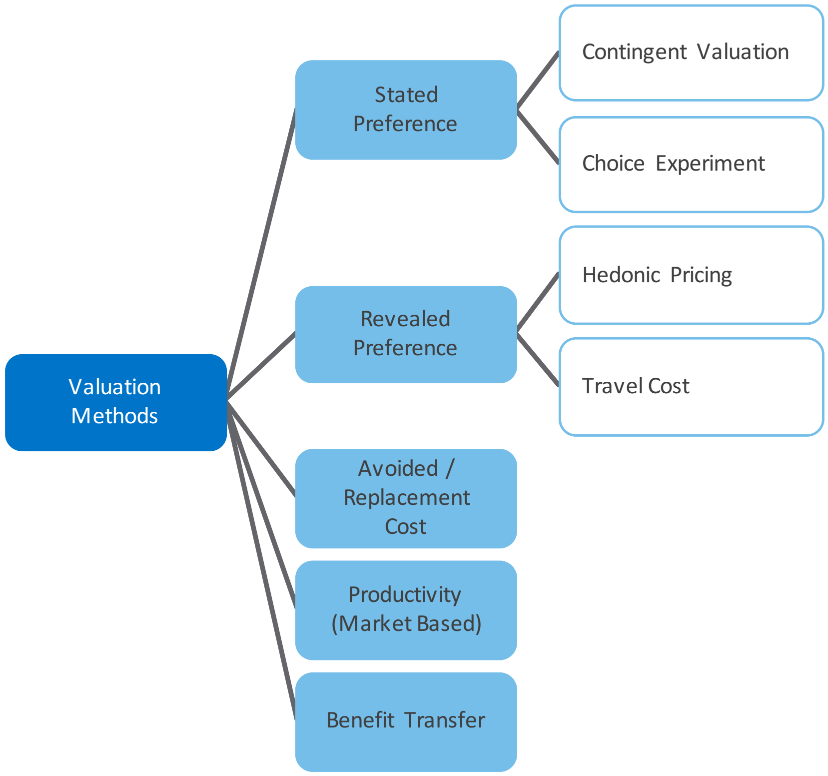

Figure 6. Methods for Valuing Natural Resources

3.2.1 Stated preference

Stated preference methods (contingent valuation and choice experiment) require surveys to estimate an individuals' willingness to pay (WTP) for a resource or their preferred ranking of individual aspects of a given resource (e.g., ecosystem services). WTP represents the perceived worth of a natural resource as stated by survey respondents. There are two commonly accepted forms of stated preference – contingent valuation and choice experiment.

Under contingent valuation, survey respondents are directly asked how much they would be willing to pay to prevent the degradation of or to improve a natural resource. Similarly, they could also be asked how much they would be willing to accept in exchange for the loss of the natural resource. Survey results are then aggregated to represent a hypothetical market for the resource and determine an overall value or worth. With this method, however, considerable caution and care must be used in the development of the survey questions and methods to limit bias in responses. Contingent valuation surveys are also generally limited to the resource as a whole and typically are not used to evaluate individual ecosystem services.

Choice experiment methods do not directly ask for the WTP of survey respondents, but has them rank or rate a set of characteristics relevant to the resource in question alongside a price or cost. The WTP is then inferred from survey results. This approach can be challenging for some survey respondents if little background information or context is known at the time of the survey. However, this method can limit some of the bias, in the form of overstated preferences, found in contingent valuation survey results.

Figure 7 identifies the primary advantages and disadvantages associated with stated preference valuation methods.

Stated Preference	
Advantages	**Disadvantages**
• Can reveal values not identified through other methods • Can more effectively identify non-use values	• Resource intense (time, money) to conduct carefully designed surveys • Subject to bias of survey respondents

Figure 7. Advantages and Disadvantages of Stated Preference Method

3.2.2 Revealed preference

Unlike stated preference, revealed preference methods determine the value of a natural resource based on real market data rather than hypothetical markets. The primary downside to this is that non-use values are rarely, if ever, captured. There are two typical revealed preference methods that can be applied to natural resources – hedonic pricing and travel cost.

Hedonic pricing generally relies on housing price data to estimate the value of natural resources. Under this method, a statistical analysis is conducted the determine the relationship between housing values and set environmental variables. The change in housing price as a function of a change in an individual environmental variable, holding all others constant, theoretically represents the value of that resource. However, this method is extremely data heavy and modeled relationships based on the data may not account for some external factors that might influence housing price.

The travel cost method also relies on large datasets, but to determine the amount of money individuals pay to visit a natural resource. Data is generally collected that shows the distance at which visitors travelled to get to the site and how often they frequent the site. This typically is only applied for parks and other recreational areas and does not capture non-use values.

Figure 8 identifies the primary advantages and disadvantages associated with revealed preference valuation methods.

Revealed Preference	
Advantages	**Disadvantages**
• Relies on actual or observed behavior • More realistic and objective method • Reflects willingness to pay for actual goods and services	• Inability to estimate non-use values • Market imperfections and policy failures can distort values • Reliance on assumptions between evaluated resource and the surrogate resource • Requires large datasets

Figure 8. Advantages and Disadvantages of Revealed Preference Method

3.2.3 Productivity (Market based pricing)

The productivity method relies on market values when a change in a given natural resource directly increases or decreases the production of a market resource. Here, a statistical relationship between the natural resource and the market resource is established to determine the overall value. For instance, if a salt marsh provides vital nursery habitat for a fishery, then the loss of that habitat would decrease the productivity and value of the fishery. Similar to some other methods, this method generally requires a large amount of data and the relationship between the natural resource and market resource must be well understood to derive applicable relationship functions.

Figure 9 identifies the primary advantages and disadvantages associated with stated productivity valuation methods.

Productivity (Market based pricing)	
Advantages	**Disadvantages**
• Market-based pricing is intuitive • Tends to have a practical appeal to policy makers	• Tendency to ignore non-use values • Market imperfections and policy failures can distort values • Modeling of biophysical relationships can be complex and/or data intensive

Figure 9. Advantages and Disadvantages of Productivity Method

3.2.4 Avoided/Replacement Cost

Avoided or replacement cost methods value a natural resource on the potential costs that would be incurred if the resource were to be lost (avoided) or the cost to replace the resource (replacement). For instance, if a habitat that provides storm surge protection is hypothetically removed, what would be the cost of damage to homes during a storm event (avoided) or the cost to build a seawall to prevent storm damage to the same degree as the habitat (replacement). Determining comparable replacement measures can limit the accuracy in valuing natural resources with this method.

Figure 10 identifies the primary advantages and disadvantages associated with avoided/replacement cost valuation methods.

Avoided/Replacement Cost	
Advantages	**Disadvantages**
• Less demanding of resources (time, data, etc.) than most other methods	• Tendency to ignore non-use values • Market imperfections and policy failures can distort values • Tendency to undervalue natural resources

Figure 10. Advantages and Disadvantages of Avoided/Replacement Cost Method

3.2.5 Benefit Transfer

Benefit transfer methodology is separate from the methodologies outlined above as it relies on information already obtained through other studies conducted for different, but comparable resources. Values can be from any of the above type of analyses and applied, or transferred, to a natural resource with similar conditions and characteristics. This method is mostly used in instances where resources (e.g., time and money) are limited. However, caution must be taken to ensure that values are transferred between comparable goods and/or services. If characteristics differ enough between them, the values may not be accurate and could significantly over or underestimate the natural resource in question.

Figure 11 identifies the primary advantages and disadvantages associated with benefit transfer valuation methods.

Benefit Transfer	
Advantages	**Disadvantages**
• Avoids the cost and time associated with conducting a primary study • Least data intense of all methods	• Must find studies with comparable natural resources • Values may not reflect actual conditions of resource being evaluated • May require 'adjusting' of values • Variations in methods from original studies may not be compatible

Figure 11. Advantages and Disadvantages of Benefit Transfer Method

3.3 Valuation Framework for Port Tidelands

Often, the ecosystem services identified in Section 2.2 can be valued with more than one method identified above. However, studies and literature have identified preferred methods for estimating the value of specific non-market based goods and services based on their respective advantages and disadvantages (Figure 12). Revealed preference methods are preferred for direct use values, productivity or avoided/replacement cost methods are preferred for indirect use values, and stated preference methods are the preferred choice for the three types of non-use values (option, existence, and bequest values). For a given natural resource, this can include the use of multiple valuation strategies specific to the individual ecosystem services being provided by that resource. However, the benefit transfer approach is the preferred method for all types of use and non-use values when resources are limited and only a broader habitat value is required.

For the valuation of habitats within the Port Tidelands, a benefit transfer approach is recommended. This approach will provide the Port with a sufficient understanding of the approximate values of its natural resources. Additionally, this will limit the time, effort, and cost associated with conducting more extensive surveys and statistical analyses. Primary studies have been conducted for similar habitats across California, the United States, and globally that can be applied to develop a range in values for the habitats within the Port Tidelands. These values are further discussed in Section 4 with limitations to this approach discussed in Section 5.

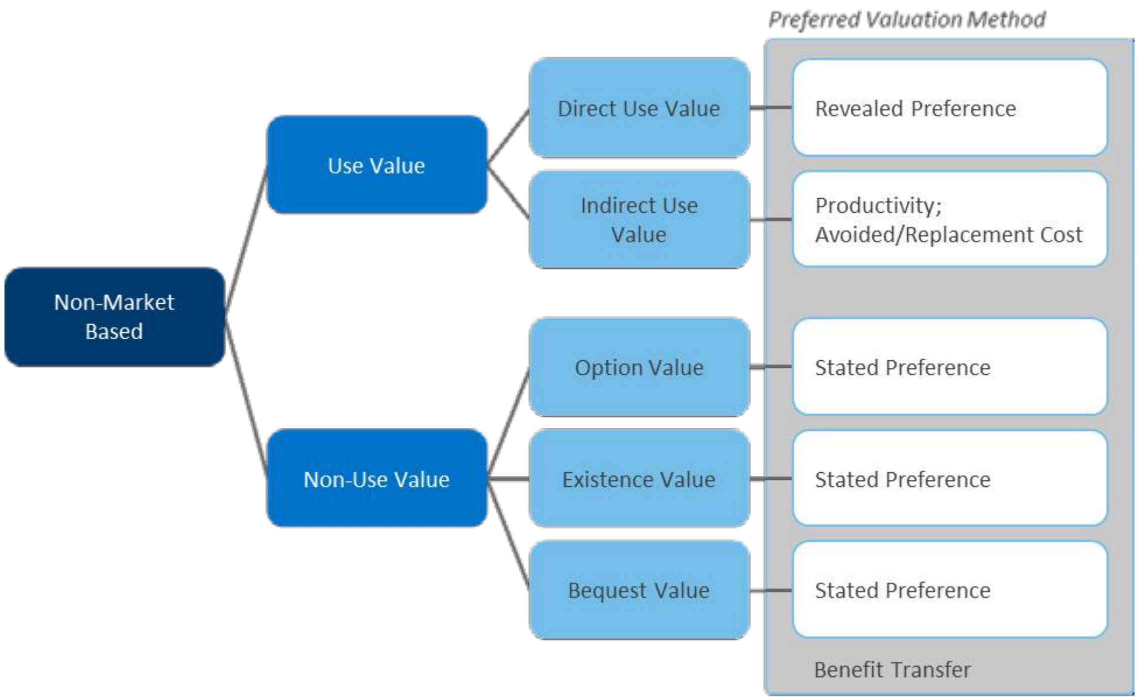

Figure 12. Non-Market Based Valuation Framework for Natural Resources within Port Tidelands

4 | Applied Valuation Strategy

A literature review was conducted to identify values that could be readily transferred to the four habitats identified within Port Tidelands. While values provided do not exhaust all potential values of the Port's natural resources, they encompass the general availability of applicable case studies.

Data provided in Table 2 indicate the low and high estimated values ($/acre/yr) for each case study. Values are differentiated by habitat type and the respective ecosystem service. In some instances, values were collected that represent the system as a whole and are not allocated to an individual habitat. For case studies where a single value was estimated, the low and high estimates are equal.

Table 2. Literature-Based Values of Habitat Values

Ecosystem Service	Low Estimate ($/acre/yr)	High Estimate ($/acre/yr)	Source(s)
Eelgrass			
Nutrient cycling	$12,302	$12,302	Brenner et al., 2010
Nitrogen sequestration	$19	$144	Capone, 1982
Carbon sequestration	$42	$44	Windham, 2008; Ballard et al., 2016
Carbon storage	$30	$30	Ballard et al., 2016
Salt Marsh			
Carbon sequestration	$23	$753	Windham, 2008; Cahoon 1993; Sifleet, 2011
Carbon storage	$9	$924	Cahoon 1993; Stifleet, 2011
Flood/Storm protection	$6,149	$6,149	Feagin et al., 2010
Recreation	$2,160	$2,160	Feagin et al., 2010
Nitrogen sequestration	$0.02	$0.12	DeLaune et al., 1986
Beach/Dune			
Carbon sequestration	$17	$45	Windham, 2008; Jones et al. 2008
Recreation	$3,055	$3,055	Raheem et al., 2009
Cultural activities	$5	$5	Raheem et al., 2009
Uplands			
Flood/Storm protection	$193	$193	Feagin et al., 2010
Recreation	$2,160	$2,160	Feagin et al., 2010
Whole System			
Pollution buffering	$35	$4,002	De Groot et al., 2002
	$11	$13	Batker et al., 2014
	$1,255	$1,415	Braux et al., 1995
	$6,792	$6,792	Brenner et al., 2010
	$565	$565	Wilson, 2010
Water flow regulation	$771	$771	Camacho-Valdez et al., 2013
	$10	$10	Costanza et al., 1997
Education	$0	$3	EPA, 2015
	$4	$4	EPA, 2015
	$0	$3	Coal Oil Point Reserve, n.d.
	$0	$0	Bolsa Chica Land Trust, 2015
Aesthetics	$4	$1,052	De Groot et al., 2002
Refugia habitat	$252	$252	Brenner et al., 2010
	$119	$283	Schmidt et al., 2014

Nutrient Cycling	$2,373	$12,302	Costanza et al., 1997
	$56	$13,656	De Groot et al., 2002
Flood/Storm protection	$87,008	$87,008	Thibodeau & Ostro 1981
	$16	$8,430	Batker et al., 2014
	$162	$3,169	Woodward & Wui, 2001
	$20	$9,324	Woodward & Wui, 2001
Cultural activities	$3	$3	Raheem et al., 2009

Table 3 presents aggregated values for each habitat and for those services valued for the whole system. Results indicate the overall low and high value estimate ($/acre/yr) using a benefit transfer approach. In instances were more than one case study was identified for the same habitat and ecosystem service, an average of the two was calculated.

Table 3. Aggregated Habitat Values

	Low Estimate ($/acre/yr)	High Estimate ($/acre/yr)
Eelgrass	$12,392	$12,520
Salt Marsh	$8,341	$9,986
Beach/Dune	$3,077	$3,105
Uplands	$2,352	$2,352
Whole System	$25,332	$44,234

Table 4 presents the total value ($/yr) of each habitat and for those services valued for the whole system under baseline conditions and four sea level rise scenarios (25cm, 50cm, 75cm, and 150cm). Results were found by multiplying the estimated acreage by the total dollar per acre ($/acre) for each habitat provided in Table 3.

Table 4. Total Habitat Values

	Acres	Low Estimate ($/yr)	High Estimate ($/yr)
Eelgrass			
Baseline	915	$11,339,205	$11,456,219
SLR 25cm	983	$12,178,846	$12,304,524
SLR 50cm	1,016	$12,593,963	$12,723,924
SLR 75cm	979	$12,137,569	$12,262,821
SLR 150cm	668	$8,279,930	$8,365,374
Salt Marsh			
Baseline	81	$676,091	$809,447
SLR 25cm	76	$632,848	$757,675
SLR 50cm	74	$620,939	$743,417

SLR 75cm	75	$627,548	$751,330
SLR 150cm	78	$653,392	$782,272
Beach/Dune			
Baseline	13	$41,459	$41,836
SLR 25cm	13	$39,002	$39,356
SLR 50cm	12	$35,616	$35,939
SLR 75cm	11	$32,919	$33,218
SLR 150cm	9	$26,559	$26,800
Uplands			
Baseline	97	$228,100	$228,100
SLR 25cm	90	$211,871	$211,871
SLR 50cm	82	$193,262	$193,262
SLR 75cm	73	$172,781	$172,781
SLR 150cm	51	$119,404	$119,404
Whole System			
Baseline	1,107	$28,029,798	$48,946,184
SLR 25cm	1,161	$29,419,821	$51,373,470
SLR 50cm	1,184	$30,003,952	$52,393,492
SLR 75cm	1,139	$28,848,345	$50,375,547
SLR 150cm	806	$20,414,163	$35,647,614

5 | Limitations

There are several limitations associated with the approach taken here to value natural resources within the Port Tidelands. Primary limitations that should be acknowledged include: data availability and transferability and scaling data to match the size of habitats within the Port's jurisdiction.

Data availability and transferability. While numerous case studies exist that provide primary valuation analysis using methods identified in this report other than benefit transfer, there is a gap in case studies specific to Southern California coastal lands and their resources. Additionally, currently available data does not uniformly cover the ecosystem services and habitats identified in this report. This decreases the relative accuracy in value ranges when comparing across habitats.

The transfer of data from other regions outside of Southern California can lead to a misrepresentation of the true value of natural resources within Port Tidelands. Conditions, such as local climate and neighboring land use patterns, will differ across regions and transferring values may not accurately reflect those in San Diego.

Scaling data. Scaling data from one or more study to reflect the size of habitats within the Port Tidelands may deviate from the true value of the Port's natural resources. This applies because of two conditions. In the first, the marginal benefits of some ecosystem services may not scale linearly. For instance, the marginal benefit of some ecosystem services may decrease as the size of the habitat that provides that service increases. Conversely, some ecosystem services may be most valuable when habitats are larger (e.g., habitat provision). Under the second condition, the make-up and extant of habitats within Port Tidelands is not explicitly known, especially when considering predicted acreage under various sea level rise scenarios. A recent analysis of Port habitats yielded greater insights into their current extant; however, how salt marsh was defined in that study may not match with how a salt marsh is defined in other case studies.

6 | Conclusion

This report summarizes the methods available to value natural resources within the Port of San Diego and establishes a framework to determine a range in values for four habitats, based on ecosystem services provided by each, using a benefit transfer method.

The four habitats identified here were evaluated by ICF consultants on behalf of the port and a set of ecosystem services were identified for each that fell into one of four categories. These categories include: provisioning, regulating, cultural, and supporting. A discussion on the types of goods and services that can be valued and how to value them was provided as a means to better understand how to translate non-monetary ecosystem services for natural resources into a dollar value.

While a preferred valuation framework was identified, current resource constraints of the Port (e.g., time) prevent the adoption of a fully comprehensive valuation assessment. The next best alternative, which significantly reduces the cost and time constraints of other methods, was select as the preferred path forward – a benefit transfer approach. Using this methodology, a literature review was conducted of the primary ecosystem services offered by the Port's habitats to establish a range in potential value.

Results of the literature review indicate a combined value of all Port natural resources to be between $40 million and $61 million currently. This range in values will change as certain habitats expand or recede in response to sea level rise. Under the most extreme sea level rise scenario (150cm), the value of Port Tidelands natural resources is projected to decrease to a range of $29 million to $45 million.

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