SEA LEVEL RISE

VULNERABILITY ASSESSMENT AND ADAPTATION PLAN

Prepared For:

City of Coronado

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Acronyms and Abbreviations

ADA	American Disabilities Act
BRIC	Building Resilient Communities and Infrastructure
CalEPA	California Environmental Protection Agency
CCC	California Coastal Commission
CCSMW	California Coastal Sediment Management Workgroup
CDAA	California Disaster Assistance Act
CDC	U.S. Center for Disease Control
CDIP	Coastal Data Information Program
City	City of Coronado
cm	centimeter
COAST	Coastal One-line Assimilated Simulation Tool
CoSMoS	Coastal Storm Modeling System
CRS	Community Rating System
cy	cubic yards
cy/yr	cubic yards per year
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
FAR	Floor area ratio
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
ft	feet
ft/yr	feet per year
GHAD	Geological Hazard Abatement Districts
GHG	Greenhouse gas
GIS	Geographic Information System
GP	General Plan
H++	Extreme SLR scenario due to rapid Antarctic ice sheet mass loss (Sweet et al, 2017)
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
H_s	Significant Wave Height

HUD	Housing and Urban Development
in	inch
IP	Implementation Plan
IPCC	Intergovernmental Panel on Climate Change
LCP	Local Coastal Program
LCPAC	Local Coastal Program Advisory Committee
lf	linear foot
LHMP	Local Hazard Mitigation Plans
LUP	Land Use Plan
m	meter
M&N	Moffatt & Nichol
MHHW	mean higher high water
MLLW	mean lower low water
MSL	mean sea level
NASNI	Naval Air Station North Island
NAVD 88	North American Vertical Datum of 1988
NE	northeast
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
OCOF	Our Coast, Our Future
OEHHA	Office of Environmental Health Hazard Assessment
OPC	Ocean Protection Council
PDM	Pre-Disaster Mitigation
RSM	Regional Sediment Management
RV	recreational vehicle
SANDAG	Sand Diego Association of Governments
SCOUP	Sand Compatibility and Opportunistic Use Program
SEPTA	Southeastern Pennsylvania Transportation Authority
SLR	sea level rise
SLR	Sea level rise
SOVI	social vulnerability index
SR-75	State Route 75
SS	Storm surge

SW	southwest
UCSD	University of California at San Diego
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
VA	Vulnerability Assessment
WWTP	Wastewater Treatment Plant
yr	Year

Glossary

100-Year Storm	Storm event that occurs once every 100 years on average. There is a 1% chance of this type of storm occurring each year.
Adaptation	Planning and activities that seek to address the impacts of climate change.
Adaptation Pathway	Sequence of related adaptation strategies to reduce risk efficiently and effectively over time as triggers for further action are reached.
Adaptive Capacity	Ability to adjust to changing hazards over time.
Adaptive Management	A flexible and strategic approach to adaptation planning that allows the City to make investments when the need for resilience reaches a critical threshold.
Coastal Hazards	Flooding or erosion impacts in coastal areas.
Coastal Resource	Natural or manmade features in coastal areas that provide a benefit to the City.
Engineering Strategies	Adaptation strategies that involve constructing or expanding a permanent structure (e.g., seawalls, elevating infrastructure).
Exposure	Type, duration, and frequency of hazards that a resource is subject to.
Inundation	Flooding due to high tides in the absence of storm events.
King Tide	Extreme high tides that occur several times annually.
Managed Retreat Strategies	Adaptation strategies that relinquish land to the natural environment.
Nature-based Strategies	Adaptation strategies that restore a natural feature using components of the environment (e.g., dunes, wetlands).
Operational Strategies	Temporary adaptation strategies that are used by the City to reduce safety risks (e.g., road closures).
Planning Strategies	Adaptation strategies that use urban planning tools, such as zoning, or planning studies to help lay the groundwork for future hard engineering, nature-based or managed retreat strategies.
Resilience	The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and thrive no matter what kinds of chronic stresses or acute shocks they encounter. This plan is specifically focused on resilience to sea level rise.
Sea Level Rise	Increases in sea level elevations over time due to global and regional factors.
Sensitivity	The degree to which a resource is impacted by a hazard.
Storm surge	The rise in seawater level during a storm above and beyond the expected tide level. Storm surge is primarily caused by winds pushing water onshore during a storm.
Trigger	An environmental (e.g., observed sea level rise) or social (e.g., political support, funding availability) change at which point planning for the next sea level rise adaptation strategy needs to begin.
Vulnerability	Overall threat level due to a combination of exposure, sensitivity, and adaptive capacity.

Executive Summary

The City of Coronado (City) is internationally recognized as a beautiful and vital community encompassing several of southern California's most valued tourist, recreational, and ecological resources. The City coastline is very accessible and supports a wide variety of public (local, state, federal), private, and environmental functions. Coronado takes the form of a peninsula, with a land-side connection at the City of Imperial Beach boundary while San Diego Bay and the Pacific Ocean surround the City on the other three sides.

Recent advancements in sea level rise and coastal hazard science indicate that valuable coastal resources in the City may become exposed to more intense coastal hazards such as beach erosion and coastal flooding in the future. This concern is echoed by City residents, demonstrated in the City's 2021 Community Satisfaction Survey that revealed that 68% of respondents are at least somewhat concerned about the threat of sea level rise to the City. This combined Sea Level Rise Vulnerability Assessment and Adaptation Plan evaluates both the potential vulnerability of City infrastructure and resources to changing future hazards due to sea level rise and outlines potential adaptation strategies available to the City to mitigate these hazards. Future sea level rise vulnerability is discussed within the Sea Level Rise Vulnerability Assessment. Potential adaptation strategies are then examined in the Sea Level Rise Adaptation Plan.

In combination, these reports outline a cyclical process to address sea level rise hazards over time, illustrated in Figure ES-1. Steps 1 – 3, from identifying appropriate sea level rise projections to assessing risks to resources and development, are covered within the Sea Level Rise Vulnerability Assessment. Development of adaptation measures (step 4) is then addressed within the Sea Level Rise Adaptation Plan, which also includes information on how best to implement future adaptation measures (step 5) and revise adaptation planning efforts over time (step 6).

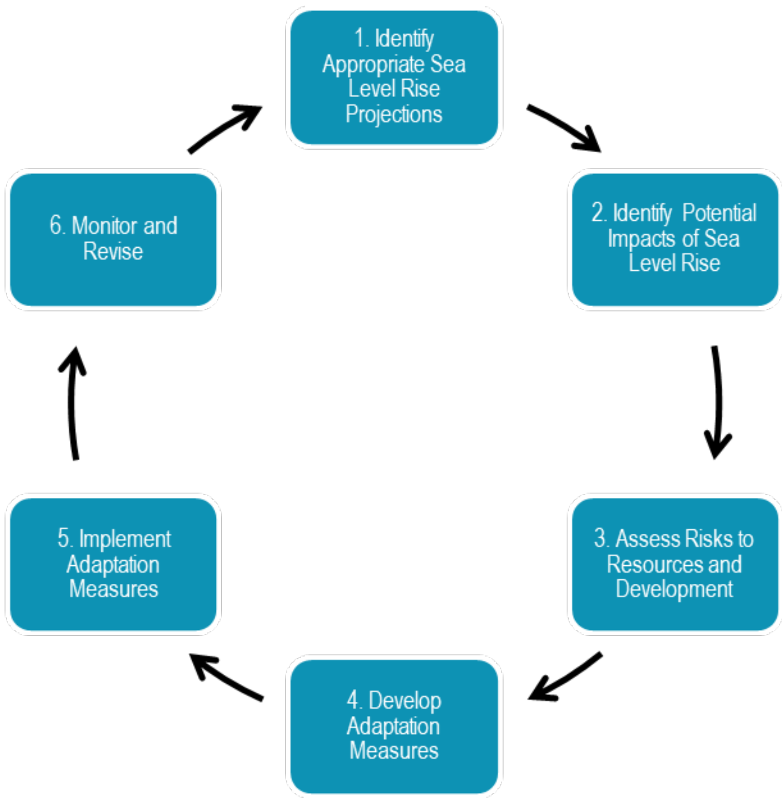


Figure ES-1: Sea level rise planning process

Assessing Future Vulnerability

The initial phase of the Sea Level Rise Vulnerability Assessment and Adaptation Plan involved determining the vulnerability of different locations and resources within the City to sea level rise. These findings are presented in the first report included in this combined document, the Sea Level Rise Vulnerability Assessment. The Vulnerability Assessment examines the vulnerability of City infrastructure and coastal resources under sea level rise scenarios ranging from 0.8 feet (0.25 meters) to 4.9 feet (1.5 meters), covering projected sea level rise from 2030 to 2130, as shown in Table ES-1.

Table ES-1: Potential timing of future sea level rise scenarios included in the Vulnerability Assessment.

Sea Level Rise	When Might it Occur?		
	Low Risk Aversion*	Medium Risk Aversion**	Medium-High Risk Aversion***
4.9 ft (1.5 m)	~2130	~2110	~2080
4.1 ft (1.25 m)	~2120	~2090-2100	~2070-2080
3.3 ft (1.0 m)	~2100	~2080	~2070
2.4 ft (0.75 m)	~2080	~2070	~2060
1.6 ft (0.5 m)	~2060	~2050	~2040
0.8 ft (0.25 m)	~2040	~2030	~2030

**17% Probability that sea levels reach of exceed this value by the designated year (Approximately 1 in 6 chance of occurrence)*
***5% Probability (1 in 20 chance of occurrence by the designated year)*
****0.5% Probability (1 in 200 chance of occurrence by the designated year)*

Vulnerability of developed land to sea level rise is defined based on three characteristics:

- **Hazard Exposure:** The hazard type, duration, and frequency subjected upon infrastructure.
- **Hazard Sensitivity:** The degree to which a resource is impaired by exposure to hazards.
- **Adaptive Capacity:** The ability of a resource to adapt to evolving hazard conditions over time.

These three factors are combined to determine the overall vulnerability of coastal infrastructure and development. The Vulnerability Assessment first identifies City resources such as infrastructure, roads, and recreational space, then analyzes the exposure, sensitivity, and adaptive capacity characteristics of each resource in response to incremental levels of sea level rise. Development or sites which are highly exposed to coastal hazards, highly sensitive to hazards such as flooding, and cannot be easily protected against or accommodate hazard impacts over time would be considered highly vulnerable. Coastal hazards investigated include shoreline erosion, tidal inundation, and flooding during a severe, 100-year coastal storm event. The overall vulnerability scores for different coastal resources throughout the City are summarized in Table ES-2.

Table ES-2: City of Coronado resource vulnerability to sea level rise

Resource	Sea Level Rise Scenario					
	0.8ft (0.25m)	1.6ft (0.5m)	2.5ft (0.75m)	3.3ft (1.0m)	4.1ft (1.25m)	4.9ft (1.5m)
Coronado Yacht Club and Boathouse	Mod	High	High	High	High	High
SR-75	Mod	Mod	High	High	High	High
Cays Yacht Club	Low	Mod	High	High	High	High
Stormwater Outlets	Mod	Mod	Mod	High	High	High
Development	Low	Mod	Mod	High	High	High
Major/Minor Roadways	Mod	Mod	Mod	Mod	High	High
Pump Stations	Low	Mod	Mod	Mod	High	High
City Hall	Low	Low	Mod	Mod	High	High
Ferry Landing	Low	Low	Low	Mod	High	High
Restrooms	Mod	Mod	Mod	Mod	Mod	Mod
Community Center	Low	Mod	Mod	Mod	Mod	Mod
Aquatics Center	Low	Mod	Mod	Mod	Mod	Mod
Club Room	Low	Mod	Mod	Mod	Mod	Mod
Golf Course	Low	Mod	Mod	Mod	Mod	Mod
Coastal Access Points	Low	Mod	Mod	Mod	Mod	Mod
Public Parking	Low	Low	Mod	Mod	Mod	Mod
Tennis Center	Low	Low	Mod	Mod	Mod	Mod
Silver Strand	Low	Low	Low	Mod	Mod	Mod
Public Services Building	Low	Low	Low	Low	Mod	Mod
Parks	Low	Low	Low	Low	Mod	Mod
Bike Routes	Low	Low	Low	Low	Mod	Mod
Hospitals	Low	Low	Low	Low	Low	Mod
Schools	Low	Low	Low	Low	Low	Mod
Fire Department	Low	Low	Low	Low	Low	Low
Police Department	Low	Low	Low	Low	Low	Low
Post Office	Low	Low	Low	Low	Low	Low
Lifeguard Stations	Low	Low	Low	Low	Low	Low
Coronado Beach	Low	Low	Low	Low	Low	Low
D Street Substation	Low	Low	Low	Low	Low	Low

The geography of the City, being surrounded by water on three sides, may initially suggest high vulnerability to sea level rise in many areas; however, the Vulnerability Assessment shows that the City is resilient in many ways to future sea level rise impacts. The open Pacific Ocean coast of the City is resilient to sea level rise due its relatively wide beaches, with the notable exception in the vicinity of the Coronado Shores condominium towers. North Beach is one of the widest beaches in southern California and is anticipated to persist through all sea level rise scenarios examined, although hazard mapping analyses show large portions becoming temporarily flooded in a 100-year coastal storm event. This area further benefits from the protection provided by the sand dunes behind the beach and the rip-rap seawall along Ocean Boulevard.

The Silver Strand Beach south of the Navy SEAL training base is similarly protected by a wide sandy beach and relatively high elevation sand dunes in certain locations. The stability of the City's sandy coastline further benefits from regular nourishment events at Imperial Beach by the Port of San Diego and the sand retention functions of Zuniga Jetty at the northwest end of the coastline that forms the entrance channel to San Diego Bay. City resources are anticipated to be generally protected from shoreline erosion and tidal inundation from the Ocean-side; however, extreme storm conditions associated with the 100-year coastal storm are projected to temporarily flood the beach and portions of the City's oceanfront under more severe, long-term future sea level rise projections.

The City is most vulnerable to sea level rise along its Bay-side boundary with San Diego Bay. Vulnerability is highest where land elevations along the Bay-front are lower than the future projected high water levels within the Bay due to sea level rise, and where a buffer between San Diego Bay and development is limited. Three particular areas where low elevations provide an entryway for coastal storm flooding from San Diego Bay include:

- The historic Spanish Bight entrance, located at the boundary between the Naval installation and the City and farther south at Alameda Blvd
- Low-lying areas of the Glorietta Bay shoreline
- Shoreline areas of the Coronado Cays community

The Spanish Bight was historically an open water harbor between Coronado and North Island. It was artificially filled with dredge material by the Navy in the early 1900's, but elevations remain low along the boundary between the City residential area and Naval Air Station North Island. With sea level rise, flooding is eventually projected to overtop the shoreline at this boundary at San Diego Bay and allow water to drain south though low elevation spots and eventually overtop Alameda Blvd through a relatively narrow low point. Once flooding breaches this low point, it is projected to run downhill farther into the Navy and City areas, with dramatically increased flooding projected at and above 3.3 feet (1 meter) of sea level rise.

The Glorietta Bay shoreline is another critical area of the City which is projected to be exposed to sea level rise hazards. Development such as the Coronado Golf Course, Yacht Club, Boathouse, City Hall, Community Center, and supporting infrastructure sit adjacent to the water at low elevations. The Coronado Yacht Club may even become vulnerable to the lowest considered sea level rise scenario of 0.8 feet (0.25 meters) during 100-year storm conditions.

The Coronado Cays community represents one of the lowest points in the City and consequently is one of the most exposed and vulnerable areas to sea level rise. Extreme high tide water levels under current conditions can be observed to encroach within several feet of the crest of bulkhead walls along residential and roadway areas (Figure ES-2). Marina infrastructure such as gangways, docks, and piles are designed for existing conditions and may be affected by sea level rise. Additionally, Santa Ana wind events create damaging wave conditions for the marina, which would only be exacerbated by sea level rise. The residents and visitors of this community would be highly sensitive to temporary coastal storm flooding projected with 1.6 ft – 2.5 ft sea level rise, and could be significantly impacted by daily tidal inundation under 3.3 ft and greater sea level rise scenarios. Furthermore, access to the community becomes strained under higher sea level rise scenarios as State Route-75 on the Silver Strand is projected to become increasingly exposed to flood hazards due to sea level rise.

Figure ES-2: Extreme high tide conditions within Coronado Cays
(Source: Mary Berube)

Identifying Adaptation Strategies

Once sea level rise vulnerabilities were identified, potential adaptation strategies that could mitigate future hazards were explored within the Sea Level Rise Adaptation Plan. In preparing the Sea Level Rise Adaptation Plan, the City is ensuring early consideration of the risks that sea level rise poses to the City and residents of Coronado, and the options available to mitigate those risks. The Adaptation Plan outlines a suite of potential adaptation strategies to mitigate projected sea level rise hazards to vulnerable locations and infrastructure to preserve safety and quality of life across the City.

The Adaptation Plan is not meant to dictate a specific set of actions the City must take, but rather provide a range of options to be further discussed, considered, and potentially implemented in the future. It is flexible and meant to be revised over time as new information emerges, climate science advances, and community preferences evolve. Effective adaptation planning and management will require coordination and communication between the City, the Navy, the Port of San Diego (Port), California Department of Parks and Recreation (State Parks), private property owners, and the California Department of Transportation (Caltrans) to ensure a comprehensive approach to sea level rise adaptation.

This plan is organized into Overarching Adaptation Strategies that are applicable City-wide and Adaptation Action Area Strategies that are tailored to the specifics of the location and vulnerable infrastructure.

Overarching Adaptation Strategies

Table ES-3 provides a summary of the overarching adaptation strategies, which are applicable City-wide and meant to complement location- and infrastructure-specific strategies.

Table ES-3. Summary of Overarching Adaptation Strategies

Type	Strategy	Description
Adaptive Management	Monitor sea level rise	Regular review of local sea level data using tidal gauges can help Coronado understand the rate at which sea level rise is progressing, and when new adaptation measures should be triggered for implementation.
	Join the Community Rating System program to reduce flood insurance costs	Participation in the Community Rating System helps provide discounted flood insurance premium rates to residents and businesses. To participate, communities implement floodplain management practices that exceed the minimum requirements of the National Flood Insurance Program. This strategy would not be triggered for implementation until the Federal Emergency Management Agency (FEMA) flood insurance rate map updates show more property in Coronado as vulnerable to the 100-year storm (i.e., when the maps are updated to account for sea level rise.)
Engineering	Develop sea level rise design guidelines or standards	Sea level rise design guidelines would help ensure that City capital projects have resilience measures (e.g., elevating structures in a floodplain, installing flood gates) incorporated from the start and that existing at-risk infrastructure receives a resilience upgrade when it comes time for a retrofit.
Operational	Communicate flood warnings to the public	Early warning systems, public notice of flood forecasts, and other channels of communication and data tracking can help provide the public with key information and timely warnings to prevent injuries during forecasted coastal storm events.
	Track flood locations and impacts	Collecting data will help to prioritize areas that experience repeated or intense flooding for investment in flood resilience measures or restriction of development in those areas.

Type	Strategy	Description
	Continue to update emergency management planning documents to include climate change, as needed	Updated emergency management plans will help ensure that emergency managers and responders are equipped to handle the impacts of climate change and have adequately prepared staff and resources in line with anticipated conditions.
Planning	Seek federal and state adaptation funding	State and federal sources of grant funding are available to jurisdictions to help implement adaptation measures, including from Caltrans and FEMA.
	Incentivize private building retrofits	Incentives for implementing adaptation strategies can help increase the likelihood of their uptake and can also be a useful tool for encouraging action by private property owners.
	Utilize available planning tools and techniques	Planning tools can help ensure future private development is resilient to sea level rise. Options include zoning adjustments (e.g., increasing setback requirements) and Transfers of Development Rights, (e.g., redirecting development that would otherwise occur on the land to an area suitable for denser development) among others.
Outreach	Bolster community resilience and garner public support for adaptation through public outreach	Public outreach about sea level rise would help increase residents understanding of climate change risks and personal property adaptation options, in addition to bolstering public support for City adaptation actions.

Adaptation Action Area Strategies

To understand location-specific adaptation options, the areas owned or maintained by the City were broken up into ten adaptation Action Areas (Figure ES-3). Adaptation strategies were not developed for Navy-owned land, Port land, and State land (e.g., California State Parks), but close coordination will need to occur with those partners over time. The three exceptions are the golf course, the area between City Hall and Glorietta Bay Park, and State Route 75 (SR75). While the golf course land is owned by the Port, it is leased to the City so potential adaptation strategies are recommended. The area of land between City Hall and Glorietta Bay Park is owned by the Port, however, the buildings within this area are owned and operated by the City so potential adaptation strategies are recommended. SR 75 is infrastructure that, although currently owned by the State (Caltrans), is considered for adaptation strategies as well since it may be transferred to the City at some point in the future.

For each Action Area, a suite of potential adaptation strategies are presented as adaptation pathways, which sequence related strategies to reduce risk efficiently and effectively over time. The adaptation pathways show what strategies to consider for each Action Area, when to start planning for each strategy based on observable sea level rise, and when to implement the strategies. The adaptation strategies fall within five categories:

- **Hard engineering:** Strategies that involve constructing or expanding a permanent structure (e.g., seawalls, elevating infrastructure).

- **Nature-based:** Strategies that restore a natural feature using components of the environment (e.g., dunes, wetlands).

Figure ES-3. The City of Coronado adaptation Action Areas
(Source: Google Earth Pro)

- **Operational:** Temporary strategies that are used by the City to reduce safety risks (e.g., road closures).
- **Planning:** Strategies that use urban planning tools, such as zoning, or planning studies to help lay the groundwork for future hard engineering, nature-based or managed retreat strategies.
- **Managed retreat:** Strategies that relinquish land to the natural environment.

Recognizing the uncertainty associated with when sea level rise projections may occur, the potential adaptation strategies in the Adaptation Plan are tied to “triggers,” such as observable sea level rise points, which will require monitoring over time. Adaptation strategies are intended to build on one another as triggers are reached (e.g., the end of effectiveness of a related strategy; decreased beach width; forecasted storm) with more advanced or aggressive strategies being triggered over time. In some cases, there may be multiple potential adaptation strategies that would protect an area, which are both presented for consideration. This flexible approach of gradually increasing protection levels over time allows for the selection of the “best” option to be determined when needed rather than predetermining a strict set of actions now based on projected sea level rise for 50+ years from now. Table ES-4 summarizes the key takeaways for the ten Adaptation Action Areas within the City.

Table ES-4. Summary of Adaptation Action Area Adaptation Pathways

Action Area	Key Takeaways
Action Area 1: Edge of Navy property to Harborview Park	Continued close coordination with the Navy will ensure sea level rise risks are managed in this area. In this area the Navy may be best suited to implement an effective strategy. City actions could include elevating First Street and installing flood walls along the border with Naval Air Station North Island (NASNI).
Action Area 2: Harborview Park to Coronado Bridge touchdown	Continued coordination with the Port is critical since the Port owns most of the bayside land in this area and may be better suited to implement an effective sea level rise adaptation strategy. Coordination can ensure a comprehensive and complementary approach. City actions could include elevating First Street to serve as a barrier against further inland flooding.
Action Area 3: Coronado Municipal Golf Course	To reduce future sea level rise risks, two long-term adaptation pathways may be considered: **Option 1:** An engineering approach focused on retaining the golf course by raising revetments, building a seawall, regrading the golf course, and elevating infrastructure over time. **Option 2:** A managed retreat approach that would eventually close the golf course and relocate the tennis center while protecting inland residences. Continued coordination with the Port is essential since the golf course land is leased from the Port.
Action Area 4: South edge of Coronado Golf Course to the east end of Strand Way parking	Continued close coordination with the Port is essential for reducing sea level rise risks in this area since they own most of the bayside land. City actions could include elevating Strand Way to protect the roadway and inland areas from flooding.
Action Area 5: Coronado City Hall to Glorietta Bay Park	To reduce sea level rise risks, two long-term adaptation pathways may be considered: **Option 1:** An engineering approach focused on elevating seawalls and redesigning Glorietta Bay Park. **Option 2:** A managed retreat approach that includes relocating City services that are currently located in this area.
Action Area 6: Coronado Beach	Coronado Beach is relatively high topographically and requires little action to protect it from sea level rise other than proactively maintaining the beach width and constructing an elevated dune or deployable flood barrier by Sunset Park to prevent storm surge flooding from entering the surrounding neighborhood.
Action Area 7: Coronado Shores Beach area to Avenida Lunar	To allow continued access of the beach, beach nourishment in combination with structural improvements and additions to flood walls and groins are recommended.
Action Area 8: State Route 75	State Route 75 becomes increasingly vulnerable to flooding as sea levels rise. To allow continued access of all four lanes of the road and protect developments alongside it from flooding, beach nourishment, dunes, operational strategies, and road elevation are recommended.
Action Area 9: Coronado Cays Residential Area	To reduce future sea level rise risks, two long-term adaptation pathways may be considered: **Option 1:** An engineering approach focused on elevating existing seawalls and roads where and when necessary. **Option 2:** An eventual managed retreat approach focused on providing residents with fair market value for their homes.

Action Area	Key Takeaways
Action Area S: Stormwater Systems	Hydraulic and groundwater studies are recommended to inform future system adaptation actions. Then, a combination of nature-based and engineering strategies, including dry floodproofing pump stations and installing backflow preventers, are recommended to improve the system's overall resilience to sea level rise.

Conclusions

Planning for and adapting to a changing climate and sea level condition is a critical challenge facing many coastal communities throughout California. The Sea Level Rise Vulnerability Assessment and Adaptation Plan represents a crucial step in this process for the City. By determining the potential vulnerability of coastal resources within the City and developing appropriate adaptation strategies, the City is positioned to proactively and cost-effectively prepare for sea level rise and reduce potential hazard impacts before they occur. Given the projected hazard impacts under near-term sea level rise scenarios, initial adaptation strategies tend to focus on planning or operational strategies while beginning to monitor sea level rise or other metrics to identify when critical hazard thresholds are reached. Future strategies must also account for the mixed ownership along the City coastline, highlighting the need for coordination and communication between entities such as the Navy, the Port, State Parks, and Caltrans to ensure a comprehensive adaptation approach.


City of Coronado
SLR VULNERABILITY
ASSESSMENT

1 Sea Level Rise Vulnerability: Introduction & Approach

The City of Coronado (City) is internationally recognized as a beautiful and vital community encompassing several of southern California's most valued tourist, recreational, and federal resources. The City coastline is very accessible and supports a wide variety of public (local, state, federal), private, and environmental functions. The approximately 7.7 square mile City limits (2.2 square miles of which fall within City jurisdiction) extend from Naval Air Station North Island (NASNI) south along the Silver Strand to the City of Imperial Beach. Coronado takes the form of a peninsula, with a land-side connection at the City of Imperial Beach boundary, while water from the San Diego Bay and Pacific Ocean surround it on all other sides. The City is connected to downtown San Diego by the two-mile long San Diego-Coronado Bridge, a part of State Route 75 (SR-75).

Recent advancements in sea level rise (SLR) and coastal hazard science indicate that valuable coastal resources in the City may become exposed to more intense coastal hazards such as beach erosion and coastal flooding in the future. This study evaluates the potential vulnerability of these resources to changing future hazards due to SLR. Future studies will address potential adaptation strategies available to the City to mitigate these hazards. Potential hazards and adaptation strategies will continue to be revised over time based on the best-available climate science and projections, forming a cyclical process to address hazards over time (Figure VA-1).

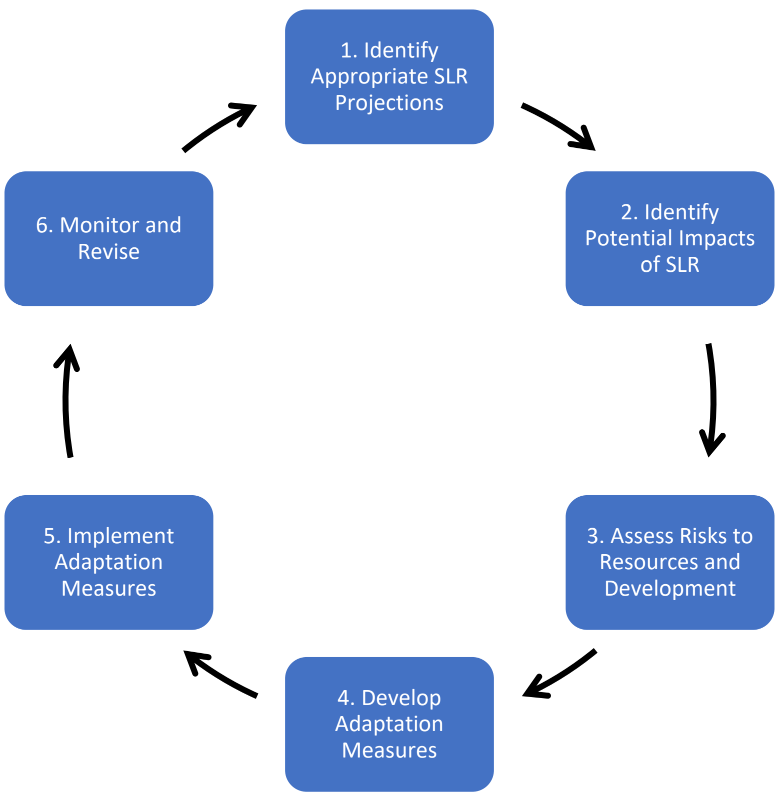


Figure VA-1: Sea level rise planning process

This study is based on SLR projections published in the California Ocean Protection Council (OPC) report *State of California Sea Level Rise Guidance* (California Ocean Protection Council, 2018), the current best-available source of SLR projections on a state and regional level. The potential effects of SLR on existing coastal hazards such as beach erosion and storm-related flooding were evaluated using results of the Coastal Storm Modeling System (CoSMoS), a multi-agency effort led by the United States Geological Survey (USGS) used widely in SLR assessments across southern California. This study is funded in part by Caltrans, but also represents an optional initiative taken by the City to prepare for the impacts of sea level rise. The study and a subsequent Adaptation Plan document included as part of this project are intended to guide current and future City staff and Council members in understanding potential sea level rise risks and potential adaptation approaches.

Community engagement and outreach is also included as part of this project. These efforts will include a variety of methods to solicit input and engage the public and stakeholders. These methods will include an online public survey, two community meetings, and stakeholder interviews. Stakeholder interviews have largely already occurred. The City's website and social media platforms will also be utilized to inform and engage interested parties. Subsequent to project completion, members of the public and stakeholders can stay informed of the project through the City's website and communication with City staff.

1.2 Study Approach

The purpose of this SLR Vulnerability Assessment (VA) is to understand how rising seas could impact coastal resources in the City. The term coastal resource is used to describe both natural and manmade features that provide a benefit to the City, including its residents, businesses, and visitors. Key questions that guide the vulnerability assessment are illustrated in Figure VA-2.

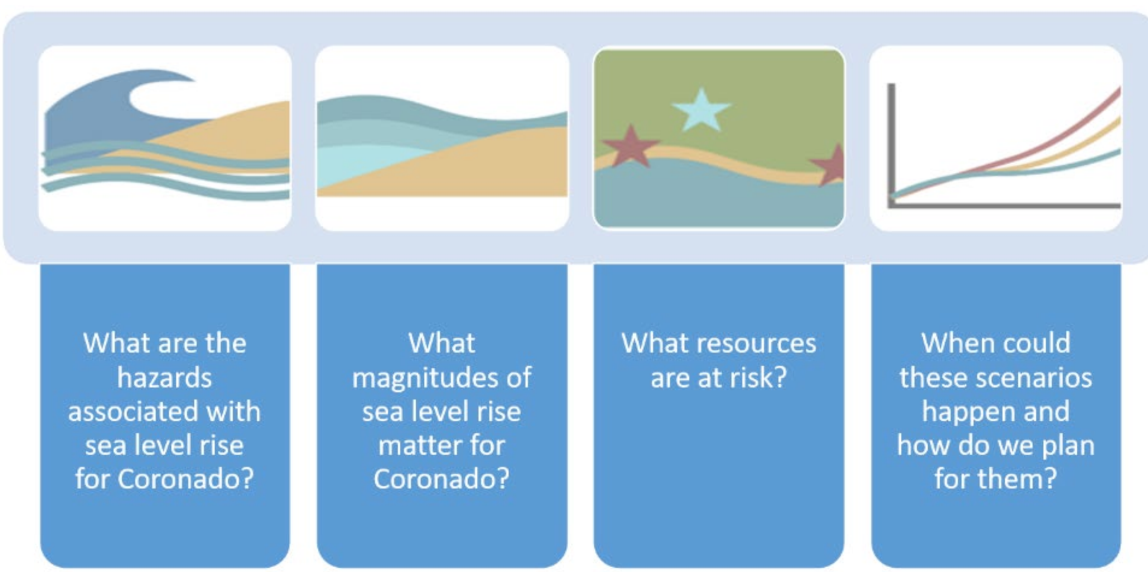


Figure VA-2: Key questions for a Vulnerability Assessment

An initial step of the assessment is to identify how coastal hazards such as flooding or erosion may change as sea levels rise. The overlap of projected future hazard zones and current coastal resources can then be used to identify future vulnerabilities and the thresholds at which SLR may impact critical City resources. The vulnerability of an individual resource is dependent on three factors:

- **Exposure**: the type, duration and frequency of the coastal hazard a resource is subject to under a given sea level rise scenario. A resource that experiences daily tidal, wave, or water level inundation would be considered to have a greater SLR exposure than a resource that only experiences minor flooding during an extreme wave or storm event.
- **Sensitivity**: the degree to which a resource is impaired by exposure to a coastal hazard. For example, a power substation at low elevation would be more sensitive to flooding than a park bench due to the consequences of it being in contact with water.
- **Adaptive Capacity**: the ability of a resource to adapt to changing coastal hazards. Resources such as beaches may have the ability to adapt to SLR over time with little outside intervention if the initial beach prior to sea level rise is wide enough. Large structures typically have lower adaptive capacity due to the costs and challenges associated with hazard mitigation.

This VA will inform the preparation of a SLR Adaptation Plan by outlining potential consequences and key SLR thresholds for the City. This information may be used by the City to support policies and adaptation strategy development to improve coastal resiliency.

1.3 Study Area and History

The study area for the VA encompasses the full extent of the City shoreline. Water surrounds the City on three sides and the City is located completely within the coastal zone. As such, the coastal setting extends across the City in its entirety to capture the full extent of coastal hazards present under each SLR scenario analyzed. The City is located within the southwestern portion of San Diego County. The Coronado-Silver Strand area is home to several federal, state, and regional jurisdictions, as listed below and depicted in Figure VA-3.

- City of Coronado (Municipality)
- City of Imperial Beach (Municipality)
- Port of San Diego (Public-Benefit Corporation)
- Silver Strand State Beach (California State Parks)
- Military Facilities (Naval Base Coronado – U.S. Navy)
    - Naval Air Station North Island
    - Naval Amphibious Base Coronado

- Fiddler’s Cove Marina
- Silver Strand Training Complex

The City limits, offshore elevations (bathymetry), and onshore elevations (topography) are presented in Figure VA-4.

Figure VA-3: Project location and jurisdictions

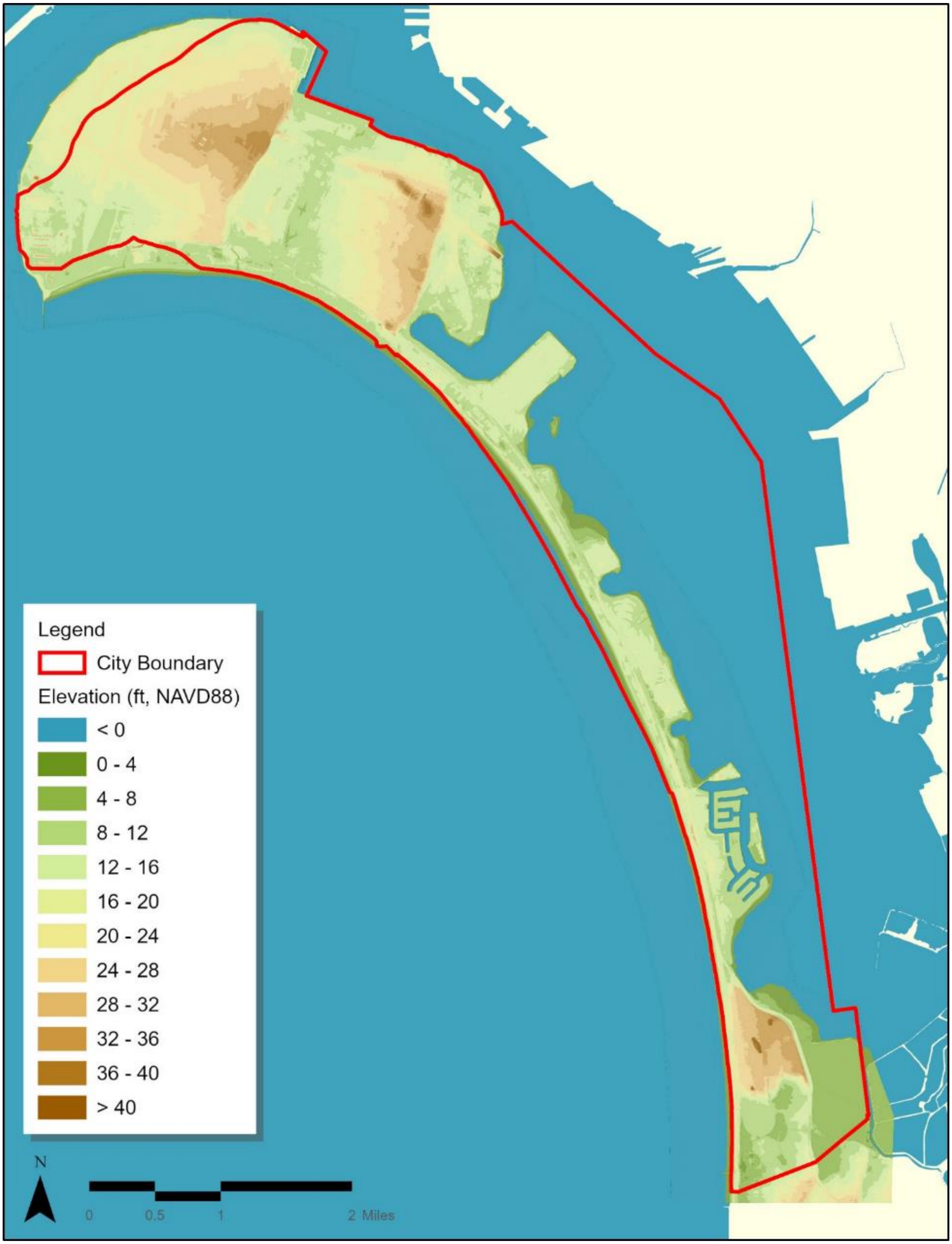


Figure VA-4: Site topography

This region's geography developed from the movement of the Rose Canyon fault zone which created a varying topography of high elevation areas (e.g., Mt. Soledad, Point Loma) and low elevation basins (e.g., San Diego Bay). Hydrologic processes of freshwater discharge across the region carved canyons and developed river plains and deltas over time, such as the San Diego River and Tijuana River (Abbott, 1999). To the west of Coronado is the Pacific Ocean, to the north is the San Diego Bay entrance, and to the east is the greater San Diego Bay. Coronado was built atop a sand spit which is a narrow band of sandy beach extending along the shore formed by sand accumulated over time. As such, is a relatively low-lying community sandwiched between two bodies of water – the Pacific Ocean and San Diego Bay. The ocean-side is characterized by wide, sandy beaches, backed by vegetated sand dunes, rock revetments, and seawalls in various locations (Figure VA-5), extending north to Zuniga Jetty at the entrance to San Diego Bay. The bay-side is characterized by intermittent armored, sandy, or wetland shoreline, extending south to the San Diego Bay National Wildlife Refuge. The following is a brief history of key regions within the City within which coastal development has played a major role in the evolution of the coastline.

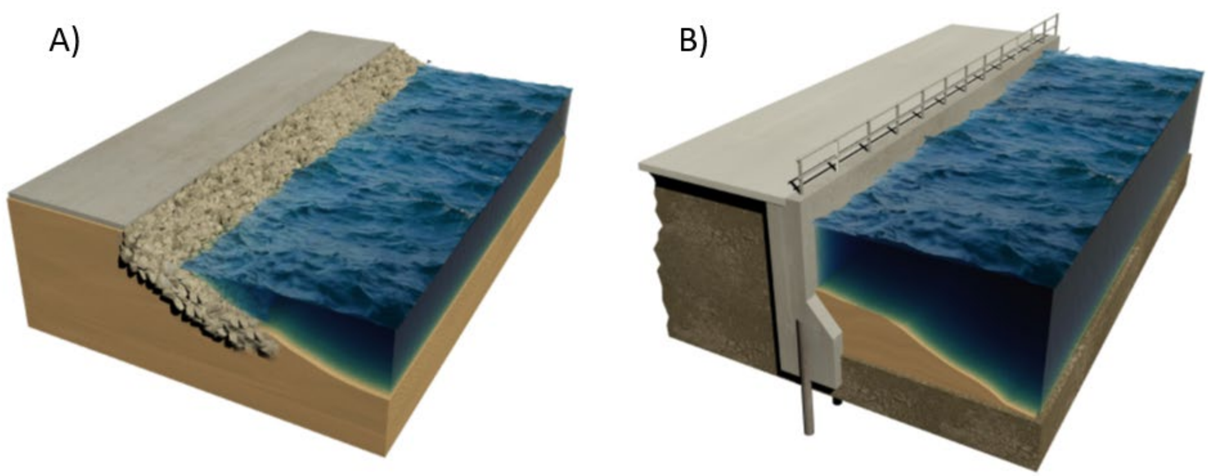


Figure VA-5: Examples of a) rock revetment and b) seawall structures used to protect coastal resources

Silver Strand

The City is situated on a sand spit which developed as a result of sediment discharge from the Tijuana River and from historic beach nourishment to the south. This material is then driven north by a predominant nearshore current which carries and deposits sediment along the coast. This deposition developed a 9-mile long sand spit, called the Silver Strand, which connects the City of Imperial Beach to North Island Coronado. City development landside of the beach includes transportation resources, private residences, visitor serving amenities, and public recreation areas. A majority of the ocean-side shoreline is owned and operated by either the U.S. Navy or the California State Parks Silver Strand State Beach. This includes several miles of beach along the Silver Strand, and the area in northern Coronado known as Naval Air Station North Island. The sub-area is continuously evolving as coastal processes such as waves, currents, and tides wash over and reshape the beach.

Throughout development of San Diego Bay, major dredging activities took place to deepen and widen channels for port and military purposes. Beginning in 1946, dredging activity pumped approximately 34 million cubic yards (cy) of sediment onto the Silver Strand, widening the beaches by hundreds of yards (Flick, 1993). The predominantly northward nearshore currents spread the sediment north to the shores of Coronado, with beaches benefitting from the sand retention effects of the Hotel Del Coronado groin and Zuniga Jetty. Prior to this massive beach nourishment event, the Silver Strand was a narrow sand spit which was occasionally overtopped by storm waves, causing overwash sediment deposits to form in San Diego Bay (Figure VA-6).

Naval Amphibious Base (NAB) Coronado was established on San Diego Bay and the open coast of the Silver Strand in 1944 by the Secretary of the Navy. Beachfront areas of the NAB were constructed on about 70% of the available beach and have since experienced encroachment from the ocean as a result of beach erosion.

Additional beach nourishment events continue to regularly take place along the Silver Strand. An average of about 50,000 cy/year of sediment is placed in the region (Coastal Frontiers Corporation, 2020). This material typically works its way north, widening beaches along the City of Coronado. Additionally, singular nourishment events, such as the Regional Beach Sand Projects (RBSPs) I and II, have placed 120,000 cy and 450,000 cy of sand at Imperial Beach, respectively, to the benefit of the Coronado shoreline (Coastal Frontiers Corporation, 2020).

Figure VA-6: Photo taken from the Hotel Del Coronado looking south along the Silver Strand in 1898 depicting narrow open coast beach and overwash deposits in the San Diego Bay. Source: U.S. Navy (2015)

North Beach

Construction of the Zuniga Jetty (completed in 1904) at the entrance to San Diego Bay has helped stabilize the Coronado shoreline. It functions to block sand from reaching the Bay entrance channel by trapping sand moving north along the Silver Strand and City beaches by nearshore currents. However, in January and February of 1905, the open coast shoreline was severely eroded by southerly storm waves (Figure VA-7). Emergency actions were attempted to protect the shoreline with 30,000 sandbags, however, erosion and flooding persisted, ultimately eroding approximately 110 feet of land, including Ocean Blvd. Two homeowners retreated their residences inland following the damage. The damage prompted the City to fund and construct what is today the nearly 1-mile-long rock seawall along Ocean Blvd. Construction began in 1906 and imported approximately 67,000 tons of rock and cost $145,000 (Coronado Historical Association, 2021). Improvements have been made to the wall over time, as the ocean has continued to lap at the wall (Figure VA-8); however, sand placement from multiple major dredging projects has expanded the shoreline several hundred feet to its current condition.

Another noticeable rock protection structure is the unfinished C-shaped rock groin which extends into the ocean from the Hotel Del Coronado. In the early 1900's, a curved groin was constructed adjacent to the Hotel Del Coronado in attempt to create a small craft harbor. The rock groin was envisioned to protect an oceanside harbor, however the construction was cut short by a lack of funds (Coronado Historical Association, 2021). The abandoned rock construction has remained in place since and has created a stable pocket beach.

In 1967, the Coronado Shores condominiums were constructed just behind the wide, accreted beach at the seaward edge of nearby land. The beach retreated under subsequent storms and a rock slope revetment was installed along the development. As a result of the development's proximity to the water and the existence of a rock revetment, the beach width is perpetually narrow in the Coronado Shores sub-area, and wave overtopping of the fronting rock revetment has been observed during high storm events.

Figure VA-7: Coastal erosion encroaching on Ocean Blvd following 1905 storm waves (Coronado Historical Association, 2021)

Figure VA-8: Ocean Blvd seawall directly adjacent to ocean waves – 1924 (Coronado Historical Association, 2021)

Spanish Bight

Naval Air Station North Island (NASNI) is a U.S. Navy complex developed at the northern end of the City beginning in 1917. The North Island is named as such because the natural geography of the region contained the Spanish Bight, a waterway and wetland that separated North Coronado from South Coronado (Figure VA-9). The waterway was periodically dredged to maintain vessel access, however towards the end of World War II, the U.S. Navy began to fill the Spanish Bight with material to create a ground surface for expanding land-based facilities. The Spanish Bight was filled with dredged and other materials, and now connects Coronado with North Island, however it remains one of the lowest elevation points in the City.

Figure VA-9: Spanish Bight depicted behind a U.S. Department of Defense military squadron flying over North Island – 1930

San Diego Bay

The northern and eastern sub-areas of the City are situated along the western side of San Diego Bay. This sub-area is composed of varying shoreline types including armor, sandy beach, and wetland which are backed by development and open/recreational spaces. A majority of the bay-side shoreline is owned and operated by the U.S. Navy, California State Parks, or the Port of San Diego. The sub-area is exposed to tidal fluctuations, storm surge, and wind-driven and boat wake generated waves; however, the sub-area is sheltered from open ocean swell waves, nearshore currents, and shoreline erosion.

Bayside portions of Coronado were altered through the placement of fill material to create artificial headlands. This includes the Naval Amphibious Base and residential developments including Coronado Cays which sit atop land created through fill activities.

1.4 Existing Land Use and Infrastructure Inventory

The coastal resources to be evaluated in the VA were determined through analysis of land use and infrastructure data provided by the City and obtained from the San Diego Association of Governments (SANDAG) SanGIS Regional Data Warehouse. Analyzed resources are constrained to public resources within the City of Coronado, and excludes resources within other jurisdictional boundaries (i.e. U.S. Navy, California State Parks, Port of San Diego). The existing land use and infrastructure inventory is summarized in Table VA-1. Due to the long, linear outline of the City, the inventory is presented in three spatial alignments representing the North, Central, and South regions. Existing land use and infrastructure is depicted in Figure VA-10, Figure VA-11, and Figure VA-12.

Table VA-1: Existing land use and infrastructure inventory

Category	Resource
Infrastructure	Development
	City Hall
	Fire Department
	Police Department
	Post Office
	Public Services Building
	Hospital
	Lifeguard Stations
	Restrooms
	Schools

Category	Resource
Recreational Space	Ferry Landing
	Tennis Center
	Coronado Yacht Club and Boathouse
	Community Center
	Aquatics Center
	Club Room
	Cays Yacht Club
	Parks
	Golf Course
	Coronado Beach
	Silver Strand Beach
	Coastal Access Points
Utilities	D Street Substation
	Pump Stations
	Stormwater Outlets
Transportation	Bike Routes
	Major and Minor Roadways
	SR-75
	Public Parking

Figure VA-10: Existing land use and infrastructure – North

Figure VA-11: Existing land use and infrastructure – Central

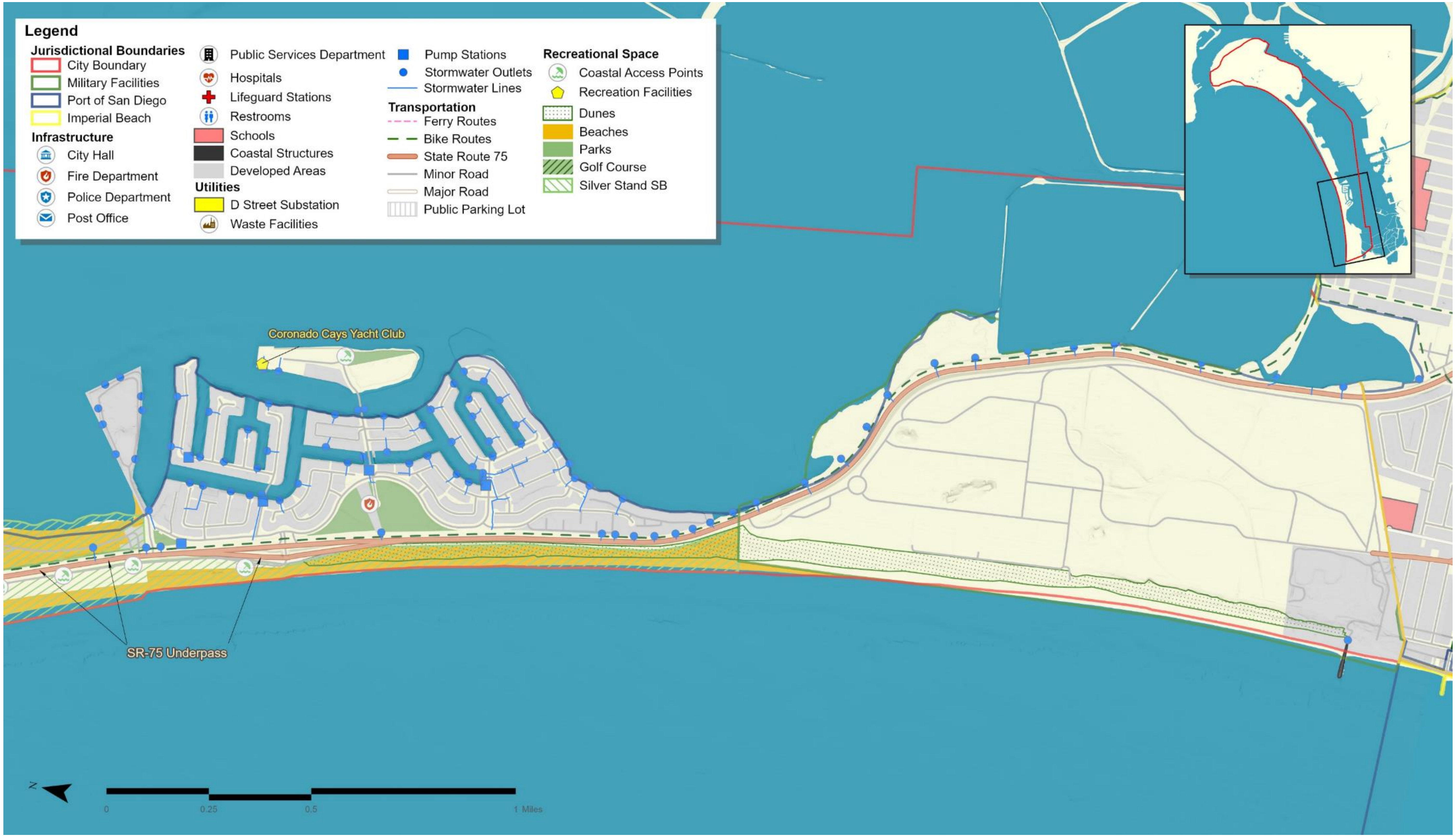


Figure VA-12: Existing land use and infrastructure – South

2 Coastal Processes

Coastal processes refer to the water levels, waves, and sediment transport patterns that shape the coastline of Coronado. These dynamic processes are largely driven by natural forces but have also been significantly modified by anthropogenic activities such as development, coastal structures, and beach nourishment. This section describes historic coastal processes and how they have affected the shoreline along Coronado in order to provide baseline information on coastal hazards within the City. Potential impacts from SLR on these processes are discussed in subsequent sections.

2.1 Water Levels

The tides in Coronado are mixed semidiurnal, meaning two high tides and two low tides of different magnitude occur each lunar day (an approximately 25-hour time period). These differences in magnitude vary with longer-term tidal cycles. Astronomical tides account for the most significant amount of variation in the total water level. The San Diego Bay tidal station (NOAA Station #9410170), located at Broadway Pier in the City of San Diego, has been collecting data since 1906. The mean tidal range at this station is 4.05 ft (NOAA, 2021). Key tidal datums which typically define the high and low end of a tidal range are the Mean Higher-High Water (MHHW) level and Mean Lower-Low Water Level (MLLW), defined as the average height of the tide recorded at a tide station each day during a 19-year recording period at its highest and lowest, respectively. The largest tides of the year, occurring in winter and summer, are sometimes referred to as “King” tides and result in high tides representing the extreme spring tide. The existing range of water levels, including daily and extreme values, is summarized in Figure VA-13. When considering the effects of SLR on coastal hazards, it is important to consider that SLR increases the entire range of existing water levels. In other words, both low and high tide elevations will be raised along with SLR.

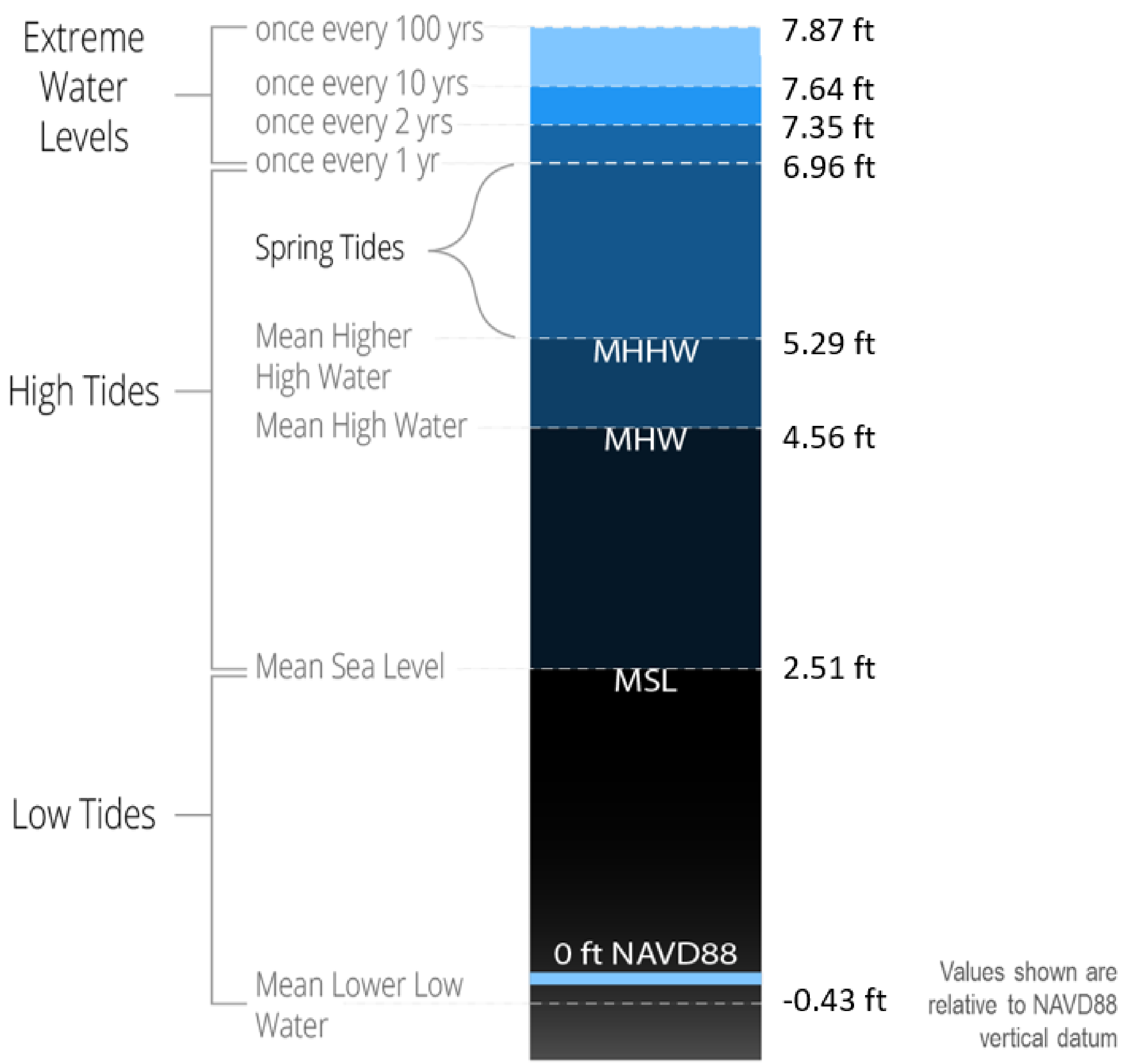


Figure VA-13: Water levels of San Diego Bay, CA (NOAA, 2021)

Sea level elevation is referenced to a datum, a fixed starting point from which elevation is measured. Unless otherwise noted, water level elevations throughout this study are referenced to the North American Vertical Datum of 1988 (NAVD88). This standard datum is consistent with the effective FEMA Flood Insurance Rate Map (FIRM) and Coastal Storm Modeling System (CoSMoS) hazard data published by the United States Geological Survey (USGS). Another commonly used datum in coastal and marine engineering applications is Mean Lower Low Water (MLLW), which is very close to the NAVD88 datum at this location (NAVD88 = MLLW + 0.43 ft).

In addition to astronomical tides, longer term climate cycles such as the El Niño-Southern Oscillation (ENSO). ENSO results from global atmospheric circulation patterns that periodically reverse and result in unusual warming of surface waters in the eastern Pacific Ocean leading to storm tracks shifting south in the northern hemisphere and wet winter conditions with high wave energy. Both ENSO and storm surge also contribute to changes in relative water levels along the Coronado shoreline. These factors can increase the predicted tidal water levels over timescales ranging from hours to months. An example of this occurred on November 25, 2015 when a king tide of 6.95 ft (NAVD88) was predicted, but a water level of 7.81 ft was measured at the San Diego Bay tide station, the highest level since 1906 when measurements were first taken. The tide series from this event is shown in Figure VA-14. The predicted astronomical tide was elevated by 0.86 feet due to a sea level anomaly associated with the strong El Niño and high ocean temperatures during the 2015-2016 winter season.

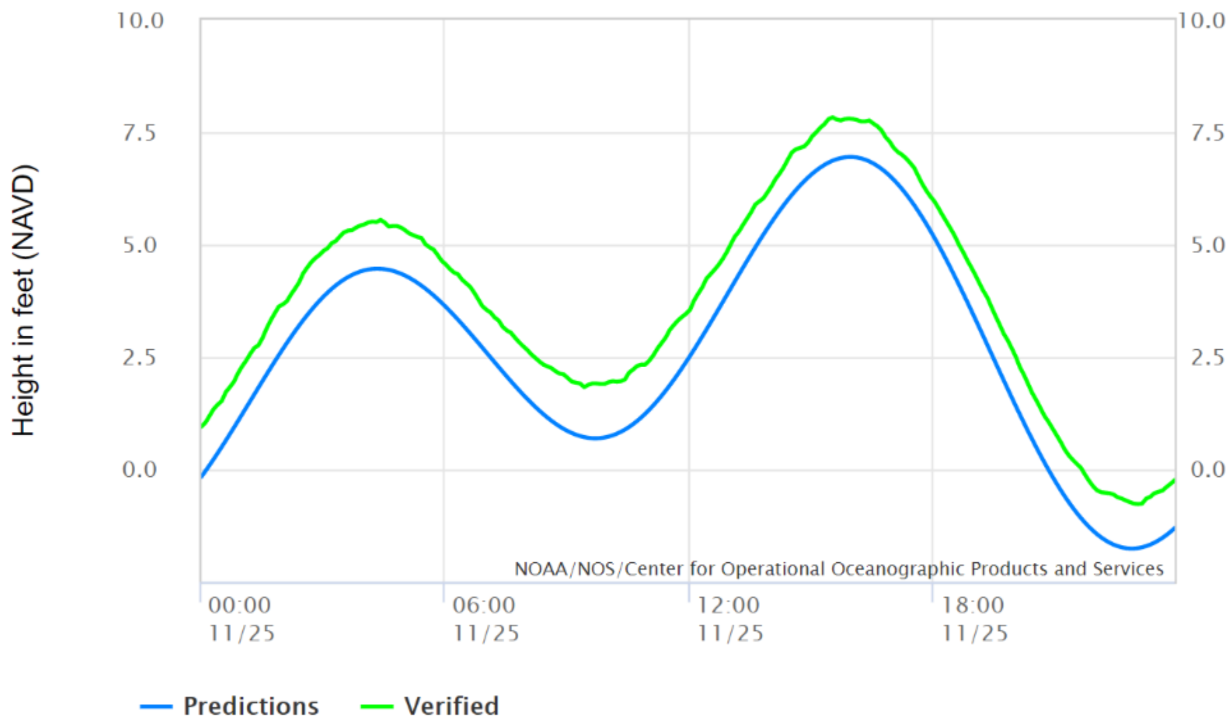


Figure VA-14: Extreme water level at Port of San Diego, November 25, 2015 (NOAA, 2021)

2.2 Wave Climate

Waves act to carry sand in both the cross-shore and longshore directions and can also cause short-duration flooding events due to wave runup, defined as the movement of water up a slope due to wave energy. Both the long-term exposure of a coastline to incoming waves and episodic extreme wave events are important in understanding future SLR vulnerabilities.

The best identified source for wave data for Coronado is the Coastal Data Information Program (CDIP) wave buoy at Point Loma South, located approximately 16-18 miles west-southwest of the City and installed above a water depth of about 3,400 ft (Figure VA- 15). That buoy is located off the Tijuana River so it may not accurately relate wave conditions of Coronado, as Coronado North

Island is sheltered from the winter northwest wave direction by Point Loma, while the Silver Strand is still exposed. As seen in Figure VA-16, the region is generally most exposed to western swell generated by Gulf of Alaska storms and south southwest swell from the southern Hemisphere (Ludka, 2019). Western swell waves tend to peak in size and period in the winter, while southern swells peak in size and period in summer. The highest significant wave heights offshore tend to measure between 18-21 ft with a peak period of about 22 seconds (CDIP, 2019). The significant wave height is defined as the average of the highest one-third of waves in a wave spectrum. The theoretical maximum wave height in a given spectrum can be two times the significant wave height. In the summer, the California high-pressure system generates additional northwestern swell.

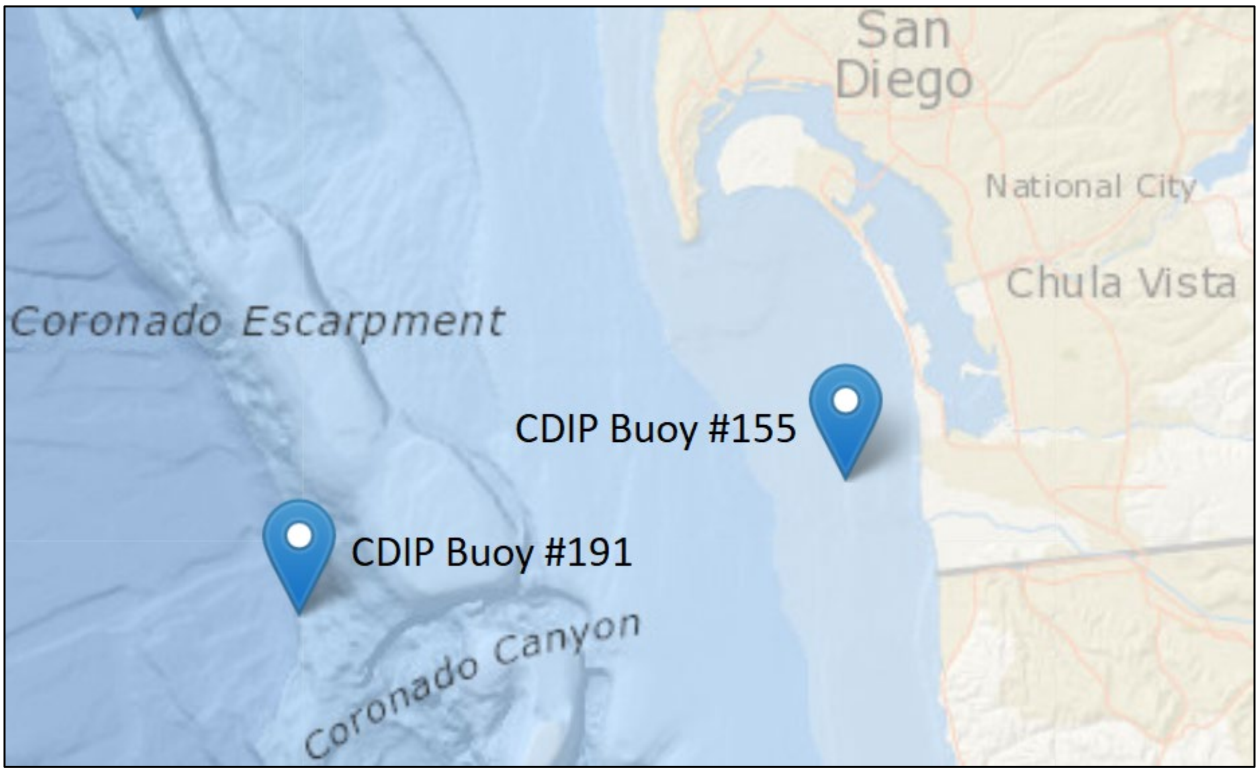


Figure VA- 15: CDIP Station 191 location

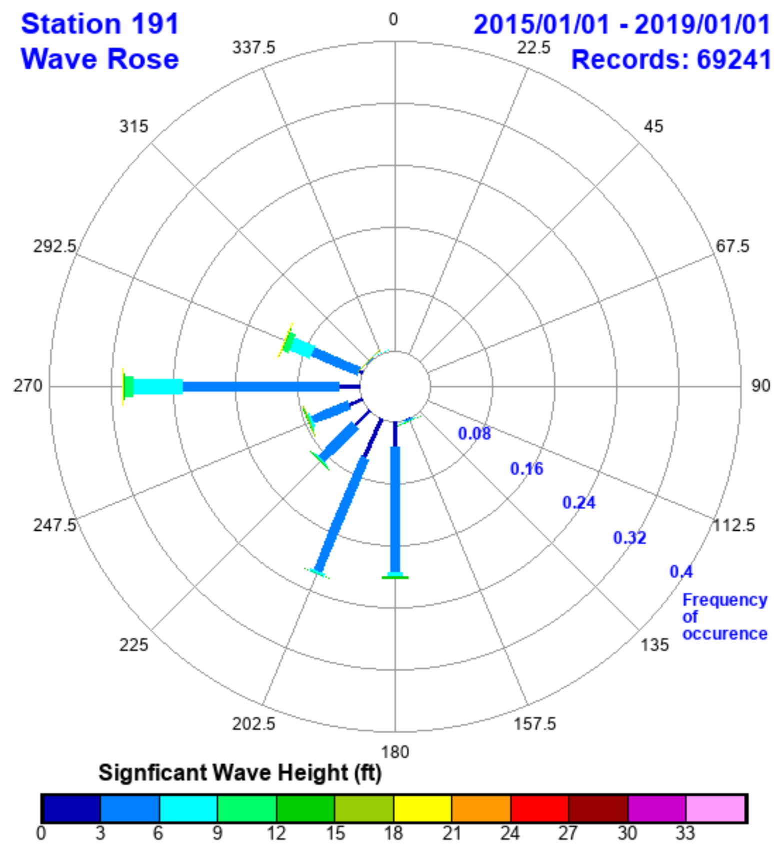


Figure VA-16: Significant wave height and direction – CDIP Station 191 Point Loma South, 2015-2019. Outer numbers refer to wave direction (0 = North). Length of colored bars represents frequency of occurrence. Bar width and color refer to wave height. The longer bars from the 180° and 270° indicate that the majority of waves impacting Coronado come from a south – southwest or west direction. Wave heights are generally in the 3 ft – 6 ft range (dark blue). The highest observed wave heights are 18 ft – 21 ft (yellow).

2.3 Sediment Transport

A littoral cell is a limited physical area along the coast that contains a complete cycle of sedimentation including sources, transport paths, and sinks. The presence of sand on any particular beach depends on the transport of sand within the cell. (Patsch & Griggs, 2007). The City's shoreline is within the Silver Strand littoral cell, which is defined as an approximately 17-mile geographic sub-area of coastline beginning three miles south of the U.S. / Mexico border at the Playas de Tijuana headland, north to Zuniga Jetty at the entrance to San Diego Bay (USACE, 1991).

The increased development in the southwestern area of the United States and in Tijuana, Mexico has affected the state of the Silver Strand. The construction of multiple dams along the Tijuana River Watershed (TRW) for water storage and flood control decreased the sand supply to the coastline. Sediment discharge prior to dam construction was estimated from 86,000 to 700,000 cubic yards/year, while post-dam construction sediment discharge has been estimated from 42,000 to 150,000 cubic yards/year (Flick, 1993).

Longshore sediment transport refers to the movement of sediment parallel to the shore and primarily varies with wave orientation relative to shoreline orientation (in the absence of littoral barriers such as groins). Sediment may be transported in one direction for some time (e.g., from north to south in winter), then transported in the reverse direction in a season with an opposing wave approach angle (e.g., south to north in summer). On a yearly timescale, gross transport refers to the total volume moved in both directions combined (north and south), while net transport is the difference between north and south transport rates and represents the annual amount of sediment moving in the dominant direction, also termed littoral drift. Gross sediment transport is estimated to be 740,000 cy/year throughout the Silver Strand littoral cell, and net longshore sediment transport is estimated to the north from between 120,000 and 200,000 cy/year (Patsch & Griggs, 2006). Patsch and Griggs (2006) indicate a split in transport direction may occur at the vicinity of the Tijuana River delta. Seasonal patterns of sediment transport reversal occur in this littoral cell as well, but the significant effect caused by the bathymetric protrusion of the Tijuana River delta and wave refraction around the tip of Point Loma results in predominant northward movement (M&N, 2011).

Cross-shore sediment transport refers to the movement of sediment perpendicular to the shore and is primarily characterized by contrasting winter and summer dynamics (Figure VA-17). Stormy winter months tend to temporarily move sand offshore causing narrowing of beaches. Sediment typically returns during the summer's relatively calm wave climate, widening the beaches (Elgar et al., 2001).

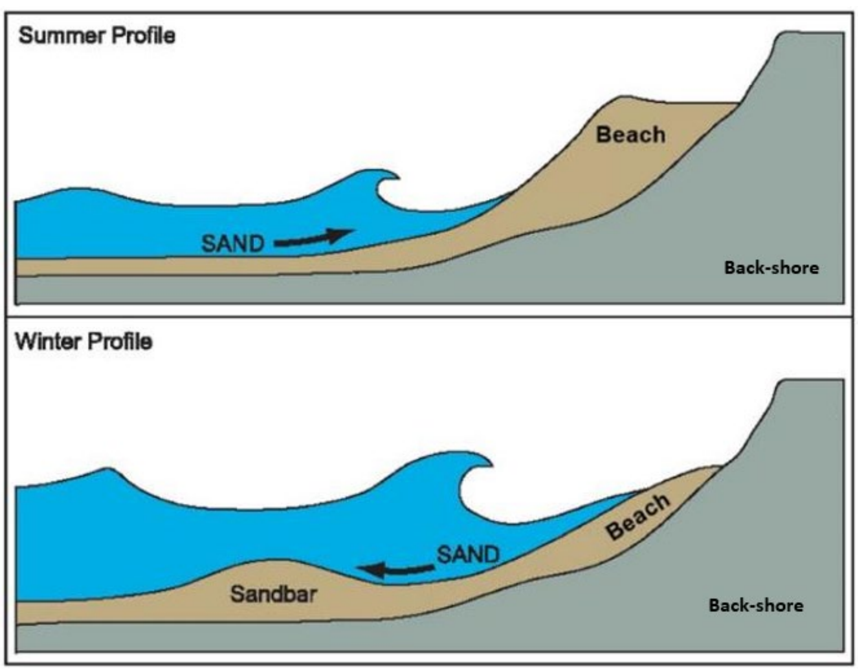


Figure VA-17: Schematic of typical seasonal shoreline change (Patsch & Griggs, 2006)

2.4 Shoreline Change

The Silver Strand had historically been a relatively narrow sand spit separating San Diego Bay from the ocean. As previously indicated, sediment discharge from the TRW prior was estimated from about 86,000 to 700,000 cubic yards (cy)/year prior to major anthropogenic development. The construction of four dams within the TRW decreased the sand supply to the coastline. Post-dam construction sediment discharge has been reduced to a minimum of 42,000 cy/year (Patsch & Griggs, 2006). This reduced sediment source has left the Silver Strand with an estimated deficit of 41,000 cy/year, meaning that, without intervention, the region is in an annual state of erosion.

In part to offset this deficit, the Silver Strand has been the recipient of significant beach nourishment events, as discussed in Section 1.2. As a result, today the Silver Strand is characterized by relatively wide sandy beaches. However, beach erosion is still actively occurring, especially south of Coronado at Imperial Beach. Bi-annual surveys, shown in Figure VA-18, since the year 2000 have shown that, unlike many other areas in Southern California, the sandy beaches of Coronado have not retreated significantly (Coastal Frontiers Corporation, 2020). In 2019, beach widths in the Silver Strand littoral cell ranged from 27 ft in Imperial Beach to 753 ft at North Beach Coronado. Looking forward on the multi-decadal timescale of SLR, the pattern of shoreline retreat occurring in the southern area of the cell is likely to spread north towards Coronado.

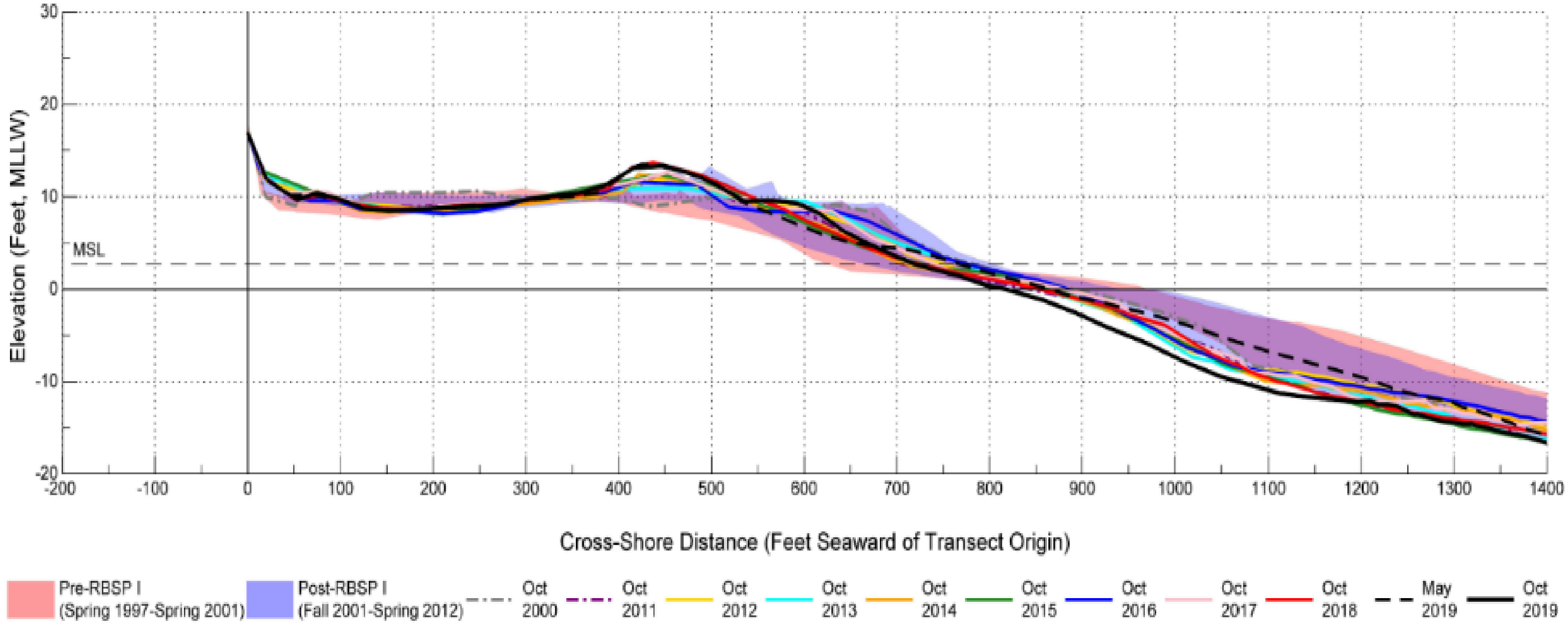


Figure VA-18: Annual fall beach profile survey at North Beach, Coronado (Coastal Frontiers Corporation 2020). Cross-sections (side-view) of the beach are shown for various years as solid and dashed line moving from the back-beach behind dunes (0) to offshore areas (1400). It shows the variation in beach width and elevation depending on conditions. The beach is very dynamic. .

2.5 Historical Coastal Storm Damage

Coastal resources in Coronado are susceptible to damage from extreme storm hazards like wave attack and high-volume surface runoff. These events provide baseline information on potential coastal hazard impacts within the City. Even if storm frequency does not increase, similar impacts may occur on a more regular basis due to higher underlying sea level elevations. On the southern California coast, significant storms occur more frequently during strong El Niño-Southern Oscillation events. Sea level rise may exacerbate this damage if ocean water levels are elevated more than would otherwise be the case.

The 1982-1983 El Niño season was particularly damaging throughout coastal California, causing over $35 million in damage to public recreational facilities alone (Dean, Armstrong, & Sitar, 1984). A sequence of eight major storms struck the state's coast between November 1982 and mid-March 1983. Resulting hazards included significant wave heights greater than 20 ft, extreme water levels, and high precipitation. The 1997-1998 El Niño season eroded beaches in Coronado, especially south of the Hotel Del Coronado, where beaches were observed to erode back to the seawall (Figure VA-19, Patsch and Griggs (2006)).

A chronological list of damaging coastal storm events in the City is derived from the USACE State of the Coast report (1991) as well as other sources, and includes but is not limited to:

- Dec 22, 1888 – Great storm in Coronado. Waves up to 30 feet at the Hotel del Coronado; tons of rocks and kelp deposited on the beach.
- Apr 4, 1958 – 6.7 foot tide and winds threatened homes in Imperial Beach and Mission Beach and nearly flooded SR-75 south of Coronado.
- Dec 1, 1982 – High waves and tides along California coast closed SR-75linking Coronado to Imperial Beach.
- Winter 1983 – Severe El Nino Winter erodes beaches along Coronado and the Silver Strand.
- Feb 10, 1983 – San Diego County, with estimated damages now $14 million, was declared a disaster area by President Reagan.
- 1998 – The El Niño storm season of 1997/1998 battered the coastline with high water levels and large waves. Beach erosion was observed along the City shoreline, including behind the sand retaining groin at the Hotel Del Coronado (Figure VA-19).

Figure VA-19: Erosion at the Hotel Del Coronado Groin – 1997/1998 El Niño Season (Patsch & Griggs, 2006)

3 Evaluation of Sea Level Rise and Related Hazards

Sea level rise science involves both global and local physical processes, as illustrated in Figure VA-20. Models are created based on the current best scientific understanding of these processes from global to local scales and, therefore, are dynamic and periodically updated to reflect these changes. At the state level, SLR projections published in the 2018 Ocean Protection Council (OPC) report *State of California Sea Level Rise Guidance* (California Ocean Protection Council, 2018) represent the current best-available science on potential SLR within the City.

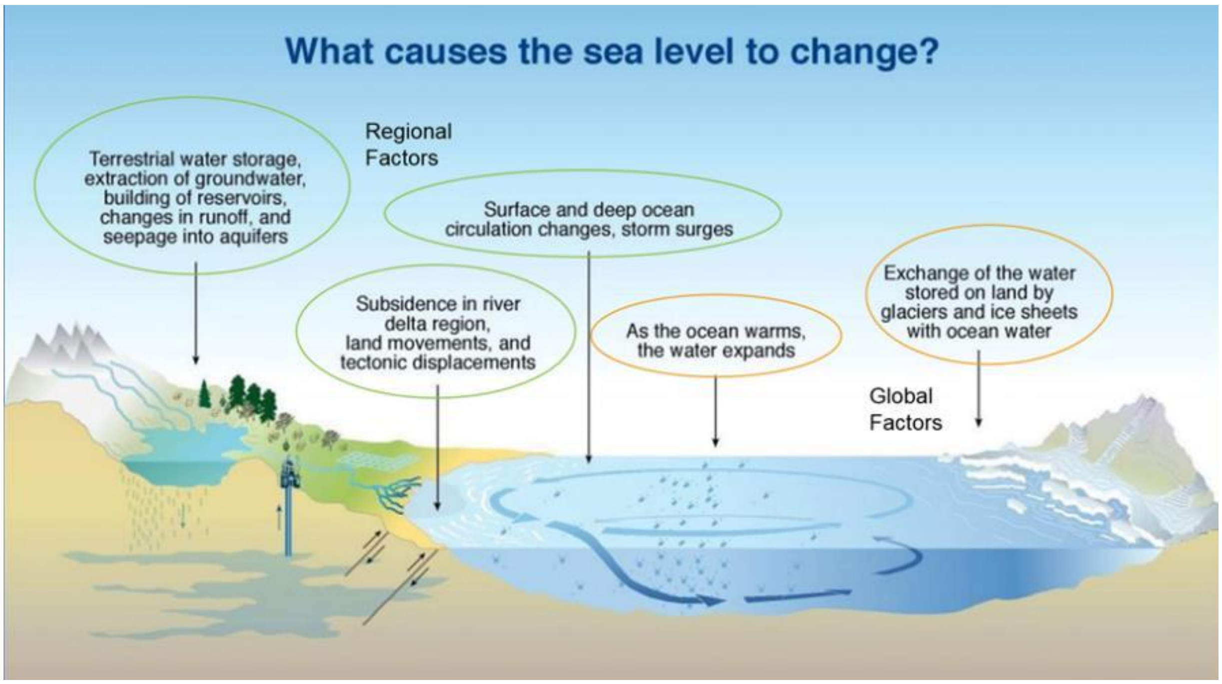


Figure VA-20: Regional and global factors that can contribute to changes in sea level (IPCC, 2013)

3.1 Projections and Probability

The State of California Ocean Protection Council (OPC) Science Advisory Taskforce recently compiled the best available SLR science relevant to California in their report *Rising Seas in California* (Griggs et al., 2017). This report was then used to update the OPC California State SLR Guidance in 2018 (California Ocean Protection Council, 2018). The 2018 OPC guidance includes SLR projections for multiple global greenhouse gas emissions scenarios and uses a probabilistic approach based on Kopp et al., 2014 to generate a range of projections at a given time horizon for 12 tide gauges along the California coast. The level of carbon dioxide emissions affects the rate of global climate change and resulting sea level rise. High emissions result in higher sea level rise rates, and vice-versa. The projections for the San Diego tide gauge under a high-emissions scenario are referenced in this section. Projections associated with a high-emissions future are used in this study as a conservative estimate given that worldwide emissions are currently following the high emissions trajectory. Long-term SLR may be lower if global greenhouse gas emissions are reduced effectively.

OPC SLR guidance defines the likely range of SLR at a given time horizon as the central 66% of projections, or all projections bounded by the 17th and 83rd percentiles, based on methods from Kopp et al., 2014. For the 2030 time horizon, the likely range of SLR for San Diego is 0.4 – 0.6 feet. At the 2050 time horizon, the likely range of SLR increases slightly to 0.7 – 1.2 feet. The likely range of SLR at the 2100 time horizon is 1.8 – 3.6 feet. This likely range of SLR projections is shown as the shaded orange area in Figure VA-21.

2018 OPC SLR Guidance also includes lower probability SLR projections with 5% and 0.5% chances occurring at a given time horizon. For the 5% cases SLR of 0.7 feet is projected at the 2030 time horizon, 1.4 feet is projected at the 2050 time horizon, and 4.5 feet is projected at the 2100 time horizon. For the low probability 0.5% cases SLR of 0.9 feet is projected at the 2030 time horizon, 2.0 feet is projected at the 2050 time horizon, and 7.0 feet is projected at the 2100 time horizon. The 5% and 0.5% occurrence chance curves are shown in green and grey respectively in Figure VA-21.

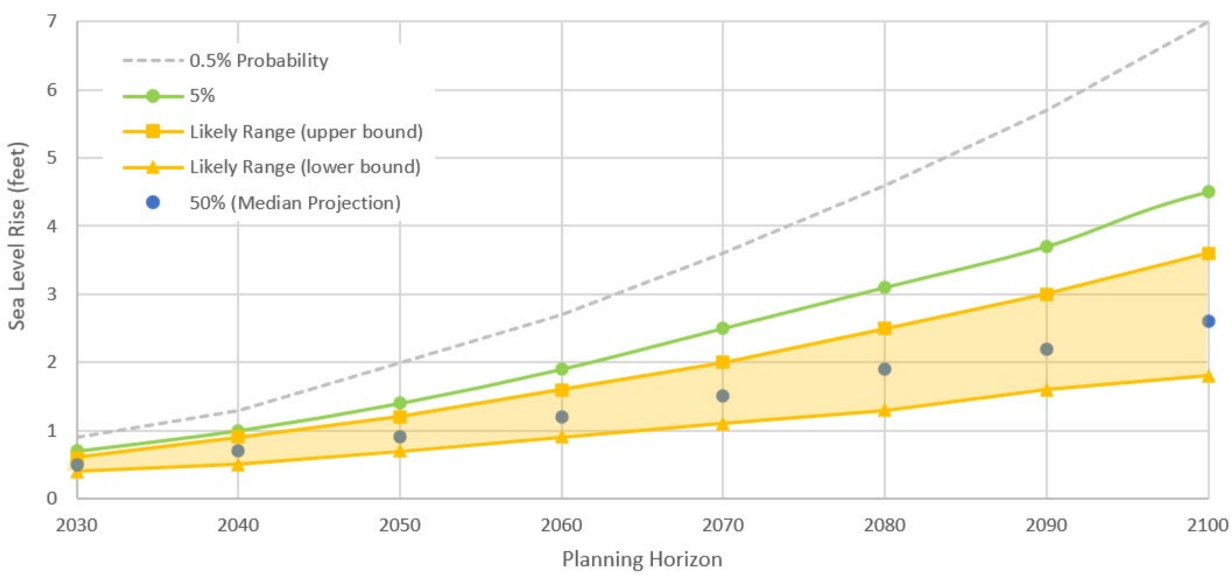


Figure VA-21: Approximate sea level rise projections for three risk aversion levels

3.2 Selected SLR Scenarios

Climate science is a constantly changing field, often with high degrees of uncertainty. In the case of SLR in California, the OPC has high confidence in estimates to approximately year 2050. After this point, greater uncertainty exists about greenhouse gas emission rates, the rate of glacial and ice sheet melt, thermal expansion of the ocean, global oceanic circulation, and how all factors will affect SLR. Due to the high degree of uncertainty associated with predicting when and at what rate SLR will occur, this study looks at a range of SLR values. Six scenarios have been selected for this study that consider increments of SLR between 0.8 ft and 4.9 ft to account for both short-term and long-term potential SLR. Selected SLR scenarios also consider available hazard data for the region, which is available in 0.8 ft (0.25 m or 9.6 inches) increments. All levels of SLR and their potential timing are described in Table VA-2. Coastal hazards under each increment of SLR are evaluated under both non-storm and 100-year coastal storm conditions.

The timing at which 0.8 ft increments of SLR may occur is not an exact science and drawing from the OPC (2018) SLR Guidance, the approximate decade of occurrence is presented for three risk aversion scenarios: Low Risk, Medium Risk, and Medium-High Risk, each with a decreasing probability of occurrence. Risk aversion consideration is important for planning purposes, especially regarding adaptation. A low risk resource, such as a park bench, may not require planning for high risk (low probability) scenarios because the consequences of coastal hazards are relatively low. Whereas a high risk resource, such as an electrical substation, may require planning for high risk (low probability) scenarios because the consequences of coastal hazards are relatively high, affecting large populations and incurring high repair costs.

Table VA-2: Risk aversion planning scenarios associated with selected SLR scenarios.

Sea Level Rise	When Might it Occur?		
	Low Risk Aversion*	Medium Risk Aversion**	Medium-High Risk Aversion***
4.9 ft (1.5 m)	~2130	~2110	~2080
4.1 ft (1.25 m)	~2120	~2090-2100	~2070-2080
3.3 ft (1.0 m)	~2100	~2080	~2070
2.4 ft (0.75 m)	~2080	~2070	~2060
1.6 ft (0.5 m)	~2060	~2050	~2040
0.8 ft (0.25 m)	~2040	~2030	~2030

**17% Probability (Approximately 1 in 6 chance of occurrence by the designated year)*
***5% Probability (1 in 20 chance of occurrence by the designated year)*
****0.5% Probability (1 in 200 chance of occurrence by the designated year)*

Note: The year of occurrence for 0.8 feet (0.25 m) for medium and medium-high risk aversions is the same because there is minimal difference in the projections at that year for those two scenarios (for 2030 the medium = 0.7 ft and med-high = 0.9 ft).

4 Coastal Hazard Evaluation

The effects of SLR on storm and non-storm related flooding were evaluated using results of the Coastal Storm Modeling System (CoSMoS) Version 3.0, Phase 2, a multi-agency modeling effort led by the U.S. Geological Survey (USGS) designed to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for Southern California (Erikson et al., 2017). CoSMoS is considered the best available science currently and is the standard used by most contemporary SLR studies in California. The Coastal Commission requires CoSMoS to be used in SLR Vulnerability Assessments to provide a standardized approach and comparable results for various locations. CoSMoS modeling results are widely used in California SLR assessments and provide predictions of shoreline erosion and coastal flooding under non-storm, high spring tide conditions and multiple storm conditions (Erikson et al., 2017). A total of 10 SLR scenarios are available, increasing in 0.8 ft (0.25 m) increments from 0 to 6.6 ft (0 to 2 m). All modeling results are based solely on topography and so do not take into account the effect of built structures or future grade changes on hazards within the City. CoSMoS projections are intended for planning level vulnerability assessments and may not capture finer-grained, site-specific information key to individual resources or areas.

Coastal hazard analyses within this assessment are presented within the three categories of: shoreline erosion; coastal inundation, and coastal flooding, as described below.

Projected Shoreline Position Hazard

CoSMoS shoreline erosion projections include long-term erosion resulting from SLR and projected wave conditions along the ocean side sub-area of the City. Erosion is not modeled on the bay-side of the City due to lack of wave impacts as the Bay is not exposed to open ocean conditions. Shoreline erosion projections are modeled with the CoSMoS Coastal One-line Assimilated Simulation Tool (COAST), which includes a suite of models that consider historic erosion trends, long-shore and cross-shore sediment transport, and shoreline changes due to increased water levels. These models were tuned with historic data to account for unresolved sediment transport processes and inputs such as sediment loading from rivers and streams, regional sediment supply including beach nourishment and bypassing, and long-term erosion. The CoSMoS-COAST shoreline projections are developed from an initial shoreline mapped from a 2009-2011 light detection and ranging (LiDAR) data set recorded by the State (Erikson, et al., 2017).

CoSMoS shoreline projections for each level of SLR are available within four management scenarios defined by the presence or absence of shoreline armoring and beach nourishment. The use of shoreline armoring is referred to as a “Hold-the-Line” scenario. Shoreline erosion modeling under this scenario assumes that the existing boundary between sandy beach areas and development is maintained with coastal structures. The “No Hold-the-Line” scenario assumes no such armoring is in place and allows shoreline erosion projections to propagate inland to the maximum potential extent based solely on topography. In a similar manner to the shoreline armoring scenarios, the “Beach Nourishment” management scenario assumes that historical beach nourishment practices are continued into the future, while the “No Beach Nourishment” scenario assumes historical beach nourishment practices do not continue within the littoral cell.

For the purposes of this study, the No Hold-the-Line, Beach Nourishment scenario is applied in order to document potential SLR hazards. Shoreline erosion modeling under this scenario allows erosion projections to propagate inland to the maximum potential extent based solely on topography, while assuming that historical beach nourishment practices within the littoral cell are continued into the future.

Inundation Hazards (No Coastal Storm Wave Event)

The CoSMoS “no storm” flood hazard zone is used to illustrate Inundation Hazards from average waves and average spring tides combined with future sea level rise. The term inundation will be used to describe areas of daily wetting and drying associated with a spring high tide. A spring high tide is an exceptionally high standing water level which occurs twice per month during the new and full moon as the gravitational pull of the sun and moon complement each other to created exaggerated tidal levels. Spring high tides are often termed king tides when seasonal water level increases further contribute to extreme water levels.

Flooding Hazards (100-yr Coastal Storm Wave Event)

The CoSMoS 100-year coastal storm wave event (i.e., one percent annual chance) flood hazard is used to illustrate the less frequent but more severe flood hazards during combined high waves, tides, winds, and sea level rise. The term coastal flooding is the episodic wetting associated with this very rare and extreme 100-year storm wave event. To conservatively capture the flood hazard zone, CoSMoS results incorporate the influence of sea level anomalies like El Niňo, increased water levels due to breaking waves, strong winds, storm surge, and a spring high tide combined with future sea level rise. Coastal flooding events are typically short in duration (i.e., hours).

The absolute maximum wave is defined as running up and potentially over sloping beaches or running up and over the crests of natural berms or structures, and it is not depicted in this analysis. Coastal storm flooding instead is representative of a minimum two-minute duration of flooding resulting from high water levels and repeated wave action. Flooding resulting from stormwater runoff is not considered. CoSMoS 100-yr storm flood maps differ from FEMA flood maps in that FEMA 100-yr maps are based on historical combined wave and flood data, whereas CoSMoS flooding is determined by projected future wave and flood events combined with sea level rise.

4.1 CoSMoS Modeling Limitations

The regional focus of the CoSMoS modeling effort results in certain limitations when applied at smaller scales or specific locations. The limitations are most evident at locations where wave action and littoral processes are heavily influenced by narrow-footprint coastal structures or episodic sediment management activities. Limitations of the CoSMoS model and how they may influence the projected exposure of coastal resources in the City are based on the project team's general understanding of the CoSMoS regional modeling approach and local knowledge of coastal hazards.

CoSMoS coastal flood modeling results assume that future shoreline erosion will be halted at the existing development line. Shoreline erosion is not expected by extend landward of the existing line of development due to the presence of wide beaches and seawalls along the open ocean coast and engineered protection structures along the San Diego Bay coast. This assumption is not anticipated to affect flood modeling results within the study area as projected coastal flood extents are permitted to extend beyond the line of development.

The majority of flooding projected by CoSMoS appears to originate from low-lying segments of the San Diego Bay coastline. CoSMoS flood projections within inland areas are a result of SLR in combination with high ocean water levels, but the hydraulic connection (i.e. flood path) inland from San Diego Bay is not well defined or described in the CoSMoS data. It is uncertain precisely how existing flood control measures such as levees, berms, revetments and seawalls were accounted for in the flood modeling. The topographic surface resolution used in the CoSMoS model may not be sufficient to resolve the existence of a relatively narrow seawall.

Also, if a hydraulic connection to either the Pacific Ocean or San Diego Bay does exist, CoSMoS does not account for the physical limitation of the volume of water conveyed through a particular connection over a period of time (i.e. peak of the tide cycle). The amount of overland flooding is limited by friction and any constrictions existing at the hydraulic connections. Narrow ground connections limit the amount of water that can pass through them over a given period of time.

Topographic data utilized within CoSMoS is an aggregate of many topographic surveys between the period of 2009 and 2011, with a 1 meter (3.3 foot) resolution, and may not accurately reflect existing conditions. Small-scale features, such as vertical seawalls less than 3.3 feet wide, may not be captured in the model due to limited resolution of the topographic data used. In areas where these small-scale coastal structures were not captured in the model, coastal flooding limits are likely overstated. A more detailed analysis of these structures would be needed to more accurately define the flood hazard zone in these areas. Such small-scale features, even if captured, are assumed within the model to "hold-the-line" and shoreline erosion does not cross landward of them. Additionally, CoSMoS data do not incorporate flooding and erosion impacts resulting from upland runoff and groundwater seepage.

4.2 Supplementary Modeling

The coastal hazard maps presented in this report depict CoSMoS results which have been amended under certain scenarios to improve upon certain limitations, such as those discussed above. Original CoSMoS results are located in Appendix VA-1 for comparison. Deficiencies in the CoSMoS results were especially prevalent in the North sub-area, and below is a summary of each amendment made to the CoSMoS results for that area:

1. Ocean Boulevard Seawall – The high-level topographic processing methods performed by the USGS intended to remove non-topographic structures, such as buildings and vegetation. However, this process erroneously removed the seawall along Ocean Blvd at North Beach from the topographic data. This seawall is a critical feature which provides significant coastal protection to landside development and was constructed in the early-1900's in response to severe erosion and flooding at North Beach. Using the original LiDAR point data for the CoSMoS topography, the project team identified and isolated the seawall, and merged it into the CoSMoS processed topographic data (Figure VA-22 through Figure VA-24). Utilizing the revised topography, SLR projections were revised. Three noteworthy changes resulted:
    - Up to and including the 3.3 ft SLR scenario, flooding projected to overtop the seawall onto Ocean Blvd was eliminated because the water elevation does not exceed that of the seawall crest.
    - Under the 2.5 ft and 3.3 ft SLR scenarios, flood projections across North Beach would overtop the public beach access point at Ocean Drive near Sunset Park. With considerations of volumetric flow rate through the narrow access way and the dissipation of flow velocity over land, flood projections were revised and ultimately reduced in this area.
    - Under the 4.1 ft and 4.9 ft SLR scenarios, flood elevations are significant, and the value provided by the seawall is reduced as flooding flanks the seawall over dunes and through beach access ways to the north and south. Being a permeable feature, flood water may permeate through the seawall as well. Additionally, flooding is projected to encroach on the area from the San Diego Bay-side through the low elevation neighborhood in the historic Spanish Bight. Therefore, only the crest of the seawall which is above projected flood elevations was revised to show no flooding under these highest two SLR scenarios.

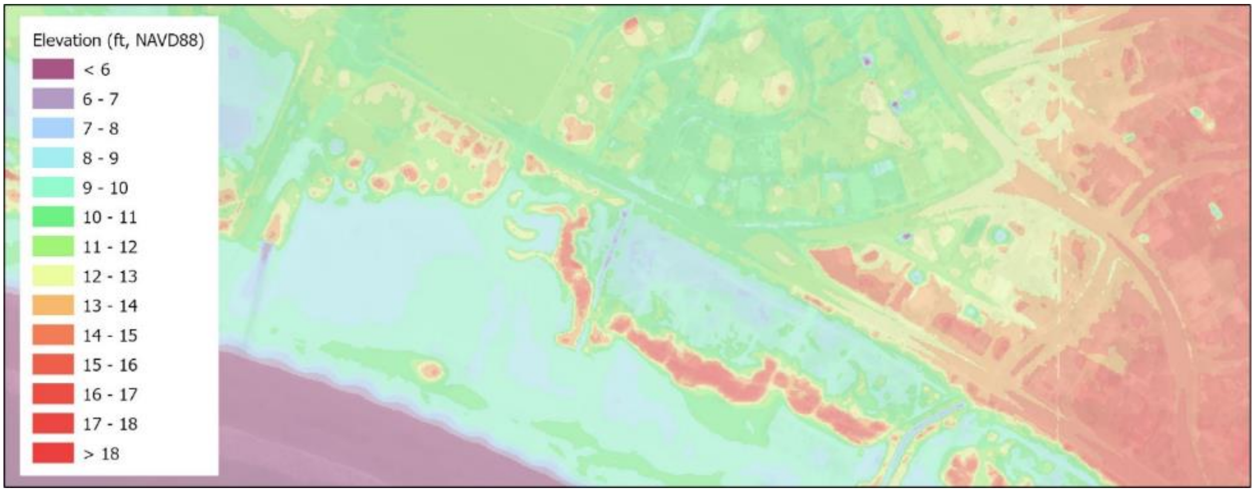


Figure VA-22: Original CoSMoS topography without the seawall located along Ocean Boulevard (no red line visible that depicts the seawall)

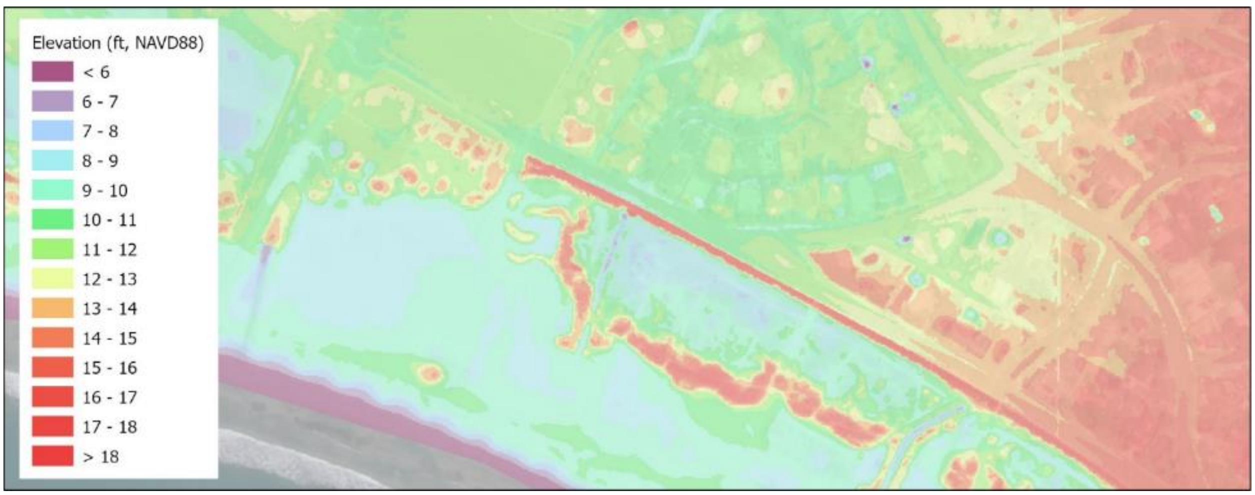


Figure VA-23: Updated topography data to include seawall located along Ocean Boulevard (red line visible depicting the seawall)

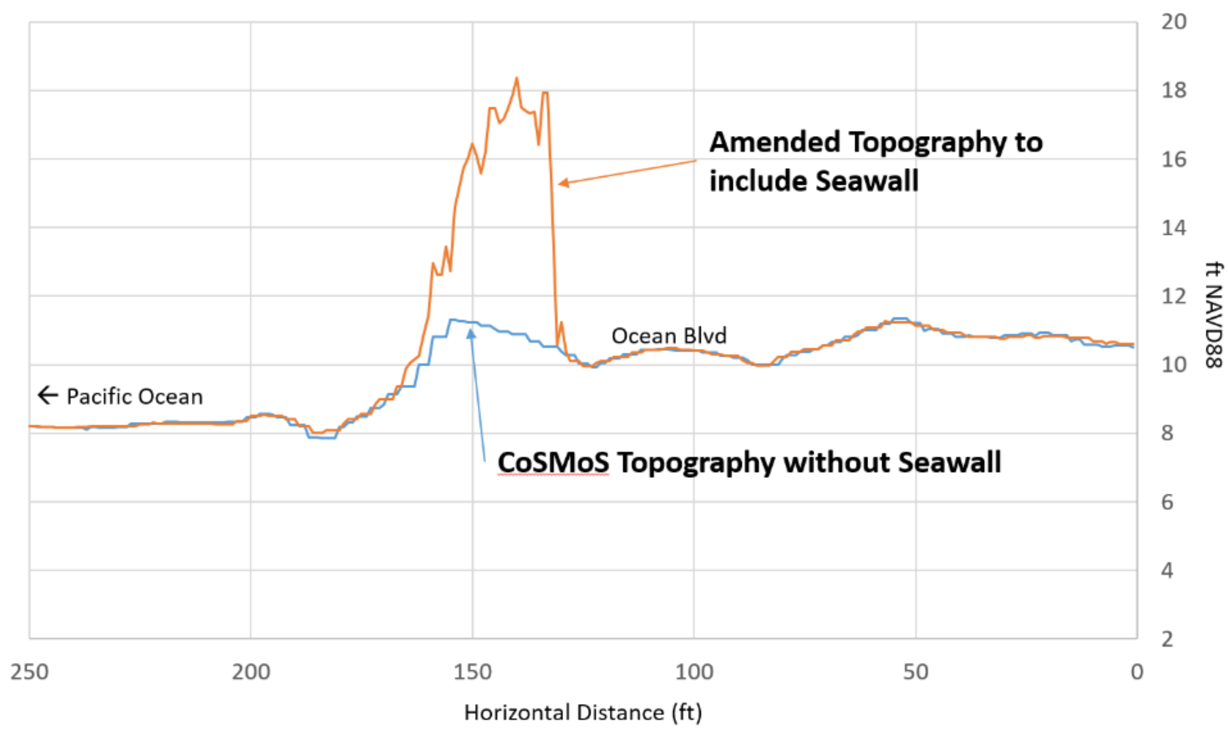


Figure VA-24: CoSMoS topography without seawall versus amended topography to include seawall – Cross-Section

2. San Diego Bay-side Flooding Along the Perimeter and at Alameda Blvd – Flood elevations, land surface elevations, and volumetric flow rate were analyzed at critical flood pathways on the bay-side along the perimeter and at Alameda Blvd. CoSMoS flood projections were determined to overestimate flooding in certain instances. Two noteworthy changes resulted:
   - Up to and including the 2.5 ft SLR scenario, the 100-yr still water level at several inland areas was below that of the land surface, however CoSMoS had projected flooding. The project team determined that in these locations there was no plausible hydraulic connection from Bay to inland. Flood hazards were then eliminated under the reasoning that flooding could not overtop these naturally high elevation areas.
   - Under the 3.3 ft SLR scenario, CoSMoS flood projections are shown to breach the Bay perimeter and pass through a narrow pathway on 3rd St at the Naval Base entrance. CoSMoS works under the assumption that as long as a hydraulic connection exists, flooding can and will impact an area. However, the ground surface elevation within the flood path in question is approximately 1 foot lower than projected flood elevations. The peak of flood events typically last approximately 4 hours, as storm effects align with the high tide peak. Flood waters cannot travel indefinitely given the relatively short duration of high tide, and flood waters would have to funnel through the limited flow area over existing ground

and around structures. These limitations on volumetric flow rate were considered and the extent of flooding through the narrow pathway was reduced accordingly. However, under greater SLR scenarios (4.1 ft and 4.9 ft), the depth of flooding is greater, creating wider and more flooding pathways and increasing the time over which flooding would occur. Therefore, these higher SLR scenario flood projections were not altered.

3. Avenida del Sol – Construction activities are underway at Avenida del Sol just south of the Hotel del Coronado. The work will increase the elevation at the ocean end of the roadway. The proposed grade of the construction activity was compared to projected flood elevations. Under certain SLR scenarios, flood elevations were no longer higher than Avenida del Sol, and flood projections were reduced accordingly. By 4.9 ft of SLR, however, flood elevations are projected to be higher than Avenida del Sol and therefore CoSMoS results were not revised.

4.3 Coastal Hazard Mapping

CoSMoS results combined with supplementary modeling results are presented in Figure VA-25 through Figure VA-42 for each SLR scenario at each sub-area included in this study. Original CoSMoS results for the north sub-area are provide in Appendix VA-1.

Figure VA-25: Projected flood and erosion hazards, North study area, 0.8 ft (0.25 m) SLR

Figure VA-26: Projected flood and erosion hazards, North study area, 1.6 ft (0.50 m) SLR

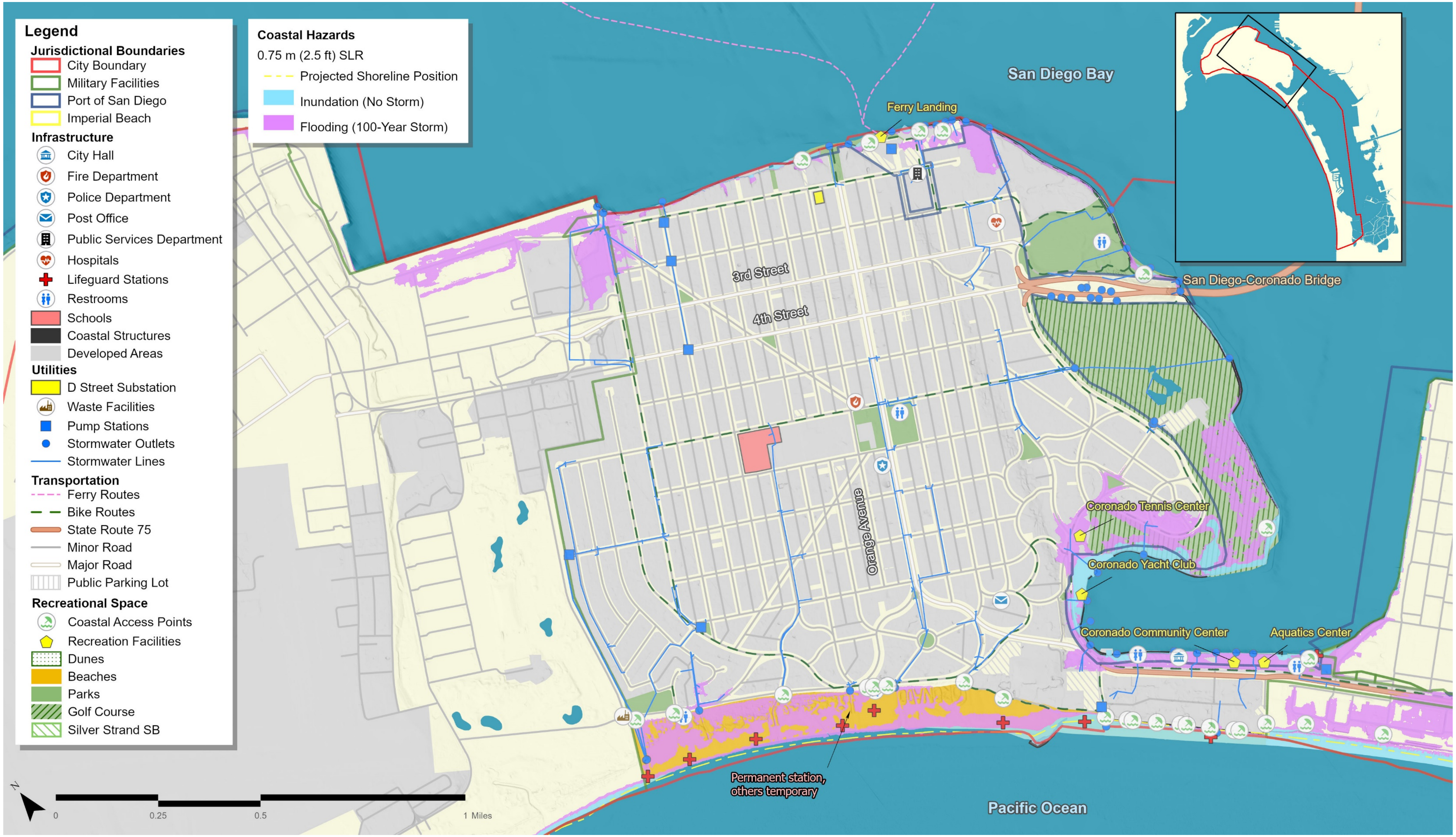


Figure VA-27: Projected flood and erosion hazards, North study area, 2.5 ft (0.75 m) SLR

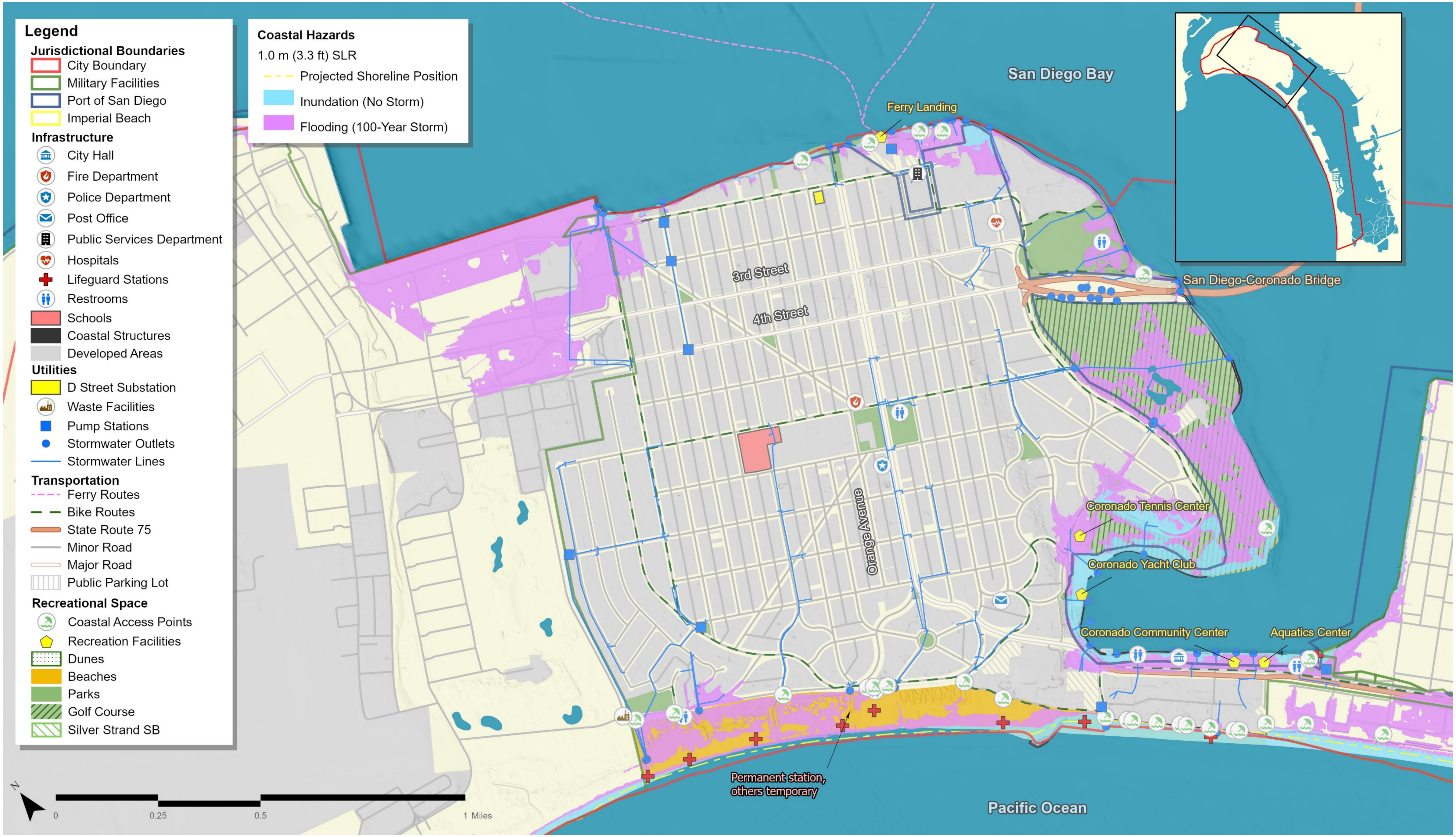


Figure VA-28: Projected flood and erosion hazards, North study area, 3.3 ft (1.0 m) SLR

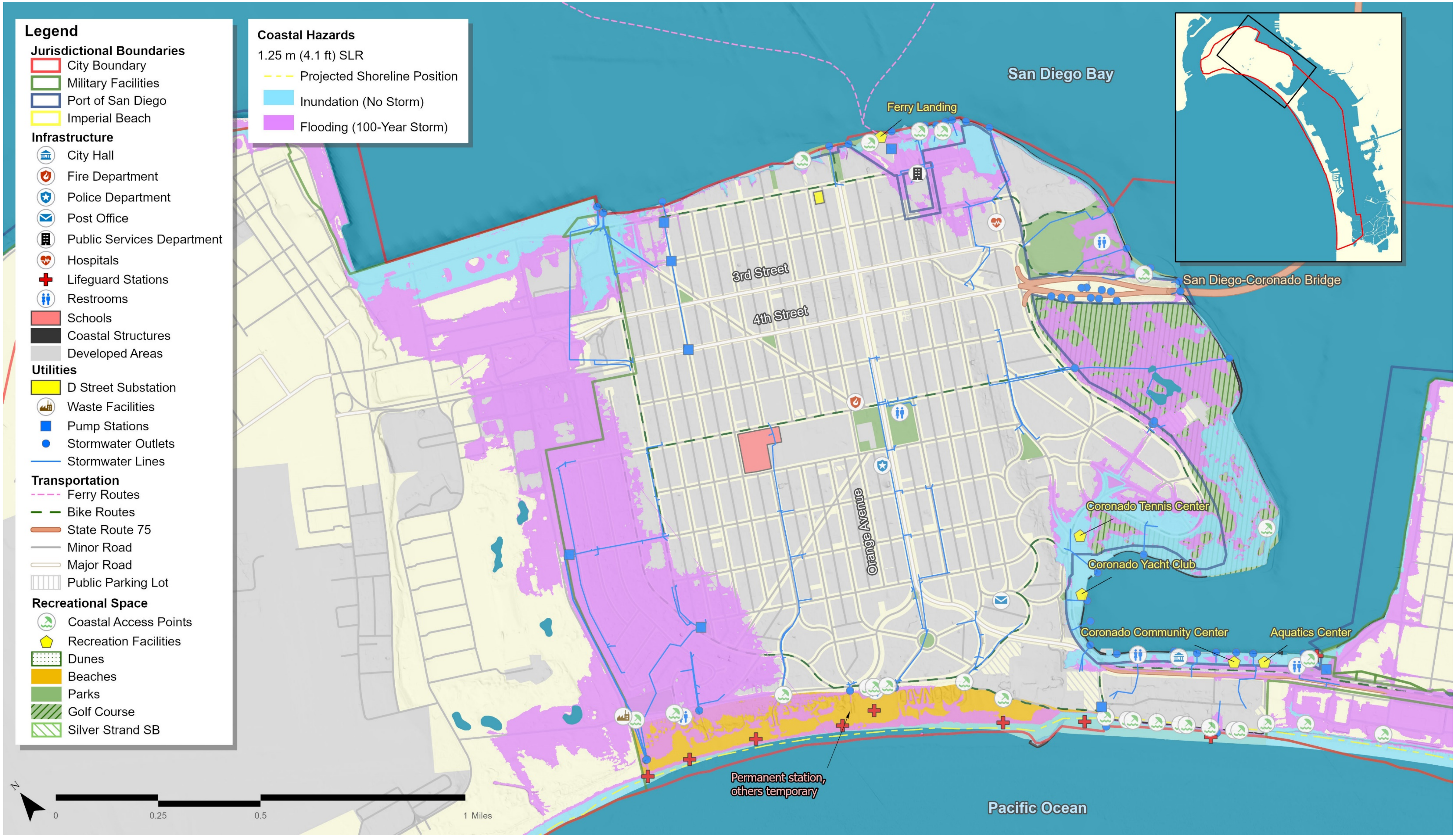


Figure VA-29: Projected flood and erosion hazards, North study area, 4.1 ft (1.25 m) SLR

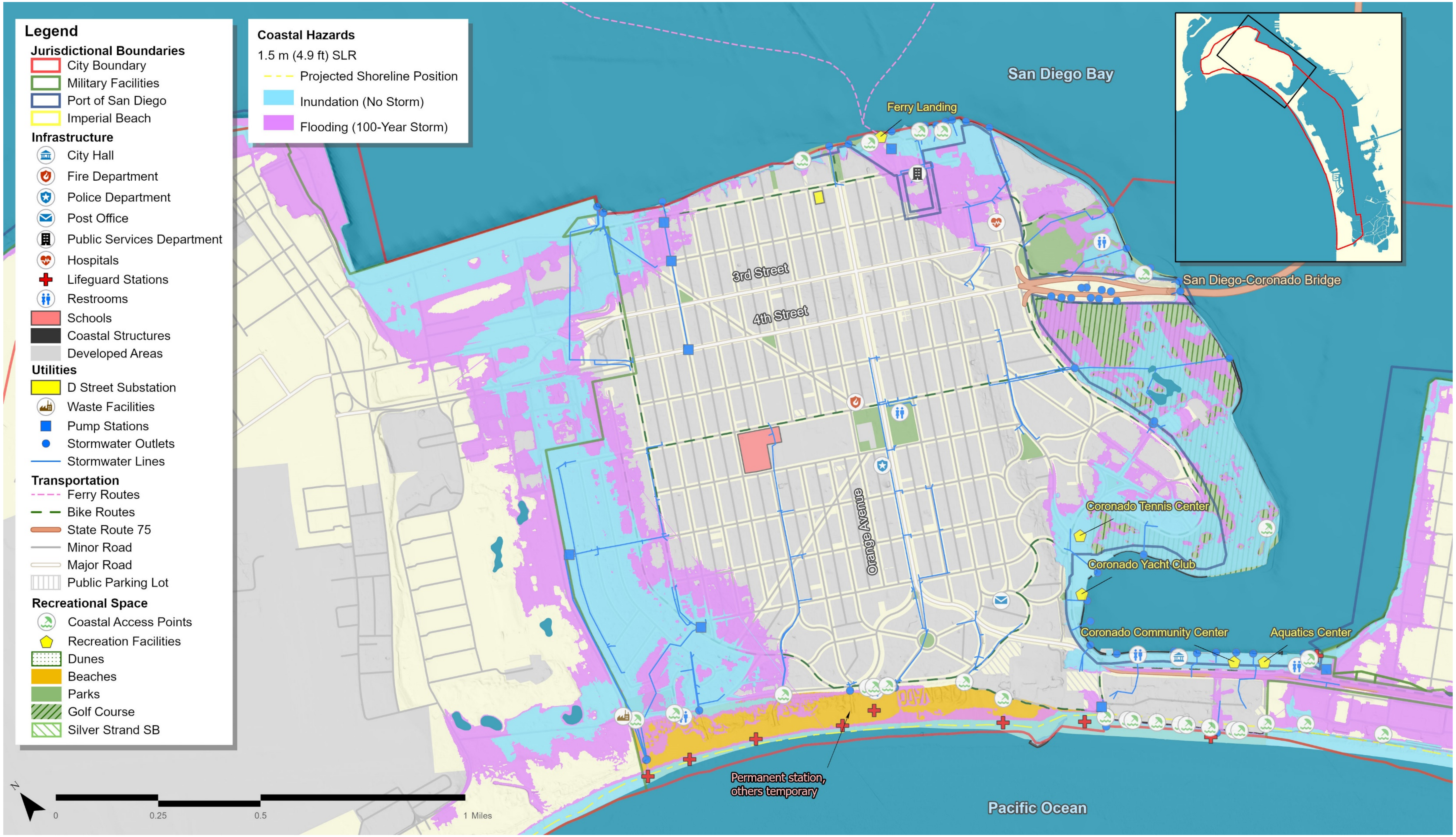


Figure VA-30: Projected flood and erosion hazards, North study area, 4.9 ft (1.50 m) SLR

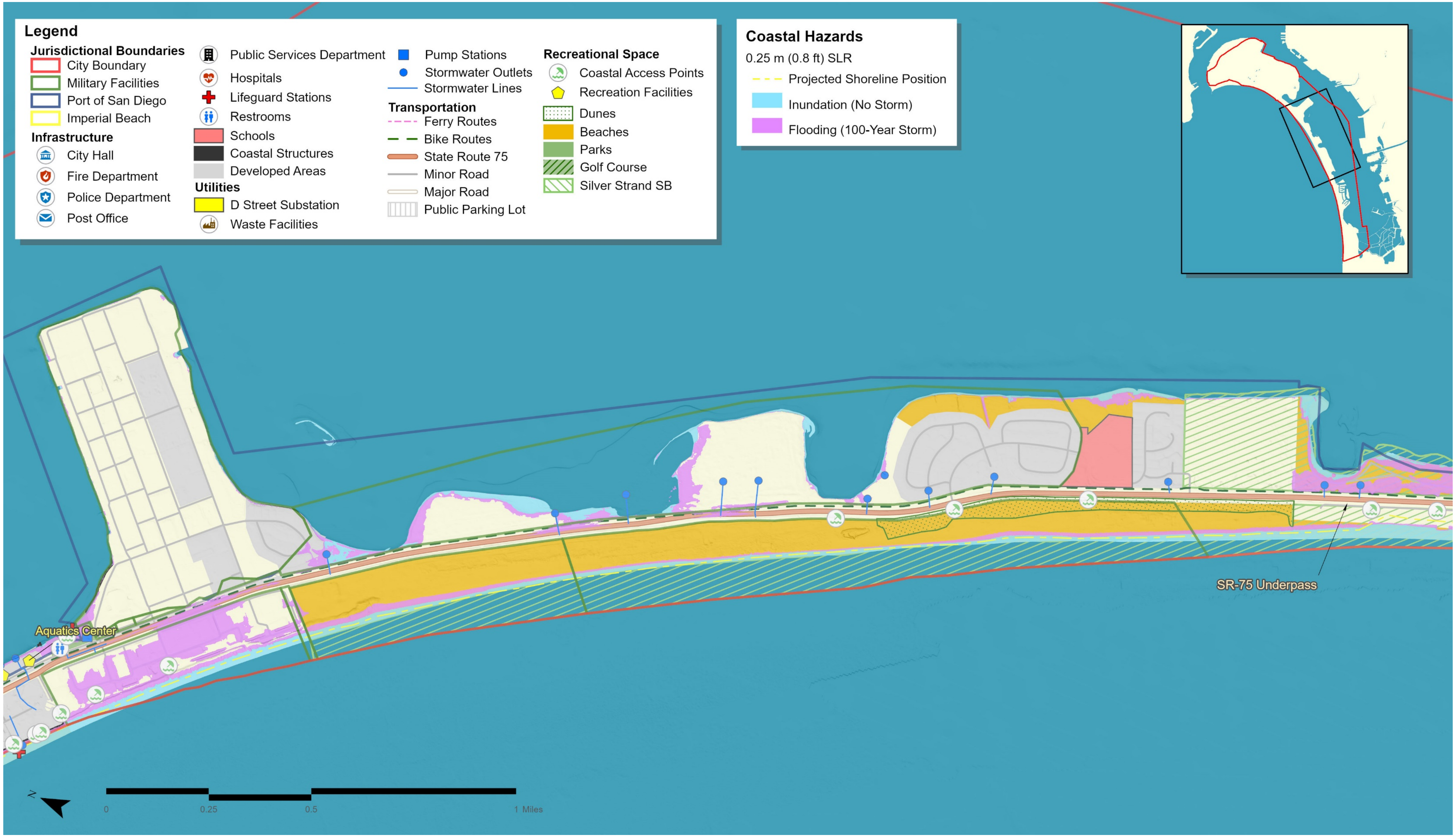


Figure VA-31: Projected flood and erosion hazards, Central study area, 0.8 ft (0.25 m) SLR

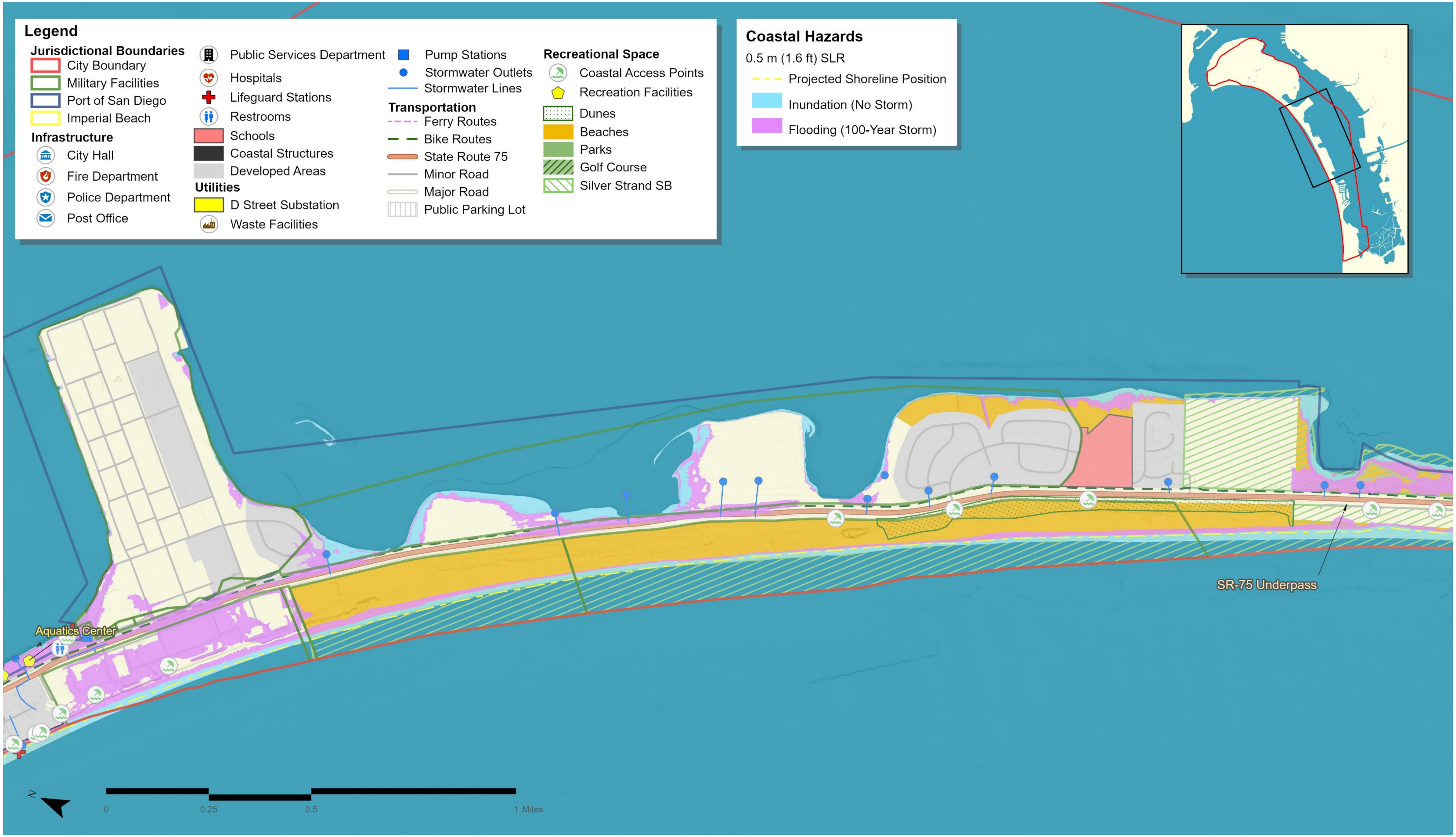


Figure VA-32: Projected flood and erosion hazards, Central study area, 1.6 ft (0.5 m) SLR

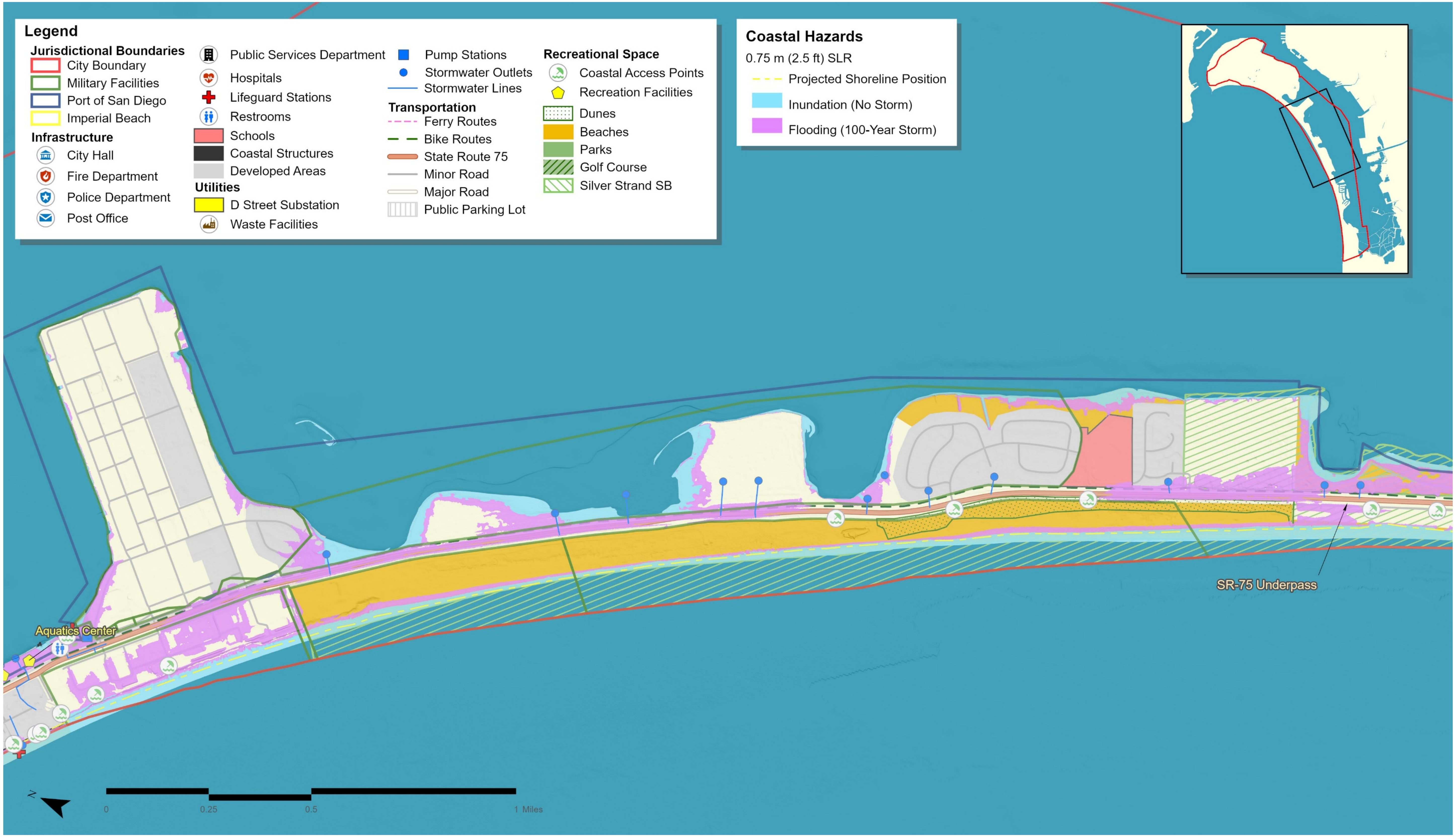


Figure VA-33: Projected flood and erosion hazards, Central study area, 2.5 ft (0.75 m) SLR

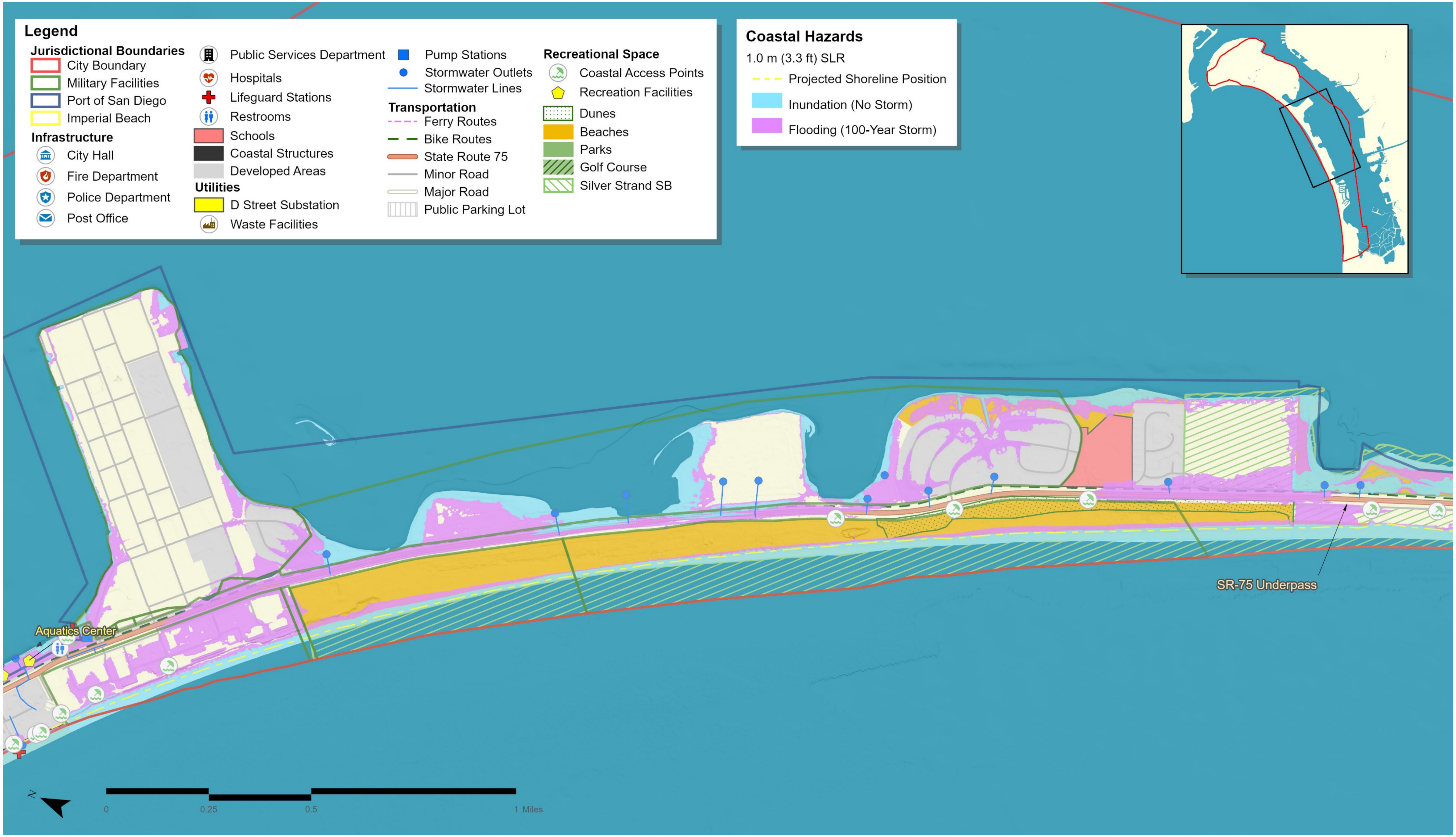


Figure VA-34: Projected flood and erosion hazards, Central study area, 3.3 ft (1.0 m) SLR

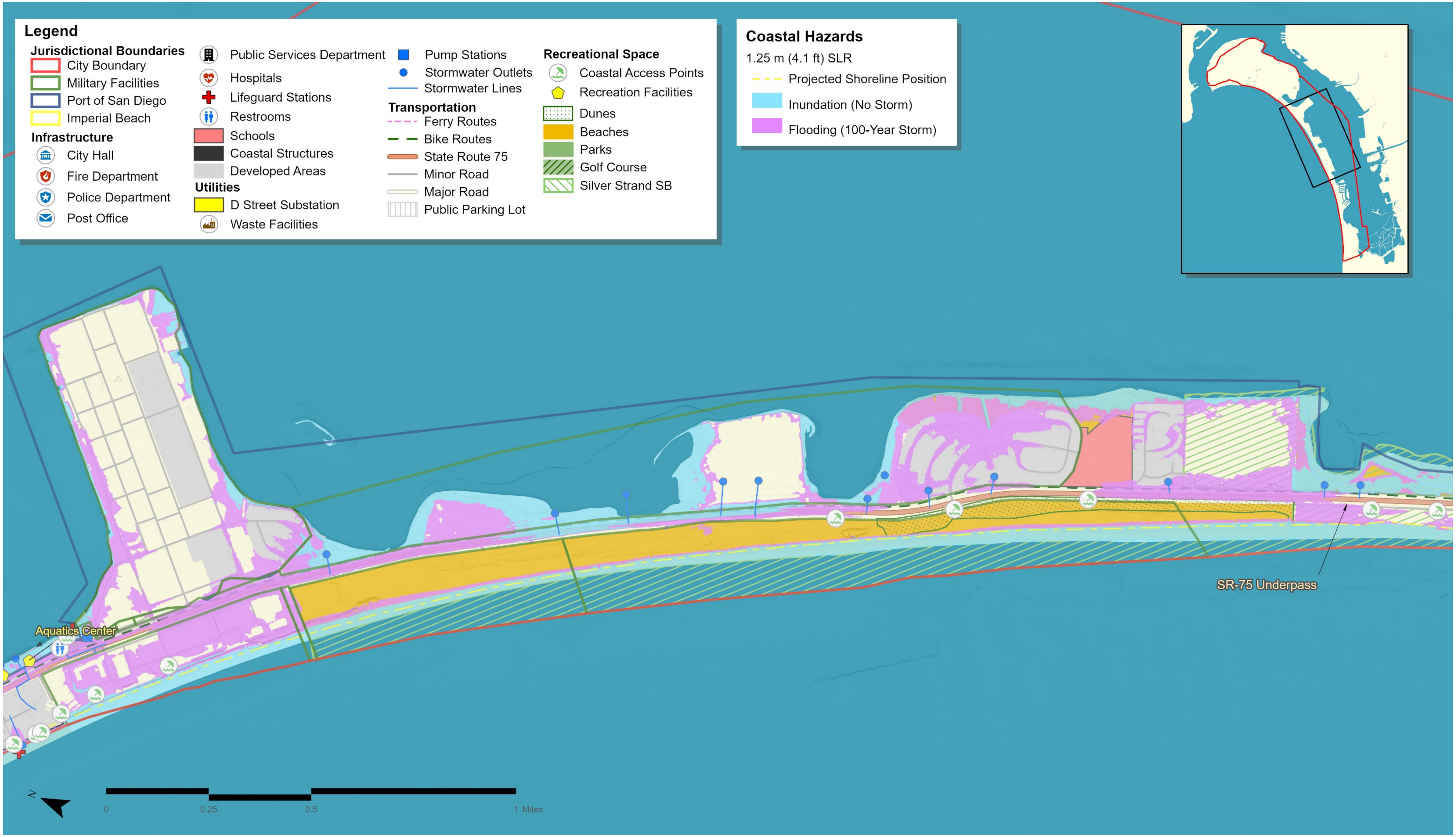


Figure VA-35: Projected flood and erosion hazards, Central study area, 4.1 ft (1.25 m) SLR

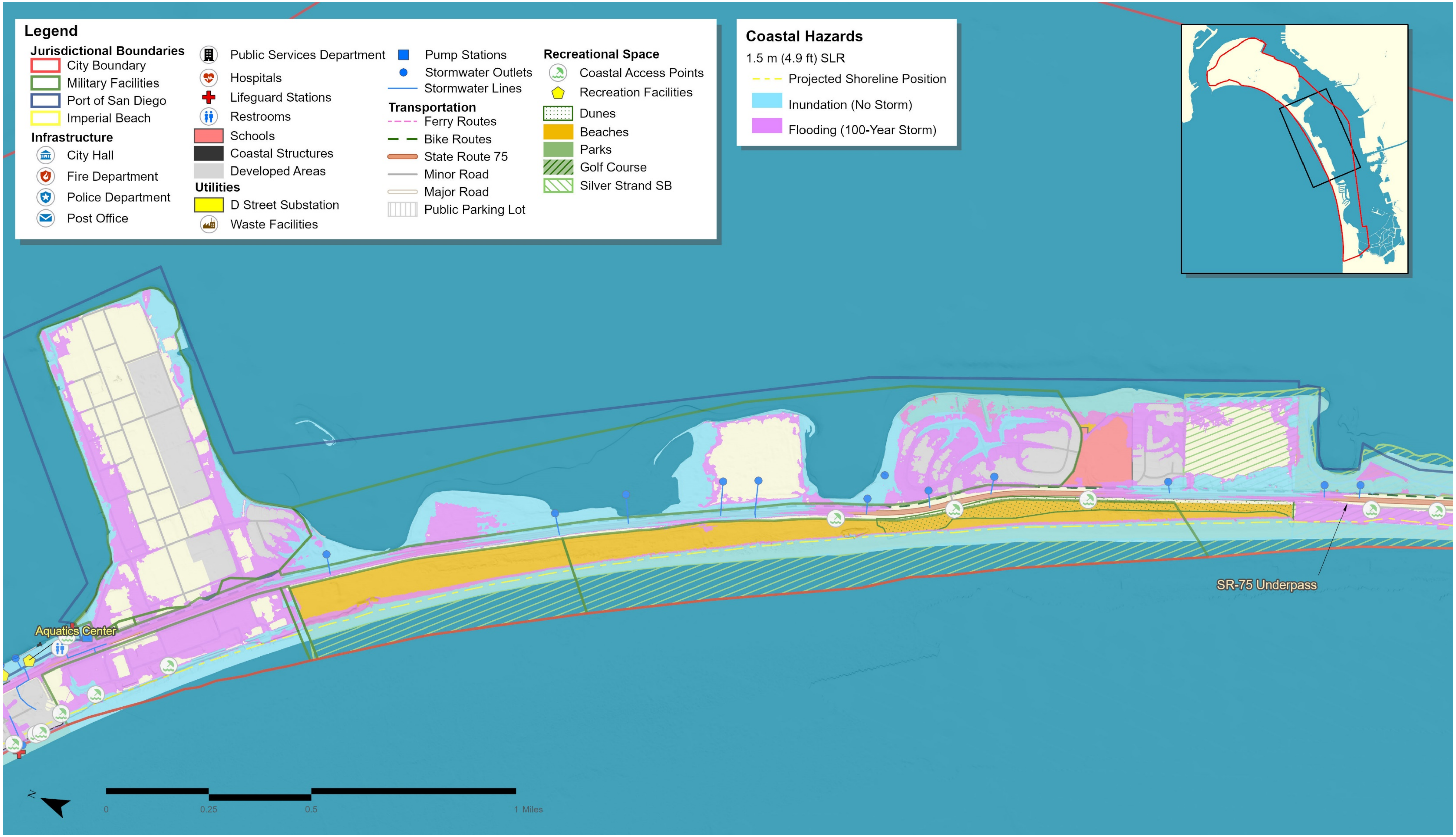


Figure VA-36: Projected flood and erosion hazards, Central study area, 4.9 ft (1.5 m) SLR

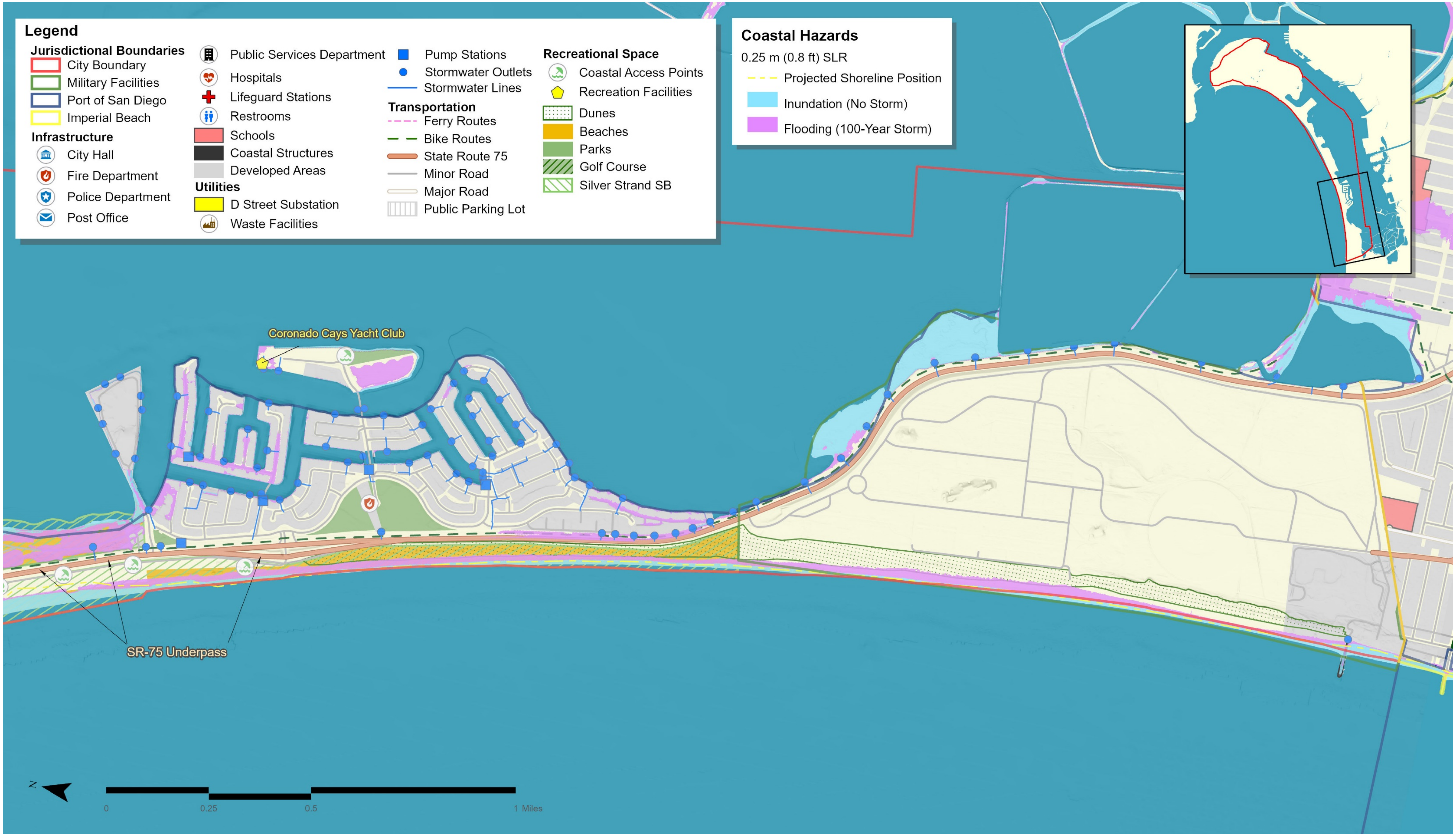


Figure VA-37: Projected flood and erosion hazards, South study area, 0.8 ft (0.25 m) SLR

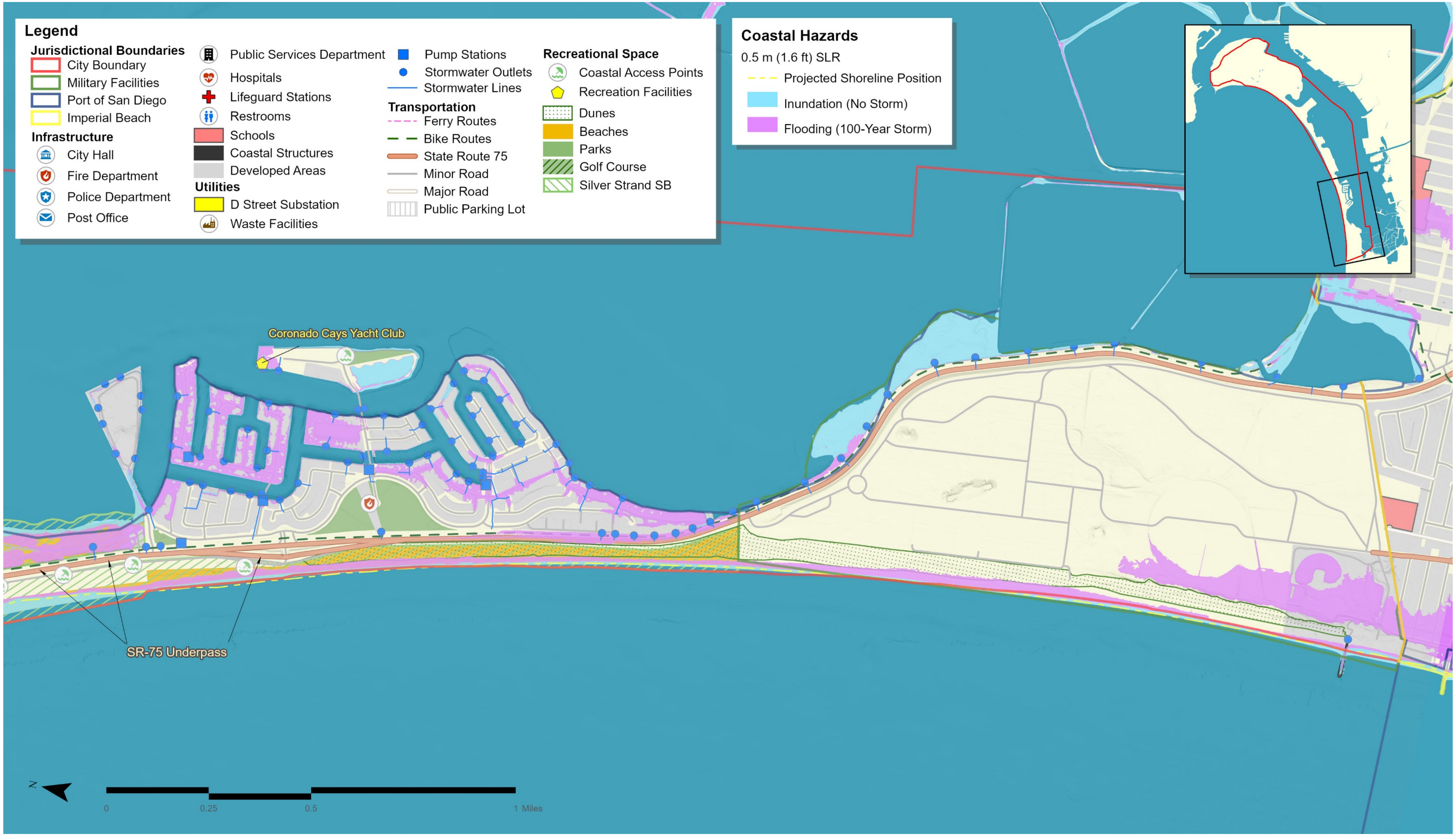


Figure VA-38: Projected flood and erosion hazards, South study area, 1.6 ft (0.5 m) SLR

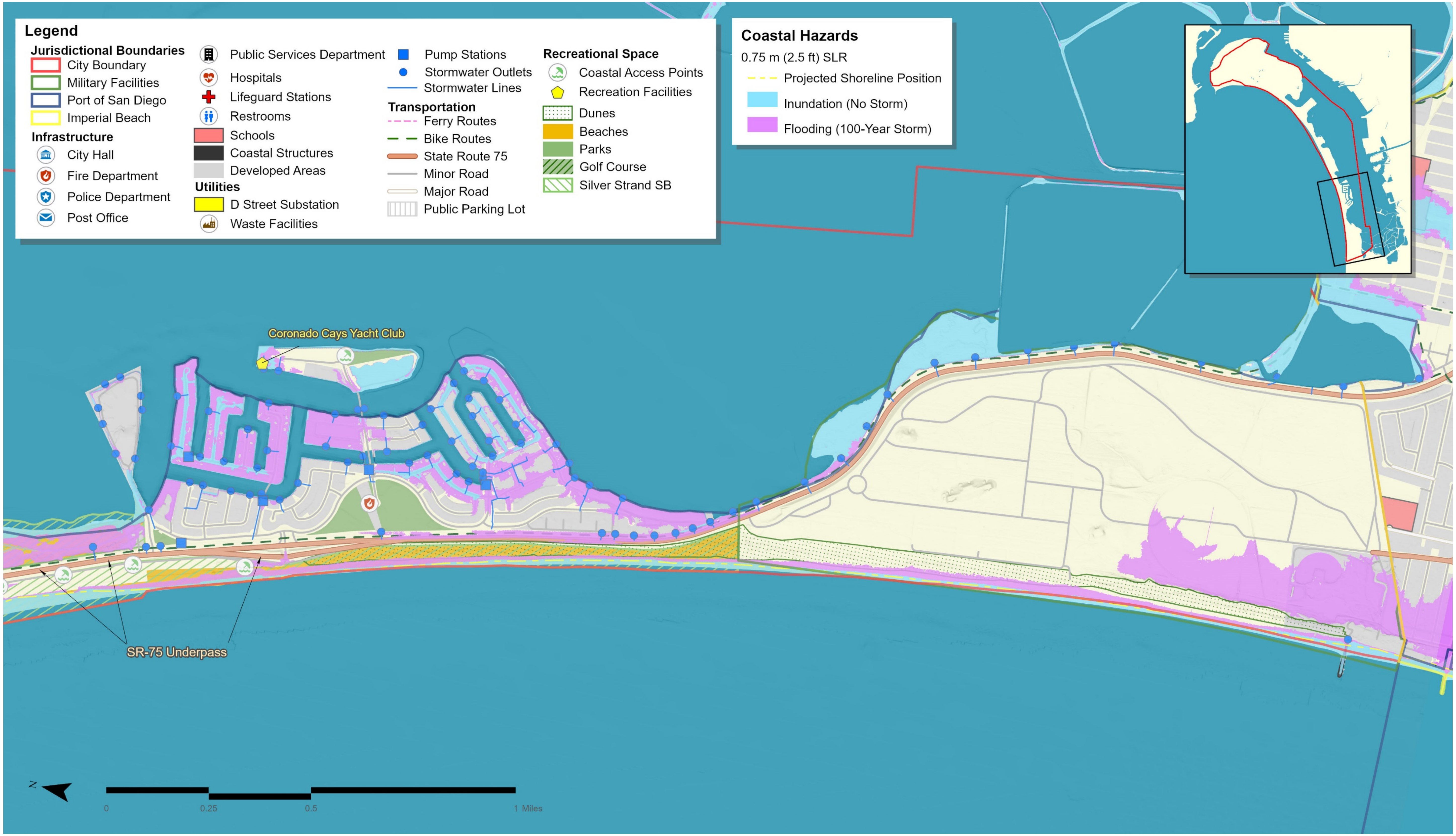


Figure VA-39: Projected flood and erosion hazards, South study area, 2.5 ft (0.75 m) SLR

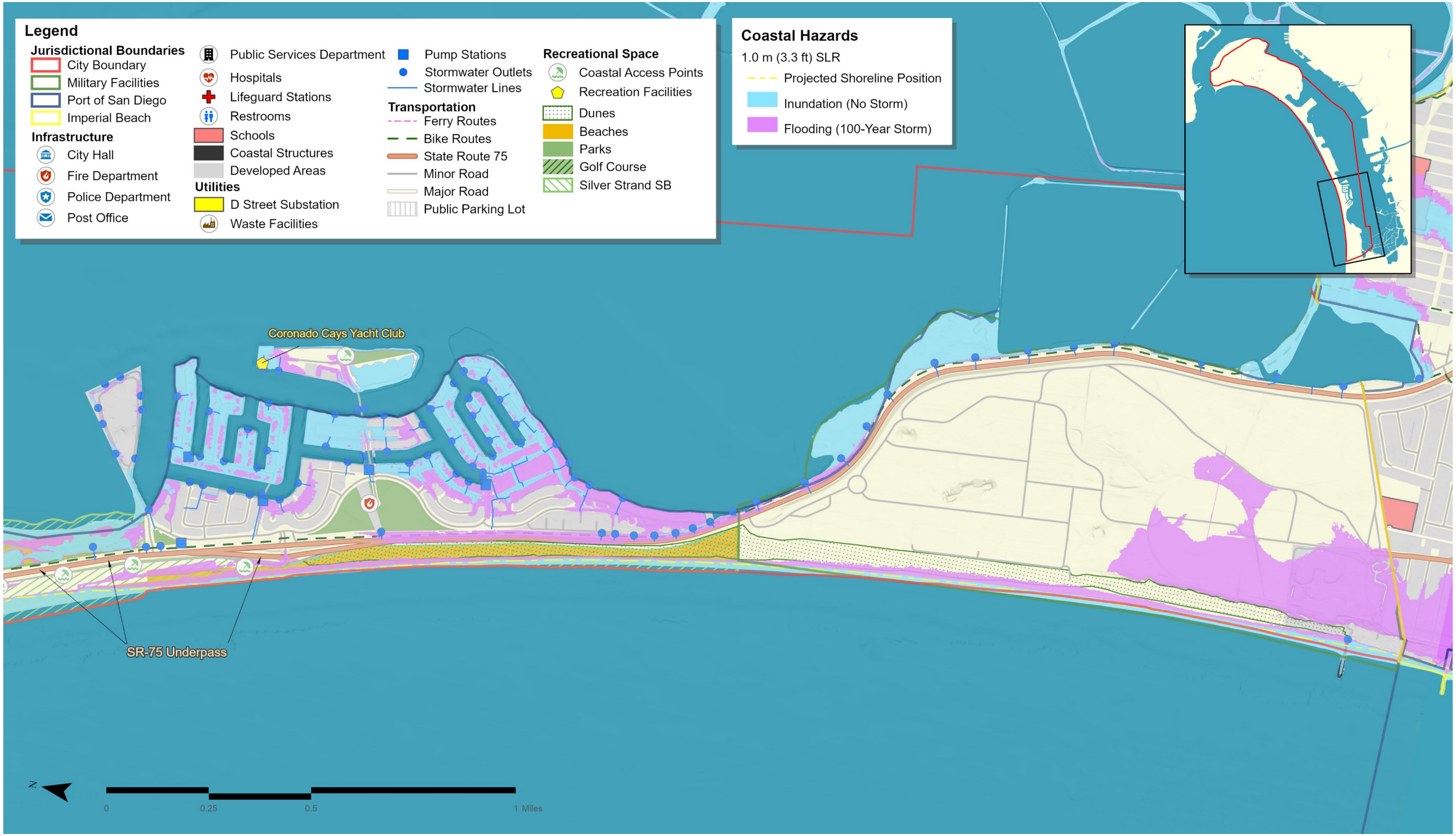


Figure VA-40: Projected flood and erosion hazards, South study area, 3.3 ft (1.0 m) SLR

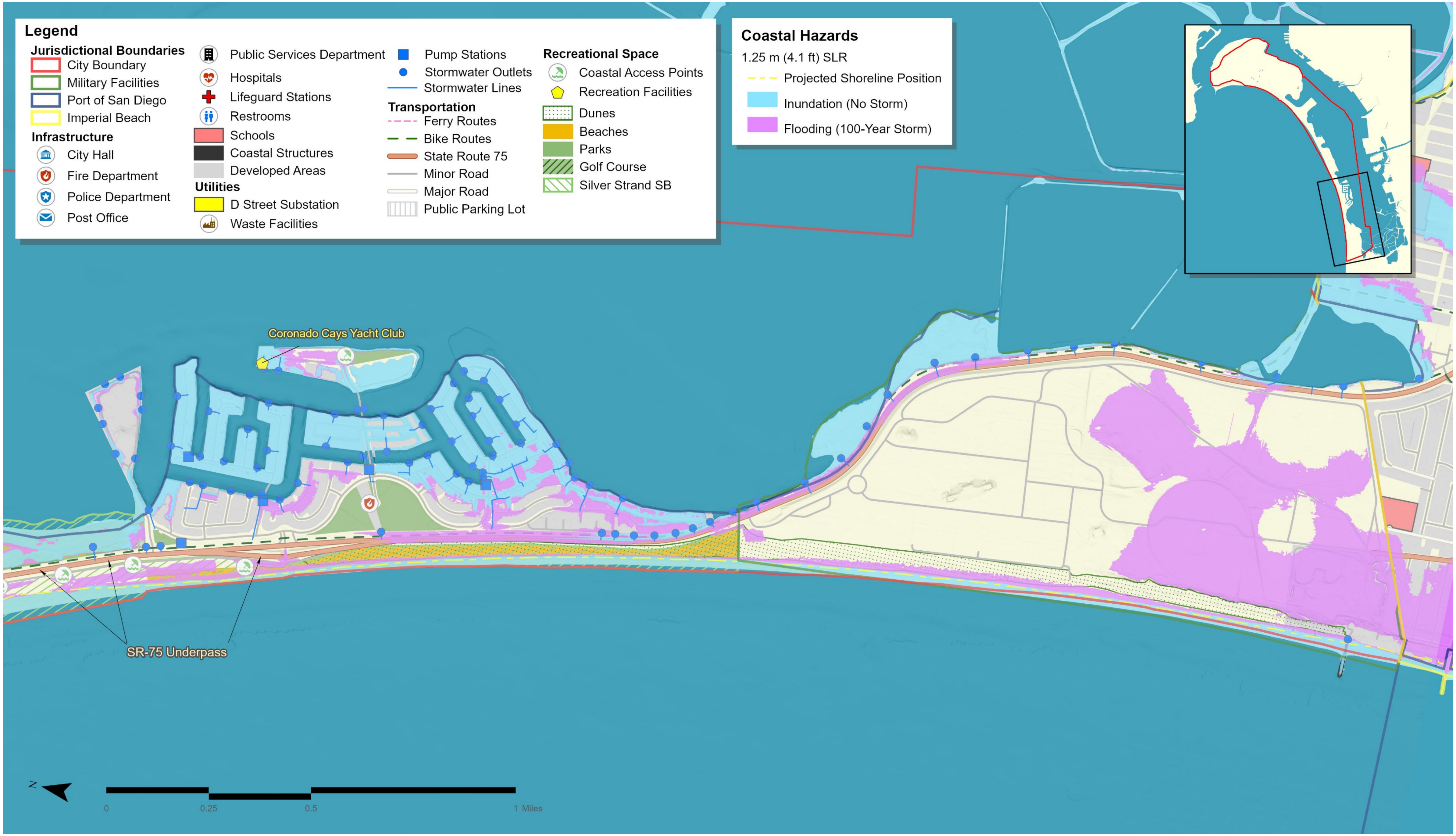


Figure VA-41: Projected flood and erosion hazards, South study area, 4.1 ft (1.25 m) SLR

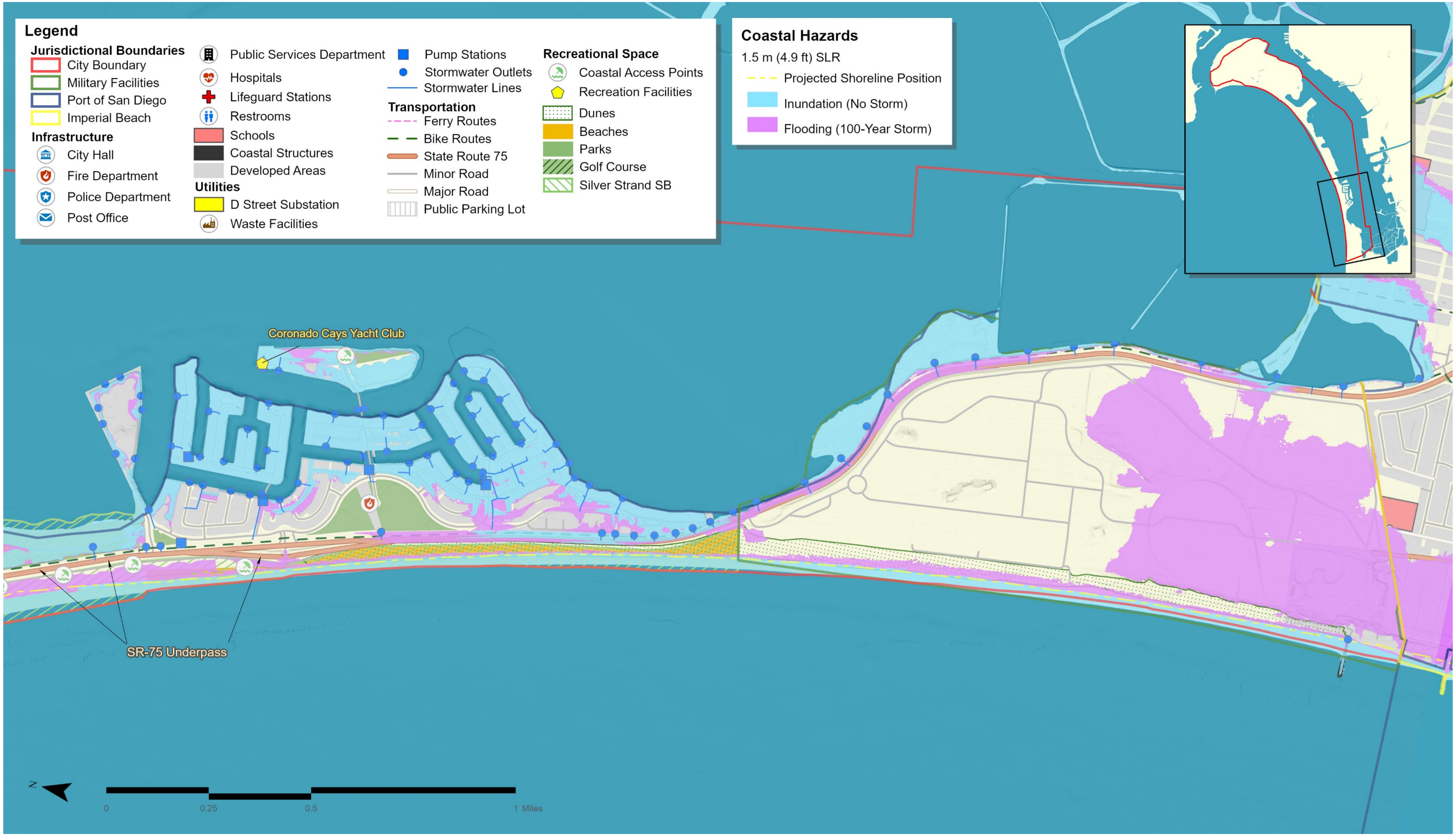


Figure VA-42: Projected flood and erosion hazards, South study area, 4.9 ft (1.5 m) SLR

5 Vulnerability Assessment

This SLR Vulnerability Assessment provides a qualitative evaluation of City resources that could be impacted by future SLR hazards. The intersection of potential SLR hazard zones and coastal resources was determined using Geographic Information System (GIS) software. Methodologies for assessing vulnerabilities and risk were based on guidelines published within the reports *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (Snover et al., 2007) and *California Adaptation Planning Guide, Planning for Adaptive Communities* (California Emergency Management Agency & California Natural Resources Agency, 2012).

In accordance with these and other state SLR planning guidelines (California Coastal Commission, 2018), SLR vulnerability for different types of resources and infrastructure is assessed as a function of exposure, sensitivity, and adaptive capacity. These concepts, in the context of how they are used within this vulnerability assessment, are illustrated in Figure VA-43.

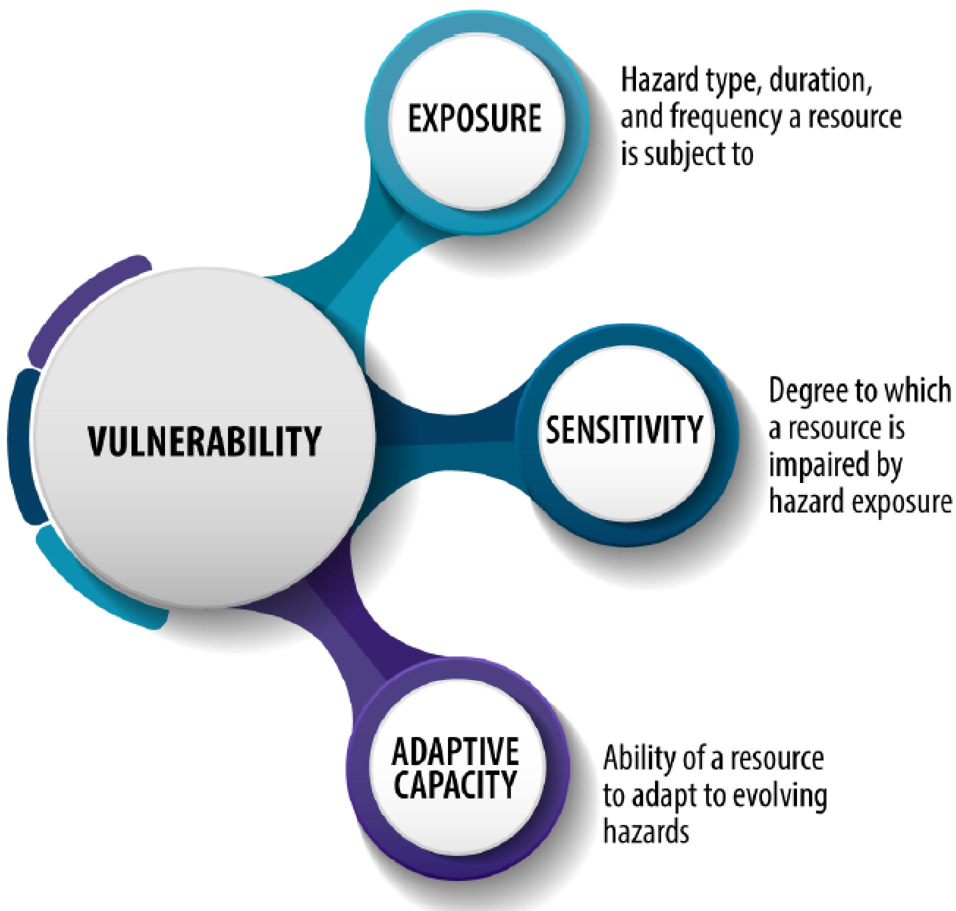


Figure VA-43: Components of SLR vulnerability as defined within this study

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

Hazard exposure, hazard sensitivity, and adaptive capacity of City resources are given qualitative ratings based on Table VA-3. These ratings were then used to determine an overall vulnerability score for each resource. The following sections describe the exposure, sensitivity, adaptive capacity, and overall vulnerability of each coastal resource identified in the existing land use and infrastructure inventory.

Table VA-3: SLR vulnerability qualitative ratings and explanations

Category	Rating	Explanation
Hazard Exposure	N/A (0)	No exposure to flooding or erosion.
	Low (1)	Exposure to storm flooding in select areas.
	Moderate (2)	Significant exposure to storm flooding and/or partial exposure to non-storm inundation.
	High (3)	Significant exposure to non-storm inundation.
Hazard Sensitivity	Low (1)	Minimal impacts to structure and function due to coastal hazards unless inundated on a regular basis.
	Moderate (2)	Moderate impacts to structure and function during temporary storm flooding. Significant impacts if inundated.
	High (3)	Significant impacts to structure and function from short-term storm flooding or inundation.
Adaptive Capacity	Low (3)	Limited options for adaptation. Adaptation likely to have significant costs.
	Moderate (2)	Multiple options for adaptation over time with relatively moderate effort and cost.
	High (1)	Multiple options for adaptation over time with minor additional effort.
Overall Vulnerability	Low (2-4, or N/A Exposure)	Any hazard exposure offset by low sensitivity or high adaptive capacity.
	Moderate (5-7)	Increased vulnerability due to higher exposure, sensitivity, or limited ability to adapt over time.
	High (8-9)	Highly exposed, high potential impacts, and limited ability to adapt over time.

5.1 Infrastructure

5.1.1 Development

Development

Description:

All residential or commercial development under City jurisdiction

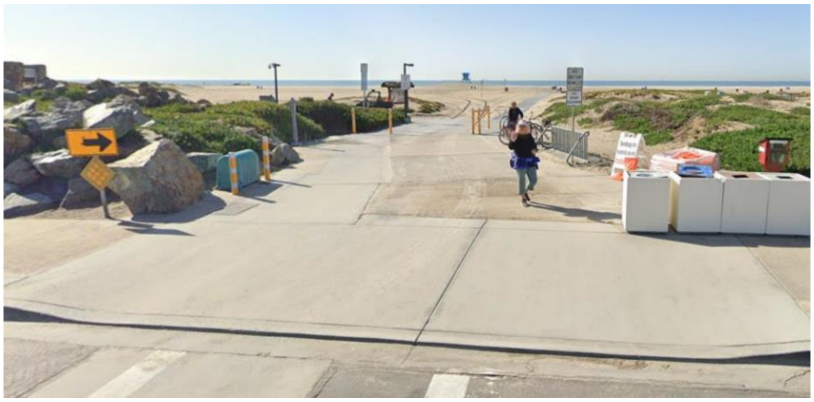
Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	Low	Low	High	High	High

- Residential development is exposed to sea level rise in various parts of the City including the low-lying Spanish Bight and Coronado Cays.
- The Spanish Bight, formerly an open water harbor in the City which was filled with dredged material, is currently one of the lowest elevation areas of the City and becomes exposed to hazards at the 2.5 ft SLR scenario and above.
- Storm waves combined with 2.5 ft SLR are projected to breach the beach access point at the intersection of Ocean Blvd and Ocean Drive near Sunset Park (image 1). On the bay-side, flooding is first anticipated to breach the low point of the shoreline at the intersection of Alameda Blvd and 1st

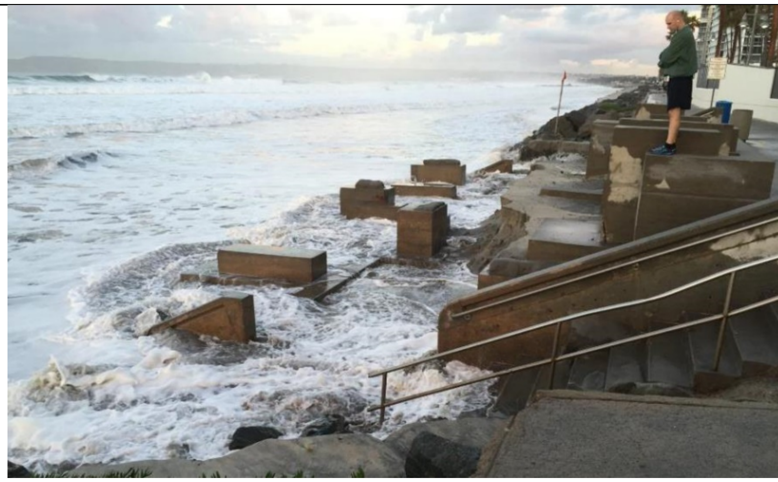
St (see image 2), the historic entrance to the Spanish Bight harbor. Under greater SLR scenarios, flooding is projected to overtop the adjacent Navy wharf and travel towards lower elevations in the center of the island.

- Development near Coronado Ferry Landing area on the bay-side is exposed to storm flooding at 0.8 ft SLR. Storm flooding moves further inland under higher SLR scenarios.
- Development surrounding Glorietta Bay becomes vulnerable to storm flooding beginning at 0.8 ft of SLR. Flooding progresses incrementally with increasing SLR scenarios. Storm flood hazards turn to potential tidal inundation hazards when SLR reaches 2.5 ft.
- The revetment on the ocean side of the Coronado Shores community has experienced wave overtopping in the past (see image 3). Wave overtopping will likely continue, however the duration of those events is not projected to be long enough to be defined as flooding (see Section 4). Coastal flooding of this is not projected until 4.1 ft of SLR, where storm flooding is anticipated to enter south of the condominiums. Under 4.9 ft of SLR, flooding is also anticipated to overtop the re-graded roadway and revetment at Avenida del Sol.
- The Coronado Cays community represents one of the most vulnerable areas within the City. The elevation of bulkhead seawalls is relatively uniform across the community, reaching low elevations of +8.5 to 9 ft NAVD88. Images 4 and 5 demonstrate the very limited freeboard which exists between the king tide water level and the existing ground surface, estimated to be as low as 2 ft in some areas. Overtopping in select locations is projected under the 0.8 ft SLR scenario. Under 1.6 ft of SLR much of the community becomes exposed to storm flooding. Under 2.5 ft of SLR regular inundation is anticipated to overtop bulkheads during spring high tide events. By 4.9 ft of SLR, the majority of the community as well as the Loews Coronado Bay Resort is projected to experience regular inundation. Bulkheads which are protecting development from the ocean have shown damage in the recent past (image 6), which may be worsened with increasing sea level.

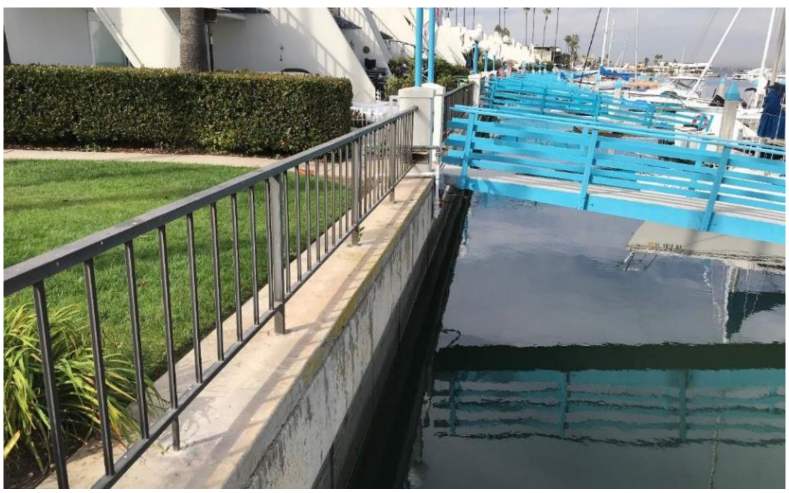


1. *Flooding at North Beach is first anticipated to overtop the beach access point by Sunset Park (Source: Google Maps)*

2. Bay-side flooding is first anticipated to breach the historic Spanish Bight waterway entrance, now Alameda Blvd (Source: Bing Maps)



2. *Wave runup at the Coronado Shores revetment and beach access ways (Voice of San Diego 2016)*



4. *Coronado Cays bulkhead with a small freeboard between the high tide line and the ground surface*

5. Coronado Cays marina during a king tide event in December 2020

6. Bay-side photo of Coronado Cays showing bulkhead seawall damage

Hazard Sensitivity:	High

- High overall sensitivity to SLR hazards for both storm and non-storm conditions, especially those structures with a first floor that sits at ground level.
- Though temporary, flooding during severe storm events can potentially cause substantial damage to the contents and underlying structure of buildings. This storm damage can impact structures well beyond the time when flood waters recede, potentially disrupting use of major residential and commercial resources for an extended period of time as costly repairs are made.
- Any flooding under non-storm conditions is likely to frequently result in structural damages and disruption of use, potentially leading to a complete loss of a structure if left unaddressed.

Adaptive Capacity:	Low

- Adaptive capacity is low for development within flood hazard areas due to the challenges and costs associated with implementing traditional flood hazard mitigation measures such as structure elevation, flood protection, or floodproofing. This is especially true for coastal development at Coronado Cays that becomes exposed to non-storm flood hazards under severe, long-term SLR scenarios, where protective bulkheads would likely require significant structural improvements to accommodate SLR.
- Inland low-lying areas such as the Spanish Bight region will also likely require substantial adaptation efforts to account for severe, long-term SLR projections. Efforts to adapt each individual structure will be most difficult and costly. Adaptation efforts would be better targeted on a larger-scale and in coordination with the U.S. Navy which shares the same hazards, with the shared aim to prevent flooding from extending inland.
- Despite overall low adaptive capacity, structures that have finished floors on elevated building pads may have improved capacity for adaptation. Options also remain present over the short-to-medium term for low lying development areas in the form of low-cost flood barriers designed to limit damage from temporary, storm-related flooding.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	High	High	High

- Development receives high vulnerability ratings at 3.3 ft and greater SLR scenarios due to increased flood hazard exposure.
- The areas of the City within development is vulnerable is primarily in the Spanish Bight by Alameda Blvd and the Coronado Cays community.
- Development has a high sensitivity to SLR hazards and a low adaptive capacity, causing overall vulnerability to increase substantially as hazard exposure rises over time.
- In the case of developed areas, hazard exposure increases from the 0.8 ft to 1.6 ft SLR scenarios as storm-related flooding begins to impact select areas in the southern portion of the City.
- The shift in ratings from moderate to high at 3.3 ft SLR is driven by non-storm inundation projections within Coronado Cays and more extensive storm-related flooding in other areas of the City.

5.1.2 City Hall

City Hall

Description:

City Hall structure

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	Low	Low	High	High

- The shoreline surrounding Glorietta Bay is vulnerable within the North Study Area.
- City Hall becomes vulnerable to storm flooding beginning at 2.5 ft of SLR.

Hazard Sensitivity:	High

- City Hall provides critical services for City operations, therefore even a short-term disruption in service caused by structural damage or lack of access to facilities could potentially have high consequences City-wide.

Adaptive Capacity:	Low

- Large structure presents challenges for elevation, flood protection, or floodproofing. Protective bulkheads surrounding the structure would likely require significant structural improvements to accommodate SLR.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Mod	Mod	High	High

- City Hall receives high vulnerability ratings occurring at 4.1 ft or greater SLR scenarios because it has a high sensitivity to SLR hazards and a low adaptive capacity, causing overall vulnerability to increase substantially as hazard exposure rises over time.
- The increase in vulnerability for City Hall from moderate to high at the 4.1 ft SLR scenario is due to projected inundation under non-storm conditions.

5.1.3 Fire Department

Fire Department

Description:

City Fire Department

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	N/A

- The Fire Department is not projected to be exposed to storm-related flooding and inundation under non-storm conditions in all scenarios.

Hazard Sensitivity:	High

- The Fire Department provides critical services for the health and safety of the City, therefore even a short-term disruption in service caused by structural damage or lack of access to facilities could potentially have high consequences City-wide.

Adaptive Capacity:	Mod

- Adaptive capacity for the Fire Department is moderate given that there are extremely limited hazard projections for the Fire Department even under long-term SLR scenarios.
- Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address these temporary, storm-driven flood impacts as is necessary without significant impacts to infrastructure functions.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

- Overall vulnerability to SLR hazards is low across all scenarios for the fire department due to a lack of hazard exposure to both storm-related flooding and inundation under non-storm conditions.

5.1.4 Police Department

Police Department

Description:

City Police Department

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	N/A

- The Police Department is not projected to be exposed to storm-related flooding and inundation under non-storm conditions in all scenarios.

Hazard Sensitivity: High

- The Police Department provides critical services for the health and safety of the City, therefore even a short-term disruption in service caused by structural damage or lack of access to facilities could potentially have high consequences City-wide.

Adaptive Capacity: Mod

- Adaptive capacity for the police department is moderate given that there are extremely limited hazard projections for the police department even under long-term SLR scenarios.
- Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address these temporary, storm-driven flood impacts as is necessary without significant impacts to infrastructure functions.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

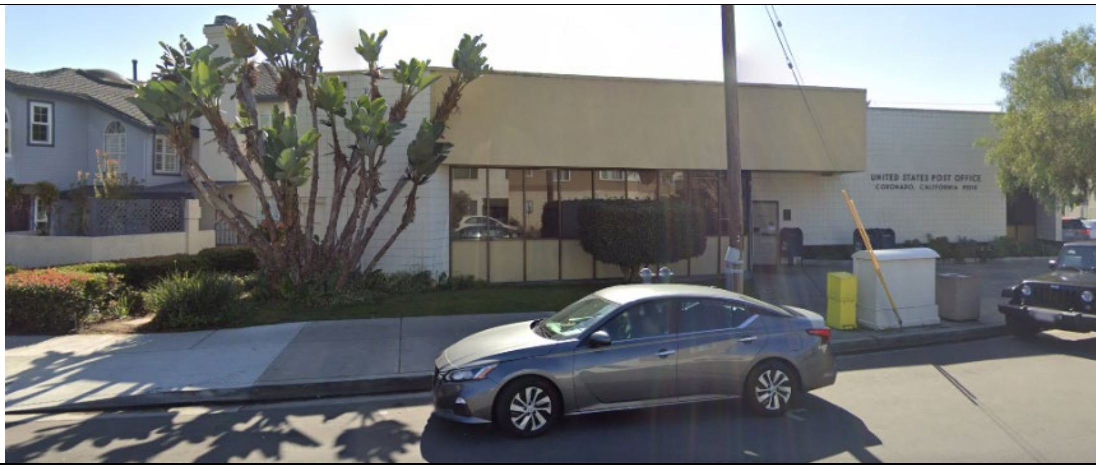
- Overall vulnerability to SLR hazards is low across all scenarios for the police department due to a lack of hazard exposure to both storm-related flooding and inundation under non-storm conditions.

5.1.5 Post Office

Post Office

Description:

City Post Office



Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	N/A

- The post office is not projected to be exposed to storm-related flooding and inundation under non-storm conditions in all scenarios.

Hazard Sensitivity:	Mod

- While a post office may experience substantial structural damage if flooded during a severe storm event, the services provided could potentially be temporarily relocated or supplemented by other City infrastructure.
- Any temporary disruption in post office services would yield less severe consequences than infrastructure given a high hazard sensitivity rating.

Adaptive Capacity:	Mod

- Adaptive capacity for the post office is moderate given that there are extremely limited hazard projections for the post office even under long-term SLR scenarios.
- Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address any temporary, storm-driven flood impacts as is necessary.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

- Overall vulnerability to SLR hazards is low across all scenarios for the post office due to a lack of hazard exposure to both storm-related flooding and inundation under non-storm conditions.

5.1.6 Public Services Building

Public Services Building					
Description:					
City Public Services Building					
					
Hazard Exposure:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
N/A	N/A	N/A	N/A	Low	Low
▪ At 4.1 ft of SLR, the Public Services Department may see storm flooding from bay-side flooding.					
Hazard Sensitivity:	High				
▪ The Public Services Building provides critical services for City operations, therefore even a short-term disruption in service caused by structural damage or lack of access to facilities could potentially have high consequences City-wide.					
Adaptive Capacity:	Mod				
▪ Adaptive capacity for the Public Services Building is moderate given that there are limited hazard projections for the Public Services Building even under long-term SLR scenarios. ▪ Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address these temporary, storm-driven flood impacts as is necessary without significant impacts to infrastructure functions.					
Overall Vulnerability:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
Low	Low	Low	Low	Mod	Mod
▪ The Public Services Building has a low vulnerability to SLR hazards until the low-probability, long-term SLR scenarios of 4.1 ft or greater. While the Public Services Building is rated as highly sensitive to SLR hazards with moderate adaptive capacity, overall vulnerability remains moderate due to limited hazard exposure projections under 100-year storm conditions and a lack of non-storm inundation.					

5.1.7 Hospital

Hospital

Description:

Sharp Coronado Hospital

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	Low

- At 4.9 ft of SLR, the hospital may begin to see encroaching storm flooding from bay-side flooding.

Hazard Sensitivity:	High

- The hospital provides critical services for the health and safety of the City, therefore even a short-term disruption in service caused by structural damage or lack of access to facilities could potentially have high consequences City-wide.

Adaptive Capacity:	Low

- Adaptive capacity for highly specialized infrastructure such as hospitals is limited due to the difficulties associated with retrofitting, elevating, or relocating infrastructure without impacts to service.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Mod

- While the hospital is rated as highly sensitive to SLR hazards with low adaptive capacity, overall vulnerability remains low to moderate due to limited hazard exposure projections under 100-year storm conditions and a lack of non-storm inundation.

5.1.8 Lifeguard Stations

Lifeguard Stations					
Description:					
Permanent lifeguard station location					
					
Hazard Exposure:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
N/A	N/A	N/A	N/A	N/A	N/A
▪ Lifeguard stations are not projected to be exposed to storm-related flooding and inundation under non-storm conditions in all scenarios.					
Hazard Sensitivity:		Mod			
▪ While lifeguard stations may experience substantial structural damage if flooded during a severe storm event, the services provided could potentially be temporarily relocated or supplemented by other City infrastructure. ▪ Any temporary disruption in lifeguard services would yield less severe consequences than infrastructure given a high hazard sensitivity rating.					

Adaptive Capacity:	High

- There are limited hazard projections for lifeguard services even under long-term SLR scenarios.
- The adaptive capacity of lifeguard stations is further bolstered by the seasonal use and relative ease of relocation compared to other structures, providing flexibility in adaptation options over the long-term.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

- Overall vulnerability to SLR hazards is low across all scenarios for lifeguard stations due to a lack of hazard exposure to both storm-related flooding and inundation under non-storm conditions.

5.1.9 Restrooms

Restrooms

Description:

Public Restrooms

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	Mod	High

- Restroom facilities become exposed to storm flooding from Glorietta Bay at 3.3 ft of SLR. Widespread hazard exposure for bathroom facilities is projected at 4.9 ft SLR.

Hazard Sensitivity:	Mod

- While restrooms may experience substantial structural damage if flooded during a severe storm event, the services provided could potentially be temporarily relocated or supplemented by other City infrastructure.
- Any temporary disruption in restroom infrastructure would yield less severe consequences than infrastructure given a high hazard sensitivity rating.

Adaptive Capacity:	Mod

- Hazard projections for restrooms are limited to flooding in select areas under severe storm conditions even under long-term SLR scenarios.
- Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address these temporary, storm-driven flood impacts as is necessary without significant impacts to infrastructure functions.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Mod	Mod	Mod	Mod	Mod	Mod

- Public restrooms are rated as moderately vulnerable to SLR hazards across all SLR scenarios. Though the hazard exposure at restroom locations increases over time from low to high, moderate ratings for both hazard sensitivity and adaptive capacity limit changes in overall vulnerability.

5.1.10 Schools

Schools

Description:

Village Elementary School and Silver Strand Elementary School

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	Low

- The Silver Strand Elementary School is vulnerable to storm flooding from the bay-side under 4.1 ft and 4.9 ft of SLR, however it is not anticipated to see regular inundation under these scenarios.

Hazard Sensitivity:	High

- High potential damages to structures if flooded.
- High potential for service disruption if flooding occurs during school hours.
- Sensitive to flooding in surrounding areas if flooding prevents access to school facilities.

Adaptive Capacity:	Mod

- Hazard projections are limited even under long-term SLR scenarios.
- Traditional flood mitigation actions such as wet or dry floodproofing remain as viable options to address these temporary, storm-driven flood impacts as is necessary without significant impacts to infrastructure functions.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Mod

- Schools have a low vulnerability to SLR hazards until the low-probability, long-term SLR scenario of 4.9 ft. While schools are rated as highly sensitive to SLR hazards with moderate adaptive capacity, overall vulnerability remains moderate due to limited hazard exposure projections under 100-year storm conditions and a lack of non-storm inundation.

5.2 Recreational Space

5.2.1 Ferry Landing

Ferry Landing

Description:

Coronado Ferry Landing on the San Diego Bay shoreline

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	Low	High	High

- Ferry Landing is anticipated to experience storm flooding with approximately 3.3 ft of SLR. Flooding begins to become inundation at 4.1 ft of SLR, especially at the low points south of the Ferry Landing.

Hazard Sensitivity:	High

- Hazard sensitivity is high for Ferry Landing because it requires coastal access. As its design is tied to existing water levels, the facilities may experience loss of service and function even if flood projections do not yet extend over built structures if access infrastructure such as gangways or docks are impacted.
- Any damage to facilities during storm events is likely to significantly diminish access to ferry operations as repairs are made.

Adaptive Capacity:	Low

- Ferry Landing has a low adaptive capacity due to its built infrastructure and because it requires access to coastal waterways.
- While strategies such as flood protection or accommodation remains an option for Ferry Landing, the need for coastal access can provide challenges and limits long-term options for relocation or realignment of facilities.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	High	High

- Long-term vulnerability transitions from low to moderate when Ferry Landing is projected to flood during storm events and later transitions from moderate to high when non-storm inundation is projected to impact facilities.
- The overall vulnerability of Ferry Landing, which requires coastal access, is higher compared to recreational facilities that can be relocated or have a higher adaptive capacity.

5.2.2 Tennis Center

Tennis Center

Description:

The Coronado Tennis Center is located on Glorietta Blvd and contains eight tennis courts, lighting, landscaping, and the pro shop

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	Low	Mod	High	High

- Storm flooding projected with 2.5 ft SLR.
- Increased storm flooding and partial non-storm inundation with 3.3 ft SLR.
- Significant non-storm inundation with 4.1 ft and greater SLR.

Hazard Sensitivity:	Mod

- Hazard sensitivity for the tennis center is moderate given the potential for structural damage and service disruption during flood events and while any repairs are made to facilities.

Adaptive Capacity:	Mod

- The tennis center has a moderate adaptive capacity as it contains built infrastructure.
- Though adaptation measures would likely be more substantial than for open space, a variety of options may protect the tennis center from flooding or accommodate future flood impacts.
- Relocation or realignment of the tennis center remains as a long-term option if other adaptation measures are not sufficient.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Mod	Mod	Mod	Mod

- The tennis center vulnerability transitions from low to moderate vulnerability at the point when storm flooding is projected to cover substantial portions of the facilities.
- Long-term vulnerability of the tennis center remains moderate due to its adaptive capacity and lower hazard sensitivity compared to facilities such as yacht clubs and the ferry landing that require coastal access.

5.2.3 Coronado Yacht Club and Boathouse

Coronado Yacht Club and Boathouse
Description:
Coronado Yacht Club and nearby Boathouse restaurant, a City-owned building that is leased to a restaurant operator.

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	High	High	High	High	High

- Storm flooding is projected to begin at low elevation areas by the Coronado Yacht Club and nearby Boathouse under 0.8 ft of SLR.
- Non-storm inundation of low-lying areas is projected at 1.6 ft SLR, increasing under each subsequent SLR scenario.
- As sea level rises, the majority of the Glorietta Bay shoreline becomes exposed to inundation.

Hazard Sensitivity: High

- Hazard sensitivity is high for the yacht club because it requires coastal access. As its design is tied to existing water levels, the facilities may experience loss of service and function even if flood projections do not yet extend over built structures if access infrastructure such as gangways or docks are impacted.
- Similarly, the Boathouse is highly sensitive to hazards because, due to its location on top of the water, its design is tied to existing water levels. Access or function is likely to be impacted at lower levels of sea level rise due to these factors.
- Any damage to facilities during storm events is also likely to significantly diminish access to recreational boating infrastructure as repairs are made.

Adaptive Capacity: Low

- The yacht club and Boathouse have a low adaptive capacity due to the built infrastructure and required access to coastal waterways at the Yacht Club.
- While strategies such as flood protection or accommodation remains an option for the Yacht Club and Boathouse, the need for coastal access can provide challenges and limits long-term options for relocation or realignment of facilities.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Mod	High	High	High	High	High

- Long-term vulnerability transitions from moderate to high when non-storm inundation is projected to impact facilities.
- The overall vulnerability of the Yacht Club, which requires coastal access, is higher compared to recreational facilities that can be relocated or have a higher adaptive capacity.

5.2.4 Community Center

Community Center

Description:

City Community Center

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	Low	Low	Mod	High	High

- The Community Center is projected to experience storm flooding beginning at 1.6 ft of SLR.
- Inundation in low-lying areas is projected with 3.3 ft SLR.
- Widespread inundation is projected at 4.1 ft and higher SLR scenarios.

Hazard Sensitivity: Mod

- Hazard sensitivity for the Community Center is moderate given the potential for structural damage and service disruption during flood events and while any repairs are made to facilities.

Adaptive Capacity:	Mod

- The Community Center has a moderate adaptive capacity as it contains built infrastructure.
- Though adaptation measures would likely be more substantial than for open space, a variety of options may protect the community center from flooding or accommodate future flood impacts.
- Relocation or realignment of the Community Center remains as a long-term option if other adaptation measures are not sufficient.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	Mod

- The Community Center vulnerability transitions from low to moderate vulnerability at the point when storm flooding is projected to cover substantial portions of the facilities.
- Long-term vulnerability of the Community Center remains moderate due to its adaptive capacity and lower hazard sensitivity compared to facilities such as yacht clubs and the ferry landing that require coastal access.

5.2.5 Aquatics Center

Aquatics Center

Description:

City Aquatics Center

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	Low	Low	Mod	High	High

- The segment of Glorietta Bay shoreline adjacent to the Aquatics Center is projected to experience storm flooding beginning at 1.6 ft of SLR.
- Inundation in low-lying areas surrounding the Aquatics Center is projected with 3.3 ft SLR.
- Widespread inundation at the Aquatics Center is projected at 4.1 ft and higher SLR scenarios.

Hazard Sensitivity: Mod

- Hazard sensitivity for the Aquatics Center is moderate given the potential for structural damage and service disruption during flood events and while any repairs are made to facilities.

Adaptive Capacity: Mod

- The Aquatics Center has a moderate adaptive capacity as it contains built infrastructure.
- Though adaptation measures would likely be more substantial than for open space, a variety of options may protect the Aquatics Center from flooding or accommodate future flood impacts.
- Relocation or realignment of the Aquatics Center remains as a long-term option if other adaptation measures are not sufficient.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	Mod

- The Aquatics Center vulnerability transitions from low to moderate vulnerability at the point when storm flooding is projected to cover substantial portions of the facilities.
- Long-term vulnerability of the Aquatics Center remains moderate due to its adaptive capacity and lower hazard sensitivity compared to facilities such as yacht clubs and the ferry landing that require direct access to coastal waterways.

5.2.6 Club Room

Club Room

Description:

Club Room within Glorietta Bay Park

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	Low	Low	Mod	High	High

- The segment of Glorietta Bay shoreline adjacent to the Club Room is projected to experience storm flooding beginning at 1.6 ft of SLR.
- Inundation in low-lying areas surrounding the Club Room is projected with 3.3 ft SLR.
- Widespread inundation at the Club Room is projected at 4.1 ft and higher SLR scenarios.

Hazard Sensitivity: Mod

- Hazard sensitivity for the Club Room is moderate given the potential for structural damage and service disruption during flood events and while any repairs are made to facilities.

Adaptive Capacity: Mod

- The Club Room has a moderate adaptive capacity as it contains built infrastructure.
- Though adaptation measures would likely be more substantial than for open space, a variety of options may protect the Club Room from flooding or accommodate future flood impacts.
- Relocation or realignment of the Club Room remains as a long-term option if other adaptation measures are not sufficient.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	Mod

- The Club Room vulnerability transitions from low to moderate vulnerability at the point when storm flooding is projected to cover substantial portions of the facilities.
- Long-term vulnerability of the Club Room remains moderate due to its adaptive capacity and lower hazard sensitivity compared to facilities such as yacht clubs and the ferry landing that require direct access to coastal waterways.

5.2.7 Cays Yacht Club

Cays Yacht Club

Description:

Coronado Cays Yacht Club

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	Low	Mod	High	High	High

- Marina infrastructure in the Coronado Cays community is anticipated to decrease in function as sea level rises. Gangways may ultimately slope upwards from bulkhead to dock, potentially damaging hinges, platforms, and stability. Piles in place are also at risk of providing insufficient stability to the docks they hold as SLR increases (image 1 and 2).
- Storm flooding is projected to impact the Coronado Cays Yacht Club under 1.6 ft of SLR.
- Widespread storm flooding and inundation of low-lying areas is projected with 2.5 ft SLR.
- Widespread inundation is projected with 3.3 ft SLR.

1. Gangways and piles near their functional limit during December 2020 king tide

2. Wave damage at Coronado Cays Marina during Santa Ana wind event

Hazard Sensitivity:	High
▪ Hazard sensitivity is high for the Cays Yacht Club because it requires coastal access. As its design is tied to existing water levels, the facilities may experience loss of service and function even if flood projections do not yet extend over built structures if access infrastructure such as gangways or docks are impacted. ▪ Any damage to facilities during storm events is also likely to significantly diminish access to recreational boating infrastructure as repairs are made.	
Adaptive Capacity:	Low
▪ The Cays Yacht Club has a low adaptive capacity due to its built infrastructure and because it requires access to coastal waterways. ▪ While strategies such as flood protection or accommodation remains an option for the Cays Yacht Club, the need for coastal access can provide challenges and limits long-term options for relocation or realignment of facilities.	

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	High	High	High	High

- Long-term vulnerability transitions from moderate to high when non-storm inundation is projected to impact facilities.
- The overall vulnerability of the Cays Yacht Club, which requires coastal access, is higher compared to recreational facilities that can be relocated or have a higher adaptive capacity.

5.2.8 Parks

Parks					
Description:					
Public park areas under City jurisdiction					

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	High	High

- Storm flooding of low-lying areas from 0.8 ft to 2.5 ft SLR.
- Widespread storm flood flooding and select areas of non-storm inundation with 3.3 ft SLR.
- Widespread non-storm inundation with 4.1 ft and greater SLR.

Hazard Sensitivity:	Low

- Park areas are mainly sensitive to inundation during non-storm conditions due to a relative lack of built infrastructure that could be damaged during storm flooding.

Adaptive Capacity:	High

- Parks have a high adaptive capacity because they benefit from a low density of built infrastructure, keeping long-term options open for flood protection, accommodation, or relocation.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Mod	Mod

- Overall vulnerability is low to moderate for parks due to their relatively low sensitivity to SLR hazards and high adaptive capacity.
- The shift from low to moderate vulnerability occurs when non-storm inundation is projected to impact significant areas.

5.2.9 Golf Course

Golf Course

Description:

Coronado Municipal Golf Course

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	High	High

- Storm flooding of low-lying areas with 0.8 ft SLR
- More widespread storm flooding and inundation of select low-lying areas from 1.6 ft to 3.3 ft SLR.
- Widespread non-storm inundation with 4.1 ft and greater SLR.

Hazard Sensitivity:	Mod

- The golf course has a moderate hazard sensitivity as it contains select some areas of built infrastructure.
- Large areas of open space help to reduce hazard sensitivity.

Adaptive Capacity:	High

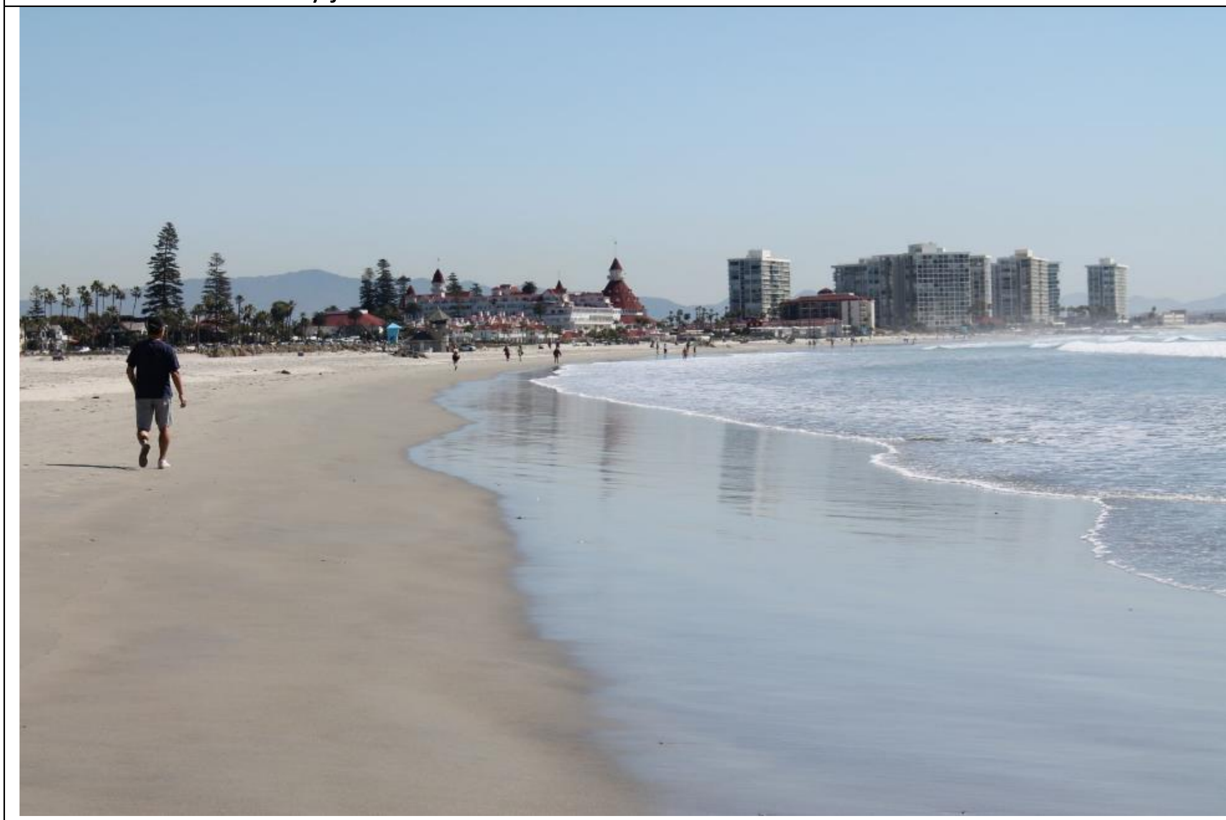
- The golf course has a high adaptive capacity because it benefits from a low density of built infrastructure, keeping long-term options open for flood protection, accommodation, or relocation.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	Mod

- The golf course vulnerability transitions from low to moderate vulnerability at the point when storm flooding is projected to cover substantial portions of the facilities.
- Long-term vulnerability of the golf course remains moderate due to its adaptive capacity and lower hazard sensitivity compared to facilities such as yacht clubs and the ferry landing that require coastal access.

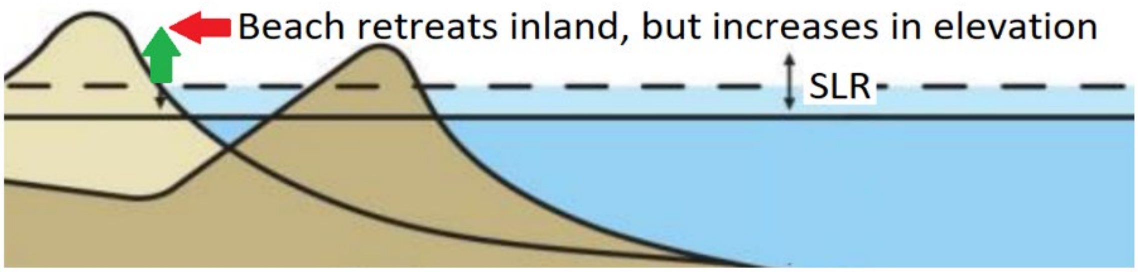
5.2.10 Coronado Beach

Coronado Beach					
Description:					
North Beach under City jurisdiction					
 *North Beach is currently one of the widest sandy beaches in southern California.*					
Hazard Exposure:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
Low	Low	Low	Low	Low	Low

- Sandy beach areas at Coronado Beach are projected to be exposed to SLR under all scenarios. However, most flooding is projected to occur during the 100-yr storm, while daily inundation and shoreline erosion are not projected to severely impact the area.
- Since construction of Zuniga Jetty at the entrance to San Diego Bay, the beach has naturally and artificially (through nourishment) grown in size, sometimes reaching over 700 ft in width.
- Flood projections vary across SLR projections as a result of anticipated changes in beach topography. North Beach has been observed to vary in up to 8-9 feet in elevation at the shoreline as a result of beach nourishment efforts and storm-induced erosion (Section 2).
- Projections show that the beach may rise in elevation as it retreats inland, a process known as the “Bruun Rule.” Beaches tend to maintain an equilibrium profile shape, which is a balance of beach slope with the ocean water level and wave conditions. As sea level rises, the increasing water level

will tend to cause a beach to retreat landward and rise in elevation (image 1). This likely accounts for the development of what look like "islands" amidst projected flooding during storms.

- The daily condition of North Beach through 4.9 ft of SLR is anticipated to look very similar to today except that the high tide line is projected to be located landward by approximately 100 feet.



1. Beach response to sea level rise, termed the Bruun Rule. Dark brown represents existing beach condition, and light brown represents the beach condition under SLR (Adopted from Shand et. al. 2013)

Hazard Sensitivity:	Low

- SLR hazard impacts for beach areas are primarily driven by erosion and shoreline retreat rather than flooding, as temporary flood impacts during storm events are unlikely to have a significant impact on beach use.
- Low hazard sensitivity for recreational beach areas within the City is based on the relatively low potential for long-term erosion impacts at Coronado Beach, where substantial portions of usable beach area remain even under low probability, long-term SLR scenarios.

Adaptive Capacity:	High

- Coronado Beach shows a high adaptive capacity over long-term SLR projections due to the wide beach and extensive dune systems in the area. This wide beach significantly mitigates any impacts from shoreline retreat.
- Beach nourishment to the south from regular San Diego Bay dredging projects are anticipated to continue to feed sediment to the City's ocean coast. Natural sediment transport processes are anticipated to continue to supply the area with sediment over time.
- Adaptive measures may also be implemented to accrete and retain sand, such as groins and breakwaters. Currently, the Zuniga Jetty acts similarly to a groin in its ability to interrupt sediment transport and retain wide beach widths. Additionally, a shipwreck offshore of what is now the Coronado Shores community demonstrated the efficacy of a very short breakwater, as reduced wave energy in the lee of the ship promoted the accretion of 50,000 square feet of beach (SANDAG, 2001). See image 1. In addition, the groin off the Hotel Del Coronado retains a beach in its lee that remains wide.

1. Beach accretion developed behind a shipwreck and leeward of the Hotel Del Coronado – 1938 Photo (SANDAG, 2001)

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

- Coronado Beach shows a low vulnerability to SLR hazards across all SLR scenarios due to limited shoreline retreat projections, low sensitivity to hazards, and natural adaptive capacity.

5.2.11 Silver Strand Beach

Silver Strand Beach

Description:

Silver Strand Beach under State Parks jurisdiction

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	High	High

- Low exposure up to 3.3 ft of SLR due to limited shoreline retreat and wide beaches.
- Moderate exposure with 3.3 ft SLR as beaches narrow in areas adjacent to parking facilities.
- High exposure with 4.1 ft and greater SLR as erosion projections extend landward towards and beyond parking facilities.

Hazard Sensitivity:	Low

- SLR hazard impacts for beach areas are primarily driven by erosion and shoreline retreat rather than flooding, as temporary flood impacts during storm events are unlikely to have a significant impact on beach use.
- Low hazard sensitivity for recreational beach areas within the Silver Strand Beach is based on the relatively low potential for long-term erosion impacts, where substantial portions of usable beach area remain even under low probability, long-term SLR scenarios.

Adaptive Capacity:	Mod				
▪ Silver Strand Beach shows a moderate adaptive capacity over long-term SLR projections due to the presence of a relatively wide beach, though potential adaptation strategies will also need to consider parking facilities. ▪ Beach nourishment to the south from regular San Diego Bay dredging projects are anticipated to continue to feed sediment to the City's ocean coast. Natural sediment transport processes are anticipated to continue to supply the area with sediment over time. ▪ Adaptive measures may also be implemented to accrete and retain sand, such as groins and potentially other devices.					
Overall Vulnerability:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
Low	Low	Low	Mod	Mod	Mod
▪ Silver Strand State Park shows low vulnerability up to 3.3 ft and a moderate rating at greater SLR scenarios when shoreline projections begin to approach parking facilities.					

5.2.12 Coastal Access Points

Coastal Access Points

Description:

Points along the City shoreline that provide access to beach areas

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	High

- Limited exposure to storm flooding with 0.8 ft SLR.
- Moderate to widespread storm flood exposure from 1.6 ft to 4.1 ft SLR.
- Widespread exposure to inundation hazards with 4.9 ft SLR.

Hazard Sensitivity:	Mod

- Lack of large structural elements helps limit hazard sensitivity. Significant damage unlikely after storm flooding.
- Significant loss of function likely if areas become inundated on a regular basis or storm damage causes unsafe conditions at stairwells or other access infrastructure.

Adaptive Capacity:	High

- Coastal access points have a high adaptive capacity because it is likely that coastal access locations and associated infrastructure can be retrofitted or relocated over time as needed to accommodate SLR impacts without substantial cost or impacts to surrounding resources.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	Mod	Mod

- Overall vulnerability is low to moderate across all SLR scenarios.
- Despite increasing hazard exposure, long-term vulnerability is limited due to high adaptive capacity.

5.3 Utilities

5.3.1 D Street Substation

D Street Substation

Description:

Electrical substation located at D Street and 1st Street

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
N/A	N/A	N/A	N/A	N/A	N/A

- No exposure to hazards across all SLR scenarios.

Hazard Sensitivity: High

- Hazard sensitivity is high for the D Street power substation, as even minor structural damages or disruptions in service may have extensive impacts to surrounding areas.

Adaptive Capacity: Low

- The D Street substation has a low adaptive capacity due to the highly specialized nature of the infrastructure and regional impacts if operations are disrupted during implementation of adaptation measures.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Low	Low

- Though the D street substation has a high sensitivity to SLR hazards and a relatively low adaptive capacity, vulnerability is limited across all SLR scenarios due to a lack of hazard exposure even under severe storm conditions.

5.3.2 Pump Stations

Pump Stations					
Description:					
Stormwater and sanitary sewer pump stations					
					
Hazard Exposure:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
N/A	Low	Low	Mod	High	High

- The center of Spanish Bight area contains one stormwater pump station and one combined sanitary sewer/stormwater pump station which are projected to flood during storm events with 4.1 ft SLR and become exposed to inundation hazards with 4.9 ft of SLR. The pump stations are located in two of the lowest elevation areas in the City and help to manage upland stormwater runoff which cannot be diverted to the ocean solely by gravity stormwater lines.
- The Transbay Sewer Pump Station, located in the northern portion of the City by the Ferry Landing, conveys all sanitary sewer off of the Coronado peninsula. Select areas surrounding the station are projected to experience storm flooding with 3.3 ft SLR. Storm flooding surrounding the station becomes more widespread with 4.1 ft SLR, and inundation is projected with 4.9 ft SLR.
- Five sanitary sewer pump stations are also present within and surrounding the Coronado Cays Community. Several of these pump stations are projected to flood during severe storms under the 0.8 ft to 2.5 ft SLR scenarios. Inundation of select pump stations is projected at 3.3 ft SLR, becoming more widespread under the 4.1 ft and 4.9 ft SLR scenarios.

Hazard Sensitivity:	High

- Stormwater and sanitary sewer pump stations are likely to experience disruptions in service if they are inundated during flood events, potentially compounding impacts to City stormwater and sewer infrastructure function.

Adaptive Capacity:	Mod

- Adaptive capacity of pump stations is moderate due the built nature of the infrastructure in fixed locations and the need to maintain utility functions if any adaptation measures are implemented.
- Any adaptation measures for stormwater and sewer infrastructure in highly exposed areas would likely require additional hydraulic studies if significant changes are made to ensure utility functions are not adversely impacted as a result.
- Though a potential challenge, opportunities exist to coordinate elevation of infrastructure such as outfalls, lines, and pump stations with any future improvements to, or adjusting the elevation of, coastal infrastructure.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Mod	Mod	Mod	High	High

- Stormwater and sewer infrastructure is considered critical, as its vulnerability has the potential to increase the vulnerability of all other resource types through the impaired flood conveyance and backflow.
- Vulnerability for pump stations remains low to moderate until the 4.1 ft SLR scenario where storm flooding is projected to impact stations within the Spanish Bight and the Transbay sewer station, and inundation of select stations is projected within Coronado Cays.
- Under the 4.9 ft SLR scenario stations in the Spanish Bight area and the Transbay sewer station are projected to become subject to non-storm inundation which will likely exceed their functional capacity or cause service disruptions.

5.3.3 Stormwater Outlets

Stormwater Outlets					
Description:					
Outlets for stormwater flow that allow rainfall or other inland floodwater to drain into coastal water bodies					
					
Hazard Exposure:					
0.8ft (0.25m) SLR	**1.6ft (0.5m) SLR**	**2.5ft (0.75m) SLR**	**3.3ft (1.0m) SLR**	**4.1ft (1.25m) SLR**	**4.9ft (1.5m) SLR**
Low	Low	Low	Mod	High	High

- Three stormwater outlets near Alameda Boulevard will become increasingly inundated, creating the potential for backflow to occur during heavy rainstorms.
- The Ferry Landing Center stormwater outfalls are projected to be increasingly inundated by SLR which may reduce the flow capacity (image 1). The inundation of these outfalls, while located on Port of San Diego property, may cause backflow and upland stormwater flooding within the City.
- The Glorietta Bay shoreline contains several stormwater outlets which discharge stormwater from residential areas, roadways, and parking areas. As sea level rises, the flow capacity will be reduced and backflow may cause upland stormwater flooding in areas such as the intersection of Pomona Ave and Orange Ave.

- In the Central Study Area, a total of twelve stormwater lines and outlets direct upland stormwater from SR-75 into San Diego Bay. As sea level rises, the flow capacity will be reduced and backflow may cause upland stormwater flooding along SR-75 and the Bayshore Bikeway.
- In the South Study Area, a total of twenty-seven stormwater lines and outlets direct upland stormwater from SR-75 into San Diego Bay. As sea level rises, the flow capacity will be reduced and backflow may cause upland stormwater flooding along SR-75 and the Bayshore Bikeway.
- At the Coronado Cays community, a total of sixty stormwater lines and outlets direct upland stormwater from the residential and visitor serving areas into San Diego Bay. As sea level rises, the flow capacity will be reduced and backflow may cause upland stormwater flooding in the community.

1. Stormwater outlets along the Bayshore Bikeway, by the Ferry Landing Center

Hazard Sensitivity:	High

- Hazard sensitivity for stormwater utilities infrastructure is high overall, as the normal operation of stormwater infrastructure can be negatively impacted if water levels rise to the point where backwater effects occur. A backwater effect occurs when a channel restriction or obstruction at the downstream end raises the surface of the water upstream from it, potentially leading to flooding. Non-storm inundation projections in areas such as Glorietta Bay, Coronado Cays, or the Spanish Bight are likely to impact stormwater operations if outfall locations become inundated for extended periods of time.
- Any stormwater infrastructure that relies on gravity flow is also likely to experience some reduction in capacity due to higher downstream water levels.

Adaptive Capacity:	Mod

- Adaptive capacity of stormwater outlets is moderate due the built nature of the infrastructure in fixed locations and the need to maintain utility functions if any adaptation measures are implemented.
- Any adaptation measures for stormwater and sewer infrastructure in highly exposed areas would likely require additional hydraulic studies if significant changes are made to ensure utility functions are not adversely impacted as a result.
- Though a potential challenge, opportunities exist to coordinate elevation of infrastructure such as outfalls, lines, and pump stations with any future improvements to, or adjusting the elevation of, coastal infrastructure.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Mod	Mod	Mod	High	High	High

- Stormwater infrastructure is considered critical, as its vulnerability has the potential to increase the vulnerability of all other resource types through the impaired flood conveyance and backflow.
- Outlets are rated as moderately vulnerable even at low SLR scenarios due to the sensitivity of the infrastructure to increasing water levels and potential challenges in adapting shoreline infrastructure.
- Vulnerability increases to a high rating at 3.3 ft and greater SLR scenarios based on the potential for frequent inundation at outfall locations in low-lying areas such as Glorietta Bay and Coronado Cays.

5.4 Transportation Infrastructure

5.4.1 Bike Routes

Bike Routes

Description:

City transportation infrastructure designed for use by cyclists

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	High	High

- Storm flood exposure along select bike routes up to 2.5 ft SLR.
- Widespread storm flood exposure and select areas of non-storm inundation projected with 3.3 ft SLR.
- Widespread non-storm inundation exposure with 4.1 ft and greater SLR.
- Approximately 7 miles of the Bayshore Bikeway projected to flood during storm events with 4.9 ft SLR.

Hazard Sensitivity:	Low

- Bike routes have a low hazard sensitivity as temporary damages or loss of service during flood events is unlikely to have as widespread of impacts as roadway closures.
- Cyclists would likely be able to find alternative routes if current bike routes are flooded or damaged.

Adaptive Capacity:	High

- Bike routes have a high adaptive capacity due to their lack of large structural elements and relatively flexible locations.
- The Bayshore Bikeway runs parallel to SR-75 for the length of the Silver Strand and its adaptation could be accommodated within adaptation plans for SR-75.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Low	Mod	Mod

- Overall SLR hazard vulnerability for bike routes remains low to moderate across all SLR scenarios.
- Long-term vulnerability is reduced by low hazard sensitivity and high adaptive capacity.
- The shift from low to moderate vulnerability occurs at the point where non-storm inundation projections cover substantial segments of major bike routes.

5.4.2 Major and Minor Roadways

Major and Minor Roadways

Description:

Local roadways not including SR-75

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Low	Mod	High	High

- Localized flooding during storm events projected for up to 2.5 ft SLR. Affected areas include Glorietta Blvd, Alameda Blvd, and local roadways within the Coronado Cays.
- Incremental increase in storm flood hazard exposure and non-storm inundation hazard exposure for Coronado Cays roadways with 3.3 ft SLR
- Significant increase in flood hazard exposure within the Spanish Bight with 4.1 ft and greater SLR as bay side flooding is projected to extend across the area. Majority of local roadways within Coronado Cays exposed to inundation hazards with 4.1 ft and greater SLR.

Hazard Sensitivity:	High

- Potentially resistant to structural damages if flooding is shallow and short duration.
- High sensitivity in terms of service disruptions during flood events or during any repairs.

Adaptive Capacity:	Mod

- Elevation of roadways in low-lying areas is viable, but potentially costly.
- Adaptation must consider the elevation of surrounding resources and local drainage patterns.
- Potential alternative routes exist if adaptation requires temporary road closure.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Mod	Mod	Mod	Mod	High	High

- Moderate vulnerability even under low SLR scenarios due to high sensitivity and potential disruptions during storm events.
- Moderate adaptive capacity helps limit overall vulnerability until the 4.1 ft SLR scenario where hazard exposure shows a significant increase.

5.4.3 SR-75

SR-75

Description:

State Route 75, only major transportation route into City and along Silver Strand

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Mod	High	High	High

- SR-75 is most exposed along Silver Strand where it is the only major transportation route across the City.
- Storm flooding is projected within select areas up to 1.6 ft SLR. One of the lowest elevation areas where the bay may breach the Strand is the area halfway between Naval Amphibious Base Coronado and Fiddler's Cove (image 1).
- Storm flood hazard exposure becomes widespread with 2.5 ft SLR, impacting several stretches of SR-75 along Silver Strand.
- Non-storm inundation hazards are projected along low-lying portions of the roadway with 3.3 ft SLR, becoming more widespread with 4.1 ft and 4.9 ft SLR.

1. Flooding is anticipated to first breach the Silver Strand at low points such as the area between Naval Amphibious Base Coronado

Hazard Sensitivity:	High

- Highly sensitive to any interruptions in service due to lack of alternative transportation routes.
- Any extensive or long-term damage from erosion or undermining likely to severely impact access to the Silver Strand area until repairs are made.
- Designated as official Evacuation Route during emergencies. Any damage of closure is also likely to impact emergency response times.

Adaptive Capacity:	Low

- Elevation of roadways in low-lying areas is viable, but potentially costly.
- Adaptation must consider the elevation of surrounding resources and local drainage patterns.
- Limited alternative routes exist if adaptation requires temporary road closure.
- Silver Strand transportation corridor is dependent on the ability of existing natural and constructed features along the shoreline to dissipate wave energy during extreme events, preventing recurring structural damages from erosion and undermining.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Mod	Mod	High	High	High	High

- Moderate vulnerability even under low SLR scenarios due to high sensitivity and potential disruptions during storm events.
- Lower adaptive capacity compared to local roadways increases overall vulnerability at 2.5 ft and higher SLR scenarios as hazard projections increase.

5.4.4 Public Parking

Public Parking

Description:

City public parking facilities

Hazard Exposure:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Mod	Mod	High	High

- Storm flood projections within select low-lying parking areas with 0.8 ft and 1.6 ft SLR.
- Widespread storm flood impacts and small areas of non-storm inundation projected under the 2.5 ft and 3.3 ft SLR scenarios.
- Widespread non-storm inundation of public parking facilities along the coast at 4.1 ft and greater SLR scenarios.

Hazard Sensitivity: Mod

- Public parking facilities have a moderate sensitivity to hazards as temporary damages or loss of service during flood events is unlikely to have as widespread of impacts as roadway closures.
- The high demand for parking along the coastline of the City exacerbates the impacts of any parking space loss.

Adaptive Capacity: High

- Parking lots have a high adaptive capacity due to their lack of large structural elements and relatively flexible locations.

Overall Vulnerability:

0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Low	Low	Mod	Mod	Mod	Mod

- Overall SLR hazard vulnerability for bike routes is low to moderate across all SLR scenarios.
- Though select areas of bike routes are projected to become inundated during non-storm conditions in long-term SLR scenarios, the moderate hazard sensitivity and high adaptive capacity of the infrastructure limits long-term vulnerability.

6 Economic Impact Analysis

SLR is expected to increase the potential for damage to natural and built resources during extreme storm events as well as high tides. The damage from these increasing hazards will have direct financial impacts including the cost to replace or repair damage to specific resources. A full inventory of impacted resources under each SLR and storm scenario included within this study is provided in Table VA-5.

6.1 Infrastructure Replacement Value Estimates

Replacement value estimates were made based on the type of infrastructure impacted under each scenario. For developed areas, a structure was assumed to require full replacement if it was projected to be inundated during non-storm conditions. Potential damages to development within the City during storm events were evaluated using depth-damage relationships established through the U.S. Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NACCS), which were developed to better capture damage to structures during coastal storms as opposed to riverine flooding (USACE, 2015). These physical depth-damage functions are intended to provide a rough order of magnitude for potential storm damages under the future SLR scenarios evaluated in this study. Exact damage estimates for individual structures would require further investigation into structure design and materials. For the purposes of this analysis, wave damage estimates are based on USACE Prototype 5B: Two Story Residence, No Basement and wave hazards during a 100-year storm event. The depth-damage functions for this type of structure are presented in Table VA-4.

Table VA-4: NACCS prototype 5B flood depth damage relationships (USACE, 2015). Damage numbers refer to the percent damage to the structure at each flood depth.

Flood Depth (ft)	Minimum Damage	Most Likely Damage	Maximum Damage
0.0	0%	5%	8%
0.5	5%	10%	10%
1.0	9%	15%	20%
2.0	15%	20%	25%
3.0	20%	25%	30%
5.0	25%	30%	40%
7.0	40%	50%	55%
10.0	50%	60%	70%

Table VA-5: Inventory of resources impacts under each SLR scenario and storm condition

Resource	Unit	SLR + Flood Scenario											
		0.8ft (0.25m) SLR		1.6ft (0.5m) SLR		2.5ft (0.75m) SLR		3.3ft (1.0m) SLR		4.1ft (1.25m) SLR		4.9ft (1.5m) SLR	
		No Storm	100-Yr	No Storm	100-Yr	No Storm	100-Yr	No Storm	100-Yr	No Storm	100-Yr	No Storm	100-Yr
Pump Station	count	0	0	0	3	0	3	1	3	3	3	4	7
Stormwater Outlet	count	10	32	13	36	23	40	31	48	34	48	42	50
Coastal Access Points	count	0	7	2	9	3	12	4	16	5	18	11	17
Roadways	linear feet	177	20,376	609	45,027	10,164	74,145	23,446	121,281	44,558	193,750	108,374	239,433
Parks	acres	12	50	11	51	19	68	35	92	50	114	85	138
Restrooms	count	0	1	0	3	0	4	1	5	1	5	2	5
Recreation Facilities	count	0	1	1	4	1	5	2	6	6	6	6	6
Golf Course	acres	2.0	8.0	4.0	12.1	8.5	31.8	13.0	62.1	34.2	81.9	63.5	92.6
Bike Routes	linear feet	525	5,640	955	13,278	1,762	23,820	6,693	32,224	14,947	44,479	27,476	51,935
Parking Lots	acres	0.0	1.1	0.0	2.1	0.4	6.2	1.2	9.7	5.4	11.8	8.7	13.0
Coronado Beach	acres	+ 0.7		+ 4.2		- 2.4		- 3.3		- 8.4		- 13.6	
Silver Strand	acres	- 18.6		- 9.7		- 29.8		- 35.9		- 55.7		- 74.6	

The USACE functions provide estimates of minimum, most likely, and maximum damages to structures as a percentage of total structure value. The range of expected damage is a function of several building characteristics, including structure type, age, utility location, and condition of connections. The "most likely" damage estimations were used throughout this study. These estimates are not intended to be exact measurements of structural damage to individual structures within the city but are instead meant to provide information on the relative scale of potential SLR damage in inland areas to inform adaptation planning initiatives.

Parcel valuations and boundaries were based on publicly available tax assessment data for total parcel value. These parcels are intended for tax assessment purposes only and are not guaranteed to be survey grade. Parcels with no taxable value, such as those under military jurisdiction, are not included. The assessed value of property may also differ from current market value due to factors such as California Proposition 13, which limits any increase in value to two percent a year. Despite these potential limitations, assessment records are reliable for the scope and purpose of this analysis. Results are presented in Table VA-6.

Table VA-6: Estimated damages to total parcel value due to projected SLR hazards

SLR Scenario	Damage Estimates ($)	
	Non-Storm Inundation	100-Year Storm Damage
0.8ft	0*	1,772,511
1.6ft	0*	52,480,216
2.5ft	10,478,158	123,819,706
3.3ft	492,436,591	235,631,638
4.1ft	1,026,113,849	428,118,913
4.9ft	1,530,362,369	508,356,487

*Small areas of inundation exist at low SLR scenarios, but inundation does not extend inland far enough to consider parcels as fully inundated.

Damages to utilities and transportation infrastructure not covered in parcel analyses were also estimated. Infrastructure cost estimates on a unit basis were determined through an examination of prior replacement projects for similar infrastructure. Infrastructure was assumed to require replacement if impacted by non-storm inundation projections (see "No Storm" columns in Table VA-5). Table VA-7 shows infrastructure replacement value estimates.

Table VA-7: Infrastructure replacement value estimates ($)

Resource	Unit	Unit Cost	SLR + Flood Scenario					
			0.8ft (0.25m)	1.6ft (0.5m)	2.5ft (0.75m)	3.3ft (1.0m)	4.1ft (1.25m)	4.9ft (1.5m)
Stormwater Outlet	count	15,000	150,000	195,000	345,000	465,000	510,000	630,000
Roadways	lf	400	70,800	243,600	4,065,600	9,378,400	17,823,200	43,349,600
Bike Routes	lf	120	63,000	114,600	211,440	803,160	1,793,640	3,297,120

6.2 Beach Capacity

Non-market value refers to those goods and services that cannot be directly measured through a market price when bought or sold. Beaches such as those within the City of Coronado provide non-market value in a number of ways, including recreation and storm buffering capacity (California Department of Boating and Waterways, 2011). These values can be quantified in terms of willingness to pay, or the amount that an individual consumer would be willing to consume the good or use the associated service (Raheem et al., 2009).

Quantification of non-market values associated with beaches remains challenging due to the inherent variability between locations. For beaches with high numbers of visitors, value can be expressed in a in terms of consumer surplus per activity day, which provides an estimate of the economic value of each beach attendee. A value of $40.00 per visitor per day has been used in similar assessments within southern California, representing a median value of past studies (Pendelton & Kidlow, 2006).

Impacts from beach loss are determined based on a comparison of beach carrying capacity (the number of visitors a beach is able to accommodate) and the number of visitors expected on a daily basis. This study assumes a beach carrying capacity of 100 sq. ft. per person per day consistent with USACE guidance. Beach visitor numbers for Coronado Beach are based on monthly visitor data provided by City of Coronado lifeguards from 2017 to 2020 (Table VA-8).

Table VA-8: Average monthly and daily beach visitors for Coronado Beach

Month	Average Monthly Visitors	Average Daily Visitors
January	157,750	5,089
February	136,000	4,857
March	208,500	6,726
April	196,000	6,533
May	270,500	8,726
June	394,750	13,158
July	618,500	20,617
August	422,750	13,637
September	229,000	7,633
October	193,250	6,234
November	127,500	4,250
December	179,250	5,782

Based on these visitation numbers minimal economic impact is projected for Coronado Beach due to SLR. The beach is currently one of the widest in southern California, with an area of approximately 3.5 million square feet fronting Ocean Boulevard and the Hotel Del Coronado. Even with projected beach loss over time, sufficient beach area is projected to remain in place to fully accommodate the average daily visitors each month.

7 Conclusions

Planning for and adapting to a changing climate and sea level condition is a critical challenge facing many coastal communities throughout California. This SLR VA determined the potential vulnerability of coastal resources in the City of Coronado. This was accomplished by first compiling an inventory of coastal resources, identifying how these resources will be affected by various increments of SLR, evaluating the risk associated with such vulnerability, and identifying the replacement value of vulnerable resources.

Resources within the City evaluated for vulnerability include infrastructure, recreational space, utilities, and transportation infrastructure. Resource vulnerability to SLR is a product of:

- Exposure to coastal hazards (shoreline erosion, flooding and inundation);
- Sensitivity to coastal hazards (potential for damage or loss of function); and,
- Adaptive capacity (ability to restore function or avoid damage).

Exposure

The most exposed areas include the Spanish Bight area, the Ferry Landing Center, the Glorietta Bay shoreline, the Silver Strand, and the Coronado Cays community. These resources all share the characteristic of having low ground surface elevations on the San Diego Bay side of the City where flooding and eventually inundation are projected to breach into developed areas. The ocean side of the City is anticipated to be more resilient to SLR, a result of the existing wide sandy beach, dune systems, Ocean Blvd seawall, and relatively higher ground surface elevations.

Sensitivity

Resources within the City which are especially sensitive to SLR are the population’s private residences, the public infrastructure which support the critical function of the population (Coronado Hospital, City Hall, utilities, etc.), and roadways which provide access to this critical infrastructure, most specifically SR-75.

Adaptive Capacity

Resources within the City which are most adaptable to SLR tend to be resources with significant open space (North Beach and the golf course), resources or functions which can be relocated temporarily or permanently (lifeguard stations, restrooms), and resources which can be more easily repaired or retro-fitted (bike ways, public parking, stormwater outlets). Conversely, resources which are least adaptable to SLR tend to be constrained for space as water levels rise and less area is available for them to occupy above that elevation.

Adapting resources to SLR can be made easier by looking at issues with consideration of the large-scale hydrologic processes (flood pathways, topography, stormwater controls), looking for adaptation measures with multiple co-benefits (protection, public access benefit, environmental benefit), and looking for opportunities for a collaborative response by partner agencies (U.S. Navy, California State Parks, Port of San Diego).

Vulnerability

Resources which are exposed to SLR, sensitive to damage or loss of function, and less easily adaptable are the most vulnerable to sea level rise. Resources are listed in order of decreasing vulnerability to SLR in Table VA-9. The lowest SLR scenario (0.8 ft) could occur by the year 2040 (1 in 6 chance) to 2030 (1 in 200 chance). The best available science (California Ocean Protection Council, 2018) predicts that SLR will accelerate in the future, and therefore high SLR scenarios begin to become more probable over time. The highest SLR scenario (4.9 ft) could occur by the year 2080 (1 in 200 chance) to 2130 (1 in 6 chance).

The Coronado Yacht Club, Cays Yacht Club, and stormwater outlets are among the most vulnerable resources, a direct result of their functional need to be located at the water's edge. Roadways, especially SR-75, are very vulnerable to SLR because of the long length of roadway which is exposed, the function of roadways to provide access to critical infrastructure and serve as evacuation routes, and the high cost to raise roadways above SLR. Development is highly vulnerable to SLR, especially parcels within the Spanish Bight area and Coronado Cays community, where large areas at low elevation are projected to flood once SLR reaches a particular tipping point.

The results of this SLR VA forms the basis for a SLR Adaptation Plan, to be developed at a later phase of planning to mitigate potential impacts.

Table VA-9: City of Coronado resource vulnerability to sea level rise

Resource	Sea Level Rise Scenario					
	0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Coronado Yacht Club and Boathouse	Mod	High	High	High	High	High
SR-75	Mod	Mod	High	High	High	High
Cays Yacht Club	Low	Mod	High	High	High	High
Stormwater Outlets	Mod	Mod	Mod	High	High	High
Development	Low	Mod	Mod	High	High	High
Major/Minor Roadways	Mod	Mod	Mod	Mod	High	High
Pump Stations	Low	Mod	Mod	Mod	High	High
City Hall	Low	Low	Mod	Mod	High	High

Resource	Sea Level Rise Scenario					
	0.8ft (0.25m) SLR	1.6ft (0.5m) SLR	2.5ft (0.75m) SLR	3.3ft (1.0m) SLR	4.1ft (1.25m) SLR	4.9ft (1.5m) SLR
Ferry Landing	Low	Low	Low	Mod	High	High
Restrooms	Mod	Mod	Mod	Mod	Mod	Mod
Community Center	Low	Mod	Mod	Mod	Mod	Mod
Aquatics Center	Low	Mod	Mod	Mod	Mod	Mod
Club Room	Low	Mod	Mod	Mod	Mod	Mod
Golf Course	Low	Mod	Mod	Mod	Mod	Mod
Coastal Access Points	Low	Mod	Mod	Mod	Mod	Mod
Public Parking	Low	Low	Mod	Mod	Mod	Mod
Tennis Center	Low	Low	Mod	Mod	Mod	Mod
Silver Strand	Low	Low	Low	Mod	Mod	Mod
Public Services Building	Low	Low	Low	Low	Mod	Mod
Parks	Low	Low	Low	Low	Mod	Mod
Bike Routes	Low	Low	Low	Low	Mod	Mod
Hospitals	Low	Low	Low	Low	Low	Mod
Schools	Low	Low	Low	Low	Low	Mod
Fire Department	Low	Low	Low	Low	Low	Low
Police Department	Low	Low	Low	Low	Low	Low
Post Office	Low	Low	Low	Low	Low	Low
Lifeguard Stations	Low	Low	Low	Low	Low	Low
Coronado Beach	Low	Low	Low	Low	Low	Low
D Street Substation	Low	Low	Low	Low	Low	Low

8 References

Abbott, P.L., 1999. The rise and fall of San Diego: 150 million years of history recorded in sedimentary rocks. Sunbelt Natural History Guides.

California Coastal Commission. (2018). *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits.*

California Department of Boating and Waterways. (2011). The Economic Costs of Sea-Level Rise to California Beach Communities. *San Francisco State University*.

California Emergency Management Agency, & California Natural Resources Agency. (2012). *California Adaptation Planning Guide: Planning for Adaptive Communities.*

California Ocean Protection Council. (2018). *State of California Sea-Level Rise Guidance 2018 Update.*

CDIP. (2019). *Station 076 - Diablo Canyon, CA.* Scripps Institution of Oceanography. University of California San Diego. Retrieved August 6, 2019

Coastal Frontiers Corporation. (2020). *2019 Regional Beach Monitoring Program Annual Report.*

Coronado Historical Association. (2021). *Rocks will barricade a repeat of history: CHA shares history of Ocean Boulevard's Seawall.* Coronado Times. January 2021.

Dean, R. G., Armstrong, G. A., & Sitar, N. (1984). *California Coastal Erosion and Storm Damage During the Winter of 1982-83.* National Research Council, Committee on Natural Disasters. National Academy Press.

Elgar, S., Gallagher, E. L., & Guza, R. T. (2001). Nearshore sandbar migration. Journal of Geophysical Research: Oceans, 106(C6), 11623-11627.

Erikson, L., Barnard, P., O'Neill, A., Vitousek, S., Limber, P., Foxgrover, A., . . . Warrick, J. (2017). CoSMoS 3.0 Phase 2 Southern California Bight: Summary of data and methods. *U.S. Geological Survey*.

Flick, R. E. (1993). *The myth and reality of Southern California beaches*. Shore and Beach 61(3): 3-13.

Griggs, G., Arvai, J., Cayan, D., Deconto, R., Fox, J., Fricker, H., . . . Whiteman, E. (2017). Rising Seas in California: An Update on Sea-Level Rise Science. *California Ocean Science Trust*.

IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

Kopp, R., Horton, R., Little, C., Mitrovica, J., Oppenheimer, M., Rasmussen, D., . . . Tebaldi, C. (2014). Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. *Earth' s Future*, 383-407.

Ludka, B. G. (2019). Sixteen years of bathymetry and waves at San Diego beaches. *Scientific data, 6(1)*, pp.1-13.

M&N. (2011). *Final Shoreline Morphology Study, San Diego Regional Beach Sand Project II.*

NOAA. (2021). *Station 9410170*. Retrieved from NOAA Center for Operational Oceanographic Products and Services: https://tidesandcurrents.noaa.gov/datums.html?id=9410170.

Patsch, K., & Griggs, G. (2006). *Littoral Cells, Sand Budgets, and Beaches: Understanding California's Shoreline.* Institute of Marine Sciences. University of California, Santa Cruz.

Patsch, K., & Griggs, G. (2007). *Development of Sand Budgets for California's Major Littoral Cells.* Institute of Marine Sciences. University of California, Santa Cruz.

Pendelton, L., & Kidlow, J. (2006). The Non-Market Value of California Beaches. *Shore and Beach*, *74*(2).

Raheem, N., Talberth, J., Colt, S., Fleishman, E., Swedeen, P., Boyle, K. J., … Boumans, R. M. (2009). *The Economic Value of Coastal Ecosystems in California.*

SANDAG. (2001). *Regional Beach Sand Retention Strategy*. Final Report. October 2001.

Shand, T., Shand, R., Reinen-Hamill, R., Carley, J. and Cox, R., 2013, September. A review of shoreline response models to changes in sea level. In *Coasts and ports* (Vol. 2013, p. 21st).

Snover, A., Whitley Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D., & Simmonds, J. (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. *ICLEI - Local Governments for Sustainability*.

U.S. Army Corps of Engineers. (1991). *State of the Coast Report, San Diego Region, Volume I – Main Report, Final, Coast of California Storm and Tidal Waves Study*. San Diego Region (CCSTWS-SD), US Army Engineer District Los Angeles, Los Angeles, CA.

U.S. Army Corps of Engineers. (2015). *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Physical Depth Damage Function Summary Report.*

U.S. Navy. (2015). A Methodology for Assessing the Impact of Sea Level Rise on Representative Military Installations in the Southwestern United States. *Technical Report 2037.*

Voice of San Diego. (2016). When it Comes to Rising Sea Levels, Coronado is Treading Water.

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City of Coronado
SLR ADAPTATION PLAN

1 Introduction

Sea level rise threatens to alter the future condition and function of the City of Coronado's (City) coastline. The City's *Sea Level Rise Vulnerability Assessment* revealed that the Pacific Ocean coastline is relatively resilient to sea level rise due to wide sandy beaches and high elevation sand dunes in certain locations. However, a 100-year coastal storm event, otherwise noted as storm surge, is projected to temporarily flood portions of the coast under high future sea level rise conditions. The northern coastline along San Diego Bay is most vulnerable, where land elevations are lower than future projected high-water levels and there is a limited buffer between San Diego Bay and development. Overall, stormwater outlets, roads (especially SR-75), and development in low-lying areas are the most vulnerable resources in the City.

The estimated damage or cost of inaction for sea level rise ranges from approximately $15 million for 2.5 feet of sea level rise to $1.6 billion for 4.9 feet of sea level rise. Combined with a 100-year storm, those damages could increase to approximately $139 million to $2.1 billion with 2.5 feet and 4.9 feet of sea level rise respectively. See Appendix AP-3 for additional details.

Building on these findings, this plan outlines potential adaptation strategies to mitigate or reduce the potential impacts and costs of sea level rise to vulnerable locations and infrastructure across the City. This adaptation plan is not meant to dictate a specific set of actions the City must take, but rather provide a range of options to be further debated, considered, and potentially implemented in the future. It is flexible and meant to be revised over time as new information emerges, climate science advances, and community preferences evolve. The City is unlikely to be able to implement all of the potential adaptation strategies due to the high cost of adaptation and will need to prioritize strategies and next steps over time.

There is still significant uncertainty associated with when the sea level rise and storm surge projections may come to pass. The severity of future sea level rise largely depends on global efforts to decrease greenhouse gas (GHG) emissions and slow the effects of climate change. Because the adaptation planning timeline is looking forward thirty to eighty years and beyond, it is likely that the projections and science will change and that global policies will advance. For this reason, adaptation strategies are tied to "triggers," or observable sea level rise points, so that the City can consider appropriate implementation actions once the sea rises, not solely based on projected timelines.

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

Regardless of the uncertainty, adaptation planning is an important process to prepare the City for upcoming impacts and implement strategies proactively to preserve safety and quality of life in the community. This plan represents a major step forward in climate change resilience planning for the City.

This plan is organized into the following sections:

- The **Overarching Adaptation Strategies** section details adaptation strategies applicable City-wide. Many support and complement location- or infrastructure-specific strategies.
- The **Adaptation Action Area Strategies** section provides an overview of existing conditions and projected coastal hazards at vulnerable areas throughout the City. It includes potential strategies for each area that the City could take to increase resilience of public facilities, infrastructure, and land. These strategies are presented as adaptation pathways, which sequence related strategies to reduce risk efficiently and effectively over time.
- The **Conclusions** section outlines key takeaways and next steps for the City to consider.
- **Appendix AP-1: Strategy Fact Sheets** provides background information on the suite of adaptation strategies considered in this plan.
- **Appendix AP-2: Benefit Details** includes qualitative information on the pros and cons of various adaptation strategies.
- **Appendix AP-3: Avoided Costs of Adaptation Action** includes the methodology for calculating the potential financial implications of flood damages if no adaptation strategies were implemented.
- **Appendix AP-4: Cost Details** provides the methodology for calculating the rough order of magnitude costs of various adaptation strategies.
- **Appendix AP-5: Outreach Results** provides a summary of community outreach efforts to date.

Addressing Climate Equity

The California Coastal Commission's Environmental Justice Policy defines equity as "the fairness of achieving outcomes for all groups and no one factor, such as race, can be used to predict outcomes". The Policy emphasizes that environmental justice communities, as well as disadvantaged, underserved, and marginalized communities, are those that already live in direct exposure to pollution and other environmental hazards that can lead to negative health effects, exposure, or environmental degradation.

The City of Coronado does not currently have state defined environmental justice communities nor communities of socioeconomic and demographic groups that may have a higher vulnerability to coastal hazards, such as the elderly, youth, low-income, minority, non-English speakers, homeless, and refugees. There are vulnerable individuals and households and there are vulnerable people that visit Coronado for work and for recreation. This plan focuses on neighborhood-level impacts and there are not particular at-risk communities to highlight for unique adaptation considerations. However, as time goes on, it will become increasingly important to take a more granular view of individual households and changing demographics as each of these recommended strategies are considered for implementation.

[1] California Coastal Commission Environmental Justice Policy.
https://documents.coastal.ca.gov/assets/env-justice/CCC_EJ_Policy_FINAL.pdf

2 Overarching Adaptation Strategies

This suite of overarching adaptation strategies is intended to be implemented City-wide to complement the site-specific adaptation strategies. These strategies cover adaptive management, engineering, operations, planning, and outreach. Each strategy is described in greater detail below, including examples of successful implementation in other jurisdictions, where applicable.

2.1 Adaptive Management

2.1.1 Monitor sea level rise over time

What it is: Monitoring sea level rise involves regularly reviewing sea level data from tide gauges, such as gauges run by the National Oceanic and Atmospheric Administration (NOAA) as part of its National Water Level Observation Network and University of California at San Diego's (UCSD's) Resilient Futures: San Diego Bay project. Data monitoring is key to understanding how sea level rise is affecting Coronado, the rate at which it is progressing, and what areas may be at greater risk of exposure or in need of adaptation strategies.

Tips for implementation: The NOAA tide gauge closest to Coronado is the station in San Diego Bay. That gauge has been collecting data since 1906 and provides a robust record of sea level rise over time in the area. Additionally, there is a tide gauge in Imperial Beach that is part of the Resilient Futures project that can provide accurate data for the oceanic coast. The Navy is also planning to install a tide gauge at the Naval Amphibious Base through the Resilient Futures project. The City should coordinate with Imperial Beach and the Navy to share tide gauge data to understand changes in local sea level.

The City can use sea level data from tide gauges as part of an adaptive management program, where sea levels at or above predetermined thresholds trigger the implementation of new/additional adaptation strategies. An adaptive management approach allows for strategic use of funds, as the City can invest when the need for resilience reaches a critical threshold without being "too late," but can plan and gather funds for implementation in the meantime.

This monitoring is best conducted on an annual basis and could be paired with a literature review of how sea level rise science and projections are evolving for the San Diego region.

2.1.2 Join the Community Rating System program to reduce flood insurance costs

What it is: If/when the Federal Emergency Management Agency (FEMA) flood insurance rate map updates are made that show more property in Coronado as vulnerable to the 100-year storm (i.e., when the maps incorporate sea level rise), Coronado could join the Community Rating System (CRS) program. The CRS is part of FEMA's National Flood Insurance Program (NFIP) and is a voluntary incentive program. To participate, communities implement floodplain management practices that exceed the minimum requirements of the NFIP and are rewarded with discounted flood insurance premium rates for businesses and residents to reflect the community's decreased flood risk. Enrolled communities document and submit their activities for credits, which are used to determine the insurance premium reduction – which ranges from 5% to 45%, with more credits earning greater reductions. Activities are organized into four categories: public information, mapping and regulations, flood damage reduction, and warning and response.

Tips for implementation: The case for enrolling in the CRS when FEMA flood maps are updated to reflect increasing risks due to sea level rise is strong due to the measurable return on investment. While the City is currently not enrolled, the County of San Diego is, and may be a resource for guidance on enrolling and pursuing creditable activities.

The efforts being conducted as part of this Sea Level Rise Adaptation Plan may be able to count toward Activity 510 of the CRS Coordinators Manual, which involves floodplain management planning, hazard assessment, and reviewing possible activities. Certified floodplain managers can provide guidance on activities and enrollment.

2.2 Engineering

2.2.1 Develop sea level rise engineering design guidelines or standards

What it is: Sea level rise engineering design guidelines or standards call upon architects and engineers to incorporate resilience measures into the design of infrastructure itself, such as elevating structures in flood-prone areas, installing flood gates, or keeping emergency generators and electric equipment above ground level. Such guidelines or standards help to ensure that development and infrastructure have resilience incorporated from the start and that existing at-risk infrastructure receives a resilience upgrade when it comes time for a retrofit.

Guidelines are a tool for ensuring that risks associated with sea level rise are considered and addressed early in the design process. By developing these guidelines, the City would help ensure that public infrastructure is able to provide services over their entire design life without damage or deterioration from coastal flooding.

While these guidelines may initially only apply to City development, they could be provided as a resource to private developers and potentially be required for private development after sufficient piloting by the City.

Tips for implementation: Publishing sea level rise engineering design guidelines or standards can be a low-cost, no-regrets strategy for increasing resilience. These types of guidelines can supplement formal building codes and standards which are infrequently updated.

Example Design Guidelines for Climate Resilience

California Ocean Protection Council's (OPC's) 2018 Sea-Level Rise Guidance provides guidance on selecting sea level rise projections, which helps to standardize the process across the state. It points planners and engineers toward the best available sea level rise science and helps them understand how to practically consider and design for sea level rise risks. Figure AP-1 summarizes the major steps. The City's Sea Level Rise Vulnerability Assessment used this document as guidance for selecting modeling scenarios. While these are not formal design guidelines, they included information on sea level rise projections and risk tolerance could form the foundation of future Coronado design guidelines.

Figure AP-1: OPC's SLR guidance decision framework
(Source: OPC's 2018 Sea-Level Rise Guidance)

The Port Authority of New York and New Jersey has developed Climate Resilience Design Guidelines that include climate projections, step-by-step instructions for applying the design guidelines, including how to adjust the project's design flood elevation based on the FEMA base flood elevation, infrastructure service life, and infrastructure criticality (Figure AP-2), and approaches for increasing resilience. This methodology is broadly applicable to other coastal assets and could easily be modified for communities who want to set design guidelines for resilience to sea level rise.

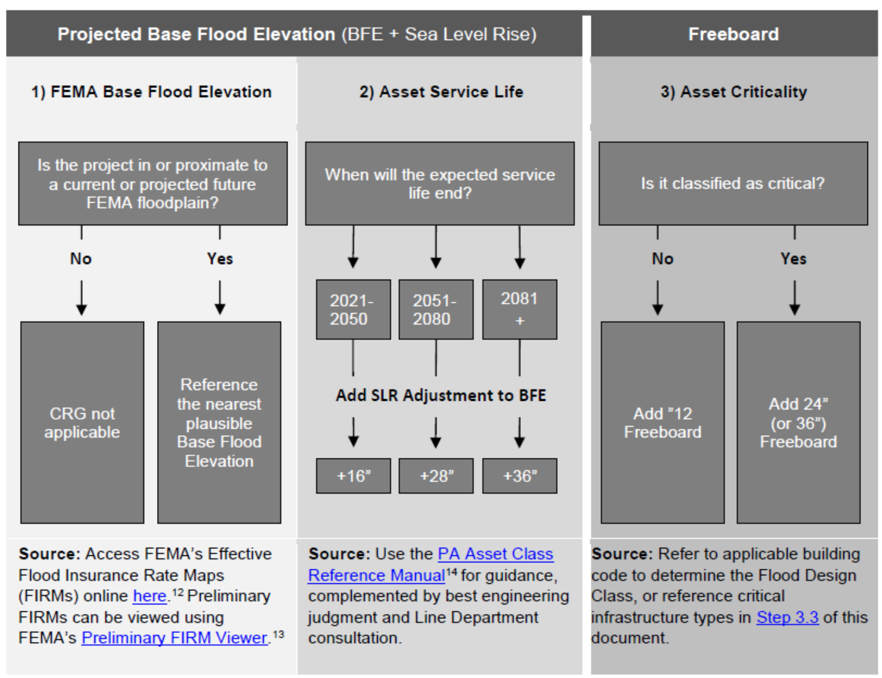

Figure AP-2: Port Authority of New York & New Jersey (PA) lays out how designers can determine the design flood elevation for their project
(Source: Port Authority of NY and NJ's Climate Resilience Design Guidelines)

2.3 Operational

2.3.1 Communicate flood warnings to the public

What it is: Providing the public with key information and timely warnings about storm events and forecasted flooding is a crucial strategy for bolstering the preparedness and safety of the public. This may include early flood warning systems, public notice of flood forecasts, and other channels of communication. As sea levels rise, new areas of Coronado will be at risk of flooding which may catch the public unprepared without clear and sufficient communication.

Tips for implementation: The benefit of this strategy is that it can tie into existing protocols, such as collecting information from meteorological stations and broadcasting via public emergency alerts. Successful early warning systems and public notices use up-to-date meteorological data collection and modeling to monitor storms and have defined scenarios for when to issue notices.

The City currently deploys signs warning motorists of flooding in advance of storms in areas known to be subject to flooding. This practice could be integrated into a broader early warning system for flooding, such as through emergency text alerts to avoid certain areas.

No matter what avenue of communication is used, it should be accessible. That includes ensuring that any audiovisual media contains captions, text-based alerts are screen reader-friendly, and multiple languages (particularly English and Spanish) are offered.

2.3.2 Track flood locations and impacts

What it is: Tracking flood locations and impacts helps Coronado quantify which areas experience repeated or intense flooding. These vulnerability "hot spots" can inform prioritization of where to invest in flood resilience measures or restrict development. Additionally, tracking impacts such as costs associated with flooding damage or public safety impacts can be used as a trigger for adaptive management – if costs or injuries reach a certain threshold, then implementation of a resilience measure would be triggered.

Tips for implementation: A tracking system for flooding may involve a few sensors at priority locations, which can be determined through consultation with experienced staff and/or stakeholders who have a strong understanding of where repeat or intense flood events happen, reviewing previous damage reports, and other sources that document previous flooding impacts. For example, Imperial Beach has partnered with UCSD to deploy a flood sensor and alert system to monitor changes in storms, flooding, and beach profile over time as part of the Resilient Futures Project. Coronado could consider joining this study or working with Imperial Beach to understand lessons learned. It is possible to implement a network of multiple low-cost sensors (see the Delaware Department of Transportation (DOT) example in the text box below). No matter what type or how many sensors are used, it is useful to collect information wirelessly, and for the sensors to send notifications when water is approaching, water has covered the area, and when flooding has reached a specified depth of concern.

Additionally, tracking City costs spent responding to flooding can help build the business case for investing in a more permanent fix in the area. For example, Southeastern Pennsylvania Transportation Authority (SEPTA) experienced significant damage on their regional rail lines due to Hurricane Sandy in 2012. In an effort to better track costs associated with weather events, SEPTA developed a system for tracking staff hours spent addressing specific weather events, which gave the agency a fuller picture of the storm's costs and helped them successfully pursue federal reimbursements and grants for additional resilience improvements. This sort of tracking allows public agencies to use weather event costs to inform adaptive management and make well-informed decisions about how to target resilience measures.

Example Flood Tracking System

Delaware DOT (DelDOT) worked with the University of Delaware's Center for Environmental Monitoring and Analysis to develop low-cost sensors to deploy throughout the state. Previously, DelDOT had installed more expensive sensors in prioritized areas that had the highest risk of flooding. With an expanded network, the agency was able to better monitor the status of roads, issue flood warnings, and close roads that may be dangerous due to flooding. The sensors used sonic, optical, or resistance technology and an inexpensive Arduino microcontroller.

Figure AP-3: Installing a flood sensor in Delaware
(Source: Kevin Brinson and Minji Kong)

2.3.3 Continue to update emergency management planning documents to include climate change, as needed

What it is: The City's emergency response plans are a critical tool for preparing for events such as severe storms and flooding and reducing damages and injuries/loss of life. Currently, the City proactively prepares for potential flooding by positioning sandbags, signage, and other equipment at frequently flooded areas in advance of an expected storm. The current plans include addressing coastal flooding and storms. Moving forward, emergency management plans can be updated to account for more frequent and higher flooding due to sea level rise, as well as an expanded number of locations that experience flooding.

Tips for implementation: Coronado departments can continue to review their emergency response plans to ensure they are prepared to address the increased intensity, frequency, and extent of flooding expected with climate change, adjusting practices and protocols accordingly.

In addition, local jurisdictions must update their Local Hazard Mitigation Plans (LHMPs) every five years to maintain eligibility for FEMA's mitigation grant programs. When it is time to update the

County's LHMP, the City can provide comments to include hazard mitigation for flooding and other impacts related to sea level rise, such as those outlined in this plan.

Example Guidance on Updating Emergency Management Plans

Safeguarding California's Implementation Action Plan for the Emergency Management Sector presents four primary recommendations:

1. Improve integration of climate impacts and projections into all phases of emergency management (i.e., Preparedness, Response, Recovery, and Mitigation).
2. Support risk sharing mechanisms. Risk sharing and cost transferring systems like insurance and disaster relief can be tools for managing climate risk.
3. Better understand climate impacts to all phases of emergency management. To understand how climate impacts will affect each phase of emergency management, it is important to assess the adequacy of surge and response capacity considering climate projections.
4. Communicate climate risks since outreach efforts are integral in helping communities better understand and plan for climate risks and extreme events. Effective emergency planning can lower emergency response risks and costs.

Figure AP-4: Cover page of Safeguarding California's Implementation Action Plan for the Emergency Management Sector (Source: Safeguarding California)

2.4 Planning

2.4.1 Seek federal and state adaptation funding

What it is: The City does not have to completely self-fund its resilience activities -- there are already several sources of funding that are available to jurisdictions to implement adaptation measures. These are available at both the state and federal level, such as from Caltrans and FEMA.

Tips for implementation: FEMA mitigation grant opportunities include the Building Resilient Communities and Infrastructure (BRIC) Program, and the Hazard Mitigation Assistance (HMA) Program, which consists of the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), and Flood Mitigation Assistance (FMA), as well as Fire Management Assistance Grants (FMAGs) and Public Assistance Grants (Categories C-G).

At the state level, Assembly Bill 2140 (AB 2140, October 2006) allows a local jurisdiction to adopt their current, FEMA-approved Local Hazard Mitigation Plan into the Safety Element of their General Plan, which in turn can increase the percentage of available state disaster assistance through the California Disaster Assistance Act (CDAA).

The Governor's Office maintains an "Investing in Adaptation" webpage that lists funding opportunities and grant aggregation sites, including the California Grants Portal.

2.4.2 Incentivize private building retrofits

What it is: Creating incentives for private property owners to implement adaptation strategies can increase the likelihood of their uptake, especially if they're not yet mainstreamed into design (such retrofitting buildings for sea level rise). Incentives are also a useful tool for encouraging action by private property owners since building resilience to sea level rise in Coronado cannot be completed through City action alone. Incentives can be used as a politically neutral tool to encourage adaptation, rather than compelling action through regulatory measures.

Tips for implementation: Financial incentives include subsidies, grants, and rebates that reduce the initial costs required to conduct retrofits; as well as tax incentives (i.e., preferential assessment programs, tax abatements, and tax credits) that reduce costs to property owners over time (or as a one-time tax credit) as a reward for retrofitting their property for resilience. Incentives can also take the form of awards and recognition programs that provide marketing opportunities and public outreach for exemplary projects. The City might partner with non-profits and the private sector (such as insurance providers) to help implement the retrofits and incentives. The design of incentive programs should consider social equity and help support those who are least able to afford retrofits on their own.

For Coronado, a resilience incentive program could be modeled after California's earthquake retrofit programs, such as California's Earthquake Brace + Bolt. This program provides a $3,000 grant to qualifying older houses to help implement seismic retrofits and has another grant specifically for low-income homeowners. The program has a registration period once a year and selects grantees through a random drawing, then invites participants to implement a specific "building-code-compliant" seismic retrofit to their home's foundation. The program provides an optional contractor directory and suggested timeline for implementation.

Example use of incentives for private home retrofits

The City and County of Honolulu, HI developed a resilience strategy with 44 specific actions, one of which is to launch a hurricane retrofit program for vulnerable homes. The City is planning to first inventory homes to identify those built prior to certain resilient codes, prone to hurricane damage, and likely to house vulnerable populations. They will then offer a tax credit to property owners of these at-risk homes that successfully retrofit and certify completion. The City is considering partnering with non-profits and the private sector to provide the incentives. They are also informing property owners that retrofitted homes should qualify for a discount in hurricane insurance premiums from providers to show the financial benefits beyond the City's tax incentive.

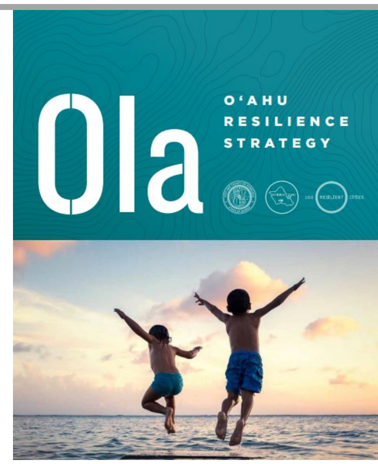

Figure AP-5: Cover page of O'ahu Resilience Strategy
(Source: City and County of Honolulu)

2.4.3 Utilize available planning tools and techniques

What it is: Coronado may consider using available planning tools to increase resilience and adapt to climate change. Options include zoning adjustments, such as:

- Increasing setback requirements to provide more space between homes and the ocean.
- Increasing allowed height of structures but limiting floor area ratio (FAR) (so structures can be elevated above future flood levels).
- Encouraging use of permeable pavement where appropriate (noting that in parts of the City where the groundwater is close to surface level like the Spanish Bight, this strategy may not be feasible).
- Using zoning overlays in areas that could use primarily nature-based solutions or hard engineered solutions.
- Implementing Transfers of Development Rights (TDR), a zoning method that conserves land by redirecting development from at-risk areas to more resilient areas.
- The City may also consider increasing density in the areas that are not flood prone, with the understanding that residents may desire to move away from the current coastline as sea level rises.

Tips for implementation: Many state and municipal planners across the U.S. have implemented or are considering strategies to integrate climate risks into existing planning processes. The City of Coronado may draw on examples of implementation (and work toward it) from municipalities such as:

- The City of Goleta (CA), which adopted a Hazard Zone Overlay District that imposed real-estate disclosures for coastal hazards, building code revisions, and development setbacks that account for accelerating sea level rise and erosion.

- Malibu's Local Coastal Program, which includes procedures for transferring development credits to encourage development outside of environmentally sensitive areas.
- In Massachusetts, many municipalities are currently using flood-resilient planning strategies such as floodplain overlay districts and design standards and guidelines to drive more resilient building construction and land development. The City of Boston is planning to implement a Coastal Resiliency Zoning Overlay District to formalize implementation of sea level rise- and storm-resilient construction and retrofits in at-risk regions.

In addition, the California Adaptation Planning Guide provides guidance to local governments on local adaptation and resilience planning, including integrating climate resilience and flood hazards into the Safety Element of General Plans in compliance with SB 379 and SB 1035.

2.5 Outreach

Climate change, sea level rise, and related impacts will not only affect City facilities and property but also the residents and businesses of Coronado. Despite the outreach conducted as part of this project, many residents of Coronado may not be aware of the risks they face due to climate change or fully understand why the City is proposing to implement adaptation strategies.

Coronado can build upon its existing public outreach activities to increase understanding of climate change risks and personal property adaptation options, in addition to bolstering public support for City adaptation actions.

Tips for implementation:

- When developing outreach materials, ground the discussion of climate change risk in real-life examples that the public can relate to, such as recent flooding.
- Explain that there is very strong scientific consensus that climate change impacts are already being experienced and will continue to increase.
- Emphasize the importance of preparing now – from both a safety as well as a cost-effectiveness standpoint.
- Ensure that outreach materials are available in multiple language (e.g., English and Spanish).
- Seek out partnerships with community leaders to help disseminate the resources to diverse segments of the population (e.g., elderly, youth, minorities).
- Engage the youth since they are the ones who will be most severely impacted by climate change within their lifetime.
- Use interactive engagement methods such as king tide photo contests or The Game of Floods.

3 Adaptation Action Area Strategies

Potential adaptation strategies are very dependent on the local sea level rise risks, the existing shape and form of the shoreline, and the amount of development. To understand location-specific adaptation options, the portions of the shoreline owned or maintained by the City of Coronado were broken up into ten Adaptation Action Areas. The Action Areas were developed based on similarities in their current land uses and the coastal form. Figure AP-6 shows the nine location-specific City of Coronado adaptation Action Areas. The areas include:

- Action Area 1: Edge of Navy property to Harborview Park
- Action Area 2: Harborview Park to Coronado Bridge touchdown
- Action Area 3: Coronado Municipal Golf Course
- Action Area 4: South edge of Coronado Golf Course to the east end of Strand Way parking
- Action Area 5: Coronado City Hall to Glorietta Bay Park
- Action Area 6: Coronado Beach
- Action Area 7: Coronado Shores Beach area to Avenida Lunar
- Action Area 8: State Route 75

Figure AP-6: The City of Coronado adaptation Action Areas

(Source: Image courtesy of Google Earth Pro)

- Action Area 9: Coronado Cays Residential Area
- Action Area S: Stormwater Systems Adaptation

Adaptation strategies were not developed for Port or Navy-owned/leased land, nor State Parks land, but close coordination will need to occur with those partners over time. Figure AP-7 shows the land jurisdictions in Coronado. However, there are a few exceptions to this. For example, adaptation strategies are proposed for the Coronado Municipal Golf Course since this area is leased from the Port by the City. State Route 75 (SR 75) is infrastructure that, although currently owned by the State (Caltrans), is considered for adaptation strategies as well since it is possible that the road will be transferred over to City management in the future. Additionally, The area of land between City Hall and Glorietta Bay Park is owned by the Port, however, the buildings within this area are owned and operated by the City so potential adaptation strategies are recommended.

In addition, the vulnerability assessment and the adaptation plan do not address utility and telecommunication assets owned by non-City entities (e.g., San Diego Gas & Electric, AT&T, Verizon, CalAM) but adaptation actions will need to be coordinated over time.

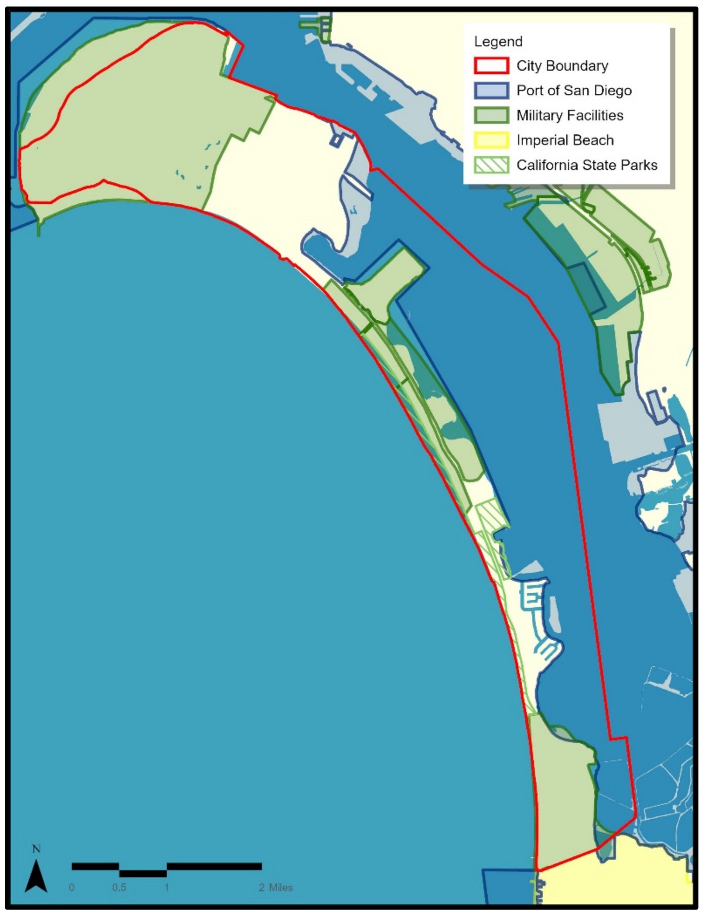

Figure AP-7: Jurisdictional boundaries for the land within the City of Coronado

The potential suite of adaptation strategies that may be appropriate in each Action Area are presented as adaptation pathways. Adaptation pathways are the visual representation of potential adaptation options with an estimated timeline for planning and implementation. The adaptation pathways highlight the relationships between adaptation strategies (e.g., when one might become ineffective and what other strategies could then be implemented to provide continuous protection) and showcase the full range of possible adaptation strategies.

The adaptation strategies are primarily presented as either/or options at different points in time, although in some cases more than one action could be taken for a given timeframe and Action Area. Adaptation strategies are intended to build on one another as triggers (e.g., the end of a related strategy; decreased beach width; forecasted storm) or certain levels of sea level rise increments are reached.[1] More advanced or aggressive strategies are triggered by higher levels of sea level rise. The exact timing of when those triggers will be reached is uncertain and requires monitoring.

The symbols used and the overall approach to adaptation pathways is exemplified in Figure AP-8. The black ovals at the top with decades are approximated and roughly align with the current 1-in-20 chance projections (i.e., a 5% probability that sea level rise meets or exceeds these amounts at the given time frame).[2] These sea level rise increments may occur sooner or later depending on how the future evolves.

In most of the following adaptation pathways, strategies are triggered (indicated by a circle) by a certain amount of sea level rise at which planning (indicated by a dashed line) for a more aggressive strategy needs to begin. This is to allow for time to implement (indicated by a triangle) the strategies by the time of expected impacts. Some strategies may only be effective up to a certain amount of sea level rise, while others may continue to be effective through the end of century (indicated by the length of the solid line). When an existing strategy is no longer effective, an alternative or additional strategy needs to be implemented (indicated by a transition arrow)

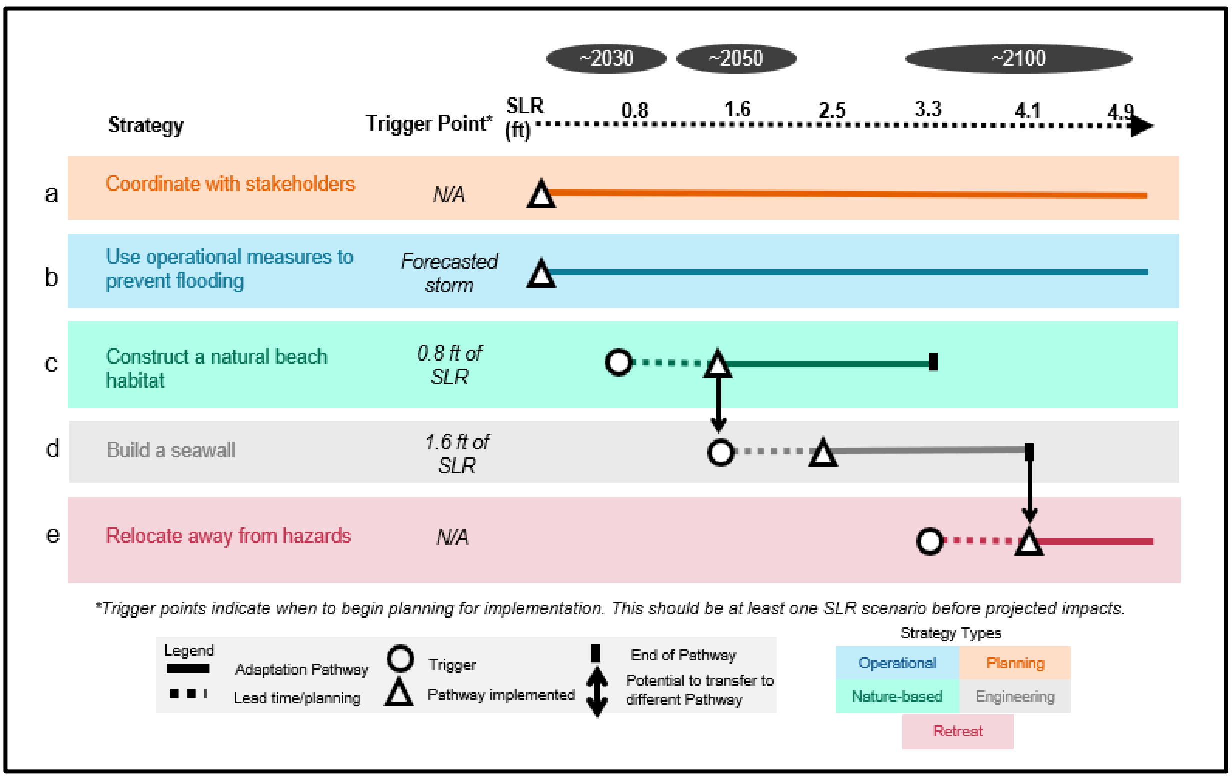

Figure AP-8: An example adaptation pathway.

[1] Sea level rise increments indicate number of feet above the baseline 2000 sea level. For example, 2030 projections indicate sea level rise of 0.8 feet above 2000 levels.

[2] Sea level rise projections are from the State of California Sea-Level Rise Guidance.

and the strategy eventually ends (indicated by a short vertical line). The use of “or” (with a double-headed transition arrow) indicates an either/or option between two potential adaptation strategies. The use of “and” (without a transfer arrow) indicates that two strategies must be implemented at the same time to effectively reduce risk.

For example, as shown in Figure AP-8, the planning process for a nature-based solution **(strategy c)** can begin at 0.8 feet of sea level rise. It should be fully implemented by the time sea levels rise 1.6 feet. It will continue to be effective until 3.3 feet of sea level rise. When the nature-based strategy is implemented at 1.6 feet of sea level rise, this triggers the start of planning for a supplemental engineering strategy **(strategy d)**, which should be implemented at 2.5 feet of sea level rise. The engineering strategy is no longer effective after 4.1 feet of sea level rise. When the engineering strategy ends, the managed retreat strategy **(strategy e)** is implemented. This strategy continues to be effective beyond 4.9 feet of sea level rise. Suggested planning and operational strategies sometimes do not have a “lead time/planning” dashed line, nor a “trigger” circle, while others—such as implementing special assessments—do include a planning period to account for the time it would take the City to organize consider where and when special assessments would be effective.

Each section also contains a discussion of the costs and benefits of the strategies to help inform priorities. These estimates should be refined as adaptation options are further considered and evaluated. A more detailed look at the strategy benefits can be found in Appendix AP-2.

The adaptation strategies fall within five categories:

- **Hard engineering:** Strategies that involve constructing or expanding a permanent structure (color coded in gray in tables and figures).
- **Nature-based:** Strategies that restore or enhance a natural feature using components of the environment (color coded in green in tables and figures).
- **Operational:** Strategies that are temporarily used by the City to mitigate hazard risk (color coded in blue in tables and figures).
- **Planning:** Strategies that use urban planning tools, such as zoning, or lay the groundwork for future hard engineering, nature-based, and managed retreat strategies (color coded in orange in tables and figures).
- **Managed retreat:** Strategies that relinquish land to the natural environment (color coded in red in tables and figures).

Table AP-1 provides an overview of the types of strategies included in each of these five categories. Refer to Appendix AP-1 for more details on each strategy.

Table AP-1: Summary of Proposed Adaptation Options

Category	Strategy	Description
Hard Engineering	Elevate or realign transportation infrastructure	Sea level rise and storm surge risks for transportation infrastructure can be mitigated by elevating the roads/bridges or moving infrastructure further inland.
	Construct/ enhance revetments	Revetments absorb the impact of incoming water to protect upland areas from coastal flooding and erosion. They may be sloped and lined with rip rap or ECOconcrete. Seawalls are a type of revetment, but they are not sloped.
	Install building retrofits	Building retrofits are constructed design elements that provide protection to existing buildings against flooding (e.g., floodproofing, increasing elevation).
	Construct/raise flood wall	Flood walls are typically a barrier made of concrete, without fill behind them. They are built at the site or regional scale to protect against storm surge.
	Construct/raise levee	Levees are wide areas with raised ground that are constructed along coastlines to reduce the risks of flooding by presenting a physical barrier to the incoming floodwaters.
	Install sand retention feature (e.g., groin or breakwater)	Groins run perpendicular to the beach and are typically made of stone or concrete. Breakwaters are structures built parallel to the shoreline and can be made of stone, formed concrete, or bagged shell material.
Nature-Based	Conduct beach renourishment/ Construct dunes	Beach renourishment involves adding sediment on or around an eroding beach and can include dune restoration. Dune restoration involves the buildup of sand at the back of a wide beach to create a mound to protect inland areas from storm surge.
	Construct floodable parks	Floodable parks make use of frequently flooded land and accommodate sea level rise by creating recreational spaces that intentionally allow for temporary inundation.
Operational	Temporary closure of asset or facility	Temporary closures of assets and facilities until flood waters recede are used to ensure public safety and avoid further damage to vulnerable areas.
	Sandbagging	Sandbags can be stacked and expanded to form temporary flood walls, protecting infrastructure from flood impacts.

Category	Strategy	Description
	Deployable flood control barriers	Deployable flood control barriers, such as sliding splash walls (walls that sit on a groove and slide into place when necessary) and water gates (inflatable plastic barriers that function similar to sandbags).
	Flooding alert system	A flooding alert system is a city-wide effort to notify residents and business owners when flood hazards are forecasted to occur.
Planning	Special assessments	Special assessments add a fee to property taxes for the area or district where resilience measures are planned to be implemented.
	Redevelopment restrictions	Redevelopment restrictions are a policy and regulatory measure prohibiting redevelopment of structures damaged by coastal impacts or requiring redevelopment to be more resilient to storm surge and sea level rise.
Managed Retreat	Managed Retreat	Managed retreat is the planned movement of people and infrastructure away from sea level rise and storm surge vulnerable areas. Retreat can be accomplished either organically or through a government program. Homeowners may choose to retreat because repeated flood damages have made it no longer cost effective to rebuild or insurance rates may increase to untenable levels. There are increasing incidence of proactive federal and state programs to create mandatory or voluntary buyout programs that encourage retreat of entire at-risk communities, although the ability to obtain funding for these programs in not guaranteed.

3.1 Action Area 1: Edge of Navy Property to Harborview Park

Figure AP-9: Existing conditions at the edge of Navy property to Harborview Park
(Source: Google Earth Pro)

> **Key Takeaways**
> Continued close coordination with the Navy will ensure sea level rise risks are managed in this area. In this area the Navy may be best suited to implement an effective strategy. City actions could include elevating First Street and installing flood walls along the border with Naval Air Station North Island (NASNI).

The coastal section of Action Area 1 extends from the eastern edge of the Naval Air Station North Island (NASNI) along First Street to Harborview Park at E Avenue (see Figure AP-9). The area consists of residential development and small neighborhood parks fronting the coastline. The shoreline is primarily covered in riprap with some homeowners having installed flood walls. The elevation in this Action Area ranges from 10 to 17 feet (NAVD88[3]), with pockets as low as 7 feet.

Coronado will need to coordinate with the Navy to implement some adaptation actions in this area due to the border with NASNI and the fact that most projected flooding in the area enters from naval property.

This Action Area also considers adaptation strategies to protect against the extensive potential flooding projected in the area of the former Spanish Bight. This low-lying filled area of residential homes is particularly vulnerable to sea level rise flooding flowing in from the coastline in this area.

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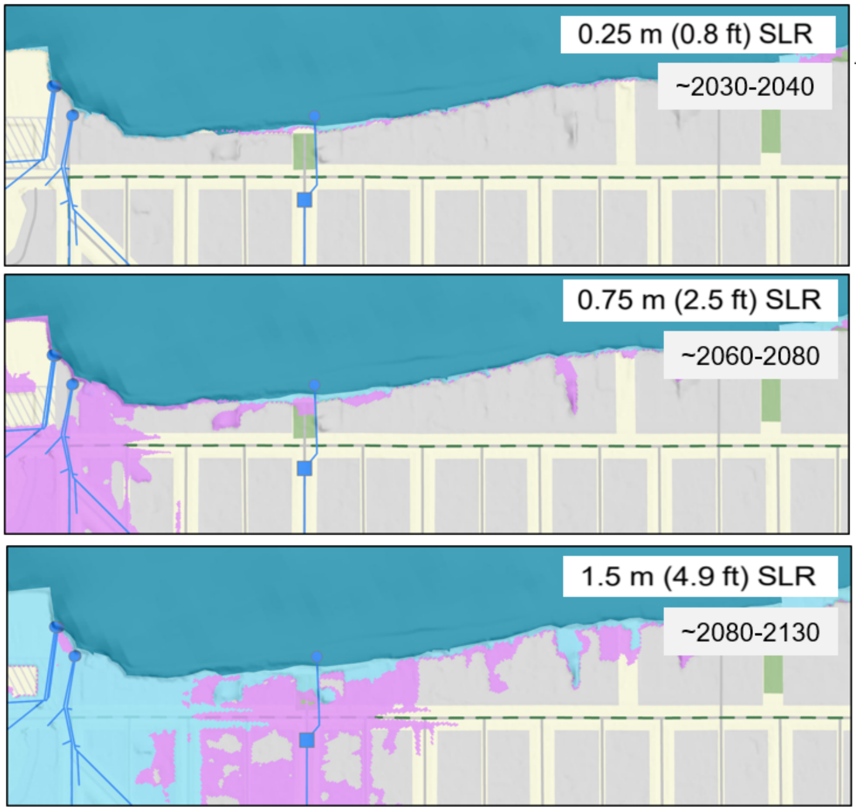
[3] Elevations are measured relative to the North American Vertical Datum of 1988 (NAVD88)

3.1.1 Coastal Vulnerability

As shown in Figure AP-10, over time this Action Area will be faced with increasing coastal flood risk from rising sea levels and 100-year storm events. For all of the flood maps in this plan, expanded maps and legends can be found in the Coronado Sea Level Rise Vulnerability Assessment.

The cost of inaction due to flooding entering from this area—or the cost of damages incurred and the value of properties lost by not implementing any adaptation strategies—is significant, estimated at $390M at 4.9 feet of sea level rise due to non-storm inundation.[4] This considered, the cost of inaction for non-storm inundation at 4.1 feet of sea level rise is $24M, indicating that almost all the costs would occur between 4.1 and 4.9 feet of sea level rise. These costs could be even greater if a 100-year storm occurred, with up to $164M more in damages if the storm occurs at 4.9 feet of sea level rise. If a 100-year storm occurred at 3.3 or 4.1 feet of sea level rise, the cost of damages is still likely to be significant, estimated at $18M and $139M, respectively.

[4] Values for cost of inaction estimates throughout this assessment are based on publicly available tax assessment data for total parcel value. The boundary data associated with the parcels are intended for tax assessment purposes only and are not guaranteed to be survey grade. The assessed value of property may also differ from current market value due to factors such as California Proposition 13, which limits any increase in value to two percent a year. Despite these potential limitations, assessment records are reliable for the scope and purpose of this analysis.



***0.8 ft. of sea level rise**: risk of flooding is minimal with only small areas exposed in the northeast, directly along the water's edge.*

***2.5 ft. of sea level rise**: flooding increases for homes and infrastructure along the border of NASNI. Multiple stormwater outlets may be regularly submerged. In the eastern portion, flooding may extend farther inland going south, but not significantly enough to impact infrastructure.*

***4.9 ft. of sea level rise**: most of the western half of the area and inland residential areas further south may be inundated or flooded. The eastern area is projected to be mostly dry except for private homes along the shore. Stormwater outlets are likely to be permanently inundated.*

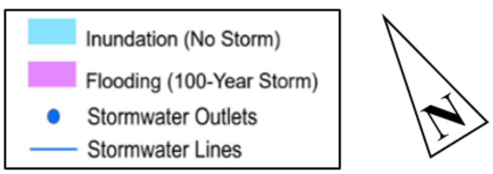


Figure AP-10: Approximate sea level rise projections over time at the edge of Navy Property to Harborview Park area.

3.1.2 Adaptation Options

The Action Area is predominantly residential, with single use and multi-unit residential development right at the water's edge. For ease of reading, the adaptation options in this area have been broken out into two core sets: one focused on the infrastructure and residential portions of the area and the other focused on the strategies for the parks.

3.1.2.1 Residential and Infrastructure Adaptation Options

The core residential and infrastructure strategies for this area focus on coordination with the Navy, updated zoning, a special assessment to fund future investments, operational strategies, and either raising First St. and Almeda Blvd. or installing flood walls (Figure AP-11).

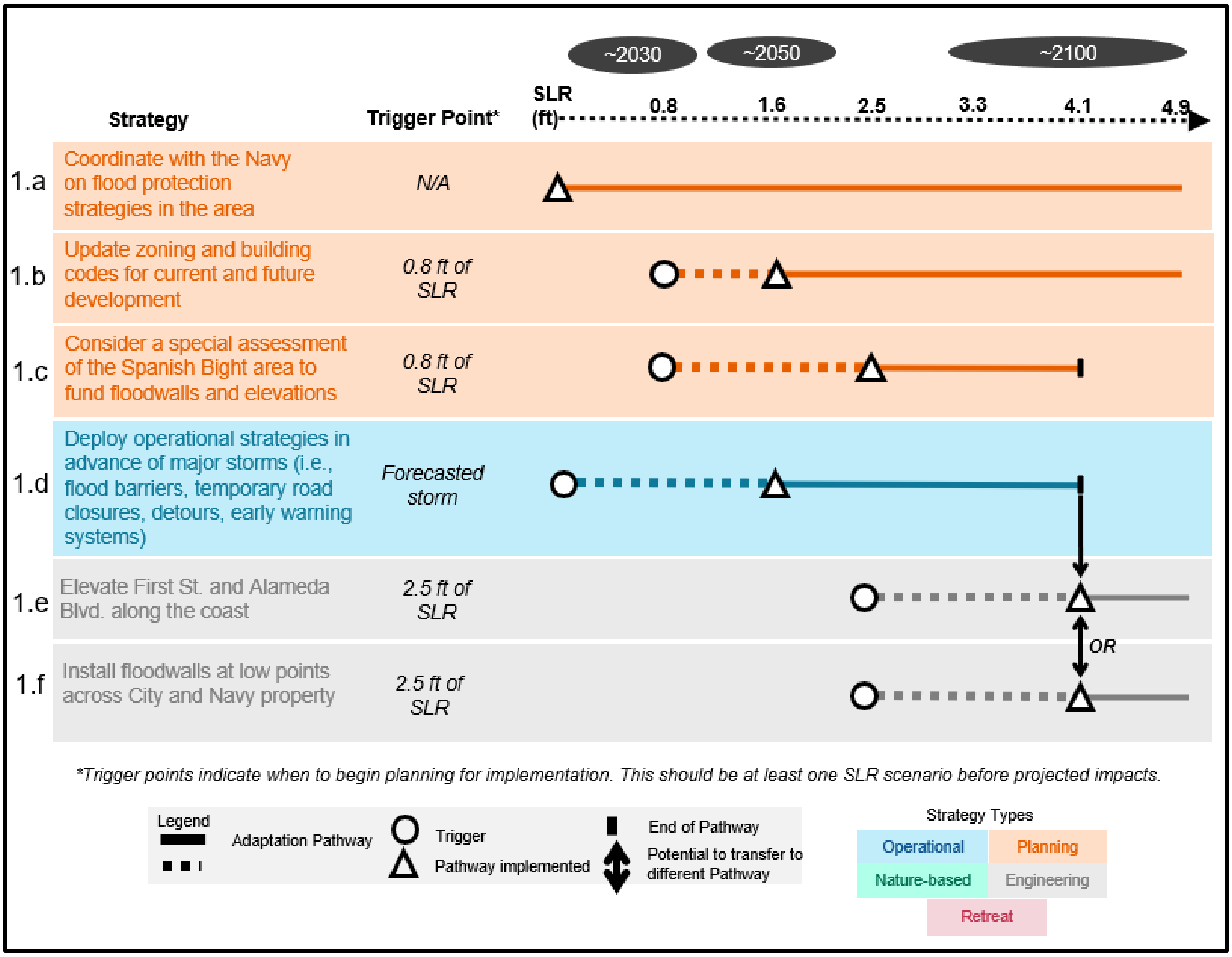


Figure AP-11: Strategies addressing infrastructure for edge of Navy property to Harborview Park area.

Adaptation strategies in this area should be planned in close coordination with the Navy, due to the border with NASNI and the significant flooding that enters the City from the Air Station. If the Navy chooses to invest in a waterfront protection measure on their property, it may significantly reduce the amount of flooding projected for this Action Area. Due to the importance of NASNI and the need to maintain Navy mission readiness, it is likely that the Navy will take action; however, it is too soon in their planning process to determine the level of protection that they may provide.

Coordination with the Navy (**strategy 1.a**) should be an ongoing effort as observed flooding and sea level rise changes over time. The City already frequently engages with leaders and planners from the Navy, including monthly public meetings of the Coronado Naval Complexes

Coordinating Group, and continued open and frequent communication will allow both parties to achieve their sea level rise resilience objectives.

While coordination with the Navy is in motion, the City may update zoning and building codes (**strategy 1.b**) including increasing setbacks to allow more room for flooding and raising height allowances to allow existing and future structures to be elevated above the future floodplain. The planning process for updating the zoning and building codes is triggered by 0.8 feet of sea level rise and could be implemented by 1.6 feet of sea level rise to be effective in mitigating flooding and inundation.

Should the Navy not implement any strategies at NASNI, the City should explore adaptation strategies that are within City purview to protect neighboring residences from flooding. The City may consider initiating planning for special assessments in the Spanish Bight area at 0.8 feet of sea level rise **(strategy 1.c)**, to fund the construction of flood walls and the implementation of elevation changes that would protect this residential area from future flooding. The special assessment program should be in place by 2.5 feet of sea level rise, because that is when the planning begins for the large investments in elevating roads or installing flood walls **(strategies 1.e and 1.f)**.

Along the Bay, the City cannot solely rely on individual homeowners to take sufficient action to protect inland City infrastructure from flooding. The first land that the City owns and could turn into a line of defense against sea level rise is First Street. Until approximately 4 feet of sea level rise, storm surge-driven flooding of the area is expected to be infrequent, so operational strategies (**strategy 1.d**) can be used to control flooding and warn residents of the risks. These operational strategies could include temporary flood barriers, temporary road closures, detours, and early warning systems for residents, some of which are already used by the City. Implementation of these operational strategies would be triggered by forecasted storms that are likely to result in flooding in the area.

Over time, the operational strategies will no longer be effective in protecting this area from flooding hazards, especially if there are no measures implemented on the Navy's property. To address the spreading inundation and flooding from 100-year storm surge events, First St. and Alameda Blvd. could be elevated to create a barrier protecting inland properties from flooding (**strategy 1.e**). Appropriate transitions from the elevated roads (assuming approximately one foot of elevation) and adjoining roads and private properties will need to be determined in future studies. This strategy has already been effectively used in Miami Beach. If the Navy does implement adaptation strategies, Strategy 1.e may be revised to only elevate First St.

An alternative to elevating the roads could be installing flood walls at low points across City and Navy property in this area (**strategy 1.f**). While this strategy takes up less physical room it may be hard to design it as robustly as needed to protect against daily water forces. Further engineering vetting would be required before selecting this strategy for implementation.

The planning processes for the potential engineering strategies 1.d and 1.e would be triggered at 2.5 ft of sea level rise, because they are large-scale strategies and will take additional time for planning and design before implementation. By 4.1 feet of sea level rise, operational strategies will be no longer effective at mitigating risks and one of the engineering strategies will need to be implemented.

3.1.2.2 Harborview and Bayview Park Adaptation Options

The adaptation approach for Harborview and Bayview Park includes two engineering strategies and a possible future retreat strategy where the parks can return to nature over time when continuing to protect them is out of step with neighboring land use decisions. Figure AP-12 shows the adaptation strategies recommended for Harborview and Bayview parks.

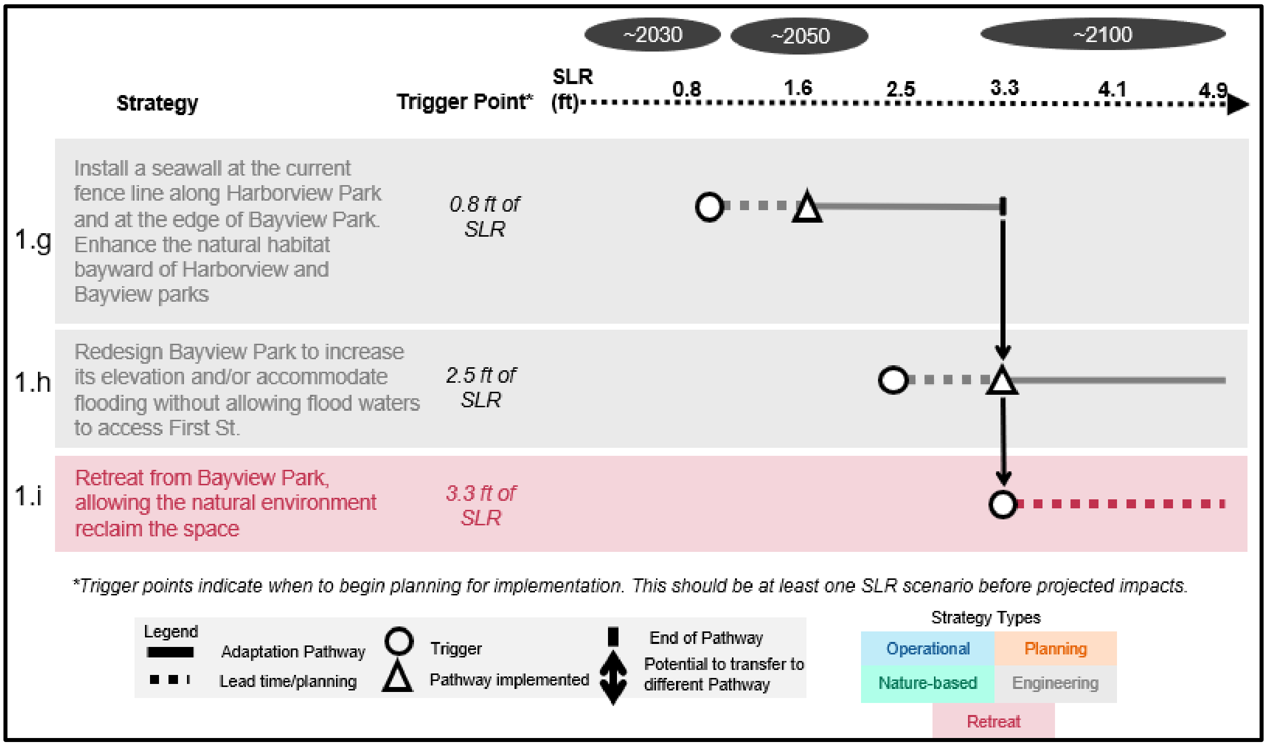


Figure AP-12: Strategies addressing Harborview and Bayview Parks.

The City may consider the installation of a seawall at the current fence line along the bayside of Harborview park and at the bayside edge of pavement at Bayview park (**strategy 1.g**). Installation

Figure AP-13: View from inside Bayview Park
(Source: City of Coronado's website)

of the seawall should consider if any enhancements to the natural habitat bayward of the seawall is possible. Enhancing natural habitat may create a better connection to the waterfront for residents and wildlife alike. Modifications to the intertidal habitat would need to be coordinated with the Port.

The seawall strategy would be triggered for planning at 0.8 feet of sea level rise and would be implemented by 1.6 feet of sea level rise. The seawall would effectively protect the parks until approximately 3.3 feet of sea level rise, at which point they would not be sufficient in preventing further inundation. At this point in the time, the seawall will be less effective in holding back flooding at Bayview Park (Harborview Park should remain operational) and the natural habitat bayward of the park will be fully inundated.

Redesigning Bayview Park at a higher elevation or to accommodate floodwater (**strategy 1.h**) is triggered by 2.5 ft of sea level rise. Elevated parks combine the community benefits of parks with the protections that engineered flood barriers provide. Elevated parks are constructed by increasing the elevation of land above future storm surge levels, generally with a seawall at the waterfront edge. Engaging, unique design can be used to maintain the publics connection to the water, such as with terracing down to the water's edge. The strategy should be implemented by 3.3 ft of sea level rise.

If the surrounding community begins to retreat from this Action Area due to unmanageable flooding beyond 4.9 feet of sea level rise, it would make sense to also retreat from Bayview Park. The Park could be planned for managed retreat by designing the structures to be removable and allowing for the area to flood and return to nature (**strategy 1.i**).

3.1.2.3 Pathway Costs and Cost of Inaction

Total Pathway Cost:	**Cost of Inaction:**
$4.5M-149M	$390M

The cost of inaction is over double the high-end cost estimate for the pathway strategies for this Action Area.

The estimated costs of the adaptation strategies outlined in this pathway range from $4.5M to $149M (2021). This depends on if the City chooses to either elevate First St. and Alameda Blvd. along the coast (**strategy 1.e**) ($74-148M) or instead install flood walls at low points across City and Navy property (**strategy 1.f**) ($4-6M). The cost of inaction of $390M for non-storm inundation at 4.9 ft sea level rise is over twice as much as the most expensive option, showing a positive return on investment from installing protective adaptation strategies proactively (see Coastal Vulnerability section above for more information on the cost of inaction). The costs of inaction rise considerably when considering projected storm impacts at 4.9 ft sea level rise, approaching an additional $140M in damages. Under these scenarios, the cost of inaction is significantly greater than the potential cost of adaptation strategies.

Elevating First St. and Alameda Blvd. (**strategy 1.e**) is the costliest strategy, accounting for approximately $74-148M of the total. The high cost is because the road is demolished and entirely rebuilt two feet higher on fill. Then, temporary detour lanes are constructed, utilities are relocated, and easements and right of way are to be modified.

This assessment may underestimate the total cost of the pathway and the cost of inaction since it is an approximation, and the cost of materials with inflation will likely increase by the time of implementation. The pathway cost estimate does not include the cost that individual homeowners on the bayside of First Street may bear to adapt their properties. However, the damage to private property is considered in the cost of inaction. It also does not include costs for grade transitions from the elevated First St. and Alameda Blvd. to adjacent roads and properties.

While comparing the cost of adaptation and inaction is useful, cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well.

Overall, the adaptation options for this area would be effective and beneficial for the economy but could have negative environmental impacts. Some of the key considerations for this pathway include:

- **Effectiveness**: These adaptation options would effectively protect public land and infrastructure in the Action Area against sea level rise and storm surge. However, the strategies do not address the action needed by individual homeowners along the Bay. These strategies aim to allow the residential community, parks, and infrastructure to remain in place as long as possible.
- **Economy:** This pathway would protect many homes and infrastructure far inland of just the coast, preserving tax revenues and spending in the community.
- **Flexibility:** The use of planning and operational strategies in the near term preserves the ability to make larger decisions about investments in seawalls, flood walls, and/or roadway elevation at a later time when the impacts of sea level rise are more evident. Once those strategies have been constructed it would be difficult to continue using a flexible approach.
- **Environment:** Seawalls do not create good habitat for flora and fauna along the shoreline, but this is mitigated by the recommended enhancement of natural habitat. The recommended strategies have a limited impact on the environmental quality of the area.

Table AP-2 summarizes the rated qualitative benefits of each individual strategy within the suite of adaptation options for this area. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-2: Qualitative Benefits of Pathway for Action Area 1.[5] *Effectiveness is broken into sea level rise (SLR) and storm surge (SS).*

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Planning	Redevelopment restrictions	SLR: green SS: green	yellow	green	yellow
	Special assessments	SLR: green SS: green	green	yellow	green
Operational	Temporary closure of asset or facility	SLR: red SS: yellow	green	yellow	red
	Sandbagging	SLR: red SS: yellow	green	yellow	green
	Deployable flood control barriers	SLR: red SS: yellow	green	yellow	green
	Flooding alert system for neighborhoods	SLR: red SS: green	green	yellow	yellow
Engineering	Construct/raise revetment	SLR: green SS: green	yellow	red	green
	Construct/raise flood wall	SLR: yellow SS: green	yellow	red	green
	Elevate or realign transportation infrastructure	SLR: green SS: green	yellow	yellow	green
Retreat	Managed Retreat	SLR: green SS: green	red	green	red

[5] Qualitative benefits for the economy and the environment were assessed on a positive (green), neutral (yellow), and negative (red) scale. Flexibility was assessed on a high (green), medium (yellow), and low (red) scale.

3.2 Action Area 2: Harborview Park to Coronado Bridge Touchdown

Figure AP-14: Existing Conditions at Harborview Park to Coronado Bridge touchdown
(Source: Google Earth Pro)

Key Takeaways

Continued coordination with the Port is critical since the Port owns most of the bayside land in this area and may be better suited to implement an effective sea level rise adaptation strategy. Coordination can ensure a comprehensive and complementary approach. City actions could include elevating First Street to serve as a barrier against further inland flooding.

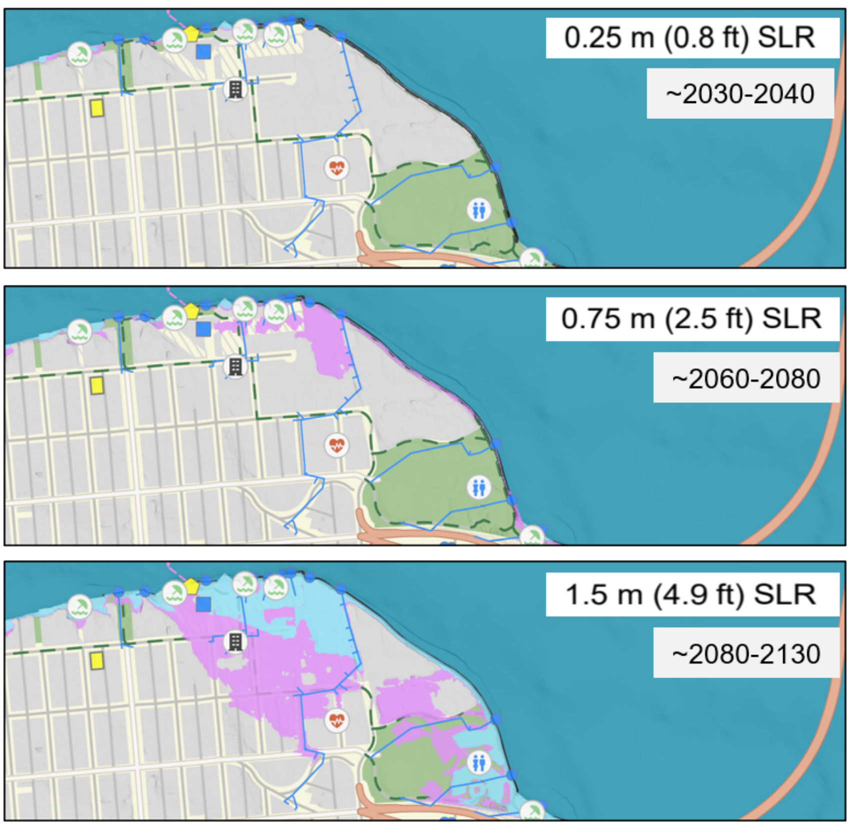
Figure AP-15: Tidelands Park and Bayshore Bikeway
(Source: Google Earth Pro)

Harborview Park to Coronado Bridge touchdown consists of a mix of residences (single family homes and a retirement community), businesses (hotels and restaurants), services (hospital and pharmacies) and public facilities (Public Services Department, parks, roads, and Bayshore Bikeway). The shore is lined with small beaches in the eastern portion of the area, a seawall by Centennial Park, and rip rap revetment in most other locations (see Figure AP-14). The elevation in this Action Area ranges from 6 to 18 feet (NAVD88). The areas with lower elevations are predominantly along the shoreline and roads. Most of the residences and businesses are at least 11 feet in elevation.

The coastal land in this Action Area is primarily owned by the Port so coordination will be necessary. The adaptation strategies provided in this section focus primarily on those that are within the City's purview to implement.

3.2.1 Coastal Vulnerability

As shown in Figure AP-16, the risk of coastal flood risk from rising sea levels and 100-year storm events will increase in this area over time.



0.8 ft. of sea level rise*: the risk of flooding is negligible.*

2.5 ft. of sea level rise*: the extent of periodic flooding increases drastically, affecting homes, businesses, beaches, parking lots, the Bayshore Bikeway and infrastructure at Ferry Landing. Multiple stormwater outlets may be regularly submerged.*

4.9 ft. of sea level rise*: Ferry Landing may be permanently inundated, with an even greater area inland area flooded by a 100-year storm surge. Tidelands Park may be partially flooded. Stormwater outlets may be permanently inundated.*

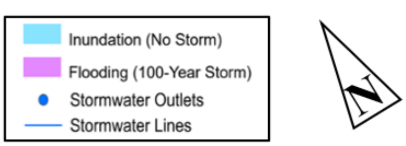


Figure AP-16: Approximate sea level rise projections over time at the Harborview Park to Coronado Bridge touchdown

3.2.2 Adaptation Options

The adaptation pathway for this Action Area includes coordination with the Port, continued elevation of First St. and dry floodproofing the Public Services Building as illustrated in Figure AP-17.

As mentioned previously, this pathway focuses on adaptation strategies within the City's purview rather than making presumptions about what actions the Port may take to protect the area. Given the Port's work identifying sea level rise vulnerabilities[6] and committing to the development of an adaptation plan in their Port Master Plan Update[7], it is likely that they will take action; however, it is too soon in their planning process to determine the level of protection that their actions may provide. For all these reasons, it is critical that adaptation strategies in this area be planned in close coordination with the Port. Coordinating with the Port (**strategy 2.a**) is a consistent and continuing priority for this area.

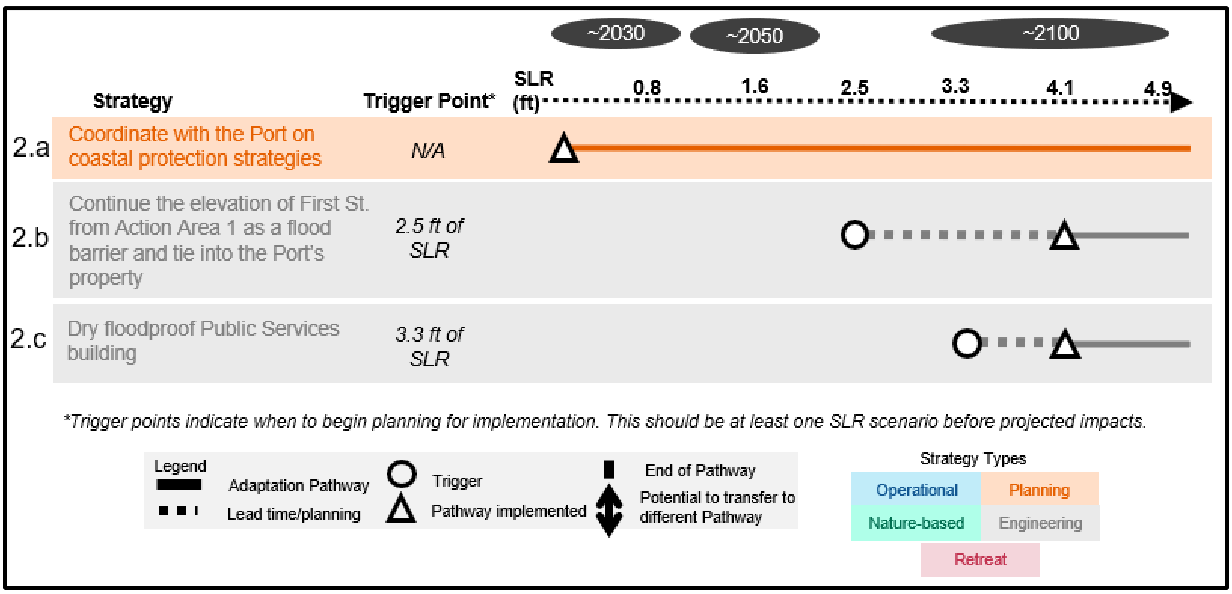


Figure AP-17: Strategies addressing infrastructure and residential areas for the Harborview Park to Coronado Bridge touchdown area.

Since the City does not have any purview over the Ferry Landing area to prevent floodwaters from entering the building, the first location where the City could realistically take action to protect inland areas from flooding is First Street. If the Port does not invest in protecting the

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[6] Port of San Diego, 2019. Sea Level Rise Vulnerability Assessment & Coastal Resiliency Report. https://pantheonstorage.blob.core.windows.net/environment/FINAL-San-Diego-Unified-Port-District-Sea-Level-Rise-Vulnerability-and-Coastal-Resiliency-Report-AB691.pdf

[7] Port of San Diego, 2021. Draft Port Master Plan Update. https://www.portofsandiego.org/waterfront-development/port-master-plan-update

Ferry Landing area, the City could elevate First Street approximately one foot to maintain connectivity and transportation access, as well as block incoming flood waters from traveling even further inland (**strategy 2.b**). Elevating First Street is also a potential strategy identified in Action Area 1. The strategy is triggered for planning at approximately 2.5 feet of sea level rise and would need to be implemented by 4.1 feet of sea level rise. This long lead time for planning represents the complexity of this strategy. Elevating First Street must account for the potential adverse impacts of infrastructure change, such as impacts to drainage and changes in transportation connectivity during and after construction. It would also need to be designed to accommodate grade transitions between neighboring streets and properties. The strategy would be effective beyond 4.9 ft of sea level rise though at some point beyond that, as sea levels continue to rise, it may become necessary to further elevate the street.

The City may also want to consider how to prepare the Public Services building for flooding if action is not taken along the coastline by the Port to protect this area. Dry floodproofing the Coronado Public Services building (**strategy 2.c**) would entail building modifications (e.g., watertight gates or shields at doors and windows, using sealants to prevent water from entering through walls, and/or preventing sewer backup). Dry floodproofing should be implemented by 4.1 ft of sea level rise if no other protection measures are put in place. Since the building is only projected to be impacted by occasional storm flooding, this strategy will continue to be effective until the end of the buildings use.

While not included in the adaptation pathway for this Action Area, some of the strategies that the Port could consider in this area include:

- Constructing a ramped wall at the back end of the pocket beaches by the Ferry Landing that can be increased in elevation over time, allowing for beach adaptation.
- Redesigning Tidelands Park as either a floodable or elevated park.
- Closing parking lots in advance of forecasted storms to deter vehicles from parking in the potentially flooded area.
- Elevating the Bayshore Bikeway on top of a levee to serve as a continuous flood barrier in this area and elevate the ferry landing pier.
- Convert developed and impervious areas around the Ferry Landing to natural conditions (e.g., beach/marsh).

While these actions may work well in this area, this list is not exhaustive. The City has no control over what the Port may choose to implement on its property.

3.2.2.1 Pathway Costs and Cost of Inaction

Total Pathway Cost:	Cost of Inaction:
$45-91M	$4M

The cost to the City of implementing strategies from this pathway is roughly $40-87M more than the cost of inaction, although the cost of inaction does not include costs to Port property. This highlights the need to coordinate with the Port on potential strategies.

The cost of inaction at this area—or the cost of damages incurred and the value of private properties lost by not implementing any adaptation strategies— is estimated based on tax assessors' data at $4M for non-storm inundation at 4.9 feet of sea level rise. This value is lower than reality since it does not account for the Port's valuable ferry landing property and commerce due to its tax-exempt status.

The cost is amplified drastically by the occurrence of a 100-year storm, with potentially $59M more in damages if the storm occurs at 4.9 feet of sea level rise since at that point the flooding extends to residential areas. If a 100-year storm occurred at 3.3 feet of sea level rise, the cost of damages would be much less at approximately $652,000. This reiterates that the spread of 100-year storm flooding is most significant at 4.1 or more feet of sea level rise.

The cost of the possible City adaptation strategies is estimated at $45-91M (2021). This is roughly $40-87M more than the cost of inaction for non-storm inundation at 4.9 ft. This emphasizes that it is worth exploring with the Port the adaptation strategies that they may undertake on their property. It may be more cost effective for the Port to address the projected flooding in this area. Depending on the actions taken by the Port, the City may not need to invest in any additional strategies.

Continuing the elevation of First St. from Action Area 1 as a flood barrier and tying it into the Port's property (**strategy 2.b**) is the costliest strategy, estimated at approximately $85M. The high cost is because the road is demolished and entirely rebuilt two feet higher on fill.

This assessment may underestimate the total cost of the pathway and the cost of inaction since it is an approximation, and the cost of materials with inflation will increase by the time of implementation. The cost for strategies implemented on Port land will be assessed by the Port.

While comparing the cost of action and inaction is useful, cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well.

Overall, the pathway for this Action Area is effective and beneficial for the economy, but it could have some drawbacks in its flexibility. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, adaptation in this Action Area will be most effective if the Port is able to address vulnerabilities at the water's edge. If that does not occur, this pathway could effectively protect the residential community, businesses, services, public facilities, and infrastructure inland of First Street to remain in place.

- **Economy:** This pathway would preserve some commerce in the area, protect valuable properties, and support necessary infrastructure. However, important landmarks such as the Ferry Landing, which attracts tourists annually, will not be preserved without efforts from the Port.
- **Flexibility:** Since physical adaptation measures do not need to be implemented till 4.1 ft of sea level rise, this pathway allows time for the Port to choose their adaptation strategies for this area. Once building retrofit and roadway elevation have been implemented, it is difficult to continue using a flexible approach within those strategies.
- **Environment:** While planning and design should continue to consider environmental impacts, the proposed strategies are not expected to have a significant impact on the environment since the area is already developed.

Table AP-3 summarizes the rated qualitative benefits of each individual strategy within the pathway. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as “good” or “bad” but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-3: Qualitative Benefits of Pathway for Action Area 2. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Engineering	Install building retrofits	SLR: 🟡 SS: 🟢	🟡	🟡	🟢
	Elevate or realign transportation infrastructure	SLR: 🟢 SS: 🟢	🟡	🟡	🟢

3.3 Action Area 3: Coronado Municipal Golf Course

Figure AP-18: Existing Conditions at the Coronado Municipal Golf Course
(Source: Google Earth Pro)

Key Takeaways

To reduce future sea level rise risks, two long-term adaptation pathways may be considered:

Option 1: An engineering approach focused on retaining the golf course by raising revetments, building a seawall, regrading the golf course, and elevating infrastructure.

Option 2: A managed retreat approach that would eventually close the golf course and relocate the tennis center while protecting inland residences.

Continued coordination with the Port is essential since the golf course land is leased from the Port.

Action Area 3's boundaries extend from the Coronado Bridge touchdown to the Coronado Tennis Center on Glorietta Bay, encompassing all of the Coronado Municipal Golf Course (Figure AP-18). The shoreline consists of some beach areas but is primarily riprap revetment. The elevation in this Action Area ranges from 6 to 16 feet (NAVD88). The areas with lower elevations are predominantly along Glorietta Bay. Most of the residences that are surrounded by the golf course are at least 10 feet in elevation.

Figure AP-19: Southern shoreline of the Coronado Municipal Golf Course
Image courtesy of Google Earth Pro.

Almost all of this Action Area is owned by the Port; however, the City leases the land for and manages the municipal golf course. Continued coordination with the Port will be needed to determine the best course of action.

3.3.1 Coastal Vulnerability

As shown in Figure AP-20, the Coronado Municipal Golf Course will be faced with increasing risk from coastal flooding due to rising sea levels and 100-year storm events.

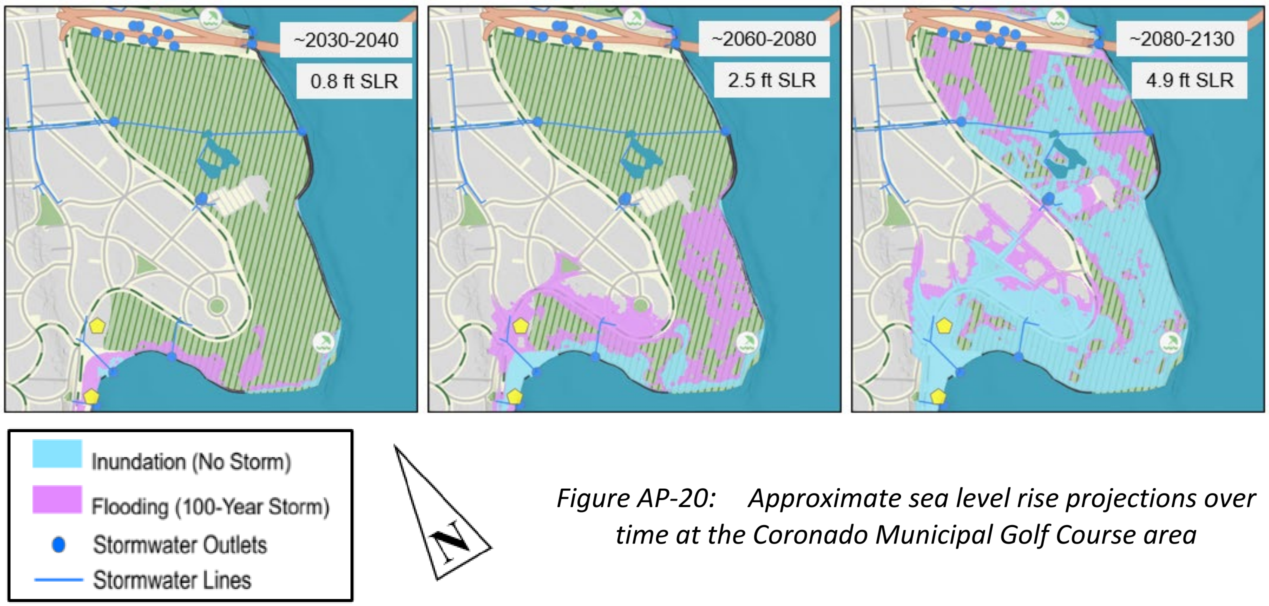


Figure AP-20: Approximate sea level rise projections over time at the Coronado Municipal Golf Course area

0.8 ft. of sea level rise: *risk of storm flooding in the southwestern portion of the area, along the shoreline of Glorietta Bay.*

2.5 ft. of sea level rise: *the extent of periodic flooding due to storms may increase, covering more of the golf course, spilling into the surrounding residential area, and flooding the tennis center. Additionally, the area along the southern and western shores fronting Glorietta Bay may be permanently inundated.*

4.9 ft. of sea level rise: *most of the golf course, the tennis center, and many homes may be permanently inundated. The inundation is expected to reach the northern end of the golf course and cover the southern section of Glorietta Boulevard that runs along the golf course. At this point, the golf course and tennis center would be entirely inoperable. Two stormwater outlets along the*

The cost of inaction at this area—or the cost of damages incurred, and the value of properties lost by not implementing any adaptation strategies—is estimated at $37M at 4.1 feet and $64M at 4.9 ft sea level rise due to non-storm inundation. This indicates that flooding and inundation continues to spread into the residential area due to non-storm inundation at 4.9 feet, causing an increase in damages. The cost is amplified drastically by the occurrence of a 100-year storm, with potentially $20M in damages from flooding if the storm occurs at 4.9 feet of sea level rise, primarily due to the value of the additional homes that will be impacted in this scenario.

Note that these costs due not account for the value of the golf course since Port land is tax-exempt and these estimates are based on tax assessors' data. In addition, if the golf course were to be redeveloped as a hotel or other commercial property, the land could be exceptionally valuable.

3.3.2 Adaptation Options

Since Coronado leases the golf course land in this area from the Port and is responsible for maintenance and upgrades, a full suite of potential adaptation options has been developed. The City may implement these strategies as long as the City leases the golf course and receives permission from the Port. If the lease is terminated, then the City would not bear the costs of adaptation. Selection and implementation of any of these options would require coordination and collaboration between Coronado and the Port.

The Coronado Municipal Golf Course area lends itself to two adaptation pathway options:

1. An approach primarily using **engineered solutions** to regrade areas, raise revetments, build seawalls, and elevate infrastructure.
2. A primarily **managed retreat** pathway that provides options in how retreat is approached.

Engineered solutions and managed retreat were selected as the strategy options for this Action Area because of the current land use and the severity of projected long-term inundation from sea level rise. The area is primarily open green space as a golf course, and engineering strategies would work to preserve the recreational value of the area. However, managed retreat would be a viable option for this area as there are few structures to remove to allow the area to transition back to natural habitat.

The adaptation pathways for the Coronado Municipal Golf Course are illustrated with two graphics. One displays the engineering pathway (Figure AP-21). The other displays the managed retreat pathway (Figure AP-22). Then both are displayed together with a combined graphic (Figure AP-23) that denotes the points at which differing strategies may be pursued.

3.3.2.1 Engineering Pathway to Withstand Sea Level Rise

One pathway option for the Coronado Municipal Golf Course area, as shown in Figure AP-21, emphasizes the continued use of this area as a golf course through the foreseeable future. This option uses hard engineering solutions to raise and reinforce existing revetments, build seawall, regrade, and elevate cycling infrastructure.

The City will need to coordinate with the Port to ensure coastal protection strategies are planned and implemented according to respective jurisdictions (**strategy 3.a**). As mentioned previously, this pathway focuses on adaptation strategies within the City's purview and assumes no action from the Port to protect the area. Given the Port's work identifying sea level rise vulnerabilities[8] and committing to the development of an adaptation plan in their Port Master Plan Update[9], it is likely that they will take action; however, it is too soon in their planning process to determine the level of protection that they may provide. For all these reasons, it is critical that adaptation strategies in this area be planned in close coordination with the Port.

Operational strategies such as temporary road closures, detours, and early warning systems could be used in the event of a forecasted storm to protect infrastructure in the area (**strategy 3.b**), such as Glorietta Blvd. The City already uses operational strategies across the City. As more robust adaptation strategies are put in place, there will not be as great of a need for operational strategies. However, a storm larger than the 100-year storm could hit at any time and having operational strategies ready to go can mitigate potential damage.

[8] Port of San Diego, 2019. Sea Level Rise Vulnerability Assessment & Coastal Resiliency Report. https://pantheonstorage.blob.core.windows.net/environment/FINAL-San-Diego-Unified-Port-District-Sea-Level-Rise-Vulnerability-and-Coastal-Resiliency-Report-AB691.pdf

[9] Port of San Diego, 2021. Draft Port Master Plan Update. https://www.portofsandiego.org/waterfront-development/port-master-plan-update

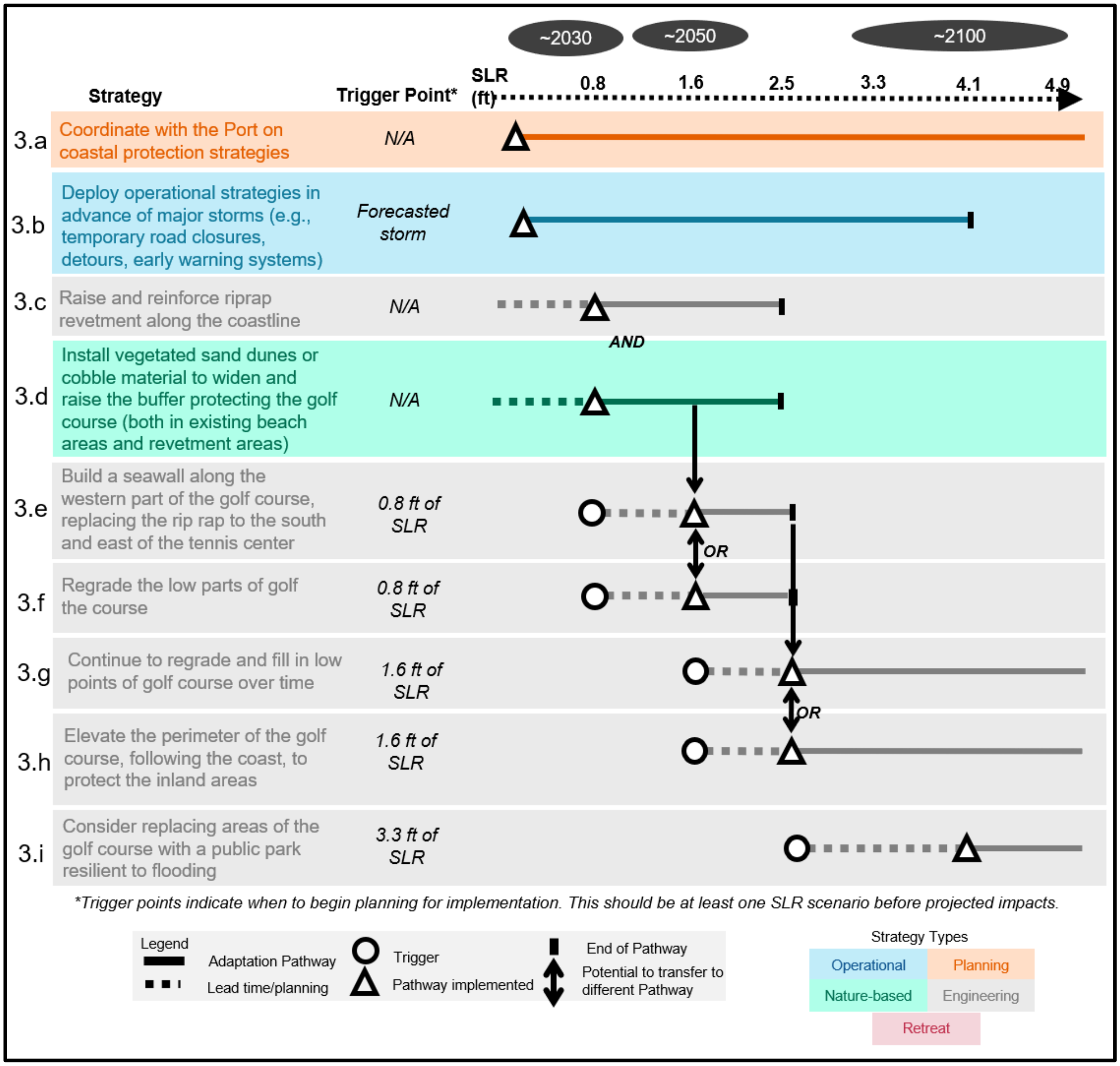


Figure AP-21: Engineering adaptation pathway for the Coronado Municipal Golf Course Area

Two strategies are recommended to be put in place by 0.8 feet of sea level rise:

1. Raising and reinforcing the riprap revetment along the Glorietta Bay coastline of the golf course (**strategy 3.c**). The revetment in this area stabilizes the shoreline and limits erosion. Since there is already existing revetment, planning for raising and reinforcing it can begin immediately.
2. Installing vegetated sand dunes or cobble material to widen and raise the buffer between the golf course and the water (**strategy 3.d**) both in existing beach areas and along existing revetments. Sand dunes or cobble material can break the movement of

water inland, dissipating storm surge. The wider the beach area is, the greater its ability to stop wave movement.

Both raising the revetments and widening the natural buffer between the golf course and the water will no longer be sufficient to prevent significant flooding from sea level rise and storm surge by 2.5 feet of sea level rise.

As sea levels continue to increase, there are two options for addressing flood risks:

1. A seawall could be built along the western part of the golf course, along Glorietta Bay, replacing the current rip rap revetment along the shoreline (**strategy 3.e**). This would provide greater protection against the risk of inundation, as seawalls are a more reinforced strategy compared to a riprap revetment and a seawall could be higher.
2. Alternatively, the City may consider regrading the low parts of the golf course (**strategy 3.f**), approximately one foot, leaving the riprap revetments in the same location but elevating them with additional rock placement to raise the revetment elevation to match the new topography. This would allow the topography of the golf course itself to prevent flooding.

Both building a seawall and regrading the low parts of the golf course will only be effective until 2.5 feet of sea level rise, at which point they are not sufficient in protecting inland areas from 100-year storm surge or sea level rise since the area where water is overtopping the existing shoreline edge will expand.

Once 2.5 feet of sea level rise is reached, additional engineering options could be implemented. One option is to continue to regrade and fill in the low parts of the golf course over time (**strategy 3.g**). Another is to elevate just the perimeter of the golf course two to three feet, following the coast, to protect the inland areas (**strategy 3.h**). Rather than regrading, elevating the perimeter would involve creating an elevated structure (e.g., a levee) along the perimeter to protect the inland golf course.

Both options (**strategy 3.g and 3.h**) would provide protection continuously beyond 4.9 feet of sea level rise. The design of both strategies should consider the projected increase in sea level rise over time, and flooding should be closely monitored to ensure the strategies are sufficient.

Lastly, the City and/or Port could consider replacing most of the golf course with a public park resilient to flooding (**strategy 3.i**). Floodable parks provide a space that can safely accommodate incoming sea water during storm surge and flooding events. Certain parts of the park may also be designed to adapt and hold water over time as inundation becomes permanent. This would offer a transformed amenity to residents that could be both engaging and innovative. The City may reimagine the area as a marquee waterfront park that's open to all and is still floodable along the water's edge to connect people to the waterfront.

3.3.2.2 Engineering Pathway Costs and Cost of Inaction

Total Pathway Cost:	Cost of Inaction:
$23M-$85M	$64M

The cost to the City of implementing strategies from this pathway may be significantly less than the cost of inaction, but that depends on the selected adaptation option and how costs evolve over time.

Depending on the strategies chosen, the estimated costs of the adaptation strategies outlined in this pathway are between $23M and $85M (2021). The cost of inaction is $64M for non-storm inundation at 4.9 feet (see Coastal Vulnerability section above for more information).

While most of the engineering strategies are within a similar cost estimate, elevating the perimeter of the golf course to protect the inland areas (**strategy 3.h**) is the costliest strategy, estimated at approximately $9-24M. The high cost is due to the revetment being built from expensive 5-ton armor stone. This is in accordance with the standard coastal engineering design designated by the U.S. Army Corps of Engineers. Current estimates indicate that regrading the golf course over time may be more cost effective than choosing the perimeter protection options.

This assessment may underestimate the total cost of the pathway and the cost of inaction since it is an approximation, and the cost of materials with inflation will likely increase by the time of implementation. The possibility of sharing the costs of these strategies will have to be examined in close collaboration with the Port.

While comparing the cost of action and inaction is useful, cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well.

Overall, the engineering pathway for the Coronado Municipal Golf Course area is beneficial for the economy, but there may be some drawbacks as to the effectiveness of operational strategies. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway will be effective at protecting the Coronado Municipal Golf Course area against sea level rise and storm surge, allowing the inland private properties, tennis center, golf course, and Glorietta Blvd. to remain in place.
- **Economy:** This pathway would preserve the operational uses of this area, protecting properties and supporting Glorietta Blvd. The golf course may continue to be used, which will be a source of revenue for the City.
- **Flexibility:** This pathway, especially the near-term nature-based and operational strategies, offers flexibility and time to decide between the various engineering strategies such as raising and reinforcing the revetment, regrading, and elevating and extending the Bayshore Bikeway. Once the engineering strategies have been constructed it may be difficult to continue using a flexible approach.

- **Environment:** These strategies largely do not have an apparent impact on the environment, except for building a seawall which may have negative environmental repercussions. Adding cobble and beach can have both positive and negative implications for habitat.

Table AP-4 summarizes the rated qualitative benefits of each individual strategy within the pathway. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making.

The proposed regrading actions (**strategies 3.f, 3.g, and 3.h**) are most aligned with the "Construct floodable parks" benefits. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-4: Qualitative Benefits of Engineering Pathway for Action Area 3. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Nature-Based	Construct dunes	SLR: 🟡 SS: 🟢	🟢	🟢	🟢
	Construct floodable parks	SLR: 🟢 SS: 🟢	🟢	🟢	🟡
Operational	Temporary closure of asset or facility	SLR: 🔴 SS: 🟡	🟢	🟡	🔴
	Sandbagging	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
	Deployable flood control barriers	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
	Flooding alert system for neighborhoods	SLR: 🔴 SS: 🟢	🟢	🟡	🟡
Engineering	Construct/enhance revetments	SLR: 🟢 SS: 🟢	🟡	🔴	🟢
	Construct/raise seawall	SLR: 🟢 SS: 🟢	🟡	🔴	🟢

3.3.2.3 Managed Retreat Pathway to Withstand Sea Level Rise

As an alternative to the engineering-focused approach, the City could implement a managed retreat approach (Figure AP-22), where the land currently occupied by the golf course and tennis center are gradually transitioned back to a natural landscape that can be reclaimed by the rising sea. The decision to use a managed retreat approach rather than a protection or redevelopment approach would need to be made by the Port (**strategy 3.a**).

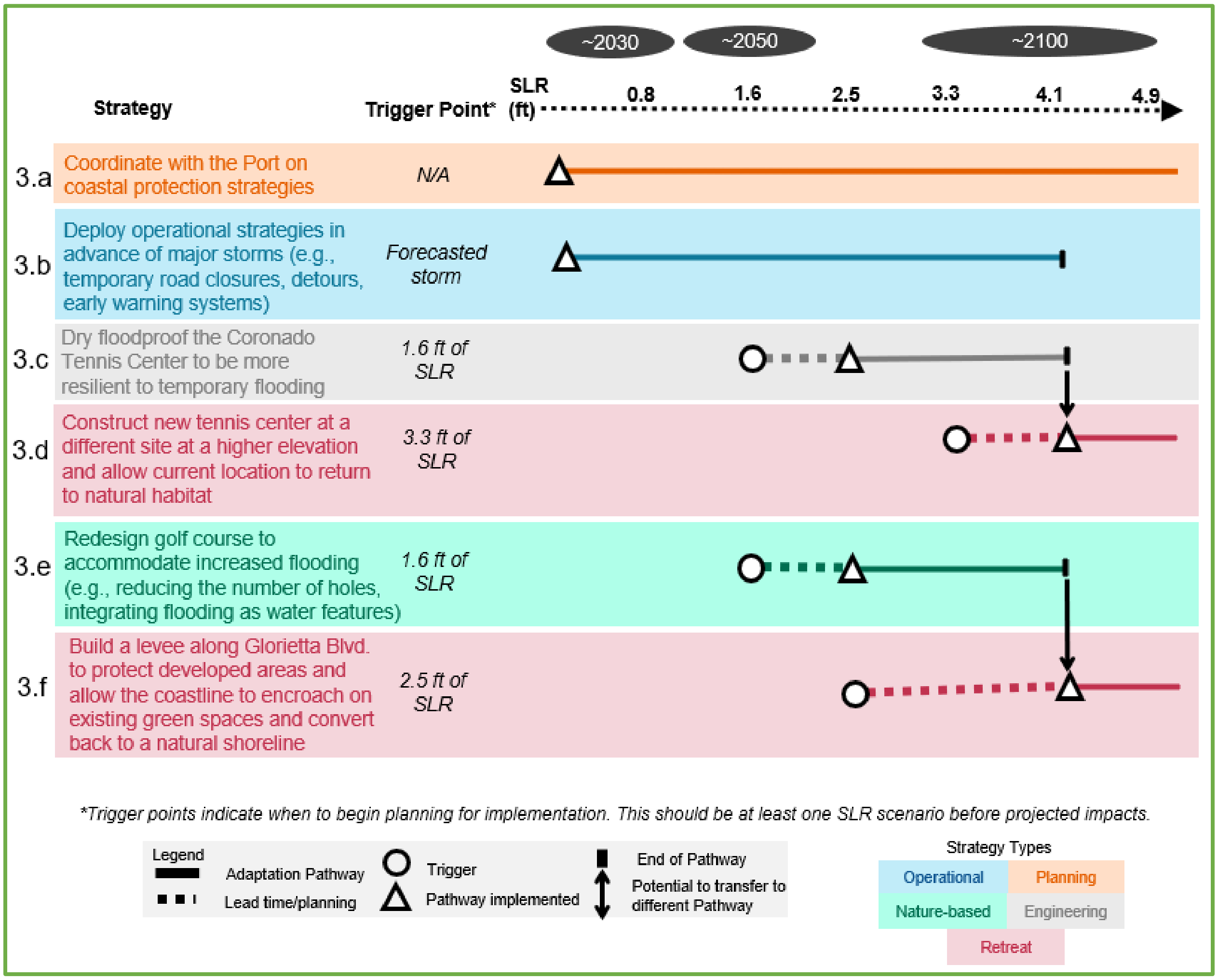


Figure AP-22: Managed retreat adaptation pathway for Coronado Municipal Golf Course area

In the near term, a combination of operational and engineering strategies would be used to allow residents to continue to enjoy the golf course and the Coronado Tennis Center until flooding presents too significant of a risk. Like the engineering approach, in the near term this pathway focuses on addressing the potential periodic flooding issues in the southern and western parts of the golf course by developing operational plans (**strategy 3.b**). These operational strategies may include detours along Glorietta Blvd., an early flood warning system for local residents, plans for golf course closures, sandbagging around the tennis center, etc.

As flooding becomes more frequent around 2.5 feet of sea level rise, the Coronado Tennis Center can be dry floodproofed, with planning beginning at 1.6 feet (**strategy 3.c**). Dry floodproofing can protect against storm flooding, which is the primary risk at this time. This would entail building low walls around the tennis center and courts, creating flood clean-up plans, and installing temporary barriers at the entrances to the building. However, floodproofing the tennis center is likely only effective until 4.1 feet of sea level rise. At that point, the tennis center would be regularly inundated and likely inoperable. Relocating the Coronado Tennis Center to another location would allow this area to become permanently flooded and gradually return to natural habitat (**strategy 3.d**) as sea levels continue to rise into the end of the century and beyond. Because this strategy would require the dismantling of existing structures and the design of a new location, it is recommended for the planning process to begin as early as 2.5 feet of sea level rise.

As the golf course becomes threatened by more frequent flooding, it could be redesigned to accommodate those flood waters and make them a feature of the course for a period of time (**strategy 3.e**). The Coronado Municipal Golf Course will experience some periodic flooding as early as 0.8 feet of sea level rise, but frequent flooding will not occur until around 1.6 feet of sea level rise. Therefore, it will be important to begin redesigning the golf course around that time with an implemented redesign before 2.5 feet of sea level rise. This redesign could include reducing the number of holes and integrating flooding as water features. This would allow the golf course to continue operations, perhaps enhancing the course with interesting features and allowing this amenity to continue for the residents of Coronado. However, this redesign strategy will have limitations. As sea level rise reaches 4.1 feet, vast portions of the golf course will be inundated with permanent floodwaters and additional 100-year storm surge, obstructing its use. At that time, the golf course would be closed and the land could be allowed to return to natural habitat.

To protect the inland communities and infrastructure, a levee can be built along the Bayside of Glorietta Blvd. to protect the road and residences (**strategy 3.f**). The levee could be designed to have a walking and biking path or other public amenities on top of it to allow the public to continue to be connected to the coastline and to observe and enjoy the new coastal habitat. This approach would be triggered for planning at 2.5 feet of sea level rise, with planned implementation at 4.1 feet of sea level rise. Allowing the golf course to return to a natural state would benefit the continued protection of private residences in the center of the Action Area. This pathway does not include the actions that individual homeowners may choose to take to adapt their properties.

3.3.2.4 Managed Retreat Pathway Costs and Benefits

Total Pathway Cost:	Cost of Inaction:
$6-22M	$64M

Retreating from this area may appear to be cost effective, but it does not include the costs of building a new tennis center elsewhere, nor does it account for the tremendous value of the land if it was redeveloped.

The estimated cost of the managed retreat pathway is difficult to ascertain due to the mix of action and inaction needed to return the tennis court and golf course areas to natural landscape. In addition, relocating the tennis center will depend on if similar facilities are able to be constructed on a property already owned or operated by the City, or if Coronado would need to acquire the land. If the newly acquired land is already developed, this would also involve the cost of demolishing the existing structures and/or constructing infill development. Regardless, the managed retreat pathway is estimated to be significantly less costly than the engineering pathway.

The strategies involving dry floodproofing the tennis center (**strategy 3.c**), redesigning the golf course (**strategy 3.e**), and building a levee along Glorietta Blvd. (**strategy 3.f**) are calculable. These strategies total an estimated cost of approximately $6-22M with the bulk of the cost going toward constructing a levee along Glorietta Blvd ($6-18M). As detailed in the previous sections, the cost of inaction for this area is substantial at $64M. Most of this cost is from damages to the residential development inland in this Action Area. Protecting those homes via the levee would mitigate the economic loss projected by the estimated cost of inaction.

Overall, the managed retreat pathway for the Coronado Municipal Golf Course area is effective and may be beneficial for the environment in the long term. However, it is not very flexible and there are significant economic considerations. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway will effectively address the risk of sea level rise and storm surge by transforming the golf course and tennis center into flooded space, allowing for protection of roads and residential development inland.
- **Environment:** Managed retreat provides the opportunity to restore an area to natural habitat, which can serve as a GHG emissions sink. Allowing the area to naturally return to habitat, or actively restoring the area, will provide habitat benefits.
- **Economy:** A managed retreat program would result in lost revenue from the golf course and tennis center, especially if a new location is not identified for the tennis center. In addition, retreating from this area means it could not be redeveloped, which would be a major economic driver.
- **Flexibility:** Once the golf course and tennis center are allowed to flood, that land cannot be redeveloped at any point in the future; significantly limiting the flexibility of future land uses.

Table AP-5 summarizes the rated qualitative benefits of each individual strategy within the managed retreat adaptation option. The ratings show the potential pros and cons of each strategy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-5: Qualitative Benefits of Managed Retreat Adaptation Option for Action Area 3. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Nature-Based	Construct floodable parks (i.e., redesign the golf course)	SLR: 🟢 SS: 🟢	🟢	🟢	🟡
Operational	Temporary closure of asset or facility	SLR: 🔴 SS: 🟡	🟢	🟡	🔴
	Sandbagging	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
	Flooding alert system for neighborhoods	SLR: 🔴 SS: 🟢	🟢	🟡	🟡
Engineering	Construct/raise levee	SLR: 🟢 SS: 🟢	🟡	🟡	🟢
	Install building retrofits	SLR: 🟡 SS: 🟢	🟡	🟡	🟢
Retreat	Managed Retreat	SLR: 🟢 SS: 🟢	🔴	🟢	🔴

3.3.2.5 Combined Pathway to Withstand Sea Level Rise

In addition to examining the engineering pathway and the managed retreat pathway separately, it is worthwhile to consider how strategies from these two pathways could work together. Figure AP-23 illustrates this combined approach and details at which points engineering pathway strategies can be shifted for retreat pathway strategies.

For example, if the City initially selected strategies along the engineering pathway but decides the cost of elevating the perimeter of the golf course at 2.5 feet of sea level rise (**strategy 3.h**) is too prohibitive, the City could work toward managed retreat (**strategy 3.k**) at a later stage. However, if managed retreat is a desired option, planning should begin as soon as reasonably possible.

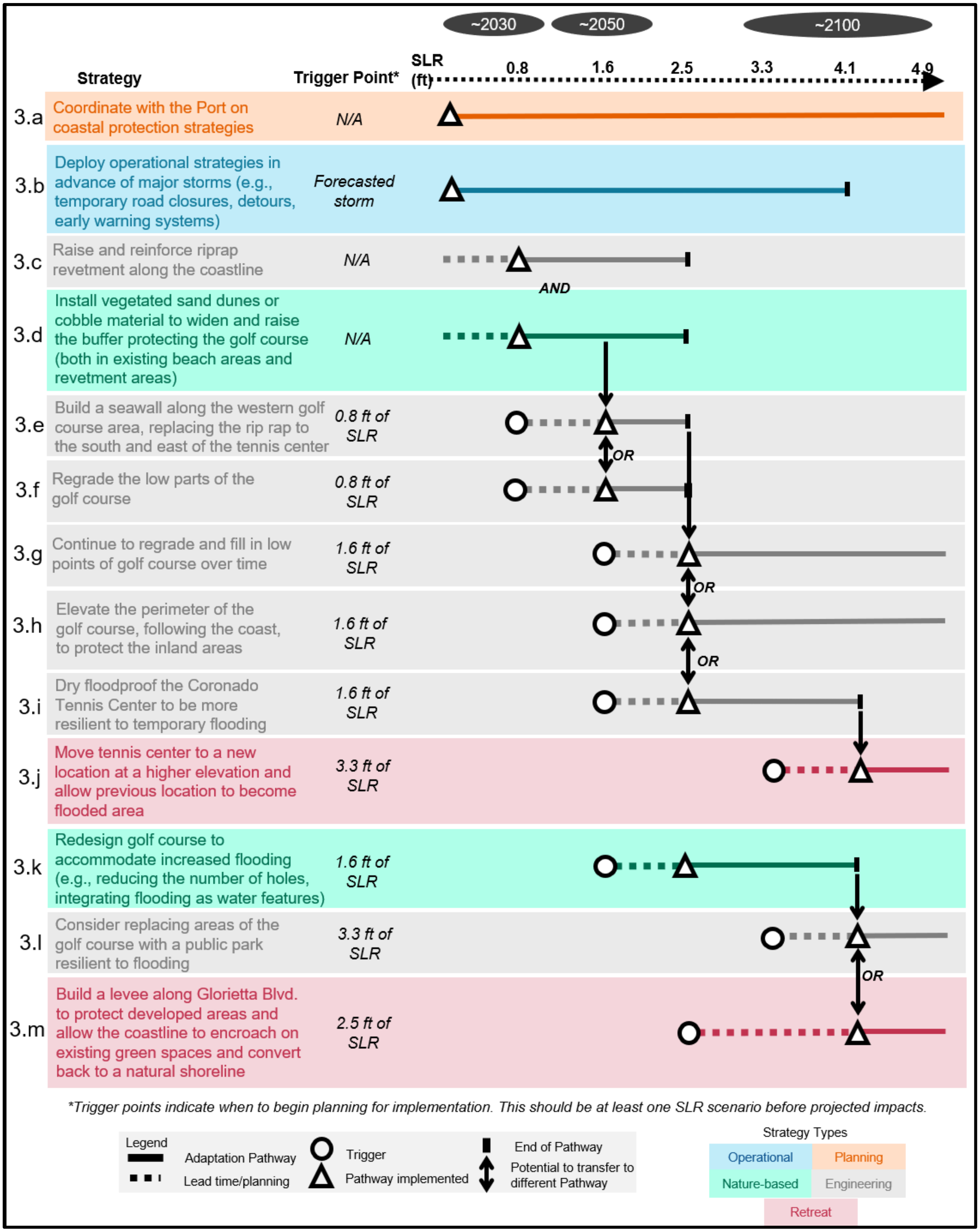


Figure AP-23: Combined adaptation pathway for the Coronado Municipal Golf Course area

3.4 Action Area 4: South Edge of Coronado Golf Course to the East End of Strand Way Parking Lot

Figure AP-24: Existing conditions at the south edge of Coronado Golf Course to the east end of Strand Way parking lot
(Source: Google Earth Pro)

Key Takeaways

Continued close coordination with the Port is essential for reducing sea level rise risks in this area since they own most of the bayside land.

City actions could include elevating Strand Way to protect the roadway and inland areas from flooding.

Figure AP-25: Bluewater Boathouse Seafood Grill
(Source: Rob Bertholf)

Action Area 4 loops around Glorietta Bay from the southern edge of the Coronado Municipal Golf Course to the eastern end of the Strand Way parking lot (see Figure AP-24). The area contains the Coronado Yacht Club, a small pocket park, a historic restaurant building owned by the City (currently occupied by Bluewater Boathouse Seafood Grill), and a parking lot along Strand Way. The shoreline is primarily edged with a riprap revetment, with a seawall running along the part of Strand Way immediately adjacent to Glorietta Bay. The elevation in this Action Area ranges from 6 to 13 feet (NAVD88). The highest elevated section is the Strand Way parking lot.

The City will need to coordinate with the Port to implement any major adaptation actions because the Port owns all of the coastal land in this area. As such, strategies proposed in this Action Area are focused on those that the City could implement. A different set of solutions would be available to the Port if they were to focus on preventing flooding on their property. Coordination will help ensure the strategies that are implemented are in the best interest of the residents of Coronado.

3.4.1 Coastal Vulnerability

As shown in Figure AP-26, over time Action Area 4 will be faced with increasing coastal flood risk from rising sea levels and 100-year storm events.

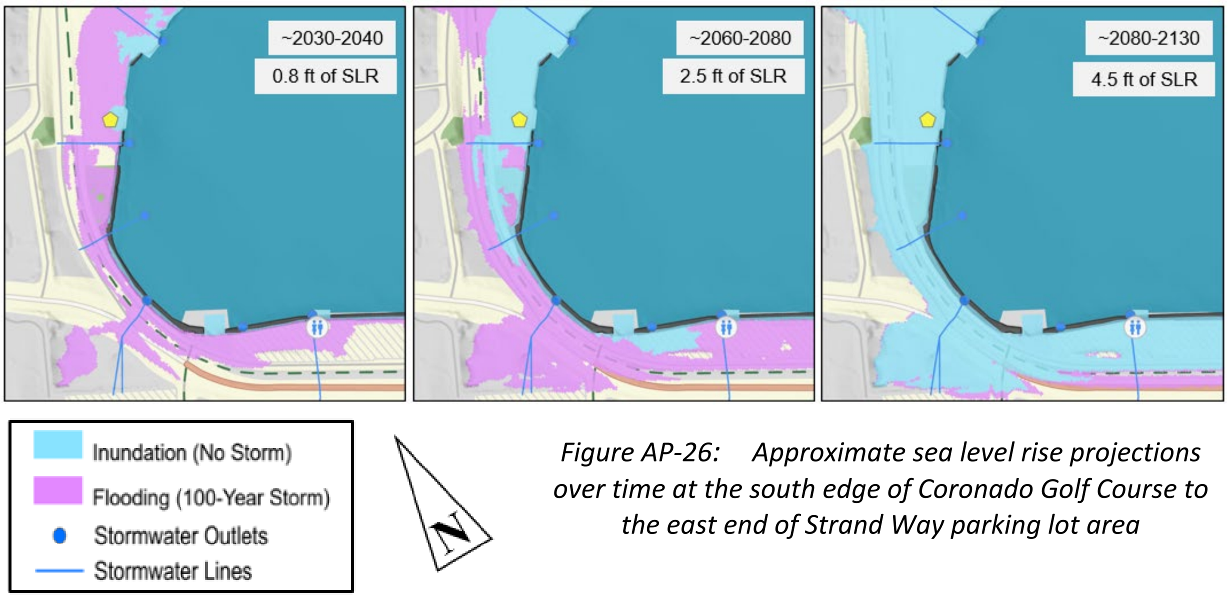


Figure AP-26: Approximate sea level rise projections over time at the south edge of Coronado Golf Course to the east end of Strand Way parking lot area

0.8 ft. of sea level rise*: risk of widespread storm flooding, including the Coronado Yacht Club, Strand Way, the Boathouse restaurant, and the Strand Way parking lot. Minor permanent inundation is expected at the Coronado Yacht Club parking lot and at the Boathouse restaurant; however, it is likely that the Boathouse exposure is not well represented in the modeling since it is on piers over the water.*

2.5 ft. of sea level rise*: storm surge flooding increases and may reach farther across Strand Way and Orange Avenue into inland development. Permanent inundation is anticipated to intensify around the pocket park, Coronado Yacht Club and its parking lot, and the Strand Way Parking lot. Two of the four stormwater outlets may be inundated, and the remaining two are likely to be periodically flooded.*

The cost of inaction due to flooding originating in this area—or the cost of damages incurred, and the value of private properties lost by not implementing any adaptation strategies—is significant, estimated at $7.5M for non-storm inundation at 4.1 feet. This is the same as the cost for non-storm inundation at 4.9 feet, indicating that most of the damage to City property will occur by 4.1 feet. These costs could be even greater if a 100-year storm occurred, with up to $1.5M if the storm occurs at 4.1 feet of sea level rise and $1.6M in damages if the storm occurs at 4.9 feet of sea level rise. These costs do not account for the significant user costs associated with flooding of Strand Way nor do they account for the significant value of amenities on Port land including the Yacht Club, the pocket park, and the Boathouse restaurant. In other words, these costs are primarily based on the flooding damages that would occur when flood waters breach Strand Way.

3.4.2 Adaptation Options

The suite of potential adaptation strategies for this area includes planning, operational, engineering, and managed retreat strategies. Figure AP-27 presents a mix of adaptation strategies that are within the City's control to protect and improve existing infrastructure. Coordination with the Port (**strategy 4.a**) should be an ongoing effort as observed flooding and sea level rise changes over time. Open and frequent communication will allow all parties to achieve their sea level rise resilience objectives while pursuing complimentary rather than redundant (or non-existent) adaptation strategies.

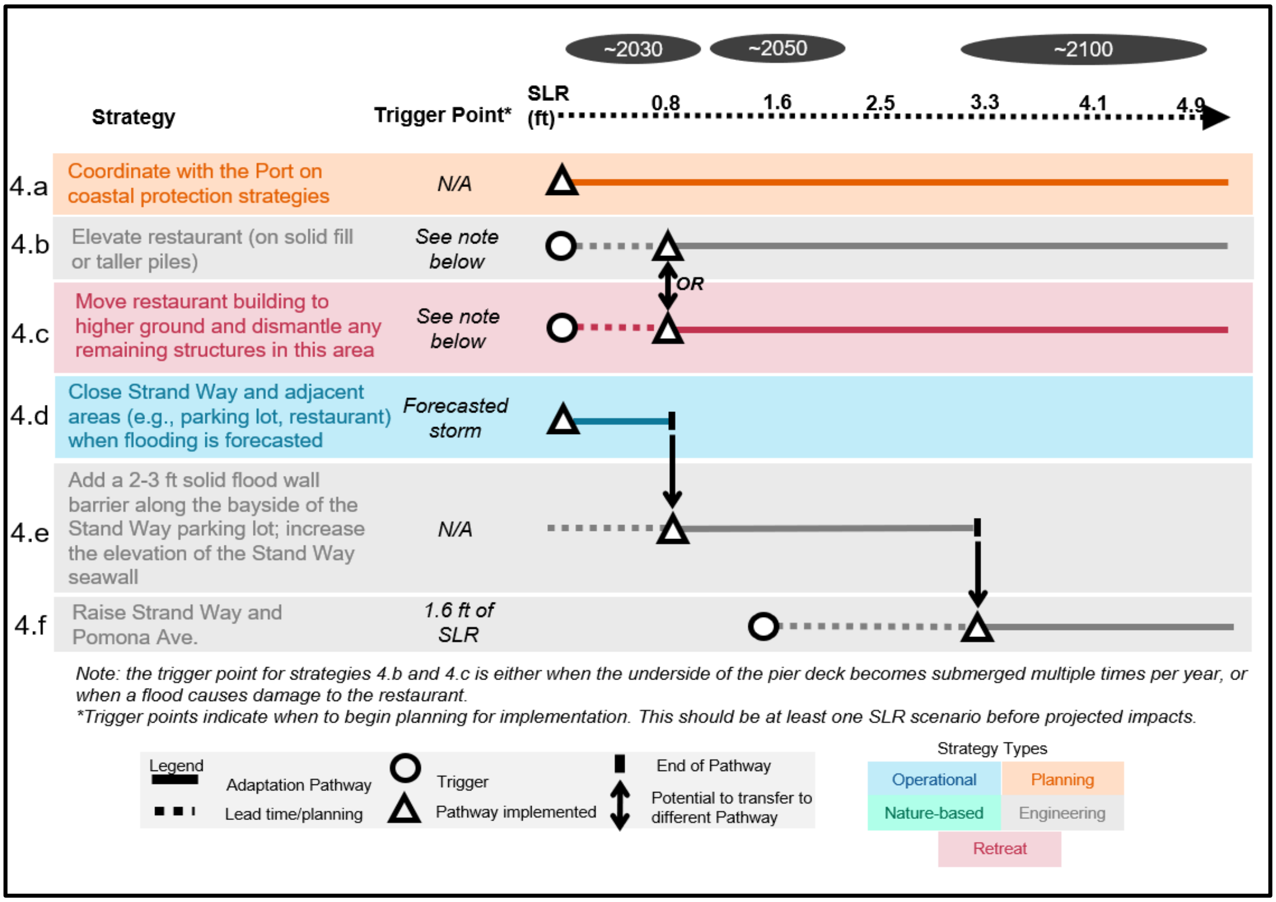


Figure AP-27: Adaptation pathway for the south edge of Coronado Golf Course to the east end of Strand Way parking lot.

While coordination with the Port is in motion, the City should monitor flooding at the historical boathouse restaurant. When the underside of the restaurant's pier deck becomes submerged multiple times per year, or when a flood causes damage to the restaurant the City may begin planning to either:

1. Elevate the historic restaurant building (**strategy 4.b**) or
2. Move the restaurant building to higher ground and dismantle any remaining pier structures (**strategy 4.c**).

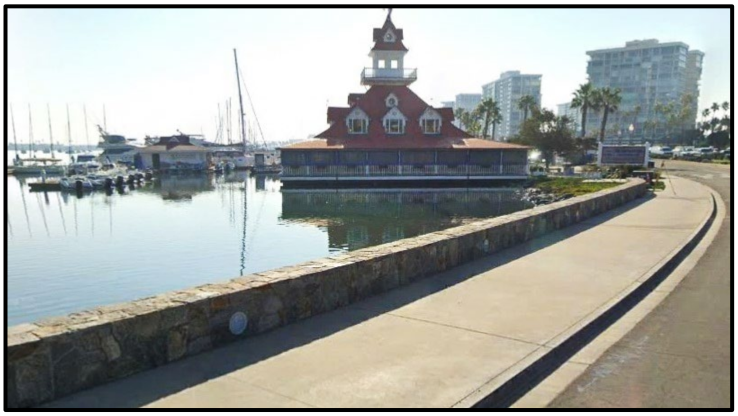


Figure AP-28: Stone wall atop the seawall along Strand Way; the restaurant building can be seen in the center, with Glorietta Bay on the left
(Source: Google Earth Pro)

The historic nature of the restaurant building presents issues related to the City's Historic Resource Code and compliance with the Secretary of the Interior's Standards for Treatment of Historic Properties. While it is not locally listed as a Historic Resource, the building is identified as a contributing resource as an outbuilding in the Hotel del Coronado nomination to the National Register of Historic Places. In 2019, the City of Coronado contracted with Heritage Architecture and Planning to produce a Coronado Boathouse Stewardship Masterplan for rehabilitation and preservation of the restaurant building, which included addressing rising water levels as result of King Tides. Elevation of the restaurant is explored as a recommendation in the Masterplan, and the Masterplan addresses structural modifications and rehabilitation to the building that may be required in association with a future raised elevation, including compliance with the California Building Code and the American Disabilities Act (ADA).

Due to the historic nature of the structure, if the restaurant is relocated to another location, its relocation could potentially trigger the California Building Code section 409 "Moved Structures" and a resulting seismic retrofit of the building. The relocation of the structure would need to be compliant with Secretary of the Interior's Standards for Treatment of Historic Properties guidance on relocation of historic structures.

The City may also periodically close Strand Way and adjacent areas, such as the parking lot, when severe storms are forecasted to flood the area (**strategy 4.d**). While sea level rise projections show potential 100-year storm flooding at 0.8 feet, flooding could occur before then (though it has not occurred to date), so the City may consider implementing this strategy soon. This operational strategy is expected to be sufficient until approximately 0.8 feet of sea level rise due to the relative infrequency of flooding during that period.

Around 0.8 feet of sea level rise, relatively unobtrusive and inexpensive adaptation measures can be undertaken by the City to protect its facilities and key roads, such as Strand Way, during storm events. Adding a two-to-three-foot solid flood wall barrier along the bayside edge of the Strand Way parking lot can add necessary protection (**strategy 4.e**). This wall could be integrated into the landscape as somewhere for people to sit and relax without obstructing the view.

In addition to a wall along the parking lot, a short wall could also be used along Strand Way. In this area, Strand Way sits atop a seawall bordering Glorietta Bay. There is a short stone wall atop the seawall (see Figure AP-28) lining Strand Way. This short wall could be increased in height approximately two feet without significantly impacting views while offering defense for Strand Way and Orange Avenue from storm flooding.

In planning for the eventual insufficiency of **strategy 4.e**, the City may consider planning as soon as 1.6 feet of sea level rise to raise Strand Way and Pomona Avenue (**strategy 4.f**) for implementation at 3.3 feet of sea level rise to protect this critical roadway and eliminate the risk of flooding for communities inland of the road. However, implementing this strategy may not be necessary if the Port decides to invest in protecting the area bayward of the road.

If the Port chooses to implement adaptation strategies bayside of Strand Way, then it may not be necessary to elevate Strand Way. Some of the strategies that the Port could consider in this area include:

- Building a levee out into Glorietta Bay adjacent to Strand Way with a pedestrian and cyclist promenade along the crest
- Elevating the Yacht Club and pocket park
- Regrading and elevating the Strand Way parking lot
- Removing structures at the Strand Way parking lot and allowing it to return to natural habitat

While these actions may work well in this area, this list is not exhaustive. The City has no control over what the Port may choose to implement on their property.

3.4.2.1 Pathway Costs and Cost of Inaction

Total Pathway Cost: $32-64M	**Cost of Inaction:** $7.5M

The cost of the pathway is much higher than the cost of inaction, but the cost of inaction does not account for the economic value of Strand Way.

The costs of the adaptation strategies outlined in this pathway are estimated at $32-64M (2021). The cost of inaction from lost property is $7.5M for non-storm inundation at 4.1 ft, which is much lower than cost of protection (see Coastal Vulnerability section above for more information on the cost of inaction). However, the cost of inaction does not capture the significant economic impacts of closing Strand Way during flood events, or permanently, nor does it include the economic impacts of flooding on Port property. Raising Strand Way and Pomona Ave is the costliest strategy (**strategy 4.f**) at $32-$63M. This assessment may underestimate the total cost of the pathway and the cost of inaction since it is an approximation, and the cost of materials with inflation will increase by the time of implementation. The pathway cost estimate does not include the costs of action that the Port or the Yacht Club may undertake to adapt their properties.

Overall, the adaptation options for this area would be effective and beneficial for the economy but could have negative environmental impacts. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, these adaptation options will effectively protect Strand Way and inland of the roadway against sea level rise and storm surge. However, the strategies do not speak to the effectiveness of any strategies the Port may implement for their land.
- **Economy:** The positive economic impacts reflect the ability of this pathway to protect or transform Strand Way, a major thoroughfare that supports residents and businesses.
- **Flexibility:** The use of operational strategies in the near term preserves the ability to make larger decisions about investments in engineering and managed retreat strategies. Once those strategies have been implemented it would be difficult to continue using a flexible approach.
- **Environment:** The proposed strategies would likely have a neutral impact on the environment. Actions taken by the Port along the waterfront will more significantly benefit or harm the natural habitat in the area.

Table AP-6 summarizes the rated qualitative benefits of each individual strategy within suite of adaptation options for this area. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-6: Qualitative Benefits of Pathway for Action Area 4. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Operational	Temporary closure of asset or facility	SLR: ● (red) SS: ● (yellow)	● (green)	● (yellow)	● (red)
Engineering	Construct/raise flood wall	SLR: ● (yellow) SS: ● (green)	● (yellow)	● (red)	● (green)
	Elevate or realign transportation infrastructure	SLR: ● (green) SS: ● (green)	● (yellow)	● (yellow)	● (green)
	Install building retrofits	SLR: ● (yellow) SS: ● (green)	● (yellow)	● (yellow)	● (green)
Retreat	Managed retreat	SLR: ● (green) SS: ● (green)	● (red)	● (green)	● (red)

3.5 Action Area 5: Coronado City Hall to Glorietta Bay Park

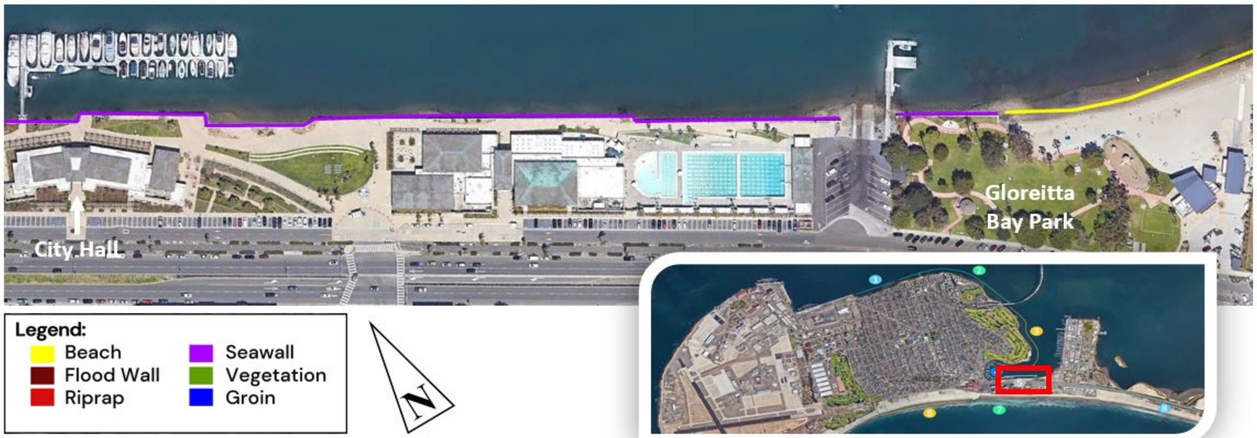


Figure AP-29: Existing conditions at Coronado City Hall to Glorietta Bay Park
(Source: Google Earth Pro)

Key Takeaways

To reduce sea level rise risks, two long-term adaptation pathways may be considered:

Option 1: An engineering approach focused on elevating seawalls and redesigning Glorietta Bay Park.

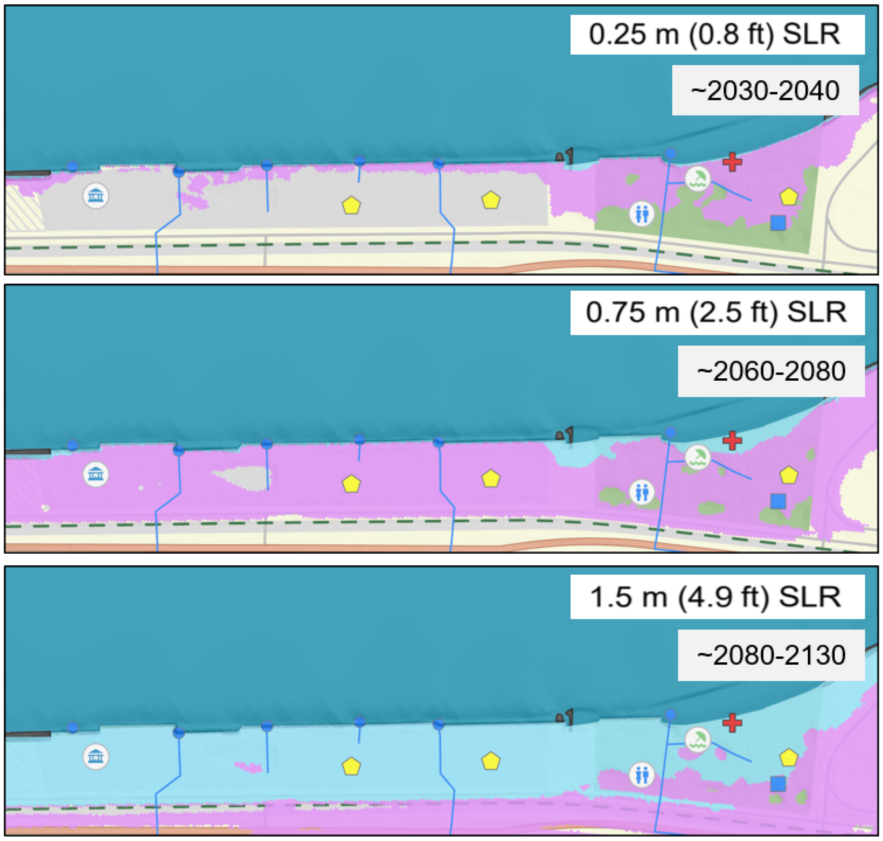
Option 2: A managed retreat approach that includes relocating City Assets within the area.

Figure AP-30: Coronado City Hall
(Source: City of Coronado website)

The Coronado City Hall to Glorietta Bay Park Action Area (see Figure AP-29) includes, from left to right, the City Hall, a public park area east of City Hall, the Coronado Community Center, the City of Coronado Aquatics Center, a public swimming pool, a public boat ramp with trailer parking, Glorietta Bay Park, and the Club Room. The shoreline is bounded by a seawall from City Hall to the boat ramp. Glorietta Bay Park has a seawall segment reinforced by revetments on the north side, while most of the park is a sandy public beach area. The elevation of the area is relatively low, not exceeding 6 feet (NAVD88). In this area, all of land between the water and Strand Way is owned by the Port and all recommended adaptation strategies should be closely coordinated with the Port District. While adaptation strategies are subject to Port approval, the strategies below focus on protecting valuable City-owned structures like City Hall, the Club Room, and the Aquatics Center.

3.5.1 Coastal Vulnerability

As shown in Figure AP-31, the risk of coastal flooding from rising sea levels and 100-year storm events will increase over time.



***0.8 ft. of sea level rise**: risk of periodic flooding, including minor overtopping of the seawall and significant flooding of the boat ramp area and Glorietta Bay Park. Flooding impacts to several stormwater outlets.*

***2.5 ft. of sea level rise**: the entirety of the area may be periodically flooded, obstructing use of the City buildings. Permanent inundation may occur at the shoreline of Glorietta Bay Park, and the size of the boat ramp may be reduced. A stormwater pump station is also at risk of flooding.*

***4.9 ft. of sea level rise**: the entirety of the area may be inundated, along with Strand Way being periodically flooded, greatly obstructing the usability of the land and buildings.*

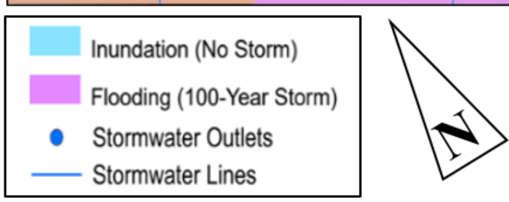


Figure AP-31: Approximate sea level rise projections over time at the Coronado City Hall to Glorietta Bay Park.

The cost of inaction is not estimated in this area because there is no tax assessment value for City-owned facilities, which are the primary at risk facilities in this area. Given this information, the implications of closing or altering a popular city park and relocating or losing iconic city buildings and services should be considered when weighing adaptation options.

3.5.2 Adaptation Options

Adaptation strategies in the near term are relatively clear, but over the long-term different options or pathways could be pursued. When sea levels rise 3+ feet, the adaptation strategies could include:

1. An **engineering-focused** option where seawalls and walkways at the waterfront are raised to protect City assets and Glorietta Bay Park is redesigned to persist through higher sea levels; OR
2. A **managed retreat-focused** option where City assets are relocated out of the area, Glorietta Bay Park is closed, and Strand Way is elevated to protect inland development.

Engineered solutions and managed retreat were selected as the strategy options for this Action Area because of the current land use (i.e., primarily a hardened seawall which would be difficult to return to a natural coastline) and the severity of projected long-term inundation from sea level rise. Both options include nature-based solutions in the near term for Glorietta Bay Park.

3.5.2.1 Engineering Pathway to Withstand Sea Level Rise

Engineering Pathway Overview

One pathway option for the area emphasizes the continued use of City buildings and Glorietta Bay Park at their current locations, as shown in Figure AP-32. This option first uses nature-based solutions and operational measures to address flooding concerns, and then recommends hard engineering solutions to raise the existing seawalls and regrade and redesign the park area.

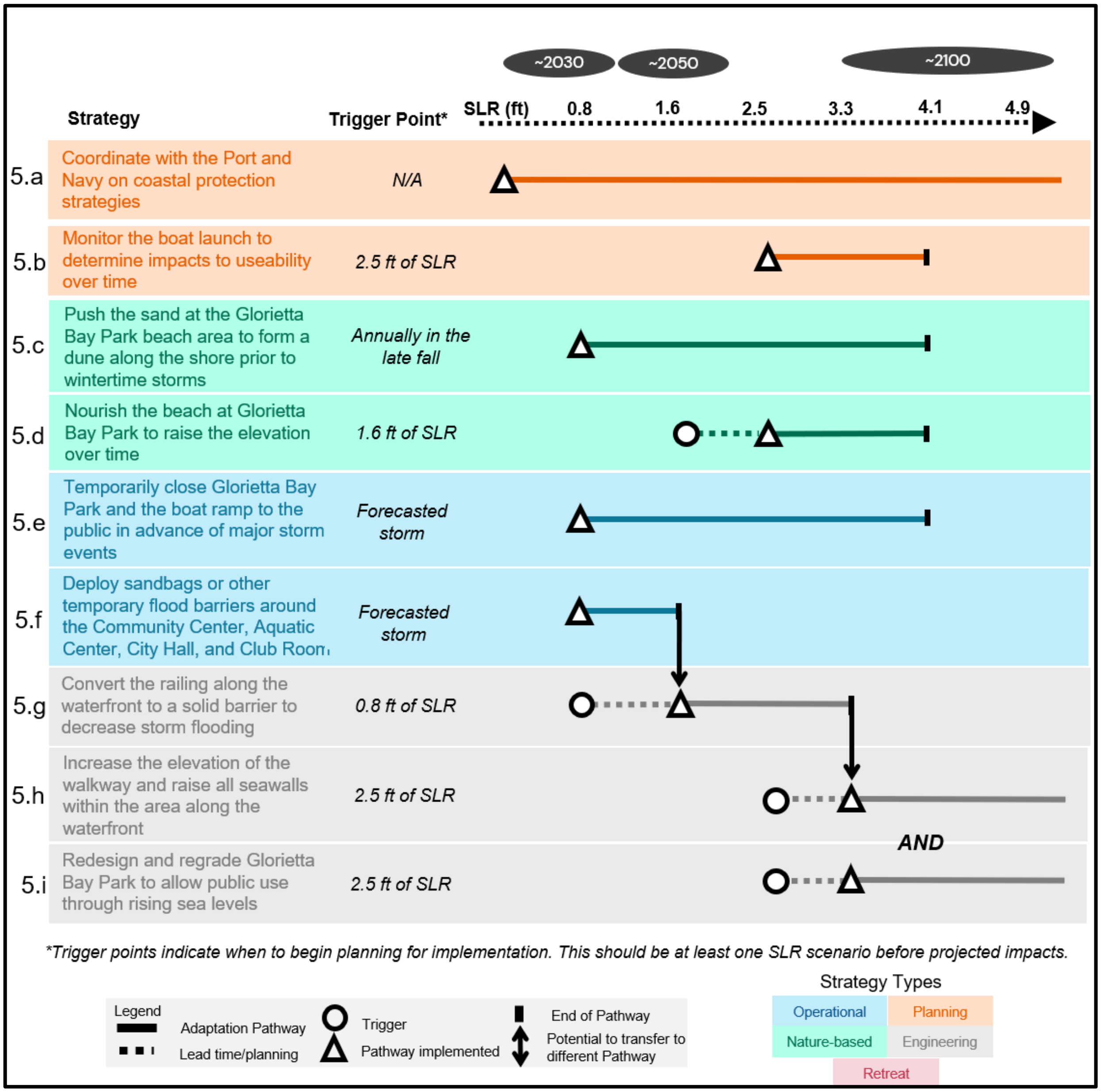


Figure AP-32: Engineering adaptation pathway for Coronado City Hall to Glorietta Bay Park

Adaptation strategies in this area must be approved by and should be planned in close coordination with the Port, which owns the land (**strategy 5.a**). Implementation should also be coordinated with the Navy which owns land just to the east of Glorietta Bay Park.

The boat ramp within the area may begin to experience more frequent flooding at 2.5 feet of sea level rise; however, boat ramps are inherently low-lying and expected to experience periodic flooding. Rather than immediately changing the design, a monitoring strategy can be used to determine when flooding is occurring frequently enough to impair use (**strategy 5.b).** Alterations to its construction should be considered once the monitoring indicates there has been a meaningful decrease in the usability of the ramp (i.e., inaccessible 15+ days per year).

To avoid the projected storm-induced flooding for Glorietta Bay Park at 0.8 feet of sea level rise, every fall the City could annually reposition the sand to create dunes along the sandy beach area prior to the winter storm season (**strategy 5.c**). To remain usable for the public at 2.5 feet of sea level rise—the point at which meaningful inundation is expected—the City could conduct beach nourishment as necessary (**strategy 5.d**). This would raise the mean elevation of the beach and avoid an encroaching shoreline to allow recreation at the site to continue.

Figure AP-33: Glorietta Bay Park
(Source: City of Coronado website)

The dunes will reduce flood impacts from minor and moderate storm events, but in the event of heavy or extremely heavy storm events, flooding may still occur at the park. When a storm is forecasted that may flood the park, the City should plan to temporarily close the park until floodwaters subside and debris is cleared (**strategy 5.e**).

In advance of a storm, the City should deploy sandbags or other temporary flood barriers around valuable assets (City Hall, the Community Center, Aquatic Center, and Club Room) since the combination of 0.8 feet of sea level rise and storm surge is projected to overtop the seawall in this area, which could cause moderate flooding (**strategy 5.f**). These relatively inexpensive strategies have few drawbacks and can keep the buildings within the area operational through 100-year storm flooding and 0.8 feet of sea level rise.

As sea level rise reaches 1.6 feet, City facilities along the waterfront will require structural adaptation to protect against storm-induced flood damages. As a first step, the City can convert the railing along the waterfront that sits on top of the seawall to a solid barrier (**strategy 5.g**) that is approximately two-feet high. This low barrier would preserve views of the water while offering necessary storm protection. While this wall would provide protection against periodic flooding, it would not be sufficient to protect against forces from permanent inundation that is projected at the area at 3.3 feet of sea level rise as there is limited space to reinforce the structure landward of the wall.

Figure AP-34: Example of a floodable park design
(Source: SCAPE Landscape Architecture)

To protect the City buildings behind the seawalls against inundation, flooding should be closely monitored and at 3.3 feet of sea level rise, the walkway along the waterfront could be raised and the seawalls elevated (**strategy 5.h**). Pending further study, it appears as though the walkway is wide enough to accommodate the increased elevation and ramps without altering the elevation of the buildings. Elevating should occur by 3.3 feet of sea level rise at the latest and planning should be undertaken at the end of the natural life of the seawalls (usually around 50 years) or at 2.5 feet of sea level rise, whichever occurs first. While the elevated walkway can be designed as a beautiful public amenity, elevating it is likely to be an intensive engineering project and could alter the feel and aesthetic for the City buildings and park lands that would sit below the elevated walkways and seawalls. Furthermore, since the life of seawalls is generally about 50 years and at some point in time sea levels will exceed the high-end 4.9 feet included in this study, a similar (and similarly costly) elevation project may have to be considered after this project is completed.

The beach area of Glorietta Bay Park also requires structural adaptations to remain usable at 3.3 feet of sea level rise since natural infrastructure solutions will only be partially effective at this stage. The park can be redesigned and regraded as a floodable park to allow for inundation in some areas and high and dry areas, allowing continued public use (**strategy 5.i**). This strategy would require significant fill but would preserve the public recreation benefits of the park.

Engineering Pathway Costs and Benefits

Total Pathway Cost: $6-18M

Cost of Inaction: Unknown

The cost of inaction at this area likely exceeds the cost of implementing adaptation strategies although because this area lacks tax assessment data, a quantitative assessment like the other Action Areas is not possible.

The costs of the adaptation strategies outlined in this pathway are estimated at $6-18M (2021). The cost of elevating seawalls and the walkway at 3.3 feet of sea level rise is the costliest strategy, accounting for $4-12M of the total cost of the suite of strategies. Since the cost of inaction in this area is unknown, it is difficult to compare the cost of inaction to the cost of action. However, it is reasonable to assume that when permanent inundation threatens the usability of City buildings and the park in this area at 3.3+ feet of sea level rise, the loss of City services and structures (e.g., City Hall, the Community Center, Aquatic Center, swimming pool) would exceed the estimated cost of the adaptation strategies in this pathway.

Cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well.

Overall, the engineering pathway is effective, beneficial for the economy, and maintains flexibility in the near term. However, it could have negative environmental impacts. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway will effectively protect City assets against sea level rise and storm surge, allowing City buildings and Glorietta Bay Park to remain in service.
- **Economy:** The positive economic impacts reflect the ability of this pathway to preserve commerce, tourism, and recreation in the area and to protect valuable City structures.
- **Flexibility:** The use of planning and operational strategies in the near term preserves the ability to make larger decisions about investments in seawall reconstruction (or managed retreat) up until 2.5 feet of sea level rise, when the impacts are more evident. Once those strategies have been constructed it is difficult to continue using a flexible approach.
- **Environment:** Seawalls and flood walls, the cornerstone strategies of the engineering pathway, do not create good habitat for flora and fauna along the shoreline. While there are some emerging techniques to improve them, they will never be as hospitable as a natural shoreline; however, these strategies do not represent a change from the current state of the shoreline environment.

Table AP-7 summarizes the rated qualitative benefits of each individual strategy within the engineered adaptation option. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as “good” or “bad” but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-7: Qualitative Benefits of Engineering Pathway for Action Area 5. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Operational	Sandbagging	SLR: ● (red) SS: ● (yellow)	● (green)	● (yellow)	● (green)
	Temporary closure of asset or facility	SLR: ● (red) SS: ● (yellow)	● (green)	● (yellow)	● (red)
Nature-Based	Conduct beach renourishment/construct dunes	SLR: ● (yellow) SS: ● (green)	● (green)	● (yellow)	● (green)
	Construct floodable parks	SLR: ● (green) SS: ● (green)	● (green)	● (green)	● (yellow)
Engineering	Construct/raise seawall	SLR: ● (green) SS: ● (green)	● (yellow)	● (red)	● (green)
	Construct/raise flood wall (e.g., railing along the waterfront)	SLR: ● (yellow) SS: ● (green)	● (yellow)	● (red)	● (green)
	Elevate or realign transportation infrastructure	SLR: ● (green) SS: ● (green)	● (yellow)	● (yellow)	● (green)
	Construct/enhance revetments	SLR: ● (green) SS: ● (green)	● (yellow)	● (yellow)	● (green)

3.5.2.2 Managed Retreat Pathway

Managed Retreat Pathway Overview

As an alternative to the engineering-focused approach, the City could implement a managed retreat approach (Figure AP-35) beginning at 3.3 feet of sea level rise, where City buildings and Glorietta Bay Park are abandoned or relocated out of highly vulnerable areas. The first seven adaptation strategies (**strategies 5.a-g**) for this approach are the same as the engineering approach (operational strategies and beach nourishment in the short term, followed by a low-cost short flood wall on top of the seawall); however, when sea level rise reaches 3.3 feet managed approach strategies (**strategies 5.h-j**) are implemented in lieu of structural ones.

Rather than raising seawalls and the walkway to protect against inundation, this pathway calls for retreat from City buildings that sit behind the seawalls. Planning for this pathway, including investigating alternative locations for government and public buildings and services, should begin at 2.5 feet of sea level rise. At 3.3 feet of sea level rise the most vulnerable buildings should be decommissioned and if feasible, the services should be relocated (**strategy 5.h**).

While this relocation is occurring, Strand Way (the roadway that runs parallel to the Bay in this area) should be elevated to serve as the new line of defense from the encroaching waters and provide protection to inland development (**strategy 5.i**).

Under this pathway, Glorietta Bay Park and the boat ramp should be permanently closed (**strategy 5.j**) as they become too inundated to be publicly accessible or safely usable, likely around 4.1 feet of sea level rise.

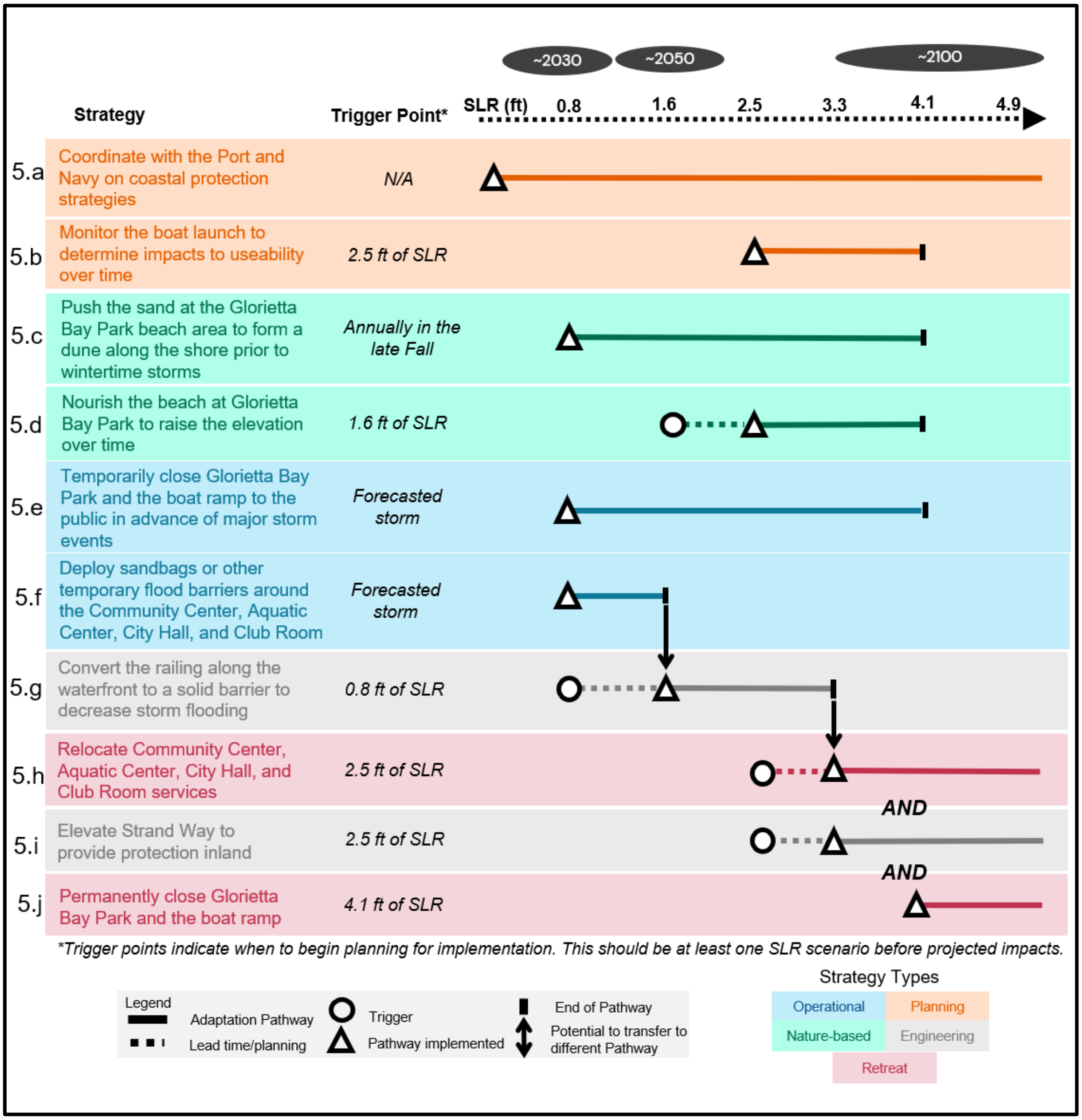


Figure AP-35: Managed retreat pathway for City Hall to Glorietta Bay Park

Managed Retreat Pathway Cost and Benefits

Total Pathway Cost: $46-92M	**Cost of Inaction**: Unknown
Elevating Strand Way would be a very costly approach to protecting inland areas.	

The total cost, including cost of adaptation strategies, asset deconstruction, asset rebuilding, and the purchase of new property, is not calculated in this assessment. Not including relocating assets (**strategies 5.h and 5.j**), the cost of adaptation strategies is estimated at $46-92M, (the majority of this total is due to the cost of elevating Strand Way, see Appendix AP-4 for more information). The high cost of this strategy relative to the engineering strategy (estimated at $6-18M) should be considered when decisionmakers choose how to approach adaptation in this area.

Providing a quantitative estimate for the cost of relocation is complicated because it is unknown whether all or only some of these assets and services in this area will be relocated. For example, while the Aquatic Center is valuable to the community, the City may decide the cost of relocating the asset is greater than the benefit it provides.

Overall, the managed retreat pathway would be effective and could have positive long-term environmental impacts even though it is costly. However, it is not very flexible and there are significant economic considerations. Some of the key considerations for this pathway include:

- **Effectiveness**: This pathway is only effective at protecting these assets until about 1.6 feet of sea level rise (projected to occur near mid-century). After that time, the effectiveness depends upon the City's ability to relocate the services and amenities located in this area.
- **Environment**: Managed retreat provides the opportunity to restore the park area to natural habitat, such as a tidal wetland.
- **Economy:** A managed retreat program would likely result in the rebuilding of several City buildings, such as City Hall, which would be expensive for the City and taxpayers.
- **Flexibility:** The use of planning and operational strategies in the near term preserves the ability to make larger decisions about investments in managed retreat (or structural adaptation) up until 2.5 feet of sea level rise, when the impacts are more evident. After retreat occurs, land cannot be redeveloped at any point in the future for anything other than open space and habitat, thus significantly limiting the flexibility of future land uses.

Table AP-8 summarizes the rated qualitative benefits of each individual strategy within the managed retreat adaptation pathway. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-8: Qualitative Benefits of Managed Retreat Pathway for Action Area 5. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Operational	Sandbagging	SLR: ● (red) SS: ● (yellow)	● (green)	● (yellow)	● (green)
	Temporary closure of asset or facility	SLR: ● (red) SS: ● (yellow)	● (green)	● (yellow)	● (red)
Nature-Based	Conduct beach renourishment/construct dunes	SLR: ● (yellow) SS: ● (green)	● (green)	● (yellow)	● (green)
Engineering	Construct/raise flood wall (e.g., solid railing along the waterfront)	SLR: ● (yellow) SS: ● (green)	● (yellow)	● (red)	● (green)
	Elevate or realign transportation infrastructure	SLR: ● (green) SS: ● (green)	● (yellow)	● (yellow)	● (green)
Retreat	Managed Retreat	SLR: ● (green) SS: ● (green)	● (red)	● (green)	● (red)

3.5.2.3 Combined Pathway

In addition to examining the engineering pathway and the managed retreat pathway separately, it is worthwhile to consider how strategies from these two pathways could work together. Figure AP-36 illustrates this combined approach and shows that the pivotal point for decision making is at 3.3 feet of sea level rise once the solid barrier along the waterfront (**strategy 5.g**) is no longer effective. Before this time, decisionmakers will have to make a critical decision of whether to opt toward managed retreat (**strategies 5.j, 5.k, and 5.l**) or to continue implementing structural adaptations (**strategies 5.h and 5.i**). This decision should be made based on the policy, science, and community opinion at that time, rather than today. In addition, different strategies may be selected for different portions of the Action Area. For example, selecting to redesign Glorietta Bay Park to be resilient to 4+ feet of sea level rise while opting for managed retreat rather than raising the seawall that protects the City buildings or vice versa.

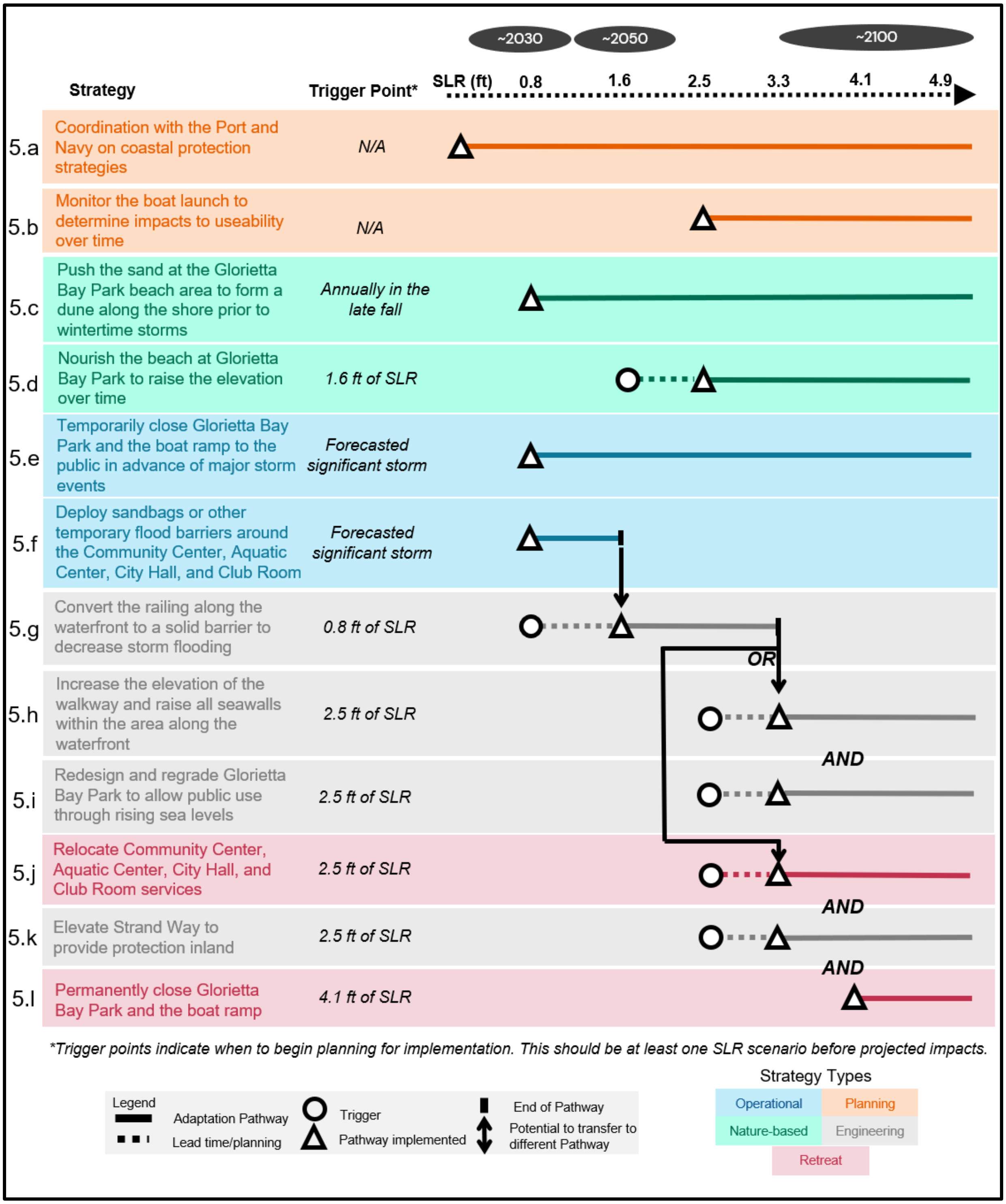


Figure AP-36: Combined adaptation pathway for City Hall to Glorietta Bay Park area

3.6 Action Area 6: Coronado Beach

Figure AP-37: Existing conditions at Coronado Beach
(Source: Google Earth Pro)

Key Takeaways

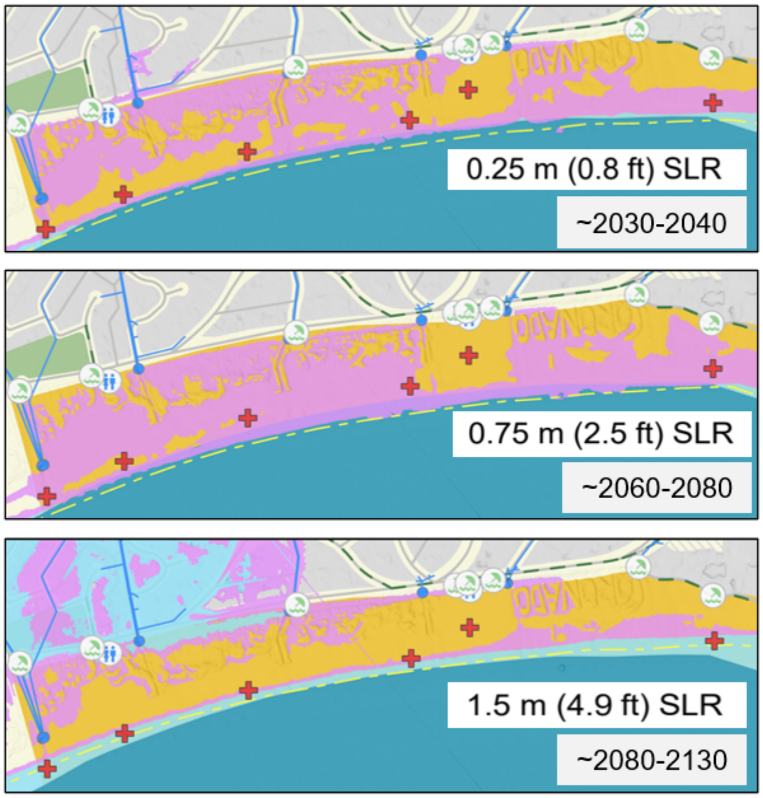
Coronado Beach is relatively high topographically and requires little action to protect it from sea level rise other than proactively maintaining the beach width and constructing an elevated dune or deployable flood barrier by Sunset Park to prevent storm surge flooding from entering the surrounding neighborhood.

Figure AP-38: Coronado beach lifeguard station
(Source: ST33VO)

Action Area 6 is comprised of Coronado Beach. It is bounded on the west by the NASNI and at the east by the groin in front of Hotel del Coronado. The Action Area is primarily focused on the beach and the residential development immediately inland of Ocean Boulevard (see Figure AP-37). The elevation in this Action Area ranges from 6 to 18 or more feet (NAVD88). The elevation increases from the shoreline back toward the back dunes. There is a high wall made of large rip rap at the back of the dunes that borders Ocean Boulevard. The inland development increases dramatically in elevation from west to east.

3.6.1 Coastal Vulnerability

As shown in Figure AP-39, the risk of coastal flooding from rising sea levels and 100-year storm events will increase in this area.



***0.8 ft. of sea level rise**: while there is a risk of temporary flooding across the beach area, impacts to infrastructure are projected to be negligible.*

***2.5 ft. of sea level rise**: a large portion of the beach and back dunes may be occasionally flooded. Small portions of residential development across Ocean Boulevard and east of Sunset Park are expected to experience periodic flooding due to 100-year storm surge.*

***4.9 ft. of sea level rise**: continued flooding of the beach is anticipated. Inundation and flooding of the residential area north of the beach is projected to travel across the City from its entry on the bayside by Alameda Boulevard and First Street, which is in Action Area 1. Stormwater outlets may be flooded or inundated.*

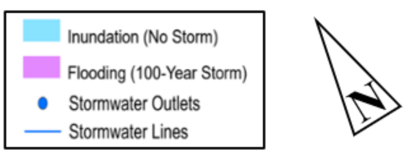


Figure AP-39: Approximate sea level rise projections over time at Coronado Beach

Coronado Beach offers non-market value as recreation and storm buffering that is difficult to measure in economic terms. The Sea Level Rise Vulnerability Assessment for the City found minimal economic impacts for Coronado Beach, as sufficient beach is projected to remain in place to accommodate the average daily visitors each month.

The cost to construct the main lifeguard tower and the north beach restrooms in 2008 was approximately $3 million. The cost of the flooded residences is covered in Action Area 1 since that is where most of the flood waters are coming from.

3.6.2 Adaptation Options

The recommended adaptation strategies for the Coronado Beach area include planning, operational, engineering strategies, and nature-based strategies. These strategies would require minimal effort to implement. The adaptation pathway for this Action Area is illustrated in Figure AP-40.

As dredged sand may become a crucial aspect to renourishing Coronado Beach over time, the City could coordinate with stakeholders who dredge in the area (**strategy 6.a**). Since the City already coordinates with stakeholders in the area, the strategy would begin immediately and continue beyond 4.9 feet of sea level rise.

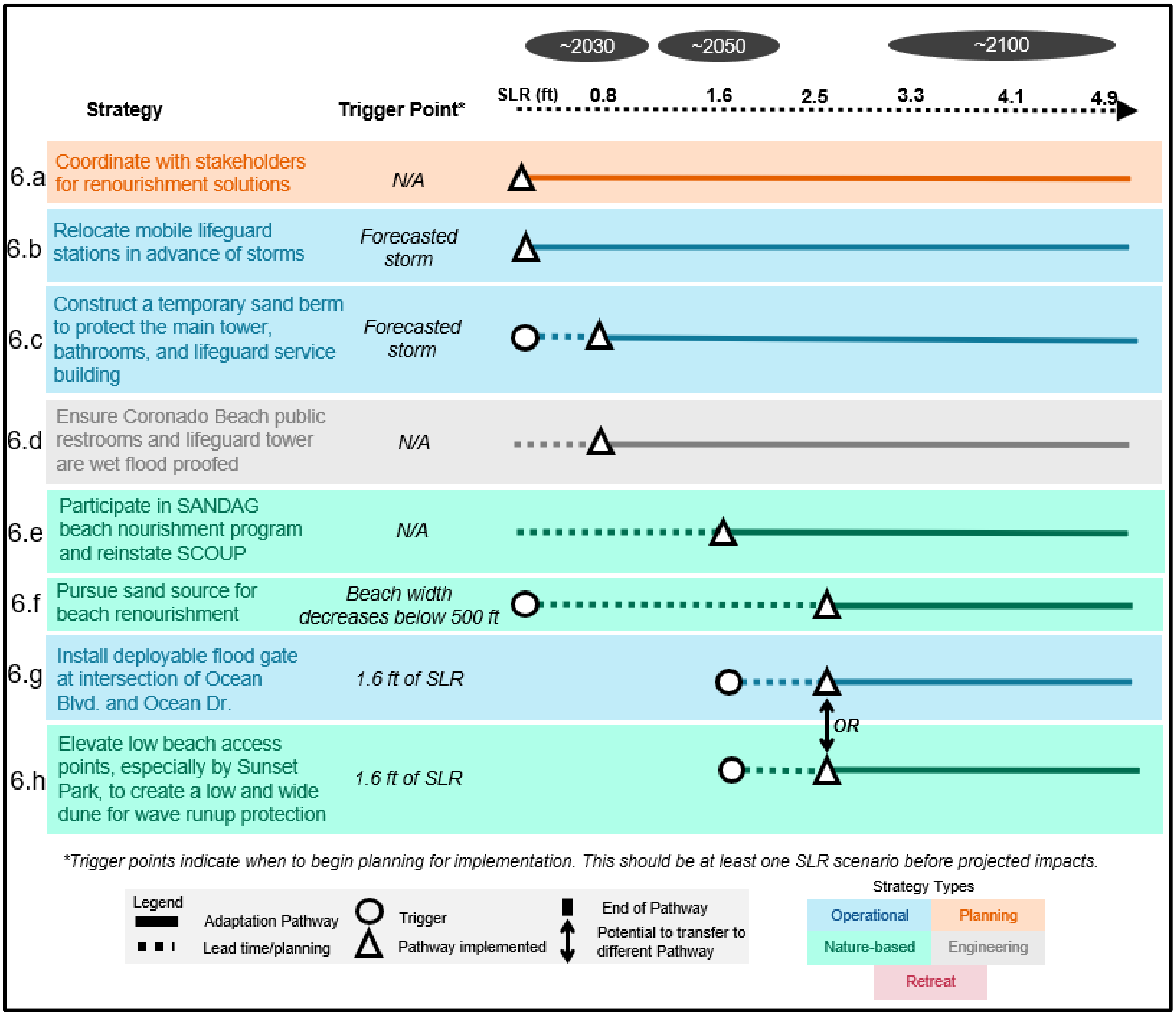


Figure AP-40: Adaptation pathway for the Coronado Beach area

Preserving the functionality of the lifeguard stations is critical for safety measures. The mobile lifeguard stations are designed to handle minor flooding and temporary storm impacts and are occasionally moved. However, they aren't moved unless necessary because lifeguards use the stations as landmarks for emergency services. Periodic flooding will occur on portions of the beach as early as 0.8 feet of sea level rise, which may require the movement of the stations to portions of the beach at higher elevations (**strategy 6.b**). This will continue throughout the timeline of sea level rise increases.

While the Main Lifeguard Tower, the Lifeguard Service Building, and the Central Beach public restrooms structures are not projected to be inundated, the beach will continue to be a changing landscape. These structures should be continuously monitored as beach conditions fluctuate over time. The City may use skip loaders to build large, temporary sand berms to protect the structures (**strategy 6.c**). The goal would be to redirect ocean water to the storm drain channels which are low points on the beach so the water can run back into the ocean. This strategy can be implemented in the event of severe forecasted storms as early as 0.8 feet of sea level rise, if needed.

The North Beach public restrooms and the primary Coronado Beach lifeguard tower could be flooded as early as 0.8 feet of sea level rise with a 100-year storm event. To minimize damages, the City may wet floodproof the restrooms and tower (**strategy 6.d**). Wet floodproofing supports buildings so that when they are flooded, they are not damaged by the water. This can include flood vents to allow flood waters to enter and leave, regrading surfaces, using flood damage-resistant interior materials, raising sensitive contents onto platforms (e.g., moving computers and electronics to a higher floor), and/or protecting or relocating utility infrastructure.

As the beach may eventually experience increased erosion and inundation, the City can consider renourishing the beach. Coronado Beach is a major economic driver for the City, so it is important to monitor erosion and to be prepared to use beach nourishment to maintain its width, as needed. San Diego Association of Governments (SANDAG) offers a beach renourishment program that the City of Coronado can participate in and has in the past. SANDAG's Sand Compatibility and Opportunistic Use Program (SCOUP) has developed environmental documentation that can support cities, including Coronado, in obtaining permits for placement of sand on their beaches (**strategy 6.e**). Part of this strategy would eventually require pursuing sand sourcing options for beach renourishment (**strategy 6.f**) as the City has a large area of beaches and competition for sand will likely increase over time. Nourishment would become necessary if the width of the beach falls below 500 feet, which may not occur. Beach erosion is difficult to accurately model due to uncertainty in the future frequency and intensity of heavy storm events, which is why the best approach is active monitoring of the beach and proactive enrollment in the SCOUP program in case nourishment becomes necessary.

Preventing floodwaters flowing from the beach into the residential community should be a priority, as this can cause significant damage and economic toll on the community. There are two options available to the City to address floodwaters, both of which are relatively easy strategies to execute:

1. Install a deployable flood gate at the intersection of Ocean Blvd. and Ocean Dr. (**strategy 6.g**) or
2. Elevate low beach access points, especially by Sunset Park, to create a low and wide dune for wave runup protection (**strategy 6.h**).

While deploying a flood gate (**strategy 6.g**) may be useful occasionally, elevating low beach access points (**strategy 6.h**) may provide more significant protection long-term.

3.6.2.1 Pathway Costs and Cost of Inaction

Total Pathway Cost: $387-1,000K	**Cost of Inaction:** Unknown

The cost of inaction at this area likely exceeds the cost of implementing adaptation strategies, although because this area lacks tax assessment data, a quantitative assessment like the other Action Areas is not possible.

The costs of the adaptation strategies outlined in this pathway are estimated at $387-1,000K (2021). The costs of installing a deployable flood barrier at the intersection of Ocean Blvd. and Ocean Dr. ($192-529K) is roughly equivalent to the alternative option of creating a low and wide dune in this area ($212-636K).

This area is difficult to compare cost of adaptation to cost of inaction since the cost of inaction is unknown. While comparing the cost of adaptation and inaction is useful, cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well. Overall, the pathway for the Coronado Beach is effective and beneficial for the economy, while also having flexibility in use. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway will effectively protect Coronado Beach against sea level rise and storm surge, supporting continued beach use and allowing the residential community to stay in place.
- **Economy:** The positive economic impacts reflect the ability of this pathway to preserve Coronado Beach, a major tourist destination and source of revenue. It also preserves valuable homes beyond the beach.
- **Flexibility:** The types of strategies used in this Action Area are mostly flexible in nature and may be adjusted over time.
- **Environment:** Beach nourishment can help maintain habitat for wildlife and processes that depend on a sandy beach, but construction also disrupts wildlife currently using the beach as habitat.

Table AP-9 summarizes the rated qualitative benefits of each individual strategy within the pathway. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details and justification behind each rating, see Appendix AP-2.

Table AP-9: Qualitative Benefits of Pathway for Action Area 6. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Operational	Deployable flood control barriers	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
Nature-Based	Conduct beach renourishment/ construct dunes	SLR: 🟡 SS: 🟢	🟢	🟡	🟢
Engineering	Install building retrofits	SLR: 🟡 SS: 🟢	🟡	🟡	🟢

3.7 Action Area 7: Coronado Shores Beach Area to Avenida Lunar

Figure AP-42: Existing conditions at Coronado Shores beach area to Avenida Lunar.
(Source: Google Earth Pro)

Key Takeaways

To allow continued access of the beach, beach nourishment in combination with structural improvements and additions to flood walls and groins are recommended.

Figure AP-41: A sunset over the Coronado beach groin in front of the Hotel del Coronado
(Source: Google Earth Pro)

The Coronado Shores Beach area extends from the groin in front of the Hotel Del Coronado about a half mile southeast along a relatively narrow section of beach (covering both Coronado Shores Beach and South Beach) with public access from Avenida Lunar (the street farthest to the right in Figure AP-42). The City has recently invested in the elevation of Avenida Del Sol (the road directly south of Hotel del Coronado) which reduces its vulnerability to coastal flooding and Hotel del Coronado is redeveloping the southernmost portion of their property which may change the potential for flooding in the area.

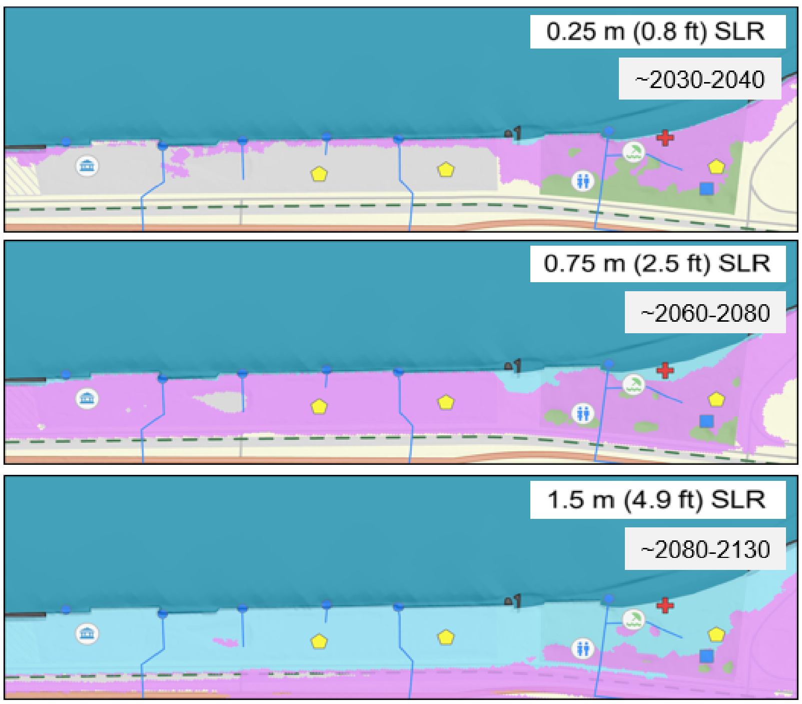
Several high-rise condominium buildings known as Coronado Shores sit behind flood walls in this area. The flood walls are reinforced with large rocks at the base (toe) of the walls to prevent erosion.

Toward the east side of the beach is the shipwrecked SS Monte Carlo, which was grounded on the beach in 1937 during a storm. The ship is only partially visible at extreme low tides, but now operates as a makeshift breakwater and influences sediment diversions on the beach. The elevation of the beach increases from the shoreline to the flood wall from 1 to 5 feet (NAVD88) and the developed area sits at 5-9 feet elevation.

The City should coordinate with the Navy to implement adaptation actions in this area since the Navy owns the land directly to the east of Avenida Lunar.

3.7.1 Coastal Vulnerability

As shown in Figure AP-43, over time rising sea levels and 100-year storm events will cause increased flooding.



***0.8 ft. of sea level rise**: risk of periodic flooding, including minor overtopping of the seawall and significant flooding of the boat ramp area and Glorietta Bay Park. Flooding impacts to several stormwater outlets.*

***2.5 ft. of sea level rise**: the entirety of the area may be periodically flooded, obstructing use of the City buildings. Permanent inundation may occur at the shoreline of Glorietta Bay Park, and the size of the boat ramp may be reduced. A stormwater pump station is also at risk of flooding.*

***4.9 ft. of sea level rise**: the entirety of the area may be inundated, along with Strand Way being periodically flooded, greatly obstructing the usability of the land and buildings.*

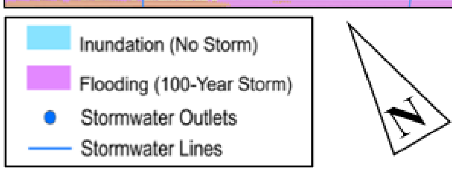


Figure AP-43: Approximate sea level rise projections over time at the Coronado Shores Beach area to Avenida Lunar

The cost of inaction is not estimated in this area because there is no tax assessment value for the City-owned beach and parking lots, which are the primary at risk sites in this area. This considered, the implications of losing a popular City beach to inundation should be considered when weighing adaptation options.

3.7.2 Adaptation Options

Adaptation strategy options for this area are broken down into separate strategies for the beach and for the flood wall and inland areas. These pathways are discussed below.

3.7.2.1 Beach Adaptation Options

Adaptation strategies for the beach include a mix of nature-based solutions, operational measures for the lifeguard stations, and the installation of groins, which could be funded by special assessments or a cost share program with adjacent properties. Figure AP-44 summarizes the suite of potential strategies and how they could be phased.

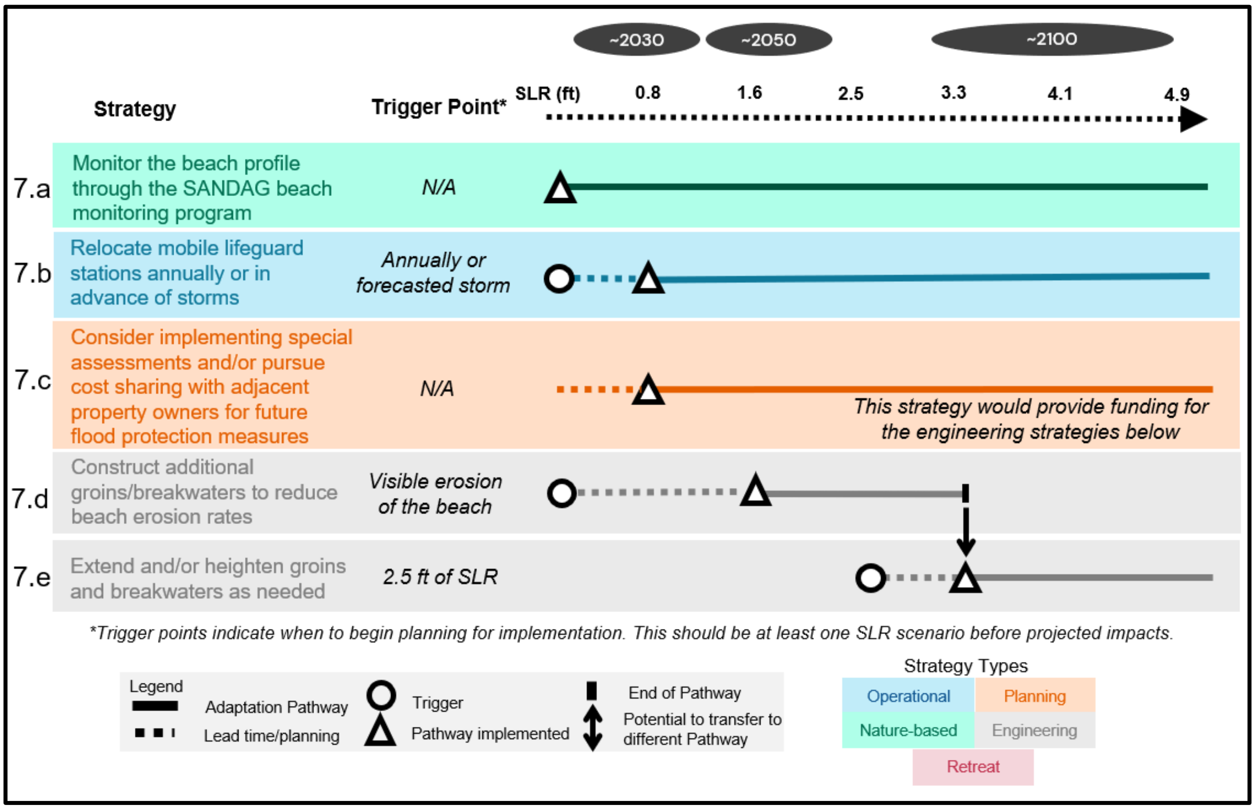


Figure AP-44: Adaptation pathway for the shoreline at Coronado Shores Beach to Avenida Lunar

The first step for the City to take is to continue working with the SANDAG Regional Shoreline Monitoring Program to monitor beach width in the area (**strategy 7.a**) via the SANDAG Regional Shoreline Monitoring Program—a program that provides data to decisionmakers regarding changes to the shoreline over time. Future beach nourishments should be coordinated with SANDAG. Monitoring beach erosion is particularly important because shoreline erosion rates can vary significantly from year to year or even season to season, which makes this phenomenon difficult to model in any long-term projection, such as those used in this analysis.

As sea levels rise to 0.8 feet above current levels, the two mobile lifeguard stations may need to be relocated annually based on erosion rates and the width of the remaining beach or prior to significant storms (**strategy 7.b**). The specific location to move these stations will depend upon the elevation profile of the beach at the time. The mobile towers can tolerate occasional flooding, which will only cause them to sink into the sand a few inches, so relocation should only occur when the stations are at risk of damage. In addition, they serve as useful landmarks for those attempting to identify their location on the beach when calling emergency services so movement should be limited.

A potential next step on this pathway is a establishing a special assessment or a joint funding venture with the neighboring Coronado Shores condominium towers and Hotel del Coronado (**strategy 7.c**) to fund construction of additional groins or breakwaters (**strategy 7.d**) and raise them as needed (**strategy 7.e**). A joint venture rather than a special assessment may make more sense in this location since they would be the primary recipients of the benefits of protecting the beach as a first line-of-defense against storm surge and sea level rise risks. While flood walls do protect the developments, those walls are designed for temporary storm surge protection, not to hold back the ocean water on a daily basis due to sea level rise. Additionally, development property values would be disproportionately negatively affected if the beach was inundated.

Groins and breakwaters can influence sediment diversion patterns on the beach, thereby helping to maintain beach width and reducing the amount of beach nourishment that needs to occur. Additional groins or breakwaters should be constructed whenever visible erosion on the beach is occurring at a rate that is too challenging or expensive to manage with continued or increased beach nourishment, likely around 1.6 feet of sea level rise. The groin that already exists in front of Hotel Del Coronado will also need to be reinforced and elevated at this stage to continue to provide the same level of erosion control and sediment diversion.

As sea levels continue to rise to 2.5 feet above current levels, all breakwaters and groins that have been installed should be assessed and extended and/or raised as needed. Reassessment and additional elevation or extension should occur at regular intervals as sea level rise continues.

3.7.2.2 Flood Wall and Inland Adaptation Options

Adaptation strategies in this area include a combination of operational measures and a special assessment or a cost share program with adjacent properties to fund engineering strategies that reinforce and expand structural protection. Figure AP-45 exhibits pathway options.

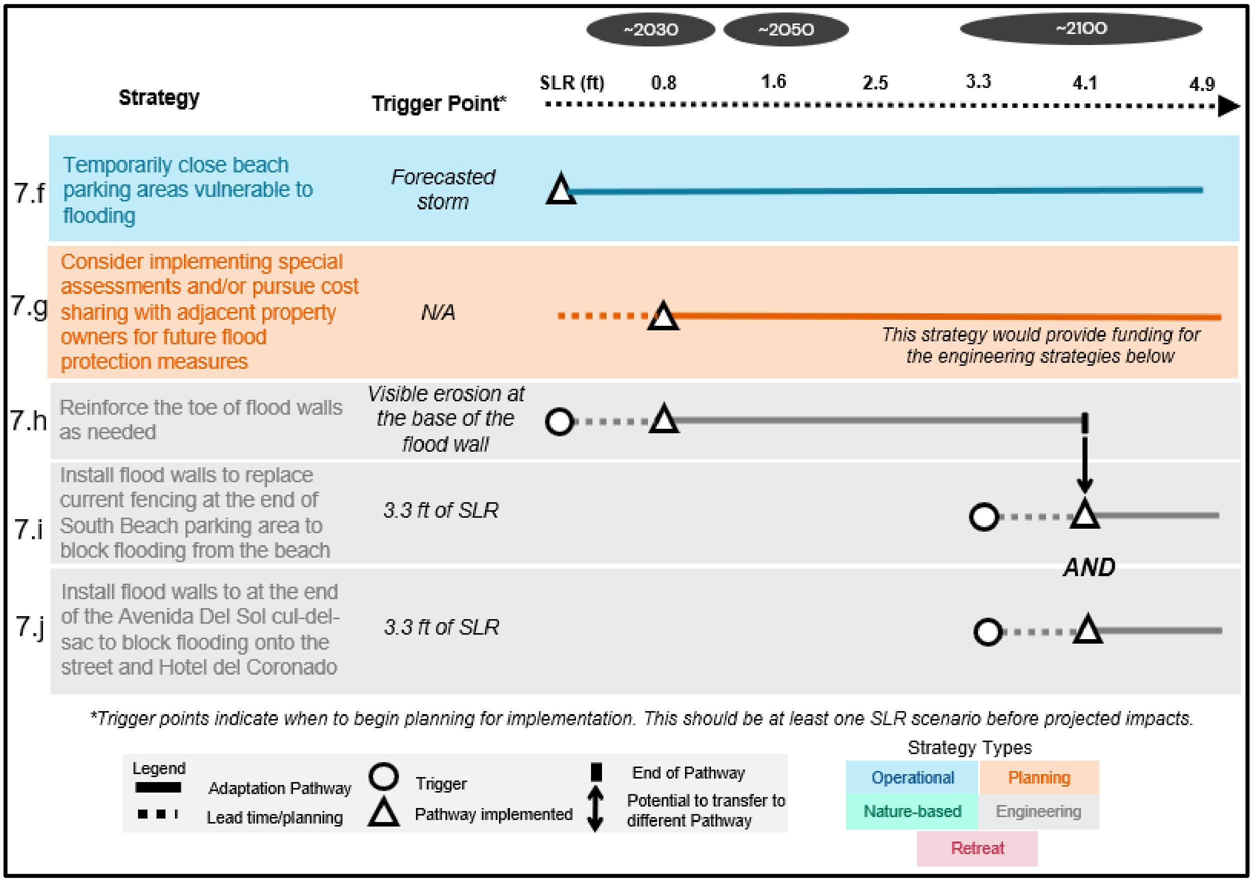


Figure AP-45: Adaptation pathway for the flood wall and back beach area at Coronado Shores Beach to Avenida Lunar

As needed, the City could plan to close the oceanside of Avenue De Las Arenas and the South Beach parking area ahead of significant storm forecasts (**strategy 7.f**). This would avoid flood damage to vehicles and enhance safety during significant storm events. These closures would likely be very rare in the near-term but become increasingly common over time.

As mentioned in the previous section regarding strategies for the shoreline, special assessments, and/or a joint funding venture with adjacent property owners such as Coronado Shores, the Navy, and Hotel del Coronado (**strategy 7.g**) could fund the engineering strategies suggested for this area. This could include:

- As visible erosion occurs at the base of the flood walls in this area, the walls should be reinforced as necessary (**strategy 7.h**). Depending upon sediment diversions and wave action, the amount of erosion may vary at different areas along the flood wall so regular monitoring should inform when and where reinforcement needs to occur.

- Reinforcing the walls would provide sufficient protection for the boardwalk, roads, and developed areas until about 2.5 feet of sea level rise, when additional flood walls or deployable flood barriers should be installed at both the end of the Souths Beach parking area (**strategy 7.i**) and at the end of the Avenida Del Sol cul-de-sac (**strategy 7.j**). Without these interventions, these low points in the area could result in flooding of the adjacent roads.

Implementing these strategies would protect the hotels and residences from both non-storm and storm-induced flooding and would avoid beach parking constraints due to flooded parking areas.

3.7.2.3 Pathway Costs and Costs of Inaction

Total Pathway Cost: $11-28M	**Cost of Inaction**: Unknown

The cost of inaction at this area primarily results in the loss of a popular public beach. The non-market value of the beach loss was not quantified in this study.

The costs of the adaptation strategies outlined in this pathway are estimated at $11-28M (2021). The cost of constructing and later elevating groins and/or breakwaters (**strategies 7.d and 7.e in** Figure AP-45) are the costliest strategies, together accounting for most of the total cost of the suite of strategies ($9-$22M). The cost of adaptation in this area is difficult to compare to the cost of inaction since the economic impacts of losing this section of beach are unknown. However, the City should consider the qualitative and economic costs of allowing a popular City beach near iconic resorts and residences to become completely inundated and inaccessible. Other qualitative drawbacks and benefits include:

- **Effectiveness**: Overall, this pathway will effectively protect the private property along the shoreline from flood damages and would preserve a popular public beach for continued residential and tourist use.
- **Economy:** This pathway will preserve commerce, tourism, and recreation in the area. The Hotel del Coronado is a significant economic draw for the City.
- **Flexibility:** Overall, strategies suggested in this area are only somewhat flexible. Special assessments can be renegotiated over time and beach nourishment can be adjusted year-to-year; however, while breakwaters, groins, and flood walls can be elevated, they can be costly and difficult to remove.
- **Environment:** Both positive and negative environmental outcomes may occur as a result of this suite of adaptation actions. Beach nourishment can create more habitat for wildlife and processes that depend on a sandy beach, but construction also disrupts wildlife currently using the beach as habitat. Groins/breakwaters can help retain this beach, although they may also cause downdrift erosion, shrinking other beaches along the silver strand.

Table AP-10 summarizes the rated qualitative benefits of each individual strategy within the engineered adaptation option. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-10: Qualitative Benefits of Pathway for Action Area 7. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Planning	Special assessments	SLR: 🟢 SS: 🟢	🟢	🟡	🟢
Operational	Temporary closure of asset or facility	SLR: 🔴 SS: 🟡	🟢	🟡	🔴
Nature-Based	Conduct beach renourishment/construct dunes	SLR: 🟡 SS: 🟢	🟢	🟡	🟢
Engineering	Install sand retention feature (e.g., groin or breakwater)	SLR: 🟡 SS: 🟢	🟡	🟡	🟢
	Construct/raise flood wall	SLR: 🟡 SS: 🟢	🟡	🔴	🟢

3.8 Action Area 8: State Route 75 (SR75)

Figure AP-46: Existing conditions of State Route 75 across the Coronado Peninsula
(Source: Google Earth Pro)

Key Takeaways

State Route 75 becomes increasingly vulnerable to flooding as sea levels rise. To allow continued access of all four lanes of the road and protect developments alongside it from flooding, beach nourishment, dunes, operational strategies, and road elevation are recommended.

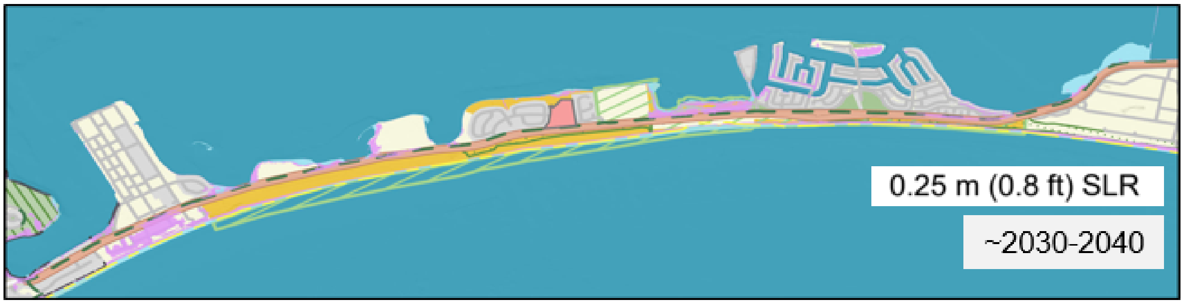
Figure AP-47:SR75 (north bound) and Bayshore Bikeway
(Source: Google Earth Pro)

SR75, also known as Silver Strand Blvd, is a four-lane road that serves as the primary egress for vehicles traveling south from Coronado. The road connects to Interstate 5 on both the north and south end of Coronado; however, for purposes of this plan, adaptation strategies are only recommended for the 7 mile stretch of the road pictured in Figure AP-47. Strategies for the road north of this area are discussed in other Action Areas, and the section of SR75 south of this area within the City of Imperial Beach is not included in this plan. The road sits at varying elevations, ranging from 3-13 feet above current sea level. Land on the ocean side of the roadway is primarily Silver Strand State Beach, which is owned and operated by California State Parks. The Navy owns an approximately half mile strip of beach toward the north end as well. The bay side consists of Navy property, residential areas, a small area of state park-managed beach, and Silver Strand Elementary School. Bayshore Bikeway, a popular paved biking trail, runs parallel to SR75 along the northbound lanes. The Bikeway is an iconic and economically valuable asset for the City of Coronado and also serves as a first line of defense for SR75 from bayside flooding.

SR75 is currently owned and operated by the California Department of Transportation (Caltrans). In recent years, the City had considered accepting the relinquishment of SR75 and SR282 and entered negotiations with Caltrans to determine if an equitable agreement for transfer of the roads could be reached. While such an agreement has not been reached as of the writing of this plan, there may be a time in the future when the owner/operator of SR75 is the City. Regardless of ownership, the road is of high value to the City and Navy, since it is one of only two ways vehicles can access and exit the City. Additionally, SR75 is one of several roads being studied by SANDAG and the Navy for a joint military installation readiness and resilience project. Considering these important usages of the road, adaptation strategy recommendations are included in this plan; although close coordination with all stakeholders of SR75 will be vital to ensuring that effective adaptation occurs.

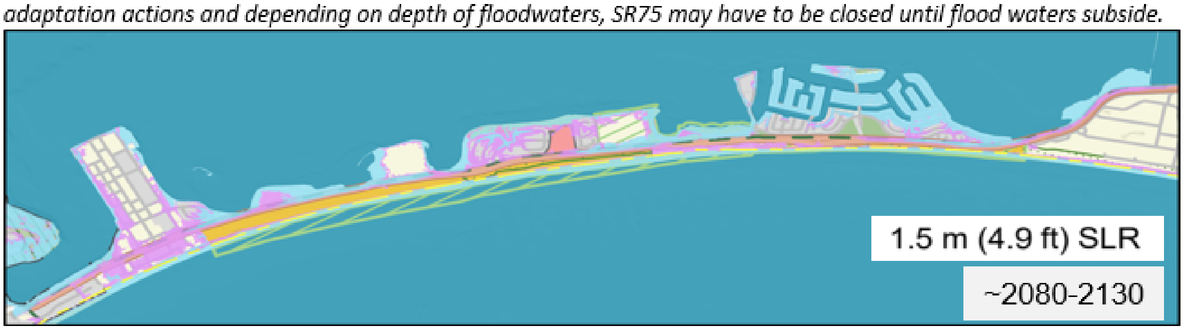
3.8.1 Coastal Vulnerability

As shown in Figure AP-48, over time SR75 will be faced with increasing coastal flood risk from rising sea levels and storm events. Flooding of any kind on SR75 can cause physical damage to the road itself as well as a variety of disruptions, including the closing of some or all travel lanes, unsafe driving conditions, increased emergency response time, impaired access to NASNI, and damage to vehicles.



0.8 ft. of sea level rise: *risk of storm-induced flooding at the south end of Coronado Cays, where several stormwater outlets could be at risk of inundation after a storm. Patches of flooding south of the aquatic center. Flooding is not projected to completely inundate the road, meaning disruptions would likely be temporary and a complete road closure would be unnecessary during a 100-year storm.*

2.5 ft. of sea level rise: *permanent inundation is still not projected on the road; however, the extent of flooding increases. Flooding near Coronado Cays also slightly increases and may cover all lanes of the road at points. Absent adaptation actions and depending on depth of floodwaters, SR75 may have to be closed until flood waters subside.*



4.9 ft. of sea level rise: *the road could become non-operational. Permanent inundation is projected to occur at several points over all lanes of the road, including near the Boathouse restaurant, near Naval Amphibious Base Coronado, and at the south of Coronado Cays. Storm-induced flooding is projected for over half of the road, yielding it completely inaccessible until waters subside.*

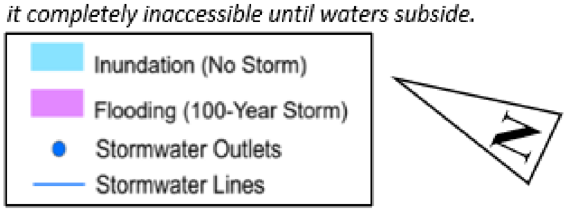


Figure AP-48: Approximate sea level rise projections over time for SR75.

The cost of inaction is not estimated for SR75 because there is no tax assessment value for the road. However, according to a 2019 City of Coronado Annual Traffic Report, an average of 26,358 vehicles use this portion of the road per weekday, demonstrating that it is critically important for continued economic prosperity in the City. In addition, SANDAG and the Navy are studying the impacts of climate change on SR75 because it is critical for military readiness at the base, although this value is also unquantifiable.

3.8.2 Adaptation Options

The recommended suite of adaptation strategies for SR75 includes planning, operational, nature-based, and engineering strategies (Figure AP-49). Due to the importance of the road for Navy readiness and community access, the City is not considering abandoning the road and letting Coronado convert to a true island that is only accessible via the existing Coronado Bridge and ferry.

As mentioned, strategies within the roadway right of way would be spearheaded by the owner/operator of SR75 and close coordination would be needed with the State of California, the City of Imperial Beach, and the Navy who own most of the land on either side of the roadway (**strategy 8.a**). State Parks and the Navy may be part of the solution in this area by undertaking protective measures outside of the Caltrans right of way that could help protect the road (e.g., installing cobbled dunes along the beach).

Well-designed operational plans for storm events are a key strategy in this area, especially in the near term while flooding is projected to occur only periodically. These plans should include contingencies for emergency service vehicle access, guidance regarding when to close or reduce operating lanes on SR75, and when to install temporary flood barriers (e.g., tiger dams) that could prevent flooding at low points in the roadway (**strategy 8.b**). These operational plans should be updated based on lessons learned from flood events and as other strategies are implemented.

To protect the road from erosion, entities who manage beach lands along the road, including Silver Strand State Beach, should work with the SANDAG Beach Monitoring Program—a program that provides data to decisionmakers regarding changes to the shoreline over time—and future beach nourishments should be coordinated with SANDAG. SCOUP may also be reinstated. Participating in these two programs (**strategy 8.c**) would allow beach renourishment projects to occur on a more frequent basis. Depending on the level of effort, beach renourishment can be effective across all sea level rise scenarios, and can be further supplemented by enhancing the vegetated dune systems along the coast with hard materials, such as cobblestone or riprap (**strategy 8.d**). This would provide an extra layer of protection that would act to prevent erosion during a storm event. If beach nourishment is being required too frequently, the use of groins to stabilize the beach could be explored as well.

While using a nature-based and operational approach to modify the coastline near SR75 is effective in the near term, elevating parts of the roadway (e.g., on an elevated embankment or as a causeway) will eventually become necessary to fully protect against flooding as sea levels continue to rise. The owner/operator of SR75 should conduct an engineering feasibility study within the next 5-10 years to inform the feasibility of elevating certain parts of the roadway up

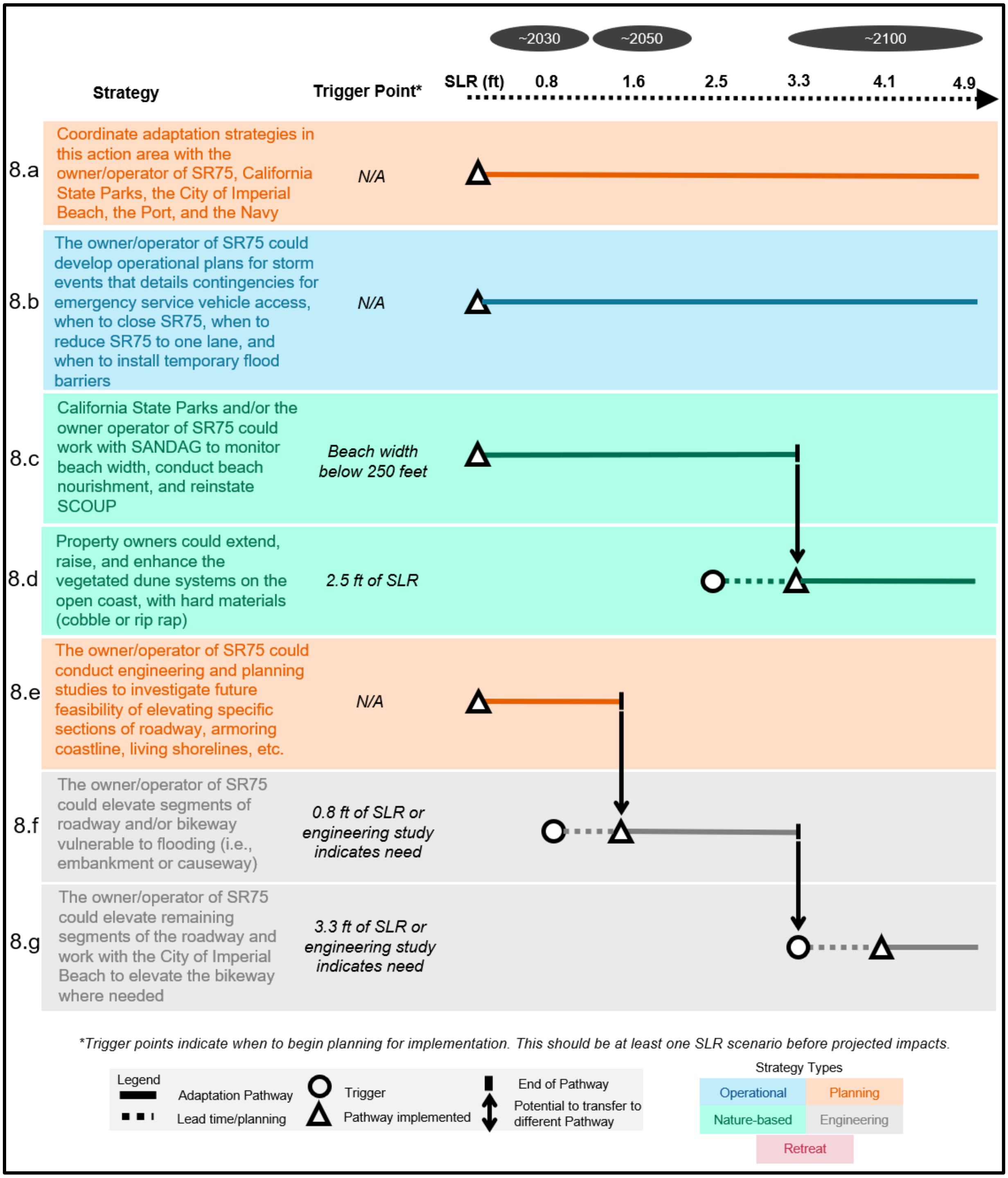


Figure AP-49: Adaptation pathway for State Route 75 to 1-3 feet (depending on location) and to determine precisely where elevation or additional coastline armoring is necessary (**strategy 8.e**).

Elevating the most vulnerable segments of the roadway and bikeway should begin around 1.6 feet of sea level rise (**strategy 8.f**). In some areas, where the source of flooding is from the bayside of the road, raising only the bikeway could provide sufficient protection to the both the bikeway and the roadway. As more sections of the road become vulnerable to flooding, elevation should continue as necessary (**strategy 5.g**).

3.8.2.1 Pathway Costs and Costs of Inaction

Total Pathway Cost: $264-541M	**Cost of Inaction**: Unknown
The cost of inaction at this area is unknown, although SR75 is highly valued by the City and losing it would impact accessibility to the City.	

The costs of the adaptation strategies outlined in this pathway are estimated at $264-541M (2021). Strategies to elevate the roadway (**strategies 8.f and 8.g**) are the costliest, accounting for most of the total cost of the suite of strategies ($250-500M). The length of roadway to be raised is approximately 12,500 feet. It is assumed that the road would be demolished and entirely rebuilt approximately two feet higher on fill with temporary detour lanes constructed. Additionally, the cost estimate assumes that utilities would be relocated, easements would be able to be modified, and that adjacent roadway access is ramped. As mentioned, the cost of inaction for SR75 is not calculated due to a lack of tax assessment data; however, the road's heavy daily usage and importance to the Navy highlights its value. It is important for the City to consider the qualitative costs of this segment of SR75 becoming frequently or permanently inaccessible.

Other qualitative drawbacks and benefits include:

- **Effectiveness**: This pathway will effectively protect SR75 from inundation and flooding. Without action, Coronado would become an island with no land connection to neighboring cities.
- **Economy:** This pathway will preserve commerce, tourism, and recreation along the Silver Strand and preserve access into Coronado from the South, thereby benefiting the economy.
- **Flexibility:** Strategies suggested in this area are flexible. Beach nourishment can be adjusted year-to-year and operational strategies are intrinsically flexible. Roads can be further elevated as time goes on if designed in such a way to allow for that.
- **Environment:** Overall, this suite of strategies would have a neutral impact on the environment. Beach renourishment may disturb habitat in the short term but preserve it in the long-term. Other strategies are unlikely to have significant environmental impact.

Table AP-11 summarizes the rated qualitative benefits of each individual strategy within the engineered adaptation option. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as “good” or “bad” but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-11: Qualitative Benefits of Pathway for Action Area 8. Effectiveness is broken into sea level rise (SLR) and storm surge (SS)

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Nature-Based	Conduct beach renourishment/construct dunes	SLR: 🟡 SS: 🟢	🟢	🟡	🟢
Operational	Temporary road closures/detours	SLR: 🔴 SS: 🟡	🟢	🟡	🔴
	Deployable flood control barriers	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
	Sandbagging	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
Engineering	Elevate or realign transportation infrastructure	SLR: 🟢 SS: 🟢	🟡	🟡	🟢

3.9 Action Area 9: Coronado Cays Residential Area

Figure AP-50: Existing conditions at the Coronado Cays residential area
(Source: Google Earth Pro)

Key Takeaways

To reduce future sea level rise risks, two long-term adaptation pathways may be considered:

Option 1: An engineering approach focused on elevating existing seawalls and roads where and when necessary.

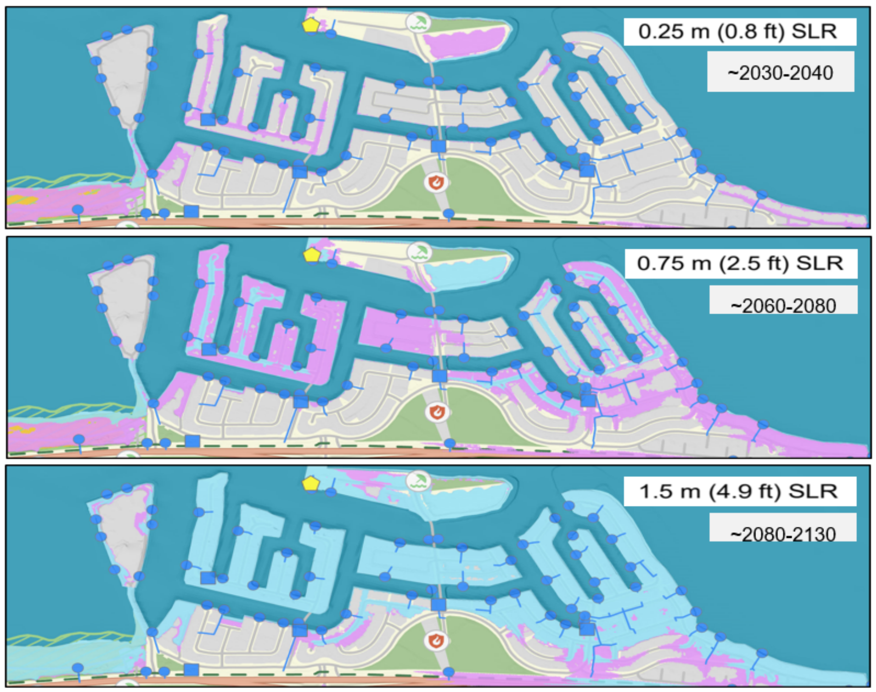
Option 2: Eventual implementation of a managed retreat approach focused on

Figure AP-51: Seawalls at Coronado Cays residential area

Coronado Cays Residential Area (see Figure AP-50) consists of residential developments along a series of canals on the bayside of the peninsula. It does not include the Loews Coronado Bay Resort area (Crown Island) nor Grand Caribe Island (includes the Coronado Cays Yacht Club) which are owned by the Port. The shoreline around the Cays is primarily seawall, with a small section of beach backed by individual flood walls along part of the southern edge of the area. The elevation is relatively low, not exceeding 6 feet above current sea level for most of the area. Coronado Cays Park and the fire station sit at a higher elevation (8+ feet). Silver Strand State Beach, the western beach area along the ocean, is owned and managed by California State Parks. The City should coordinate with the Port and State Parks to implement adaptation actions in this area.

3.9.1 Coastal Vulnerability

As shown in Figure AP-52, over time Action Area 9 will be faced with increasing coastal flood risk from rising sea levels and 100-year storm events.



***0.8 ft. of sea level rise**: risk of flooding in the northern and southernmost portions of the area. Some streets may experience periodic flooding, as well as several stormwater outlets.*

***2.5 ft. of sea level rise**: the extent of periodic flooding increases drastically, affecting a large area of private homes and infrastructure. Many roads are projected to experience flooding or inundation. Additional stormwater outlets are likely to be flooded.*

***4.9 ft. of sea level rise**: most neighborhoods and stormwater outlets will likely be inundated, greatly obstructing the usability of the land. Coronado Cays Park and the fire station are anticipated to remain dry, although nearby may experience permanent inundation.*

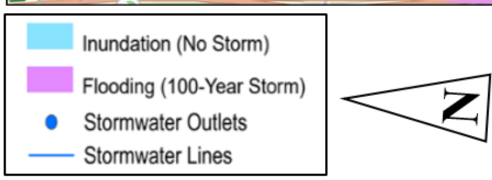


Figure AP-52: Approximate sea level rise projections over time for the Coronado Cays area

The cost of inaction at this area—or the cost of damages incurred and the value of properties lost by not implementing any adaptation strategies—is significant, estimated at $877M for non-storm inundation at 4.1 feet. This considered, the cost of inaction for non-storm inundation at 2.5 feet is only $10M, indicating that almost all the costs due to inaction occur between 2.5 and 4.1 feet of sea level rise. These costs could be even greater if a 100-year storm occurred, with up to $182M more in damages if the storm occurs at 4.1 feet of sea level rise. If a 100-year storm occurred at 1.6 or 2.5 feet of sea level rise, the cost of damages is still likely to be significant, estimated at $38M and $92M, respectively.

3.9.2 Adaptation Options

The Coronado Cays Residential Area lends itself to two adaptation pathway options:

1. An approach primarily using **engineered solutions** to raise and strengthen the existing seawalls and roads to withstand sea level rise, or

2. A **managed retreat** approach when sea levels exceed levels that can be operationally managed.

Engineered solutions and managed retreat were selected as the strategy options for this Action Area because of the current land use and the severity of projected long-term inundation from sea level rise. The Action Area is relatively high-density single use and multi-unit residential development, right at the water's edge which makes other strategies, such as nature-based solutions, difficult to implement. Other engineering strategies, such as walling the canals off and draining them to reduce the length of seawalls in the area that would need to be elevated, or converting to a community on stilts or floating structures (like Venice, Italy) with only boat access were briefly considered, but ultimately not recommended. It is unlikely that those strategies would be attractive to the community or permissible under current coastal permitting laws and regulations.

The adaptation pathways for Coronado Cays are illustrated with three graphics. One displays the engineering pathway (Figure AP-53). The other displays the managed retreat pathway (Figure AP-54). Then both are displayed together with a combined graphic (Figure AP-55) that denotes the points at which differing strategies may be pursued.

3.9.2.1 Engineering Pathway to Withstand Sea Level Rise

Engineering Pathway Overview

The engineering pathway adaptation strategies for Coronado Cays includes planning, operational, and engineering strategies to raise the existing seawalls (Figure AP-53). It emphasizes the continued use of this area as a residential area through the foreseeable future. Adaptation strategies in this area should be planned in close coordination with the Port which owns Crown Island (which contains Coronado Cays Yacht Club and Grand Caribe Shoreline Park),

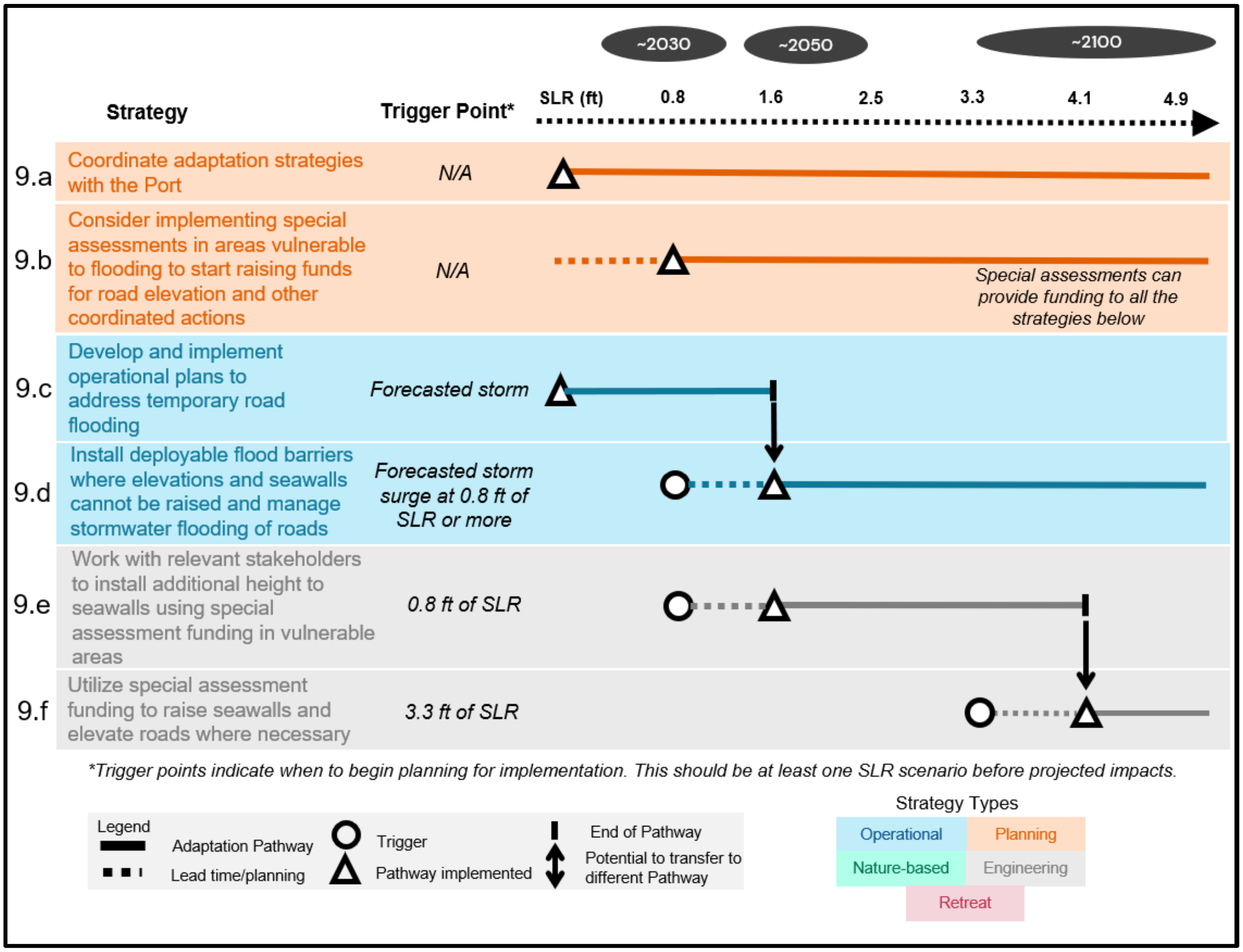


Figure AP-53: Engineering adaptation pathway for the Coronado Cays residential area

and the Loews Coronado Bay Resort area (**strategy 9.a**).

A critical, initial piece of this pathway is special assessment funding (**strategy 9.b**), which would raise funds from local homeowners to collectively raise the seawalls on homeowner property. In addition, while the City does not own the seawalls in this area, the City could pursue state and federal grants to help raise some of the funds. Raising collective funding is essential since this strategy will not be effective if it is not universally implemented in the area. Otherwise, single residences with lower seawalls could become flood pathways for large portions of the neighborhood. Under this option, planning to implement special assessments would occur as soon as possible, with a goal to approve special assessments sometime near the 2030 timeframe, or when sea level rise begins to cause temporary flooding.

While special assessment planning is underway, operational plans should be developed to address periodic storm flooding of local roads before advanced engineering solutions are put in place, such as warning systems and sandbagging or tiger dam plans (**strategy 9.c**). As flooding becomes more common, more dependable and easier to deploy strategies such as deployable flood barriers can be installed ahead of significant storm forecasts where needed (**strategy 9.d**). Implementation of these operational measures would be triggered by a significant storm forecast that could result in localized flooding.

As flooding worsens and sea level rise increases to near 1.6 feet, operational strategies will no longer be sufficient. To address this, 2.5-foot flood walls can be added to the top of the existing seawalls in vulnerable areas (**strategy 9.e**). Construction of these flood walls could occur during the same time that seawalls need to be repaired and/or replaced as they reach the end of their life cycle (generally ~50 years from the date of construction for seawalls). This additional elevation is relatively easy to install, but would not be backed by soil, so it is best suited to provide protection during storms and exceptionally high tides rather than everyday water levels.

As sea levels continue to rise, flooding should be closely monitored to determine when waters are regularly up against the flood walls that were added on top of the seawalls as part of strategy 9.e. When that occurs (approximately around 3.3 feet of sea level rise), planning to elevate the seawalls and raise roads would begin (**strategy 9.f**). Elevating seawalls in this area is likely to be an intensive engineering project. Raising seawalls requires adding fill behind the wall to provide sufficient strength to the structure to handle the force of the water in the Bay. Since the residences in the area are situated so close to the seawall it is likely that the homes would also have to be elevated since there is insufficient space to slope the new fill in a stable manner between the seawall and the homes. In addition, the roads would need to be raised due to emerging groundwater in the area. In summary, nearly the entirety of the Action Area would need to be raised. This massive engineering undertaking would require an initial feasibility study to determine if the project is realistic. While special assessments could help fund these projects, the City will likely need to consider other funding sources as well. Furthermore, since the life of seawalls is generally about 50 years, a similar (and similarly costly) engineering would have to be implemented 50 years after this project is completed.

To minimize inundation, this strategy should be implemented by 4.1 feet of sea level rise, when the flood walls and deployable barriers become insufficient to mitigate flooding. This elevation is projected to be necessary roughly in line with the end of the useful life of the previous seawall repair/replacement.

Engineering Pathway Costs and Benefits

Total Pathway Cost: $621M-1.3B	**Cost of Inaction:** $877M

While the cost of this strategy relative to other Action Areas is substantial, so is the cost of inaction. The cost of inaction falls in the middle of the range of the adaptation strategy costs.

The estimated costs of the adaptation strategies outlined in this pathway are at least $621M-1.3B (2021). The cost of elevating seawalls and roads at 4.1 feet of sea level rise is by far the costliest strategy, accounting for the majority of the total ($606M-$1.3B). This assessment likely underestimates the total cost of the pathway since the cost of elevating private residential properties is not included. Additionally, the $621M-1.3B estimated for these actions will only provide protection until the life of the seawalls expires, generally about 50 years after construction. The period of time that this investment would provide protection for the area should be considered. While the cost of this strategy relative to other Action Areas is substantial, the cost of inaction for this area is also large; estimated $877M for non-storm inundation at 4.1 feet (see Coastal Vulnerability section above for more information).

While comparing the cost of action and inaction is useful, cost data alone cannot provide a comprehensive assessment of the suite of proposed strategies. Qualitative drawbacks and benefits should be considered as well. Overall, the engineering pathway is effective and highly beneficial for the economy and maintains flexibility in the near term, but it could have negative environmental impacts. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway could effectively protect the Coronado Cays against sea level rise and storm surge over the next 50+ years, allowing the residential community to remain in place, although additional investment would be necessary as seawalls erode and eventually require replacement and as sea levels rise even higher.
- **Economy:** The positive economic impacts reflect the ability of this pathway to protect valuable homes and properties.
- **Flexibility:** The use of planning and operational strategies in the near term preserves the ability to make larger decisions about investments in seawall reconstruction (or managed retreat) later when the impacts of sea level rise are more evident. Once those strategies have been constructed it is difficult to continue using a flexible approach.
- **Environment:** Seawalls and flood walls, the cornerstone strategies of the engineering pathway, do not create good habitat for flora and fauna along the shoreline. While there are some emerging techniques to improve them, they will never be as hospitable as a natural shoreline.

Table AP-12 summarizes the rated qualitative benefits of each individual strategy within the engineered adaptation option. The ratings show the potential pros and cons of each strategy. The strategies are rated by their effectiveness, flexibility, environmental impact, and impact on the economy. These ratings are not meant to declare a pathway as “good” or “bad” but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-12: Qualitative Benefits of Engineering Pathway for Action Area 9. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Planning	Special assessments	SLR: 🟢 SS: 🟢	🟢	🟡	🟢
Operational	Flooding alert system for neighborhoods	SLR: 🔴 SS: 🟢	🟢	🟡	🟡
	Deployable flood control barriers	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
	Sandbagging	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
Engineering	Construct/raise revetment	SLR: 🟢 SS: 🟢	🟡	🔴	🟢
	Construct/raise flood wall (i.e., add a wall on top of the existing seawall)	SLR: 🟡 SS: 🟢	🟡	🔴	🟢
	Elevate or realign transportation infrastructure	SLR: 🟢 SS: 🟢	🟡	🟡	🟢

3.9.2.2 Managed Retreat Pathway

Managed Retreat Pathway Overview

As an alternative to the engineering-focused approach, the City could implement a managed retreat approach (Figure AP-54), where homeowners and businesses that have or are likely to experience flooding opt in to be paid market value for their properties through state and/or federal buyout programs.

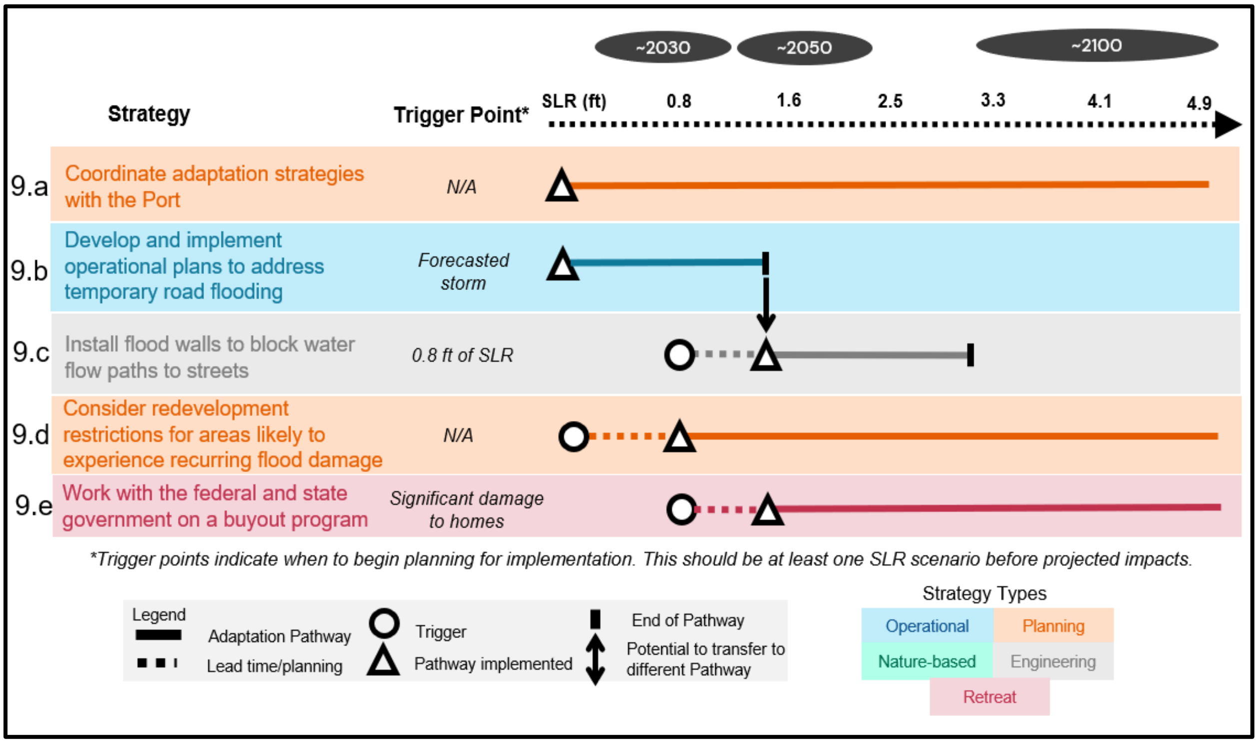


Figure AP-54: Managed retreat adaptation pathway for the Coronado Cays residential area

The goal is to move households out of highly vulnerable areas. However, in the near-term operational strategies would be used to allow residents to continue to enjoy their properties until flooding presents a significant risk.

Like the engineering approach, in the near term this pathway focuses on coordination with the Port (**strategy 9.a)**, and addressing the potential periodic roadway flooding issues with operational strategies (**strategy 9.b).** Operational plans such as warning systems and sandbagging or tiger dams could be deployed in advance of a forecasted storm. As flooding of the roads becomes more frequent, permanent flood walls to block water entry points to the streets would be implemented at approximately 1.6 feet of sea level rise, with planning beginning at 0.8 feet (**strategy 9.c**). These strategies will likely only be effective until 3.3 feet of sea level rise, at which point, large sections of the existing seawall could be regularly overtopped and flooding would be significant. As described below, at this point a voluntary buyout program would need to be well underway to move people out of harm's way.

Redevelopment restrictions (**strategy 9.d**) for areas likely to experience recurring flood damage are also a key piece of this pathway and planning to implement these restrictions should begin in the near-term, with the restrictions becoming effective near 0.8 feet of sea level rise. Redevelopment restrictions prohibit redevelopment of structures damaged by flooding or other coastal impacts or require that redevelopment will be more resilient to flooding and sea level rise.

These redevelopment restrictions would work in tandem with a voluntary government buyout program (**strategy 9.e**). As sea levels continue to rise, managed retreat would occur across the residential area in locations that experience flooding or are projected to experience flooding. These types of voluntary buyout programs would be coordinated with the state and FEMA, who has instituted these programs across the U.S. While the trigger for strategy 9.e is listed as "significant damage to homes" in Figure AP-54, some homeowners may not wish to leave their households after the first significant flood event, while others may be proactive and willing to retreat prior to a significant flood event. As insurance becomes more expensive, property values decrease, and homeowners experience repeated flood damages, there is potential for homeowners' opinions about retreat to become more favorable.

If desired and based on funding availability, the land in this area could be returned to a more natural wetland state to increase ecosystem services.

Managed Retreat Pathway Costs and Benefits

The estimated cost of the managed retreat pathway is difficult to ascertain and depends on partnerships with state or federal government. The bulk of funding for voluntary buyout programs have historically been provided by federal agencies, especially FEMA and the Department of Housing and Urban Development (HUD), while state and local governments often provide some amount of funding through a cost-match and are responsible for administering the funds. The costs of such a program for the City of Coronado would need to be developed in tandem with those partners. Managed retreat can also be encouraged using planning techniques, such as transfer of development rights programs. As detailed in the previous sections, the cost of inaction for this area is very significant and should be considered when making managed retreat choices.

Overall, the managed retreat pathway is effective and may be beneficial for the environment in the long term. However, it is not very flexible and there are significant economic considerations. Some of the key considerations for this pathway include:

- **Effectiveness**: Overall, this pathway will effectively mitigate the risk of sea level rise by removing residents from harm's way in the Coronado Cays area.
- **Environment:** Managed retreat provides the opportunity to restore an area to natural habitat, which can serve as a greenhouse gas emissions sink. If adequate hydrology exists, it may be possible for some areas to return to wetlands naturally over time.

- **Economy:** A managed retreat program would likely result in residents moving out of Coronado, thus deceasing tax revenues and economic activity in the city.
- **Flexibility:** Once a homeowner is bought out, that land cannot be redeveloped at any point in the future for anything other than open space and habitat, thus significantly limiting the flexibility of future land uses.

Table AP-13 summarizes the rated qualitative benefits of each individual strategy within the managed retreat adaptation option. The ratings show the potential pros and cons of each strategy. These ratings are not meant to declare a pathway as "good" or "bad" but rather to provide useful context for decision making. For additional details on the methodology and justification behind each rating, see Appendix AP-2.

Table AP-13: Qualitative Benefits of Managed Retreat Pathway for Action Area 9. Effectiveness is broken into sea level rise (SLR) and storm surge (SS).

Category	Strategy	Effectiveness	Flexibility	Environment	Economy
Planning	Zoning/building codes changes	SLR: 🟡 SS: 🟡	🟡	🟢	🟡
Operational	Flooding alert system for neighborhoods	SLR: 🔴 SS: 🟢	🟢	🟡	🟡
	Sandbagging	SLR: 🔴 SS: 🟡	🟢	🟡	🟢
Engineering	Construct/raise flood wall	SLR: 🟡 SS: 🟢	🟡	🔴	🟢
Retreat	Managed Retreat	SLR: 🟢 SS: 🟢	🔴	🟢	🔴

3.9.2.3 Combined Pathway

In addition to examining the engineering pathway and the managed retreat pathway separately, it is worthwhile to consider how strategies from these two pathways could work together. Figure AP-55 illustrates this combined approach and details at which points engineering pathway strategies can be shifted for retreat pathway strategies and vice versa. For example, if the City initially selected strategies along the engineering pathway but decided the cost of elevating seawalls and roads at 4.1 feet of sea level rise (**strategy 9.i**) was too prohibitive, the City could work toward managed retreat (**strategy 9.h**) at this later stage. However, the development process for buyout programs can be lengthy and state or federal financial support is not guaranteed. If managed retreat is a desired option, planning should begin as soon as reasonably possible.

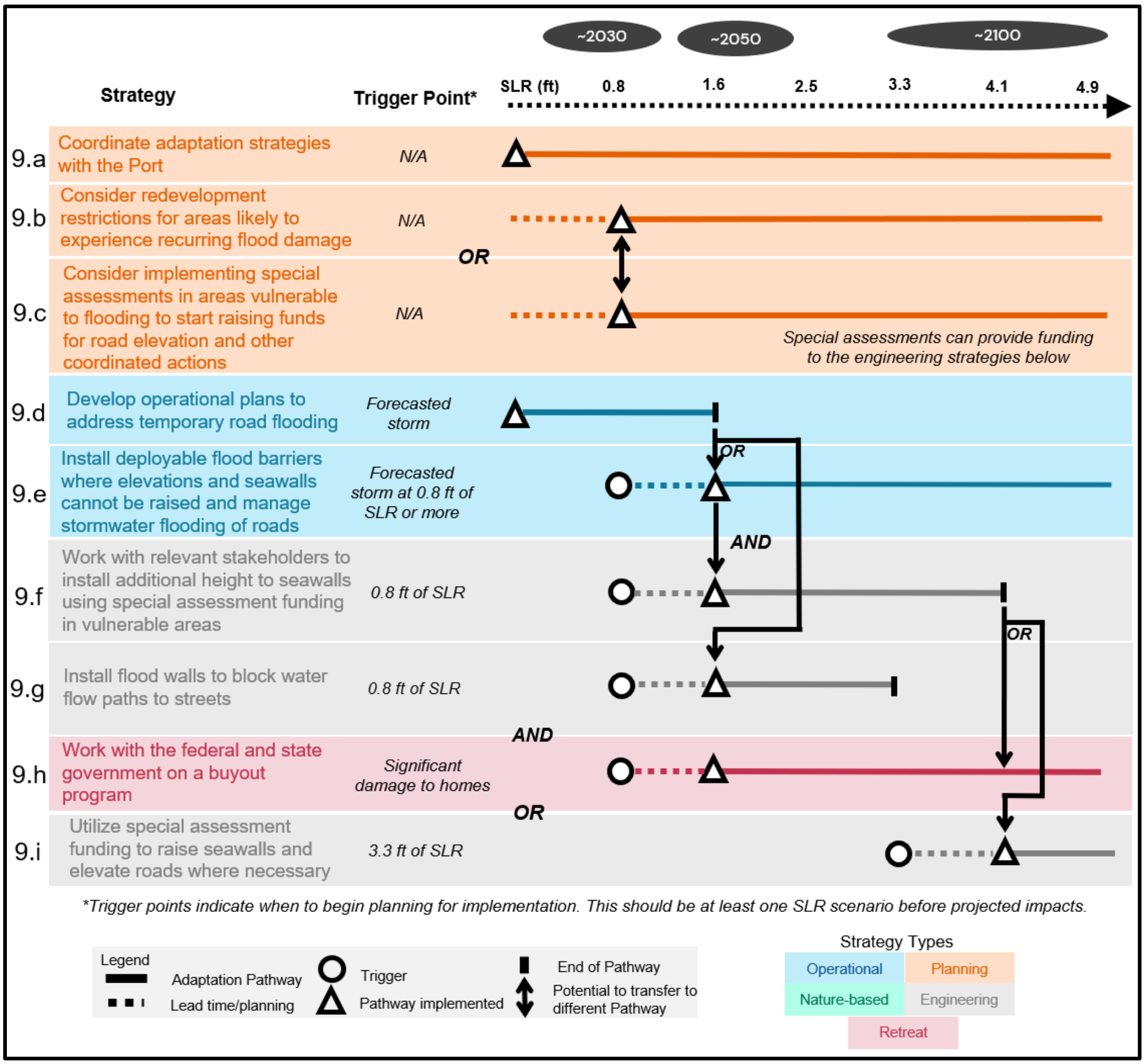


Figure AP-55: Combined adaptation pathway for Coronado Cays residential area

3.10 Action Area S: Stormwater Systems

Key Takeaways

Hydraulic and groundwater studies are recommended to inform future system adaptation actions. Then, a combination of nature-based and engineering strategies, including dry floodproofing pump stations and installing backflow preventers on outlets, are recommended to improve the system's overall resilience to sea level rise.

Figure AP-56: Stormwater pump station along Coronado Cays Boulevard
(Source: Google Earth Pro)

Coronado employs a variety of infrastructure solutions to manage stormwater across the City, including stormwater lines, pump stations, and outfalls. Sea level rise can cause a range of challenges for this infrastructure, such as flooding when water backs up submerged outfalls and emerges onto streets at street drains, damage from prolonged saltwater exposure, and clogging due to debris (especially after large storm events). Figure AP-58 exhibits an adaptation pathway to prolong the viability of stormwater management on Coronado. Risks to specific assets are noted within individual Action Area assessments, while the adaptation strategies discussed in this section apply to stormwater assets across the City.

Since stormwater infrastructure exists near or on properties owned by different entities, it is important that the City coordinates adaptation actions with property owners (**strategy S.a**), including the state, Navy, Port, and private property owners.

To properly inform future stormwater adaptation strategies, the City should conduct both groundwater depth and seepage studies (**strategy S.b**) and hydraulic studies (**strategy S.c**). These studies would inform the specific timeline and type of system changes that need to be made to maintain functionality over time. Groundwater depth and seepage studies may prove to be highly important data points for City decision makers since rising groundwater could require unique adaptation solutions to avoid damage such as increased corrosion, infrastructure damage, the mobilization of buried pollutants, and potentially emergent groundwater in neighborhoods like the Spanish Bight area.

Concurrent with planning strategies, as funding arises or as new projects are undertaken, the City can expand its use of green infrastructure (**strategy S.d**). Strategies such as green roofs and street trees help reduce overall stormwater volumes and reduce stress on stormwater infrastructure. For example, in the median of SR75, the City has installed and will continue to install drought tolerant landscaping, including converting hard scape areas to landscaped areas.

Figure AP-57: Permeable medians, such as this one along Coronado Cays Boulevard, can help reduce flooding on streets
(Source: Google Earth Pro)

As sea levels continue to rise, stormwater infrastructure upgrades will be necessary. Continuing to install backflow preventers at stormwater outfalls should begin as soon as possible for outlets that are already experiencing occasional inundation with a goal of having these preventers installed at the most vulnerable outfalls by 0.8 feet of sea level rise (**strategy S.e**). Additional preventers should be installed over time as more outfalls become submerged or as hydraulic studies inform vulnerability. These backflow preventers will prevent water at high tides or during storms from backing up the stormwater drainage pipes and flooding neighboring roads and properties.

At 0.8 feet of sea level rise, Coronado should begin planning to dry-proof at risk stormwater pump stations (**strategy S.f**) and to install additional pump stations (**strategy S.g**). This will increase the City's capacity to prevent flooding and to remove floodwaters from streets and properties after flooding occurs. To avoid substantial damage and mitigate flooding, dry-proofing should occur when pump stations first experience flood damages and additional pump stations should be installed when flooding occurs at streets or properties at least once annually.

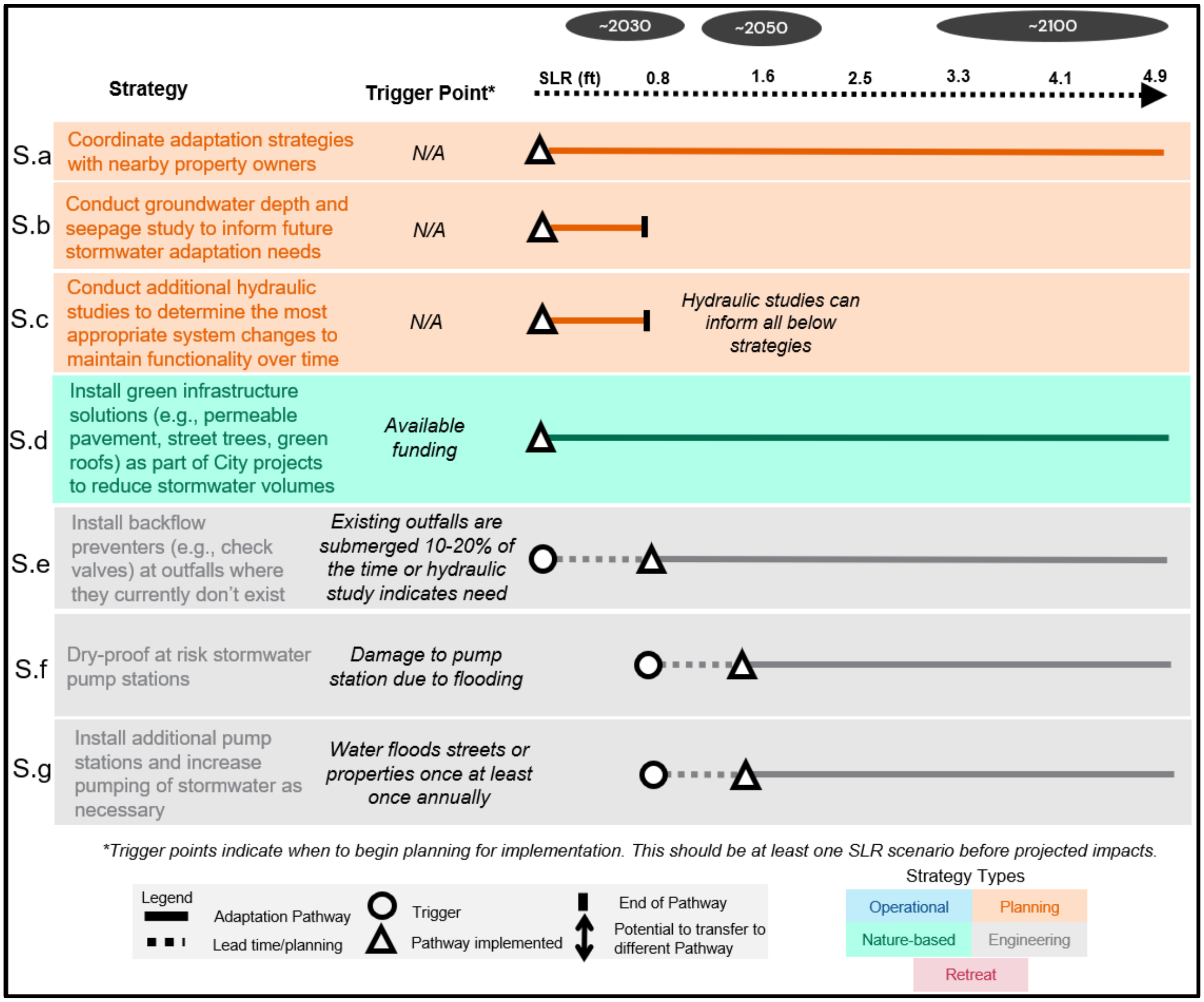


Figure AP-58: Stormwater systems adaptation pathway

4 Conclusions

The coastal vulnerability summaries for each Action Area illustrate the potential scale and severity of sea level rise impacts to the City. The estimated damage or cost of inaction for sea level rise could be as high as $1.6 billion for 4.9 feet of sea level rise or $2.1 billion for 4.9 feet of sea level rise and a 100-year storm.

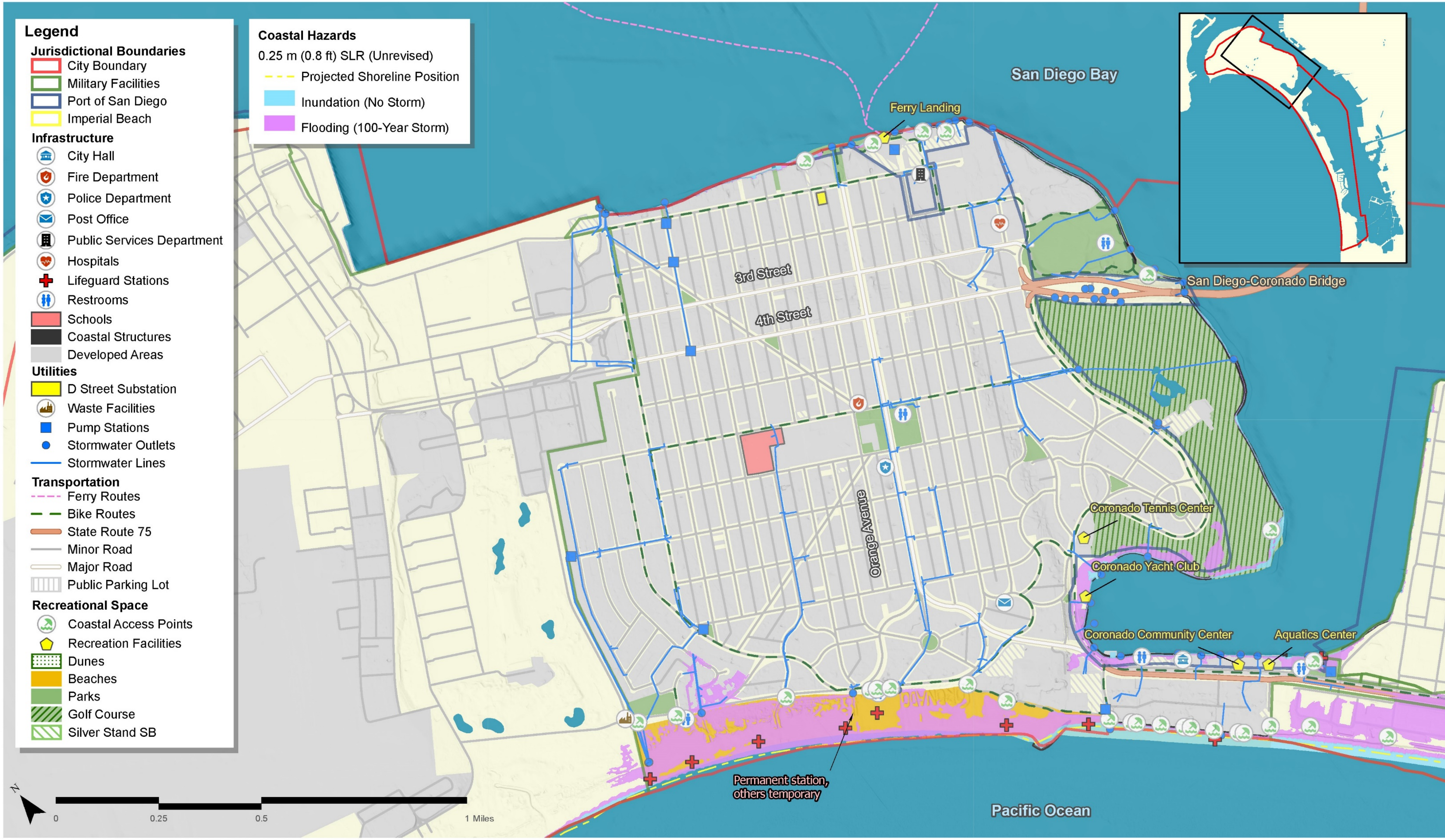
Adaptation planning is critical to prepare the City for sea level rise impacts and to preserve safety and quality of life in the community. Adaptation planning will position the City to proactively and cost-effectively prepare for sea level rise and reduce potential impacts before the occur.

A unique challenge for the City is mixed ownership along the coastline. The City does not have the authority to implement adaptation strategies on Navy, Port, State Parks, or Caltrans-owned land and infrastructure, however the actions of these entities have implications for the community. Effective adaptation planning and management will therefore require coordination and communication between these entities to ensure a comprehensive approach.

As outlined in this plan, there are near-term actions the City can begin to consider implementing now, particularly for Action Areas 3, 5, and 7 where the City manages most of the land or infrastructure. Near-term actions tend to focus on planning or operational strategies, while beginning to monitor sea level rise or other metrics to identify when critical thresholds are reached.

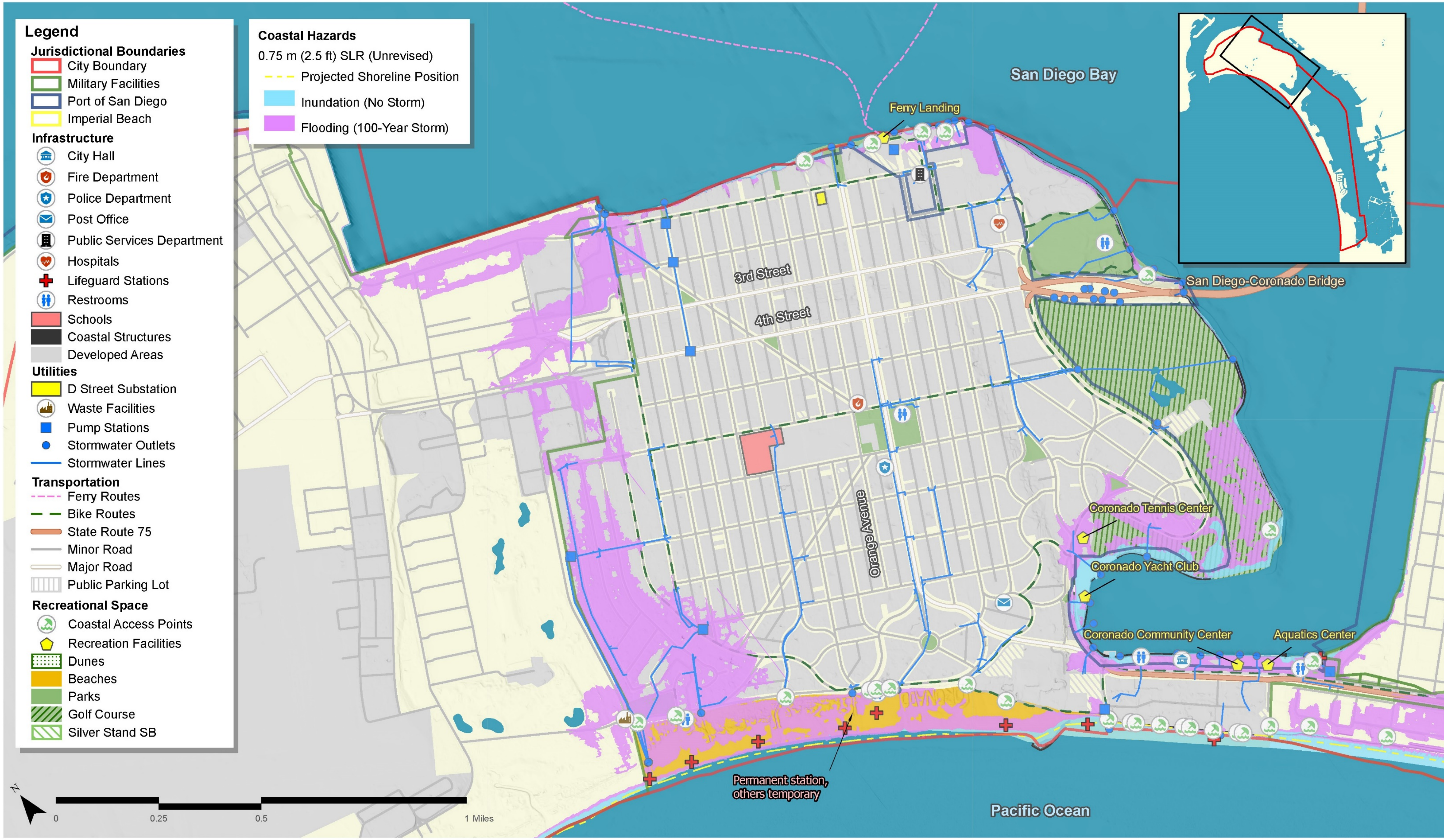
The City should consider engaging community members, City staff, and other stakeholders to discuss the feasibility and benefits of the adaptation strategies presented in this plan for each respective area to move toward selecting strategies to pursue over the next 10 to 20 years.

Appendix VA-1: Original CoSMoS Maps for the North Study Area

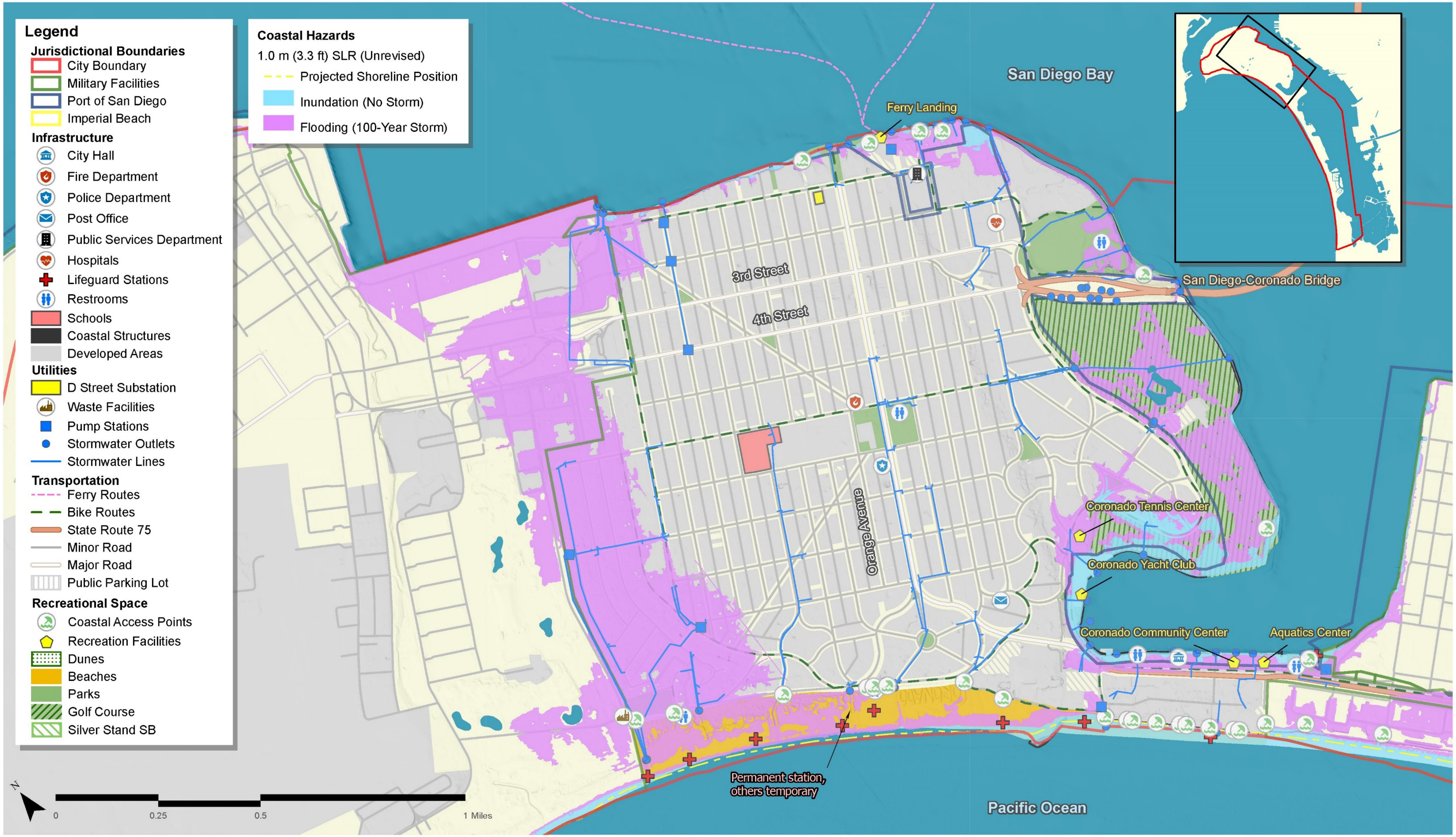


Unrevised CoSMoS flood and erosion hazard projections, North study area, 0.8 ft (0.25 m) SLR

Unrevised CoSMoS flood and erosion hazard projections, North study area, 1.6 ft (0.50 m) SLR



Unrevised CoSMoS flood and erosion hazard projections, North study area, 2.5 ft (0.75 m) SLR



Unrevised CoSMoS flood and erosion hazard projections, North study area, 3.3 ft (1.0 m) SLR

Appendix AP-1: Strategy Fact Sheets

Appendix AP-1 includes the strategy fact sheets. The strategy fact sheets explain many of the technical adaptation approaches that are recommended in this plan. The fact sheets provide brief but useful explanations that touch on the nuances of each strategy. The fact sheets include sections on:

- A description of the strategy,
- What protection is offered by the strategy,
- Considerations for using the strategy (such as the effectiveness, flexibility, and policy implications), and
- Co-benefits of the strategy.

The strategy fact sheets should be used as reference points when reading the plan. If the reader would like to learn more about the meaning of the approaches laid out in the plan, they may use Appendix A to better understand the strategies in question. The strategy fact sheets cover the following adaptation approaches:

1. Beach nourishment/construction of dunes
2. Building retrofits
3. Flood walls
4. Floodable/elevated parks
5. Groins and breakwaters
6. Levees
7. Managed retreat
8. Redevelopment restrictions
9. Seawalls
10. Special assessment districts
11. Tidal marshes
12. Elevate or realign transportation
13. Zoning and overlay zones

Beach Nourishment/Construction of Dunes

Description

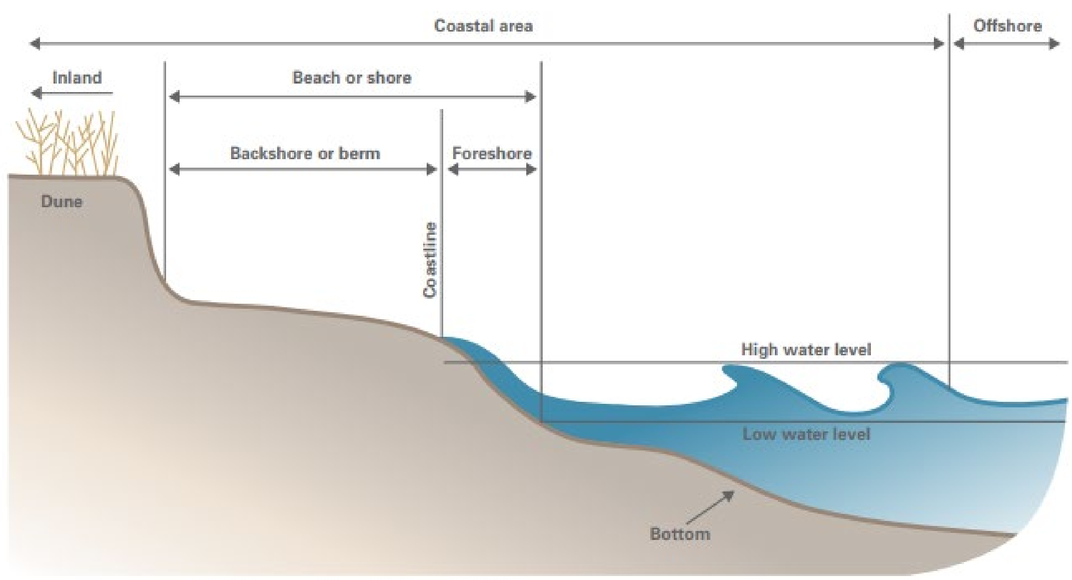
Coronado Beach. Image courtesy of the City of Coronado website.

Beaches and dunes are important shoreline features, providing habitat, recreation, and natural resources. They are also the first line of defense against sea level rise and storm surge for the inland communities and infrastructure. However, sea level rise can erode beaches and dunes over time, causing them to lose area and their ability to protect coastal infrastructure.

Beach nourishment involves adding sand on or around an eroding beach and can include dune restoration. Dune restoration involves the buildup of sand at the back of a wide beach to create a mound. Beaches and dunes are dynamic and adaptive and can be paired with a variety of other coastal resilience measures such as breakwaters and groins to offer enhanced protection.

Protection Offered

Beaches and dunes attenuate wave energy, protect coastal areas from flooding, and mitigate erosion. By presenting a sloping physical barrier between the incoming waves and coastal land, beaches and dunes absorb and dissipate wave energy before the waves can reach further inland. Dunes and beaches form a protective barrier that can prevent flooding and storm damage from storm surge, wave runup, and overtopping. In the near term, beaches and dunes also act as a buffer and barrier between rising sea levels and coastal development.



Beaches and dunes provide protection through elevation and serving as a buffer. Image courtesy of USACE 'How Beach Nourishment Works.'

Beach nourishment and dune construction facilitate these natural protective measures by adding beach-quality sand to the coastal system. Beach nourishment is usually employed where the beach has been eroded or to raise the elevation of the beach to protect inland areas from sea level rise but can also be used where there was a small or no beach before.

Considerations

The following table provides some key considerations in the selection of beach nourishment and dunes as a sea level rise protection measure. Beach nourishment can cost approximately $600-1,000 per linear foot as of 2021; the cost is variable based on the source of the sand, area of beach, and amount of intervention. There are some funding sources for beach nourishment, including the U.S. Army Corps of Engineers (USACE) Flood and Coastal Storm Damage Reduction Program.

Key Aspect	Opportunities	Challenges
Effectiveness	• Provides protection against multiple climate stressors (e.g., erosion, storm surge, short-term sea level rise) • Can be tailored to different levels of protection	• Generally not a feasible solution for extreme, long-term sea level rise
Flexibility	• Highly adaptable (can adjust elevations over time) • Easily combined with other coastal strategies	• Need to identify borrow source that has matching type of beach sand • Requires maintenance (design lifespan is 10-50 years) including periodic renourishment (e.g., every 3-10 years) • Dunes require wide beaches in front of them
Policy	• Because this is a nature-based solution, it may be easier to receive permitting than for a ‘hard’ infrastructural measure	• Requires permits for modifying shoreline • Requires environmental reviews/environmental impact statements • Requires strong coordination with regulatory agencies
Other	• Recreates natural landscape • Co-benefits include public access to water body, recreational use, and biodiversity support	• Only suitable for low-lying coastal areas

Co-Benefits

Biodiversity: Beaches can provide breeding or foraging habitat for birds, fish (e.g., grunion), and other coastal wildlife. Grasses and other vegetation can populate dunes.

Cultural services: Coastal communities have strong cultural ties to beaches.

Economy: Beaches are a major tourist attraction and economic driver. Enhancing beaches allows them to continue to exist in the face of rising sea levels and continue to provide economic benefits.

Other resilience: Access to beaches can provide an escape from the heat during high heat events, as beaches are generally cooler than inland urban areas.

Recreation: Beaches provide public access to the ocean for swimming, surfing, fishing, and other activities. They also serve as an outdoor gathering space.

Sources

FHWA. White Paper: Nature-Based Solutions for Coastal Highway Resilience. 2018. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/nature_based_solutions/fhwahep18037.pdf

SF Port Resilience. Waterfront Resilience Program: Beaches. No date. https://www.sfportresilience.com/beaches

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

USACE. Beach Nourishment. No date. https://www.iwr.usace.army.mil/Missions/Coasts/Tales-of-the-Coast/Corps-and-the-Coast/Shore-Protection/Beach-Nourishment/#:~:text=Beach%20nourishment%20is%20the%20adding,beach%20nourishment%20project%20as%20well

USACE. How Beach Nourishment Projects Work. 2007. https://www.iwr.usace.army.mil/Portals/70/docs/projects/HowBeachNourishmentWorksPrimer.pdf

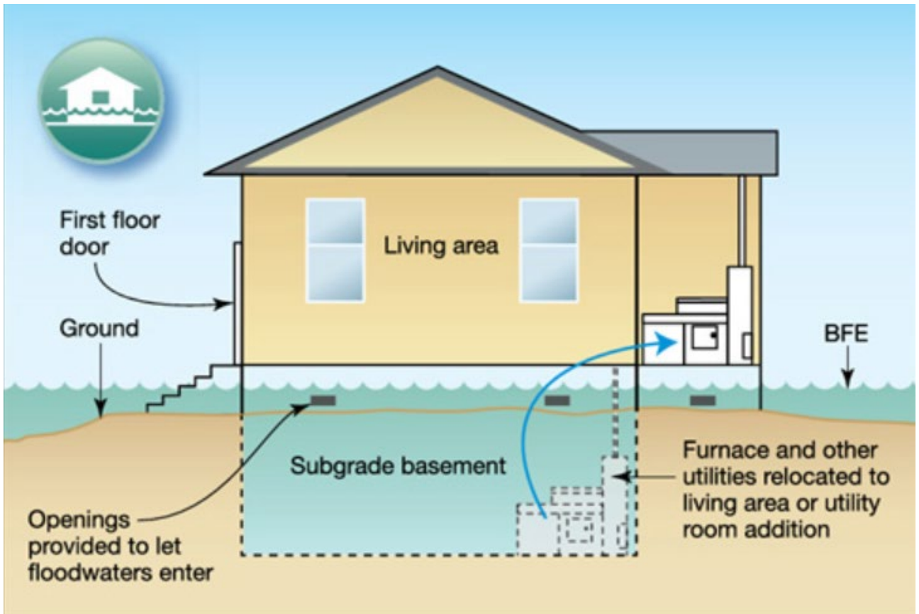
Building Retrofits

Description

Building retrofits are constructed design elements that provide protection to existing buildings against flooding. Design options include:

- **Dry floodproofing:** Preventing floodwaters from entering the building by making areas below the design flood elevation watertight (e.g., watertight gates or shields at doors and windows, using sealants to prevent water from entering through walls, and/or preventing sewer backup);
- **Wet floodproofing:** Avoiding water damage when the building is flooded (e.g., flood vents to allow flood waters to enter and leave, regrading surfaces, using flood damage-resistant interior materials, raising valuable contents onto platforms, and/or protecting or relocating utility infrastructure); and
- **Elevation:** Elevating important equipment inside lower levels or even entire structures on piles or fill above a design flood elevation.

To encourage building retrofits, a municipality may enact an ordinance, create an overlay zone, or use incentives for building owners. Note that a retrofit ordinance would only be triggered once a homeowner applied for a development permit (such as a remodel, addition, etc.).



Example of wet flood proofing. Image courtesy of FEMA.

Protection Offered

Building retrofits are intended to protect the structure against temporary flooding events during storms. They are not well suited for offering protection against permanent flooding due to sea level rise since the structure likely cannot be occupied while the surrounding area is flooded.

Considerations

The following table provides some key considerations in the selection of building retrofits as a sea level rise protection measure.

Some buildings cannot be retrofitted, and in seismically active areas, some buildings cannot be safely elevated. Elevating buildings might trigger additional accommodations under the Americans with Disabilities Act. Finally, increasing building elevation or ground floor floodproofing may have urban design implications—walls can affect access, pedestrian circulation, and streetscape appearance. Elevation is not a very flexible strategy and may only work for the short term, depending on how fast sea levels rise.

Key Aspects	Opportunities	Challenges
Effectiveness	• Provide specific and direct protection to the building • Improves the safety of building occupants	• Not designed for permanent inundation due to sea level rise – these strategies are better suited for protection against storm surge • Does not protect surrounding area
Flexibility	• Can be paired with coastal protection measures to provide redundant storm protection for critical facilities	• Elevation is not a flexible strategy; cannot be easily modified in the future
Policy	• Retrofits can be required through overlay zones or updated zoning, though action would be triggered by a development permit request	• May require additional changes to continue compliance with ADA and ensure accessibility to the building

Co-Benefits

Cultural services: Retrofitting important sites can protect culturally important structures in-place.

$ Economy: Retrofitted buildings can more quickly recover from flooding. This strategy protects property values and allows existing structures and businesses to remain in place.

Sources

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Measures Explorer: Building Adaptations. https://www.sfportresilience.com/building-adaptations

SF Port Resilience. Measures Explorer: Dry Floodproofing. https://www.sfportresilience.com/dry-floodproofing

SF Port Resilience. Measures Explorer: Structure Elevation. https://www.sfportresilience.com/structure-elevation

SF Port Resilience. Measures Explorer: Wet Floodproofing. https://www.sfportresilience.com/wet-floodproofing

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

Flood Walls

Description

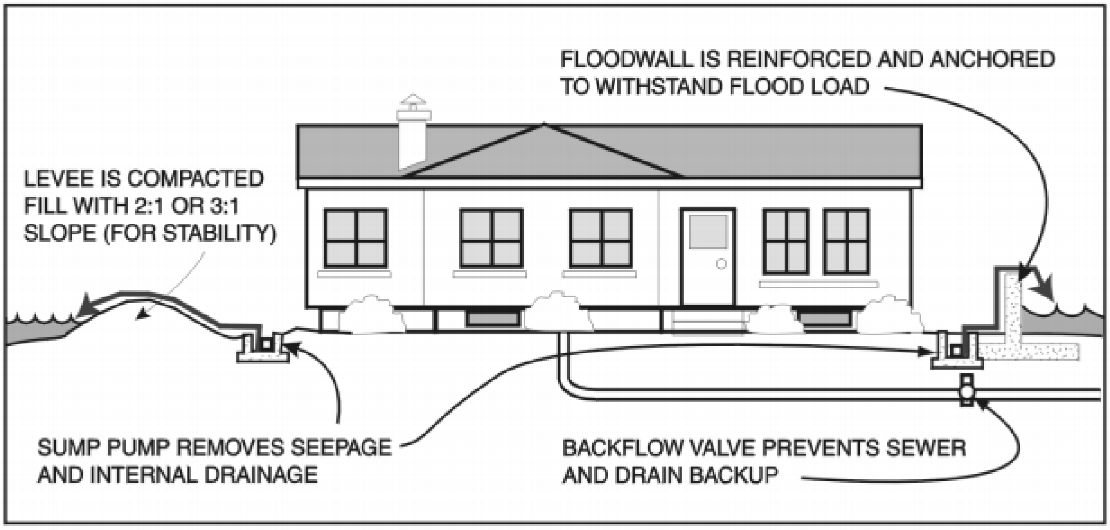
Flood wall in Hamilton Wetlands, Novato. Image courtesy of SFEI.

Flood walls are built at the site or regional scale to provide protection against extreme weather events. While typically a vertical barrier made of concrete, flood walls can also double as structures that provide landscaping features, such as planters and benches. They can also be demountable, meaning they can be deployed on an as-needed basis once the foundation is installed.

Flood walls prevent water from accessing buildings and sites without requiring significant changes to the structures they protect. These structures offer the same type of protection as levees but do so on a smaller scale, reducing potential costs while still reducing flood risk. Flood walls are often paired with other adaptation measures, such as seawalls and levees, to provide robust protection against sea level rise and storm surge. Note that flood walls are not the same as seawalls, which are described in a separate fact sheet (seawalls are shoreline measures directly adjacent to the water, are generally larger than flood walls, and provide height and armoring to the shoreline).

Protection Offered

Flood walls surround buildings or site topography and are typically reinforced at the base to withstand storm surge. Flood walls also have high resistance to erosion as they are made of concrete or masonry, allowing them to serve as a long-term solution against sea level rise.



Example of flood wall protection. Image courtesy of California Water Boards: Urban Drainage and Flood Control District.

Flood walls work well in urban areas due to the relatively small space they require. These structures can be incorporated into the existing aesthetic, and they allow preservation of existing site features, such as trees and gardens.

While flood walls serve as good adaptation options in smaller-scale urban sites, they may not be robust enough for severe flood events. Flood walls may be overtopped, and adding to the height of a wall also requires adding to its overall size to reinforce its strength against a flood load.

Considerations

The following table provides some key considerations in the selection of flood walls as a sea level rise protection measure. As for cost, a 5-foot-tall flood wall can cost $400-$600 per linear foot.

Key Aspect	Opportunities	Challenges
Effectiveness	• Most appropriate to protect against limited storm surge elevations	• Increasing level of protection requires increasing the size of the entire structure
Flexibility	• Flexibility in design as they can be permanent or demountable/ deployable • Protected structures can still operate during construction	• Demountable flood walls can have high operational and maintenance requirements • Permanent flood walls may impede pedestrian movement, building access, and transportation • Must consider drainage when building to avoid trapping stormwater behind the wall or

		diverting and concentrating flood waters to nearby properties
Policy	• Use comparatively less land area than other strategies, so may face fewer political barriers	• If installing around buildings or streets, may need to consider ADA requirements or fire codes
Other	• Ideal for sites where not much space is available	• Flood walls can have negative impacts on ecosystems as they limit connectivity and may cut off wildlife corridors

Co-Benefits

$ **Economy**: Flood walls effectively protect businesses from damage, allowing them to remain open during storm events and preventing damages that would require longer repair periods.

Sources

City of Millbrae, CA. Sea Level Rise Adaptation Assessment. 2020. https://seachangesmc.org/wp-content/uploads/2020/06/Millbrae-Sea-Level-Rise-Adaptation-Assessment.pdf

San Francisco Bay Urban Drainage and Flood Control District. Drainage Criteria Manual (V. 2) Flood Proofing. 2001. https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/muni/nrdc/11%20chapter%2011%20flood%20proofing.pdf

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

Floodable/Elevated Parks

Description

Floodable parks make use of frequently flooded land and accommodate sea level rise by creating recreational spaces that intentionally allow inundation. Elevated parks also create recreational space, but they build up from rather than accommodate sea level rise. Both options provide a buffer of land that can safely accept inundation between the shoreline and more vulnerable structures inland.

Floodable park design for Mission Rock, San Francisco, CA. Image courtesy of SCAPE Studio.

Protection Offered

Floodable parks provide a space that can safely accommodate incoming sea water during storm surge and flooding events. During these events, the park cannot operate, but after the storm has subsided and floodwaters have infiltrated or drained away, people can resume use of the park. Certain parts of the park may also be designated to become water retention ponds or artificial tide pools over time if inundation is expected to be permanent. Park managers can design the ecology of the park so that inundation does not damage the park, but rather, the park adapts to the inundation.

Elevated parks combine the nature-based solution benefits of parks with the protections that engineered flood barriers provide. Elevated parks are constructed by increasing the elevation of land above future sea levels and storm surge, generally with a seawall at the waterfront edge.

Considerations

The following table provides some key considerations in the selection of floodable and elevated parks as a sea level rise protection measure.

Key Aspects	Opportunities	Challenges
Effectiveness	• Reduces risk from sea level rise, storm surge, and erosion	• Floodable areas will need to be closed before storm events and cleaned up before reopening
Flexibility	• Can be designed to accommodate a variety of future sea level rise projections over time	• Requires ample land
Policy	• Developing green spaces or installing green infrastructure can	• May require land acquisition

	contribute to sustainability- and stormwater-related goals	

Co-Benefits

Biodiversity: Creating parks offers natural spaces for new habitats to form and maintains habitat connectivity.

Climate regulation: Park features can help regulate climate by providing shade and cool spaces in extreme heat and natural drainage for stormwater during heavy precipitation or flooding events.

Cultural services: Parks create opportunities for flexible, open spaces that can support markets, performing arts, and other community events.

Other resilience: Parks can enhance social equity; green space has been shown to improve mental health and quality of life for residents.

Recreation: Parks provide recreational opportunities for surrounding communities.

Water quality improvement: Green infrastructure in parks can enhance water quality through stormwater filtration.

Sources

Miami-Dade County. Sea Level Rise Strategy. 2021. https://www.miamidade.gov/global/economy/resilience/sea-level-rise-strategy.page

NYC Parks. Design and Planning for Flood Resiliency: Guidelines for NYC Parks. N.d. https://www.nycgovparks.org/pagefiles/128/NYCP-Design-and-Planning-Flood-Zone__5b0f0f5da8144.pdf

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

University of Massachusetts Amherst. Adaptation Strategies and Actions: Manage floodwater: Create a floodable park or open space. 2017. https://climateactiontool.org/content/manage-floodwater-create-floodable-park-or-open-space

Groins and Breakwaters

Descriptions

Installing groins can slow the movement of sand out of the project area, supporting the renourishment of beach area.

Groin in front of Hotel del Coronado. Image courtesy of UCSD.

Groins are extensions perpendicular to the beach, typically made of stone or concrete. They disrupt storm surge, waves, and tidal currents and trap the longshore flow of sand, building up sand within the groin area. Creating a groin can improve the stability and longevity of beach fill. The structure reduces waves and significantly improves the stability of the beach, which also functions to ease waves during storms.

Groins in Alabama on a private property. Image courtesy of Scott Douglass.

Breakwaters are structures built parallel to the shoreline and can be made of stone, formed concrete, or bagged shell material. Breakwaters can be built as wave barriers, artificial reefs, or floating wave disruptors that can be installed offshore, submerged, or connected to the land. Breakwaters protect an area against storm surge, waves, and tidal current impacts. Especially when breakwaters are installed in tandem with a native tidal marsh, they can greatly reduce coastal flood risk. Breakwaters also stabilize marshes and beaches by lessening the impacts of wave activity.

Breakwater at Dana Point, CA. Photograph by D. Ramey Logan.

Protection Offered

Groins and breakwaters can increase sand accumulation and protect beach area. They offer protection inland from storm surge, waves, and tidal currents by reducing wave height and providing friction to incoming water.

Considerations

The following table provides some key considerations in the selection of groins and breakwaters as sea level rise protection measures.

Key Aspects	Opportunities	Challenges
Effectiveness	• Groins and breakwaters can effectively mitigate the impacts of storm surge and coastal erosion, protecting inland areas. • These structures increase the longevity of the beach as little sand is lost to longshore sand transport.	• These strategies are not as effective at mitigating SLR long-term as they are typically limited to a specific area. • There are potential negative impacts of sediment accretion on adjacent shorelines by changing the longshore current.
Flexibility	• The strategies can be combined with tidal marshes to further protect inland areas by reducing impacts of sea level rise, storm surge and by encouraging wave attenuation. • These structures are flexible in that they accumulate sediment over time, making them more adaptable to changes in the climate. • Breakwaters and groins can be elevated relatively easily.	• Requires attention to materials used (i.e., type of sand used and the size of the stones) and design to ensure proper installation. Standard riprap is not effective.
Policy	• Natural strategies may be more politically feasible than 'hard' infrastructure. • There are initiatives and policies in California that encourage planners to choose green infrastructure over 'hard' options.	• There would be difficulty obtaining permitting because of impacts to adjacent shores and environmental considerations. • There may be right-of-way issues due to the conversion of submerged land to emergent dry beach, causing property interest to revert to the State.

Co-Benefits

Biodiversity: Forming groins can increase beach area, thereby creating additional habitat for native wildlife such as foraging shorebirds and nesting sea turtles. Underwater breakwaters can provide habitat for marine animals.

Other resilience: Beaches can enhance social equity by providing a free space for people to gather and enjoy themselves. Additionally, it provides a place to cool off during heat waves and in increasing temperatures due to climate change.

Recreation: Beaches provide recreational opportunities for surrounding communities.

$ **Economy**: Groins protect businesses from damage due to storm surge or tidal waves, allowing them to remain open. Additionally, groins help support tourism by continuing visitation to beaches.

Sources

FHWA Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/#toc18511918

SF Port Resilience. Waterfront Resilience Program. Measures Explorer. N.d. https://www.sfportresilience.com/measures-explorer

National Park Service. Groins and Jetties. 2019. https://www.nps.gov/articles/groins-and-jetties.htm

Levees

Description

Levees are areas with raised ground that are constructed along coastlines to reduce the risks of flooding by presenting a physical barrier to the incoming floodwaters. Levee creation is a major intervention in the landscape, but the levee can include amenities such as walking and biking paths along the crest.

There are several types of levees, including:

- **Traditional levees** -- a large continuous earthen mound that is wider at the base and narrower at the crest;
- **Super levees** – are very wide and tall with a very gradual slope on the landward side that is integrated into the urban form;
- **Dikes** – are similar to levees, but they are designed so that the waterfront side can be permanently flooded;
- **Ecotone levees** -- a very gradually sloping levee on the waterfront side with natural habitat integrated into the design.

Levee along the Jedediah Smith Memorial Trail in California. Image courtesy of AFAR.

Note that levees differ from flood walls and seawalls. While levees are typically earthen (but may be reinforced with human-made materials), flood walls and seawalls are ‘hard’ or ‘grey’ infrastructural measures with structural anchoring below ground, often made from concrete. Many levees are quite large and function as hills along rivers or bays to protect inland areas from moderate flooding; by comparison, seawalls are often narrower and built along beaches to protect inland regions against storm or high-wave inundation, and flood walls are even smaller (often both narrower and shorter than levees and seawalls) and tailored to protect low-lying urban areas or buildings from flooding.

Protection Offered

The scale of levees and dikes allow them to hold back large quantities of water. Traditional levees and super levees are usually used to protect against storm-related flooding and storm surge, but they can be designed to offer permanent protection from sea level rise.

Considerations

Depending on the size and type of levee developed, these structures can be useful to protect significant amounts of land from water risk and support coastal recreation and local economy, but levees can be very expensive to construct. The following table provides some key considerations in the selection of levees as a sea level rise protection measure.

Key Aspect	Opportunities	Challenges
Effectiveness	• If land is available, can be built relatively high to protect against large amounts of sea level rise and storm surge • Protects inland structures against sea level rise and storm surge • Ecotone levees may enhance resilience of natural ecosystems	• Super levees require a large area of land and may cause land compaction, making them unsuitable solutions for some locations
Flexibility	• Flexibility in setting height during design • Elevation of traditional levees can be increased over time if sufficient space is available to widen the base • Potential for long design life (75+ years) if built to mitigate long-term risks	• Potentially less flexibility for adjusting ecotone or super levee heights over time • Can require large quantities of fill depending on the design
Policy	• Ecotone levees create green spaces and promote marshes, which can contribute to sustainability goals and coastal marsh programs	• Permitting and consultation would require coordination and permits from state and federal actors (e.g., USACE, Coastal Commission, Fish and Wildlife Service) • Levees may impede site lines and access to the water, thus limiting coastal resources

Co-Benefits

Co-benefits vary based on the size and type of levee developed (e.g., an ecotone levee may lead to greater biodiversity benefits).

Biodiversity: Ecotone levees larger transition zone can support marsh habitat between the water and built infrastructure and may support ecosystem functions.

Climate Regulation: Ecotone levees may lead to co-benefits that could support climate regulation, such as carbon sequestration.

Water Quality Improvement: Use of ecotone levees could support improved water quality through natural filtering.

Recreation: Levees may be designed to support recreation (e.g., in low-elevation areas protected by the levee, or in a park or walkway on the levee).

Sources

Aerts, Jeroen C.J.H. A Review of Cost Estimates for Flood Adaptation. 2018. Water. 10, 1646. doi:10.3390/w10111646

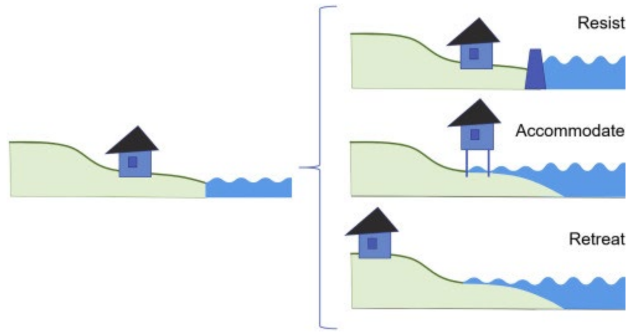
Naturally Resilient Communities. Setback Levees. 2017. http://nrcsolutions.org/wp-content/uploads/2017/03/NRC_Solutions_Setback_Levees.pdf

San Francisco Waterfront Resilience Program. N.d. Measures Explorer: Levees. https://www.sfportresilience.com/levees

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

Managed Retreat

Description



Coastal adaptation categories: resist, accommodate, and retreat. Image courtesy of A.R. Siders.

Managed retreat refers to the physical retreat from the coastline and the movement to new structures. This coordinated transition moves people and assets out of harm's way. It presents an opportunity as vulnerable coastal areas are threatened by hazards such as flooding and land loss due to sea level rise to proactively move away from harm and minimize damage. In best case scenarios, this relocation process is voluntary and equitable though it can be a highly controversial and difficult decision due to people's love and connection to "home". This disruption must be seriously considered before deploying this strategy.

In cases where the relocation process is voluntary, it may have been triggered by repetitive loss and/or issues with insurance (e.g., flood insurance premiums become too high, or provider will no longer cover the property due to increased flood risk). In cases where it is a regulatory process, an agency might restrict redevelopment, remodeling, and/or building permits that would maintain the existing structure.

Protection Offered

Managed retreat can provide protection against sea level rise by literally removing infrastructure from high-risk areas. The removal of hard infrastructure can allow natural ecosystems to form and flourish, which may also help to strengthen coastal protection.

Managed retreat can provide protection to individuals or entire communities by physically moving them to safer locations. This process may include incentives, compensation, or government buyouts for homeowners. FEMA has already contributed funding for managed retreat programs throughout the United States. A managed retreat plan can incorporate programs to support individuals and communities with this process, related to both retaining social cohesion and the physical transition itself.

Considerations

The following table provides some key considerations in the use of managed retreat as a sea level rise protection measure.

Key Aspect	Opportunities	Challenges
Effectiveness	• Managed retreat increases resilience as communities and infrastructure are physically moved out of harm's way	• Some residents or businesses may choose to stay put if the process is voluntary, which requires the continued provision of public services despite increasing risks and maintenance costs
Flexibility	• Can be tailored to specific context and resilience needs • Can be combined with other resilience measures	• Practicality of moving will vary by location and the context • Dependent on community buy-in • Requires a high initial investment, so is dependent on whether funding is available • Land cannot be redeveloped after it has been retreated from
Policy	• Can provide subsidies or compensation as an incentive or to assist those who want to leave but cannot because of fiscal barriers • Can implement social programs to assist the transition of individuals and communities	• Often politically unpopular, especially in the context of moving out of private residences or properties • Currently lack a coherent managed retreat policy at all government levels, so has often been reactive not proactive • It can be difficult to secure the funding necessary for a large, mandatory managed retreat program

Co-Benefits

Biodiversity: Natural coastal habitat may be re-created and provide protection to shorelines.

Other resilience: Provides a more sustainable and long-term solution. Savings with likely be long-term after high initial costs.

Sources

California Natural Resources Agency. Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy. 2018.

https://resources.ca.gov/CNRALegacyFiles/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf.

Georgetown Climate Center. Managed Retreat Toolkit. N.d. https://www.georgetownclimate.org/adaptation/toolkits/managed-retreat-toolkit/introduction.html.

Nevitt, M. Climate Adaptation Strategies: How Do We "Manage" Managed Retreat? 2020. https://kleinmanenergy.upenn.edu/research/publications/climate-adaptation-strategies-how-do-we-manage-managed-retreat/.

Siders, A.R. Managed Retreat in the United States. 2019. https://doi.org/10.1016/j.oneear.2019.09.008.

Redevelopment Restrictions

Description

Redevelopment restrictions are a policy and regulatory measure with the goal of facilitating managed retreat over time. They accomplish this goal by requiring that redevelopment will be more resilient to flooding and sea level rise than the previous structure or prohibiting redevelopment of structures damaged by flooding or other coastal impacts.

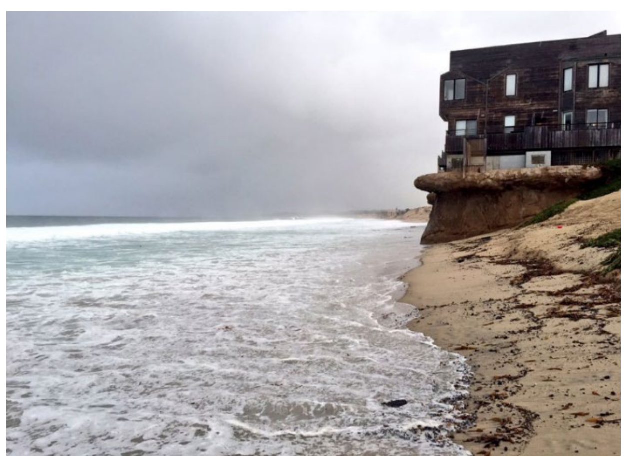
Surfers' Point Park in Ventura, CA has experienced repeated damage from coastal erosion. Image courtesy of Surferspoint.org.

Redevelopment restrictions are currently part of FEMA's National Flood Insurance Program (NFIP) but are only triggered under this program when structures are substantially damaged (that is, where the cost of restoring the structure would be equal to or greater than 50 percent of the market value of the structure pre-damage).

Outside of the NFIP, local governments can impose redevelopment restrictions to ensure that sea level rise and related impacts do not continually damage the same properties and that development at these locations is phased out when significant damage does occur. Redevelopment restrictions can also restrict the expansion or intensification of development in high-risk areas (such as where there is a high likelihood of repetitive loss due to current and projected coastal conditions).

Protection Offered

Redevelopment restrictions address high-risk areas (such as where there has been or is expected to have a high likelihood of repetitive damage and loss) by ensuring that further development does not occur.



Existing houses and other current coastal structures may not be viable in the future as sea levels rise and coastlines are squeezed. Image courtesy of Sara Aminzadeh.

Rebuilding and redevelopment restrictions can be implemented through a zoning ordinance or an overlay zone. They can also be accompanied by building code changes that require elevation or other floodproofing strategies. Local governments that are considering implementing these types of event-triggered restrictions might consider developing community-led recovery plans in advance of hazardous events that may occur in their areas. These recovery plans can help the community secure both political support and financial resources, such as catastrophe bonds, to aid implementation of different land uses after a loss event.

Considerations

The following table provides some key considerations in the selection of redevelopment restrictions as a sea level rise protection measure.

Key Aspects	Opportunities	Challenges
Effectiveness	• Rebuilding restrictions phase-out high-risk uses over time and provide long-term protections to people and property	• Rebuilding restrictions typically are not triggered unless a structure is significantly damaged and/or experiences repetitive loss, so it will not offer proactive protection
Flexibility	• Updating zoning and building codes to reflect evolving se level rise science is less expensive and may be easier than modifying investments in physical flood protection strategies	• Changes in zoning and building codes can take a long time to result in physical changes
Policy	• The California Adaptation Strategy recommends that local governments consider restricting rebuilding "when structures are damaged by sea level rise and coastal storms"	• Redevelopment restrictions are generally very unpopular and may not be politically feasible • Restrictions may conflict with other goals such as historic preservation • Prohibiting redevelopment may impact the City's tax base • May face legal challenges as a regulatory taking depending on the specific changes

Co-Benefits

Biodiversity: Redevelopment restrictions can be used to allow natural areas along the coast to migrate inland with sea level rise.

$ Economy: Prohibiting rebuilding or requiring strong resilience measures after significant damage prevents repetitive loss of structures.

Other resilience: Redevelopment restrictions can specify requirements other than flood protection (e.g., cool roofs, multi-paned windows, or natural infrastructure to combat extreme heat).

Sources

California Coastal Commission. 2018. Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. https://documents.coastal.ca.gov/assets/slr/guidance/2018/0_Full_2018AdoptedSLRGuidanceUpdate.pdf

Grannis, Jessica. 2011. Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise. Georgetown Climate Center. https://www.georgetownclimate.org/files/report/Adaptation_Tool_Kit_SLR.pdf

Grannis, Jessica. 2012. Zoning for Sea-Level Rise: A Model Sea-Level Rise Ordinance and Case Study of Implementation Barriers in Maryland. Georgetown Climate Center. https://www.georgetownclimate.org/files/report/Zoning%20for%20Sea-Level%20Rise%20Executive%20Summary%20Final.pdf

Land Use Law Center, Pace University School of Law. 2009. Local Land Use Response to Sea Level Rise. https://coast.noaa.gov/data/digitalcoast/pdf/long-island-land-use-law.pdf

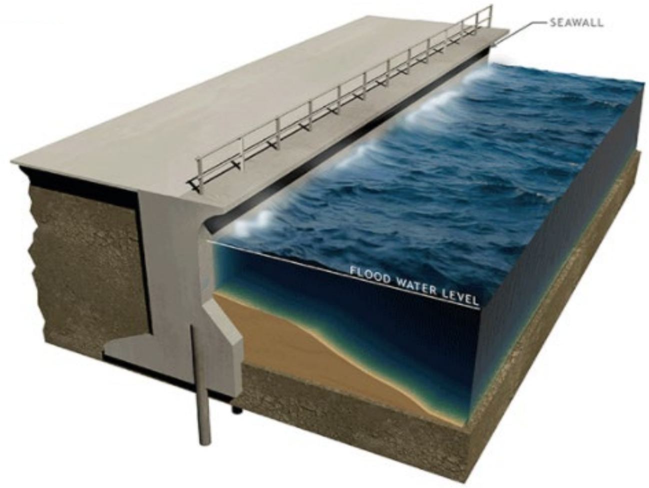
SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

Revetments/Seawalls

Description

Seawalls are large stone, rock, or concrete structures built along the shoreline with fill behind them that protect upland areas from coastal flooding and erosion. Seawalls may also include bulkheads (vertical structure that stabilizes the shoreline and retains soil but does not contribute much to protection against waves and flooding) and revetments (sloped structure that primarily serves to prevent or slow erosion), which stabilize the shoreline and limit erosion.



Seawall Diagram. Image courtesy of US ACE.

Because they are passive protection devices with low maintenance costs, seawalls can provide adequate long-term protection along a shoreline. They also require less space than other shoreline measures, such as levees or beaches.

Seawall along Coronado Cays causeway. Image courtesy of the City of Coronado.

Protection Offered

Seawalls add to the height of the shoreline, providing physical barriers that prevent overtopping and wave runup from reaching the land behind them. They can also provide shoreline armoring, which dissipates wave energy and prevents further shoreline erosion. Seawalls are ideal for environments with high wave energy since they can withstand large storms. The U.S. Army Corps of Engineers often constructs seawalls as part of larger flood control projects.

Seawalls typically have sturdy foundations, so they are not easily undermined by high wave energy. Different designs repel wave energy in various ways. Curved faces accommodate the runup of large waves and redirect the flow away from protected structures, while stepped faces limit wave runup and overtopping. Seawalls made of stones and rubble absorb and dissipate wave energy.

Considerations

The following table provides some key considerations in the selection of seawalls as a sea level rise protection measure. Installing new seawalls may cost ~$4,000 per linear foot and increasing the height of existing seawalls may cost $100-500 per linear foot in 2021.

Key Aspects	Opportunities	Challenges
Effectiveness	• Can withstand high wave energy and storm surge • Highly effective against sea level rise	• Beach in front of seawalls could eventually become lost if sufficient sea level rise occurs • Seawalls could worsen erosion on neighboring shorelines by reflecting wave energy and interrupting sediment replenishment
Flexibility	• Flexibility in setting the design height • Height may be adjusted in the future if there are no structures immediately behind the wall • Long design life with robust foundations	• Pumping may be required inland of seawall if the wall impedes drainage • Seawalls could impede inland migration of coastal habitats
Policy	• Use comparatively less land area than other strategies, so may face fewer political barriers	• Lengthy permit process required with the need to consult USACE, CA Coastal Commission, and potentially other state and federal regulatory agencies

Co-Benefits

$ **Economy**: Seawalls effectively protect businesses from damage, allowing them to remain open during storm events and preventing damages that would require longer repair periods.

Sources

California Coastal Commission. Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. 2018. https://documents.coastal.ca.gov/assets/slr/guidance/2018/0_Full_2018AdoptedSLRGuidanceUpdate.pdf

City of Millbrae, CA. Sea Level Rise Adaptation Assessment. 2020. https://seachangesmc.org/wp-content/uploads/2020/06/Millbrae-Sea-Level-Rise-Adaptation-Assessment.pdf

City of Newport Beach CA and Everest International Consultants, Inc. Seawall Assessment for Balboa Island and Little Balboa Island Main Report. 2011. https://newportbeachca.gov/Home/ShowDocument?id=10073

Port of San Francisco. https://www.sfportresilience.com/seawalls

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

U.S. Army Corps of Engineers. Design of Coastal Revetments, Seawalls, and Bulkheads. 1995. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1614.pdf

U.S. Army Corps of Engineers North Atlantic Division. Risk Management Strategies. N.d. https://www.nad.usace.army.mil/CompStudy/Risk-Management-Strategies/

Special Assessment Districts

Description

Local governments and/or groups of coordinated private homeowners can raise funding for sea level rise resilience measures through special assessments, which add a fee to property taxes for the area or district where the measures are planned to be implemented. This strategy helps to fund resilience measures that are localized and/or particularly costly by collecting the fees from the specific area and property owners that will benefit from the increased resilience.

However, because special assessments are added to property taxes, the impact of these fees will not be felt evenly across property owners (i.e., some will be better able to afford the extra fees than others). Additionally, voters must approve new fees in California under Proposition 218, so special assessments require voter support.

Protection Offered

Special assessments are not a resilience tool in and of themselves; instead, they are a mechanism for funding the construction and implementation of resilience measures. Therefore, they are a flexible strategy that can be paired with any physical or operational strategy in need of funding.

Because special assessments are targeted to a specific area and the fees are earmarked for resilience, the resources can be pooled and deployed with coordination and oversight.

Abalone Cove Landslide Abatement District in Los Angeles County was the first GHAD established. Image courtesy of Martin L. Stout.

Special assessments can take the form of districts such as community facilities districts (CFDs) and Geological Hazard Abatement Districts (GHADs). CFDs are flexible because the revenue they collect can be applied to general benefits, while GHADs must specify a 'special' benefit that will be received by the parcel(s) paying the fee. On the other hand, CFDs require a two-thirds approval from property owners or voters, while GHADs only require a simple majority. GHADs are also specific to geological hazards, which includes erosion, but can be designed to also address sea level rise hazards. For example, a GHAD was formed in the City of Malibu to restore and nourish an eroding beach and dune system, increasing the resilience to both erosion and flooding in the nearby area.

Considerations

Special assessments are useful tools for gathering and earmarking funds for place-specific resilience measures. However, this strategy also raises certain considerations, such as the need to garner enough political support among the tax base within a designated assessment district to implement and ensuring that the fees collected are not too burdensome. The following table provides some key considerations in the selection of special assessments as a sea level rise funding measure.

Key Aspects	Opportunities	Challenges
Effectiveness	• Paves the way for resilience measures by collecting funds	• Must be able to demonstrate that the resilience benefits are experienced by the property owners paying the special assessment
Flexibility	• Flexibility to fund various adaptation strategies	• Changes to the special assessment fees and areas would require voter approval
Policy	• Does not require changes to zoning	• Requires approval by taxpayers
Other	• Different types of special assessments (e.g., CFDs, GHADs) can be chosen based on the type of measures to be implemented and the level of support anticipated from the tax base	• Equity considerations arise when the burden of the tax is disproportionate across property owners in the area

Co-Benefits

Other resilience: Special assessments provide a stream of income for funding resilience measures in the parcel(s) under the special assessment.

Sources

SFEI and SPUR. SFEI SF Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

Resilient By Design Bay Area Challenge. Finance Guide for Resilient by Design Bay Area Challenge Design Teams Final Version 1.0. 2017. https://arccacalifornia.org/wp-content/uploads/2018/01/RBD-Financing-Guide-NHA-Advisors-171204-Final.pdf

Elevate or Realign Transportation

Description

Shifting transportation infrastructure routes or infrastructure (e.g., rail, road) out of a flood zone or above a specified flood height can mitigate sea level rise risks. There are various options to accomplish this, such as changing routes (e.g., for buses), elevating infrastructure (e.g., turning a road into a bridge or raising it onto an embankment or causeway), or moving infrastructure further inland or to higher-elevation land.

Sea level rise strategies for SR 37, which runs along the northern shore of San Pablo Bay to the north of San Francisco (top: current condition; middle: proposed embankment; bottom: proposed causeway). Images courtesy of Metropolitan Transportation Commission.

Such projects must involve consideration of potential adverse impacts of infrastructure or land change, such as impacts to drainage (e.g., from adding fill), changes in transportation connectivity during and after construction or rerouting, and removal of flood protection for other needs (e.g., if the transportation infrastructure currently protects other land from flood hazards).

Protection Offered

If transportation infrastructure is in a sea level rise hazard zone, moving or raising it is one option to mitigate that risk. Depending on the amount of elevation (e.g., 6 inches vs. 3 feet), this measure may manage the risks of storm flooding and short- or long-term sea level rise.

In addition, if designed for this purpose, elevated roads can serve as a levee and protect land and infrastructure inland of the road. However, most roadway embankments are not designed to serve as a levee.

Considerations

The following table provides some key considerations in the selection of elevated roads as a sea level rise protection measure.

Key Aspects	Opportunities	Challenges
Effectiveness	• Fundamentally, moving infrastructure out of harm's way can significantly increase its resilience • Elevating a roadway on a levee or seawall can provide protection for inland areas against sea level rise and storm surge • Elevating or realigning transportation infrastructure along the coast may be the only way to provide continued service	• Potential land use challenges (e.g., drainage issues associated with fill) must be considered to ensure safety
Flexibility	• Design may vary based on the degree of sea level rise engineers want to plan for (e.g., amount of freeboard that is built into design) • Causeways and embankments can be designed to be elevated further over time	• Practicality of moving, elevating, or re-envisioning infrastructure will vary by location and the needs that it must meet
Policy	• There is currently support at the federal level for increasing the resilience of transportation infrastructure	• Regulations, planning and permitting, and political considerations may be significant barriers to implementation • Transportation infrastructure may not be owned or managed by the City

Co-Benefits

Biodiversity: Ecological improvements such as improved habitat or transition zones may be achieved by infrastructure redesign.

Other Resilience: Elevating infrastructure may have co-benefits of protecting other land (e.g., creating a levee to elevate a coastal road may protect a lower-lying recreation area or economic center behind it)

Sources

SFEI SF Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

Zoning and Overlay Zones

Description

Zoning is a regulatory tool where policymakers can control land uses, urban density, structure height and size, and other features of the developed landscape. As such, it presents an opportunity for integrating resilience and hazard mitigation design requirements into an area.

Overlay zones are a type of zoning that add restrictions onto existing zoned areas. In this case, municipalities can outline areas that face exposure to sea level rise and associated hazards and stipulate that development in such areas be designed and constructed in a manner that increases resilience.

Clatsop County, OR adopted a flood hazard overlay zone for residents to be eligible for the National Flood Insurance Program (NFIP). Image courtesy of Clatsop County.

Protection Offered

Zoning and overlay zones can provide protection against sea level rise by requiring development (particularly in areas at risk of exposure) to incorporate resilience measures, such as:

- Widening setbacks from the shoreline;
- Clustering development away from water or low-elevation areas;
- Allowing buildings to be raised above a flood elevation);
- Retrofit ordinances to implement flood protection measures in existing structures and require floodproofing for mechanical equipment and ground floors.

This strategy can also be used to protect nature-based solutions, such as by creating an overlay zone to protect undeveloped space for coastal wetlands, beaches and dunes, and other natural areas that provide protection against sea level rise and flooding.

As a policy tool, zoning changes can be implemented over time – which provides a degree of flexibility. For example, the policy may stipulate that a greater setback distance becomes required once sea level rise measurements reach a determined height threshold. Overlay zones also provide flexibility because they tailor regulations to certain properties or districts with specific goals in mind, such as resilience, and do not require wholesale changes to existing zones.

Considerations

The following table provides some key considerations in the selection of zoning overlays as a sea level rise protection measure.

Key Aspect	Opportunities	Challenges
Effectiveness	• Can be targeted at addressing sea level rise and storm surge	• Is a regulatory tool to require implementation by other actors rather than directly implementing/constructing resilience measures • Does not provide broader protection of infrastructure in the area • Changes in zoning focus on new development or major remodels, and may not increase resilience of existing structures
Flexibility	• Can be tailored and updated to reflect specific context and resilience needs • Can be combined with other resilience measures • Allow for adaptive management	• Landowners are unlikely to support multiple changes to zoning for sea level rise over time due to the burden of keeping up with the changes and loss of development rights
Policy	• Overlay zones may be more politically feasible as they can be tailored to specific areas • May facilitate implementation of large-scale resilience measures once zoning that calls for resilience is in place	• May face legal challenges as a regulatory taking depending on the specific changes • Ease of implementing zoning changes depends in part on existing land uses, community sentiment, and political climate

Co-Benefits

Biodiversity: Zoning can be used to protect natural landscapes, prevent development in green spaces, or require including green infrastructure in design.

Sources

City of Coronado. Local Coastal Program Land Use Plan. 2005. https://www.coronado.ca.us/UserFiles/Servers/Server_746006/File/government/departments/comm%20dev/building/1373656741_71747.pdf

SFEI and SPUR. San Francisco Bay Shoreline Adaptation Atlas. 2019. https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_lowres.pdf

SF Port Resilience. Waterfront Resilience Program. N.d. https://www.sfportresilience.com/

SF Port Resilience. Measures Explorer: Zoning Codes. N.d. https://www.sfportresilience.com/zoning-codes

Appendix AP-2: Benefit Details

This section details the methodology and justifications for the qualitative benefits of the proposed adaptation strategies. As sea level rise and storm surge encroach on coastal municipalities like the City of Coronado, planning for climate change adaptation becomes ever more important to ensure the right strategies are implemented at the right time to reduce risks and meet the needs of the City. The following tables describe the benefits and tradeoffs associated with different adaptation strategies using a "stoplight" rating system. This will help to inform the City of Coronado's adaptation approach and considerations for implementation. Each strategy was evaluated according to:

- Effectiveness: The ability of each strategy to protect an area from sea level rise (SLR) and/or storm surge (SS).
- Flexibility: The capacity for each strategy to be adjusted to meet changing needs. This takes into consideration the built structure or implementation process, as well as if the strategy itself is malleable.
- Environment: The impacts of the strategies on the surrounding natural ecosystems and landscapes.
- Economy: The potential impacts of each strategy on the local economy.

The qualitative benefits were determined using information gathered for the strategy factsheets (see Appendix AP-1: Strategy Fact Sheets), as well as through technical and logistical insight from research conducted for this plan. The strategy tables have columns for the category, the strategy itself, the stoplight rating, and the justification. The category describes the overall type of strategy: hard engineering, nature-based solutions, operational, and planning. The strategy is a description of a proposed action to address sea level rise (SLR) and/or storm surge (SS) (100-year storm) impacts. The stoplight rating indicates the rating for each evaluation criteria on a three-point scale.[10] The scale for each topic area is explained in greater detail above each table. In general, green indicates a stronger strategy and red a weaker strategy for a given topic area. The justification column explains the rationale and significance of each stoplight rating.

[10] The Effectiveness table includes two stoplight ratings for each strategy: one for SLR and one for SS. For the evaluation criteria tables, the stoplight rating is for both SLR and SS.

Effectiveness

Effectiveness refers to the ability of each strategy to protect an area from sea level rise (SLR) and/or storm surge (SS). This takes into consideration the increasing impacts of the two environmental hazards over time. The green rating signifies that the strategy will effectively protect an area from either SLR or SS over a long-term period, such as the year 2100 or approximately 3.3-4.9 ft SLR. The yellow rating signifies that while the strategy may be initially effective, it may become less capable beyond 2050 or beyond approximately 2.0 ft SLR as the hazard worsens over time. Yellow may also note that the strategy will not adequately protect an area from SLR and/or SS unless paired with an additional strategy. Lastly, the red rating means that the strategy is not highly effective at mitigating the impacts of SLR and/or SS.

Effectiveness			
Category	**Strategy**	**Stoplight Rating** ●●●	**Justification**
Hard Engineering	Elevate or realign transportation infrastructure	SLR: ● (green) SS: ● (green)	Transportation infrastructure elevation/realignment in areas most at risk can protect this infrastructure from SLR and SS. In addition, elevated transportation infrastructure, if properly designed, can serve as a levee that protects inland communities from sea level rise and storm surge.
	Construct/enhance revetments	SLR: ● (green) SS: ● (green)	Revetments are an engineered solution that can withstand SLR and SS long-term. They can be designed to withstand high permanent and temporary inundation levels.
	Install building retrofits	SLR: ● (yellow) SS: ● (green)	This measure is effective at preventing severe impacts on buildings and can make recovery easier after a SS flood event. For SLR, this strategy should be used in tandem with other methods to adequately protect a building from long-term inundation.

Effectiveness			
Category	**Strategy**	**Stoplight Rating 🔴🟡🟢**	**Justification**
	Construct/raise flood wall	SLR: 🟡 SS: 🟢	Flood walls can reduce flood risk to structures and protect an area from inundation caused by SS. Flood walls are not meant to be used for long-term SLR inundation.
	Construct/raise levee	SLR: 🟢 SS: 🟢	Levees can be effective for SLR and SS if built in the right location and are well maintained.
	Install sand retention feature (e.g., groin or breakwater)	SLR: 🟡 SS: 🟢	Groins and breakwaters can effectively mitigate the impacts of SS and coastal erosion, protecting inland areas. They are not as effective at mitigating SLR long-term as they are typically limited to a specific area and have longshore drift impacts on surrounding coastlines.
	Construct floodable parks	SLR: 🟢 SS: 🟢	Floodable parks can be an effective strategy for limiting the impacts of SS and SLR on inland areas by accepting excess floodwater.
Nature-Based Solutions	Conduct beach renourishment/construct dunes	SLR: 🟡 SS: 🟢	Beach nourishment helps to prevent coastal erosion, coastal flooding, SLR impacts, and damage from SS by acting as a natural barrier. Beach nourishment may not be as effective in mitigating the impact of SLR in the long-term, especially if the beaches are relatively small. Dunes helps to prevent coastal erosion, coastal flooding, and damage from SS by acting as a natural barrier. Dunes may not be as effective in mitigating the impacts of long-term SLR inundation.

Effectiveness			
Category	**Strategy**	**Stoplight Rating ●●●**	**Justification**
Operational	Temporary closure of asset or facility	SLR: ● (red) SS: ● (yellow)	Temporary closures can be effective in the event of SS flooding, but the restricted infrastructure is not usable during the storm. They are not to be used for consistent and permanent inundation caused by SLR.
	Sandbagging	SLR: ● (red) SS: ● (yellow)	Sandbags are effective in the event of SS flooding but does not allow use of the protected infrastructure during the storm. They are not for consistent and permanent inundation caused by SLR.
	Deployable flood control barriers (e.g., sliding splash walls, water gates)	SLR: ● (red) SS: ● (yellow)	Deployable flood control barriers are effective in the event of SS flooding but does not allow use of the protected infrastructure They are not for consistent and permanent inundation caused by SLR.
	Flooding alert system for neighborhoods	SLR: ● (red) SS: ● (green)	A flooding alert system will effectively notify the community of oncoming floods, helping residents find a safe evacuation place or prepare their properties for the flood event. This strategy is not effective with long-term inundation from SLR.
Planning	Special assessments	SLR: ● (green) SS: ● (green)	Special assessments can support an effective, wide-spread effort to address SLR and SS by making adaptation projects more financially feasible to implement.

Effectiveness			
Category	**Strategy**	**Stoplight Rating ●●●**	**Justification**
	Zoning/building codes changes	SLR: ● SS: ●	Zoning and building code changes, such as instating redevelopment restrictions and raising the maximum height allowance, can prevent damage to existing, rebuilt, and future structures for SS and SLR.
Managed Retreat	Managed Retreat	SLR: ● SS: ●	Managed retreat can effectively move residents out of areas impacted by both SLR and SS, preventing harm.

Flexibility

Flexibility refers to the capacity for each strategy to be adjusted to meet changing needs. This takes into consideration the built structure or implementation process, as well as if the strategy itself is malleable. The green rating signifies that the strategy can be designed to allow manipulation over time to meet future needs. The yellow rating signifies that certain aspects or varieties of the strategy may be changed, while others may not. The red rating notes that the strategy is not flexible. None of the strategies were rated red.

Flexibility			
Category	**Strategy**	**Stoplight Rating ●●●**	**Justification**
Hard Engineering	Elevate or realign transportation infrastructure	●	Causeways and embankments can be designed to be elevated further over time. Practicality of moving, elevating, or re-envisioning infrastructure will vary by location and the needs that it must meet.
	Construct/enhance revetments	●	Revetment crests can be elevated over time, if needed; however, this may require a wider footprint.

Flexibility			
Category	**Strategy**	**Stoplight Rating** 🔴🟡🟢	**Justification**
	Install building retrofits	🟡	Some building retrofits can be altered or made redundant, but other adjustments such as elevation cannot be easily modified in the future.
	Construct/raise flood wall	🟡	The elevation of flood walls can be increased over time assuming the foundation is initially designed to bear the heavier load.
	Construct/raise levee	🟡	Levees can have flexibility in deciding the height during design and the elevation can be increased over time; however, this may require a wider footprint.
	Install sand retention feature (e.g., groin or breakwater)	🟡	Overall, groins are somewhat flexible in that they accumulate sediment over time, making them more adaptable to changes in the climate. Breakwaters and groins can also be elevated relatively easily. However, groins and breakwaters, especially larger projects can be costly and difficult to remove.
	Construct floodable parks	🟢	The method by which floodable parks function is inherently flexible. When the park is not flooded, it is a green space for residents to enjoy, allowing flexibility of use.
Nature-Based Solutions	Conduct beach renourishment and/or construct dunes	🟢	Beach nourishment and dune construction is an ongoing process with the flexibility to change location, height, or design over time. Both beaches and dunes will erode over time, which will provide opportunity for adjustments.

Flexibility			
Category	**Strategy**	**Stoplight Rating 🔴🟡🟢**	**Justification**
Operational	Temporary closure of asset or facility	🟢	Temporary closures are only used when and where needed, making them highly flexible.
	Sandbagging	🟢	Sandbags can be modified as needed and applied in various locations if necessary, allowing greater flexibility.
	Deployable flood control barriers (e.g., sliding splash walls, water gates)	🟢	Deployable flood control barriers allow for flexible use as needed.
	Flooding alert system for neighborhoods	🟢	A flooding alert system can be updated and changed according to community needs, allowing for flexibility.
Planning	Special assessments	🟢	Special assessments are mechanisms for funding the construction and implementation of resilience measures. They are a flexible strategy that can be paired with any physical or operational strategy in need of funding and can be renegotiated over time.
	Zoning/building codes changes	🟡	Zoning and building codes can be altered, but changes must be feasible within the political climate and acceptable in the public eye. Therefore, flexibility is not possible for all zoning and building code changes.
Managed Retreat	Managed Retreat	🔴	Managed retreat takes extensive time and funds to organize and execute effectively. There is not flexibility for residents to move back once they have vacated.

Environment

The Environment rating focuses on the impacts of the strategies on the surrounding natural ecosystems and landscapes. This includes issues such as wildlife movement, habitats preservation and creation, hydrology, encouraging native species, and water quality. The green rating signifies that the strategy may improve the natural environment. The yellow rating signifies that the strategy does not appear to have a significant impact on the natural environment. Yellow may also signify that there are certain aspects or approaches to the strategy that may be positive, while other aspects are negative. The red rating indicates that the strategy may harm the natural environment.

Environment			
Category	**Strategy**	**Stoplight Rating ●●●**	**Justification**
Hard Engineering	Elevate or realign transportation infrastructure	● (yellow)	Transportation infrastructure elevation/realignment can cause potential land use challenges by altering drainage, changing runoff patterns, or damaging the surrounding landscape through environmental disturbances. However, ecological improvements can be considered, such as improved habitat or transition zones through infrastructure redesign. Most pavements have a significant amount of embodied carbon.
	Construct/enhance revetments	● (yellow)	Revetments may prevent erosion, therefore protecting some natural habitats. While they do not support natural shorelines, they can still incorporate green elements, such as ECOconcrete, to provide ecosystem benefits. Because cement can create an impervious surface, it is important to consider alternative materials and design. Revetments can also impede inland migration of coastal habitats.

Environment

Category	Strategy	Stoplight Rating 🔴🟡🟢	Justification
	Install building retrofits	🟡	Building retrofits are not expected to have either negative or positive impacts on the natural environment.
	Construct/raise flood wall	🔴	Flood walls can have negative impacts on ecosystems as they limit connectivity and may cut off wildlife corridors. Most concretes have a significant amount of embodied carbon.
	Construct/raise levee	🟡	Ecotone levees larger transition zone can support marsh habitat between the water and built infrastructure and may support ecosystem functions such as natural filtering. If substantial protection is needed, super levees require a large area of land and may cause land compaction. Levees may impede site lines and access to the water, thus limiting coastal resources.
	Install sand retention feature (e.g., groin or breakwater)	🟡	Groins can increase beach area, thereby creating additional habitat for native wildlife such as foraging shorebirds and nesting sea turtles. Underwater breakwaters can provide habitat for marine animals. However, groins and breakwaters can also cause downdrift erosion, shrinking the beach in other areas.
	Construct floodable parks	🟢	Parks offer natural spaces for new habitats to form and maintains habitat connectivity. Green infrastructure in parks can enhance water quality through stormwater filtration.

Environment			
Category	**Strategy**	**Stoplight Rating** 🔴🟡🟢	**Justification**
Nature-Based Solutions	Conduct beach renourishment and/or construct dunes	🟡	Beaches can provide breeding or foraging habitat for birds, fish (e.g., grunion), and other coastal wildlife. Grasses and other vegetation can populate dunes, thereby offering carbon sequestration benefits. There may be adverse impacts on wildlife and vegetation from the disturbance of the existing habitat.
Operational	Temporary closure of asset or facility	🟡	Temporary closures have neither a positive nor negative impact on the environment.
	Sandbagging	🟡	Sandbags have neither a positive nor negative impact on the environment.
	Deployable flood control barriers (e.g., sliding splash walls, water gates)	🟡	Deployable flood control barriers likely do not impact the natural environment since they are used in already developed areas.
	Flooding alert system for neighborhoods	🟡	Flood alerts alone do not have a significantly positive nor negative impact on the environment
Planning	Special assessments	🟡	Special assessments have neither a positive nor negative impact on the environment.
	Zoning/building codes changes	🟢	Zoning and building codes can restrict development spread. Zoning techniques, such as redevelopment restrictions, can be used to allow natural areas along the coast to migrate inland with sea level rise.
Managed Retreat	Managed retreat	🟢	Managed retreat allows natural areas to migrate inland and reclaim previous impervious land.

Economy

The Economic rating summarizes the potential impacts of each strategy on the local economy. The green rating indicates that the strategy has the potential to improve or support the economy. The yellow rating signifies that the strategy does not have a significant impact on the economy. Yellow may also signify that there are certain aspects or approaches to the strategy that may be both positive and negative regarding the economy. The red rating notes that the strategy may have a negative impact on the economy.

Economy Category	Strategy	Stoplight Rating ●●●	Justification
Hard Engineering	Elevate or realign transportation infrastructure	● (green)	Transportation infrastructure elevation/realignment can ensure that businesses and other income-generating services are still accessible with flooding.
	Construct/enhance revetments	● (green)	Revetments can protect businesses and other income-generating features to ensure they are still accessible.
	Install building retrofits	● (green)	Building retrofits can more quickly recover from flooding. This strategy protects property values and allows existing structures and businesses to remain in place.
	Construct/raise flood wall	● (green)	Flood walls effectively protect businesses from damage, allowing them to remain open during storm events and preventing damages that would require longer repair periods.

Economy

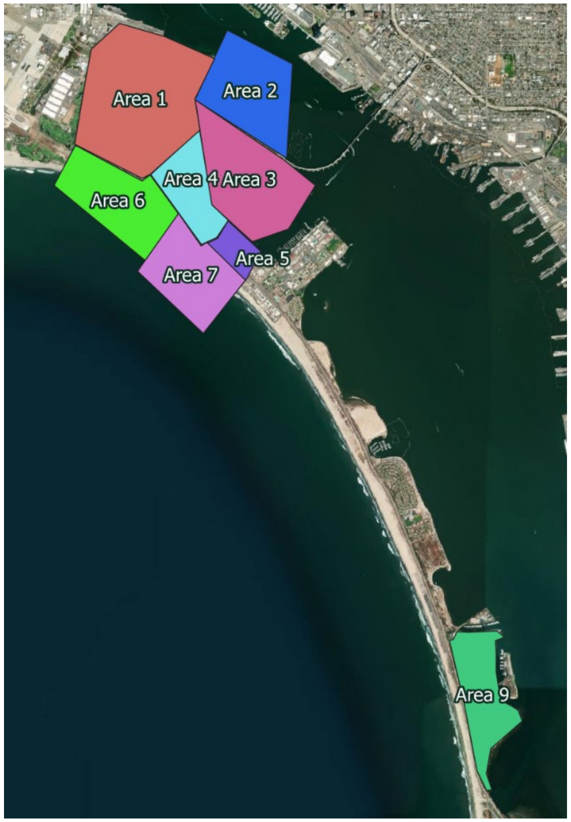
Category	Strategy	Stoplight Rating 🔴🟡🟢	Justification
	Construct/raise levee	🟢	Levees protect businesses from damage, allowing them to remain open during storm events. Prevents damages that would require longer repair periods, therefore protecting property values and allowing structures to remain in place. Levee construction should avoid displacing revenue-generating uses, such as local businesses.
	Install sand retention feature (e.g., groin or breakwater)	🟢	Breakwaters protect businesses from damage due to storm surge or tidal waves, allowing them to remain open. Additionally, groins help support tourism by continuing visitation to beaches.
	Construct floodable parks	🟡	Floodable parks may require land acquisition because the strategy requires ample land to function. It will also require continued maintenance of facilities for use.
Nature-Based Solutions	Conduct beach renourishment and/or construct dunes	🟢	Beaches are a major tourist attraction and economic driver. Enhancing beaches allows them to continue to exist in the face of rising sea levels and continue to provide economic benefits.
Operational	Temporary closure of asset or facility	🔴	Temporary road closures may block businesses and cause traffic, delaying movement of vehicles into areas of commerce. Other closures (such as a boat ramp or park) could restrict recreation access, thereby reducing economic activity

Economy Category	Strategy	Stoplight Rating ●●●	Justification
	Sandbagging	● (green)	Sandbags protects residential and business buildings from damage, preventing damages that would require longer repair periods.
	Deployable flood control barriers (e.g., sliding splash walls, water gates)	● (green)	Deployable flood control barriers can prevent significant damage and help to protect economically important areas.
	Flooding alert system for neighborhoods	● (yellow)	A flood alert system has neither a positive nor negative impact on the economy.
Planning	Special assessments	● (yellow)	Special assessments can provide a stream of income for funding resilience measures in the parcel(s) under the special assessment. There may be negative implications for the economy if the increased taxes reduce consumer spending capacity.
	Zoning/building codes changes	● (yellow)	Zoning and building codes may make communities more resilient to SS and SLR, reducing the economic impact of these hazards. Changes to zoning and building codes may also push out residents or businesses unwilling or unable to comply, which may eventually reduce the City's tax base.
Managed Retreat	Managed retreat	● (red)	Managed retreat can displace community members, potentially reducing the tax base and depriving an area of those who would otherwise patron the area's businesses. Additionally, buyouts can be expensive to implement.

Appendix AP-3: Avoided Costs of Adaptation Action

To estimate quantitative benefits of adaptation strategies, the potential costs were calculated across a range of sea level rise increments. Data involved in this analysis included GIS layers projecting inundation extents at each sea level rise increment for both spring tide and 100-year storm conditions, as well as spreadsheets indicating total damage costs by parcel. Using this data, the project team:

- Generated a shapefile layer in GIS delineating Adaptation Action Areas 1-9 (see figure)
- Linked flood areas to spreadsheets with corresponding damage cost totals using the assessor's parcel number—a number assigned to parcels for identification by jurisdiction tax assessor—in both the parcel layers and the spreadsheets
- Joined the flood parcels and their damage totals to Adaptation Action Area polygons created in step one; if a flood parcel overlapped with more than one Action Area polygon, it was joined to the area polygon with which it exhibited the greatest overlap
- Exported the joined layers as .csv files and calculated total damage by Adaptation Action Area by summing all damage totals in parcels falling within a given Action Area



Adaptation Action Area Polygons Generated for the Quantitative Benefits Analysis.

Notably, the methods described above do not model the ways in which proposed strategies would mitigate flooding; as such, by using the cost of inaction as the assumed "benefit" of adapting, the avoided cost values in the table below may overestimate benefits. Additionally, the analysis did not capture flow paths between Action Areas, so an assumption of action in one area may not correspond to a complete lack of flooding in that area, given that flood waters may flow in from adjacent areas. Conversely, action in one area may reduce impacts of flooding in other areas, which would be unaccounted for in this analysis.

The tables below, gives total summed damage costs, by Adaptation Action Area, across a range of sea level rise scenarios in a "no storm" scenario. In calculating costs for the "no storm," or spring tide scenario, it was assumed that structures would lose their function – and therefore their value – if they were being flooded every spring tide, and as a result, were treated as total losses. Table 7 details the costs of a 100-year storm event. In calculating costs for the 100-year storm event, total loss was not assumed, as repairs and resumed function were assumed to be feasible between events; as such, the values represent total *damage* costs, based on depth of flooding. Due to these differing assumptions associated with both scenarios, "no storm" or more permanent inundation damage costs are often *higher* than 100-year storm damage costs.

Total Cost of Inaction across Sea Level Rise Increments, by Adaptation Action Area (No Storm Scenario)

Adaptation Action Area	Total Cost of Inaction ($) Sea Level Rise Increment (ft) (No Storm Scenario)					
	0.8	1.6	2.5	3.3	4.1	4.9
Area 1	0	0	0	13,067,400	23,779,300	389,818,600
Area 2	0	0	0	0	4,347,800	4,347,800
Area 3	0	0	0	13,881,700	37,203,100	64,459,200
Area 4	0	0	0	0	7,526,300	7,526,300
Area 5	0	0	0	0	0	0
Area 6	0	0	0	0	0	57,389,000
Area 7	0	0	0	0	0	0
Area 9	0	0	10,476,700	465,376,900	876,752,700	930,316,700

Total Cost of Inaction across Sea Level Rise Increments, by Adaptation Action Area (100-year Strom Scenario)

Adaptation Action Area	Total Cost of Inaction ($) by Sea Level Rise Increment (ft) (100-year Storm Scenario)					
	0.8	1.6	2.5	3.3	4.1	4.9
Area 1	0	0	5,269,300	17,548,900	138,725,800	163,880,300
Area 2	0	0	869,600	652,200	53,722,400	59,260,900
Area 3	0	1,969,100	4,707,100	10,540,000	12,653,400	20,878,300
Area 4	794,700	794,700	1,393,900	1,351,800	1,552,900	1,664,300
Area 5	0	0	0	0	0	0
Area 6	0	0	7,775,000	17,555,600	24,664,700	30,019,000
Area 7	0	0	0	0	0	0
Area 9	947,200	38,229,900	92,315,100	173,969,000	181,689,700	213,773,600

Appendix AP-4: Cost Details

Cost estimates for each adaptation strategy type are summarized in the table below to help compare costs between adaptation strategies. These are rough order of magnitude values based on example costs from other locations identified through a literature search or otherwise noted as a professional estimate. To capture some of the uncertainty intrinsic to these cost estimates since costs depend on many site-specific characteristics, low- and high-end ranges are provided for each adaptation strategy type. While the true cost of strategies may still fall outside these ranges, they provide useful starting points for low- and high-end estimates for planning purposes. It is worth noting that over the COVID-19 pandemic costs of construction projects have significantly increased. Where possible, example costs from regional sources were prioritized to be more comparative to the City of Coronado. These estimates will need to be further refined over time with engineering studies and site-specific estimates.

Adaptation strategy type costs.

Adaptation Strategy Type	Cost Per Unit (USD)	Unit	Source	Cost Assumptions
Raise transportation infrastructure	20,000 -40,000	lf (linear feet)	Moffatt & Nichol order of magnitude estimate	Cost range varies depending on project scale, with typically lower costs applying to relatively small and simple situations, and higher costs for larger and more complex situations. For example, at SR-75 the length of roadway to be raised may be approximately 12,500 feet from the south end of the Naval Amphibious Base Coronado to Crown Cove on the Bay side; road is demolished and entirely rebuilt 2 feet higher on fill; temporary detour lanes are constructed, utilities are relocated, and easements/ROW are able to be modified (e.g., adjacent land can be purchased); adjacent roadway access is ramped.
Raise parking lot	100 – 300	sf	Moffatt & Nichol order of magnitude estimate	Parking lot is demolished and raised 2 feet on fill, then entirely rebuilt; driveway access is ramped.
Construct revetments	1,500 – 4,000	lf	Moffatt & Nichol (1998) *Protection of Highway 101 Study, Encinitas, CA, Final Report.* Order of magnitude estimate.	Revetment built from 5-ton armor stone according to standard coastal engineering design by the U.S. Army Corps of Engineers; crest elevation ranges from +12 feet to +18 feet Mean Lower Low Water (MLLW).

Adaptation Strategy Type	Cost Per Unit (USD)	Unit	Source	Cost Assumptions
Building retrofits	30 – 60	sf	The San Diego Regional Climate Collaborative. (2017). *Comparing Sea Level Rise Adaptation Strategies in San Diego: An Application of the NOAA Economic Framework*. https://digital.sandiego.edu/cgi/viewcontent.cgi?article=1010&context=npi-sdclimate	Square footage should be calculated as the building footprint area (i.e., the square footage of the first floor). Costs primarily reflect the cost to elevate a structure, but the range covers other dry floodproofing measures. This value represents the midpoint of estimated costs between raising foundations on pilings and raising slab structures. Building retrofits should be done in accordance with the current best practices and in line with regulatory guidance.
Seawall	2,500 – 7,500	lf	Moffatt & Nichol (1998) *Protection of Highway 101 Study, Encinitas, CA, Final Report.* Order of magnitude estimate escalated to 2021 dollars from 1998.	Vertical seawall built from cast-in-place concrete with 5-ton armor stone at the toe for scour protection, according to standard coastal engineering design by the U.S. Army Corps of Engineers; crest elevation is +12 feet MLLW.
Levee	1,000 – 3,000	lf	Nexus Planning & Research. (2017); Moffatt & Nichol order of magnitude estimate obtained from a contractor for construction of river levees in 2011.	Assumed no pile driving and no soil import (i.e., soil could be used from the golf course for the levee); no internal rock core; crest elevation is to +20 feet MLLW with base at +3 feet MLLW. Levee is adjacent to the road and does not connect to it.
Flood wall	400 – 600	lf	US Department of Transportation Federal Highway Administration. (2019). *Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide*. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/#toc18511922	This average cost is based on six example projects that had a variety of project characteristics; however, most were relatively small walls to limit occasional flooding.

Adaptation Strategy Type	Cost Per Unit (USD)	Unit	Source	Cost Assumptions
Groins	2,000 – 5,000	lf	San Diego Association of Governments. (2001). *Regional Beach Sand Retention Strategy*. https://www.sandag.org/uploads/publicationid/publicationid_2036_20694.pdf	Constructed of 5-ton stone at seaward end with smaller stone at the landward end; individual groin lengths of 930 feet; two groins spaced 1,500 feet apart; structure crest elevation of +14 feet MLLW at the beach berm, sloping down to -14 feet MLLW in the water. These require sand to be added to the beach. That cost is $1,450/lf and is not included.
Breakwaters	6,000 – 15,000	lf	San Diego Association of Governments. (2001). *Regional Beach Sand Retention Strategy.*	Constructed of 10-ton armor stone; length of 1,000 feet; distance offshore of 1,000 feet (with water between the shore and the breakwater); structure crest elevation of +6 feet MLLW (about 3 feet above mean sea level). These require sand to be added to the beach and that cost is $1,450/lf and is not included.
Beach renourishment/dunes	1,000 – 3,000	lf	SANDAG Regional Beach Sand Project II from 2012 construction.	Assumes offshore dredging of sand off of Mission Beach at SANDAG MB-1 source location; large hopper dredge constructs it with sand pumped onshore through a discharge line, with earthmoving equipment on the beach working a containment dike and forming the final grade.
Living shoreline	2,000 – 5,000	lf	Moffatt & Nichol construction estimate for the Cardiff Living Shoreline constructed in 2018-2019.	Constructed of sand and cobble materials available within 1 mile of the site; cobble toe protection covered by sand; length is 1,100 feet and crest elevation is +16 feet MLLW, with toe at +6 feet MLLW. These typically require sand to be added to the beach and that cost is $1,450/lf and is not included.
Floodable parks	50,000-500,000	acre	Estimate from Bayside Community Resilience Project in Imperial Beach.	Cost based on grading for a multi-purpose detention basin.
Vegetation	70 – 120	lf	US Department of Transportation Federal Highway Administration. (2019).	This average cost is based on 18 example projects that had a variety of project characteristics.
Sandbagging	10-20	lf	City of Coronado.	Assumes a 3 feet tall sandbag wall with sandbags costing $3 per bag (including delivery) and staff time costing $25/hour. Assumes deployment of sandbags 10 times over the effective use of this strategy.

Adaptation Strategy Type	Cost Per Unit (USD)	Unit	Source	Cost Assumptions
Deployable flood barrier	2,000 – 5,500	lf	US Army Corps of Engineers. (2015). *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk*. https://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf	High end estimate based on typical design including anchor plates, stanchions, gasketed stop logs, and bracing. Wall assumed to be 8 inches thick and 6 feet in height. Cost estimate includes mobilization, construction, assembly, and storage. Low-end estimate is based on more simple and lower-technological versions of barriers.

The tables below outline cost estimates for specific recommended adaptation strategies within each action area. The estimated length/size of area where each strategy would be deployed was measured using Google Earth Pro. The estimated cost for each strategy was found by multiplying the length/size by the cost per unit. To account for inflation, this product was then multiplied by 1.0312 to the power of the number of years since the cost per unit was found (as determined by the year of the source) to bring all values to 2021 dollars. In the past year, inflation rates have been significantly higher than this assumption, but it is unknown how long that trend will continue for.

Action Area 1: Edge of Navy property to Harborview Park

Action area 1 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Seawall at the current fence line along Harborview Park and at the edge of Bayview Park	Seawall	147	lf	2,500 – 7,500	366,000 – 1,099,000	4,457,000 - 149,018,000
Enhance the natural habitat bayward of Harborview and Bayview parks	Vegetation	147	lf	70 - 120	11,000 – 19,000	
Redesign Bayview Park to increase its elevation and/or accommodate flooding without allowing flood waters to access First St.	Floodable park	0.36	acres	50,000 – 500,000	18,000 – 180,000	
Elevate First Street and Alameda Blvd. along the coast	Raise Transportation Infrastructure	3,693	lf	20,000 – 40,000	73,860,000 – 147,720,000	
Install flood walls at low points across City and Navy property	Flood wall	9,550	lf	400 – 600	4,062,000 – 6,093,000	

Action Area 2: Harborview Park to Coronado Bridge Touchdown

Action area 2 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Continue the elevation of First Street from Action Area 1 as a flood barrier and tie into the Port's property	Raise Transportation Infrastructure	2,129	lf	20,000 – 40,000	43,000 – 85,000	45,375,000 – 90,750,000
Dry floodproof Public Services building	Building retrofits	82,395	sf	30 – 60	2,795,000 – 5,590,000	

Action Area 3: Coronado Municipal Golf Course

Action area 3 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Raise and reinforce riprap revetment along the coastline	Construct Revetments	5,245	lf	1,500 – 4,000	7,867,000 – 20,979,000	Engineering 23,449,000 – 84,701,000
Install vegetated sand dunes or cobble material to widen and raise the buffer protecting the golf course (both in existing beach areas and revetment areas)	Beach renourishment/ dunes	6,015	lf	1,000 – 3,000	6,015,000 – 18,045,000	
Build a seawall along the western part of the area	Seawall	2,277	lf	2,500 – 7,500	5,693,000 – 17,079,000	
Regrade the low parts of the golf course	Construct Revetments	3,045	lf	1,500 – 4,000	4,568,000 – 12,180,000	
Continue to regrade and fill in low points over time	Construct Revetments	3,045	lf	1,500 – 4,000	4,568,000 – 12,180,000	
Elevate the perimeter of the golf course, following the coast, to protect the inland areas	Construct Revetments	6,071	lf	1,500 – 4,000	9,160,000 – 24,283,000	
Consider replacing areas of the golf course with a public park resilient to flooding	Floodable Parks	9	acre	50,000 – 500,000	432,000 – 4,315,000	
Dry floodproof the Coronado Tennis Center to be more resilient to temporary flooding	Building retrofits	1,217	sf	30 – 60	41,000 – 83,000	Managed Retreat 6,367,000 – 22,080,000
Consider replacing areas of the golf course with a public park resilient to flooding	Floodable Parks	9	acre	50,000 – 500,000	432,000 – 4,315,000	
Build a levee along the road to protect developed areas and allow the coastline to encroach on existing green spaces and convert back to a natural shoreline	Levee	5,894	lf	1,000 – 3,000	5,894,000 – 17,682,000	

Action Area 4: South Edge of Coronado Golf Course to the East End of Strand Way Parking Lot

Action area 4 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Add a 2-3 ft solid flood wall barrier along the bayside of the Stand Way parking lot	Flood wall	722	lf	400 – 600	307,000 – 461,000	32,175,000 – 64,197,000
Elevate restaurant	Building retrofits	5,553	sf	30 – 60	188,000 – 377,000	
Raise Strand Way and Pomona Road	Raise transportation infrastructure	1,584	lf	20,000 – 40,000	31,680,000 – 63,360,000	

Action Area 5: Coronado City Hall to Glorietta Bay Park

Action area 5 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Convert the railing along the waterfront to a solid barrier to decrease storm flooding	Flood wall	1,626	lf	400 – 600	692,000 – 1,037,000	Engineering 6,050,000 – 17,575,000
Increase the elevation of the seawall and walkway along the waterfront.	Seawall	1,626	lf	2,500 – 7,500	4,065,000 – 12,196,000	
Push the sand at the Glorietta Park Bay beach area to form a dune along the shore prior to wintertime storms	Beach renourishment/ dunes	478	lf	1,000 – 3,000	478,000 – 1,434,000	
Nourish the beach at Glorietta Bay Park to raise the elevation over time	Beach renourishment/ dunes	478	lf	1,000 – 3,000	478,000 – 1,434,000	
Deploy sandbags or other temporary flood barriers around the Community Center, Aquatic Center, City Hall, and Club Room	Sandbagging	2,369	lf	10 - 20	237,000 - 474,000	
Redesign and regrade Glorietta Bay Park to allow public use through rising sea levels	Floodable park	2	acres	50,000 – 500,000	100,000 – 1,000,000	
Convert the railing along the waterfront to a solid barrier to decrease storm flooding	Flood wall	1,626	lf	1,500 – 4,000	692,000 – 1,037,000	Managed Retreat 45,565,000 –91,739,000
Push the sand at the Glorietta Park Bay beach area to form a dune along the shore prior to wintertime storms	Beach renourishment/ dunes	478	lf	1,000 – 3,000	478,000 – 1,434,000	
Nourish the beach at Glorietta Bay Park to raise the elevation over time	Beach renourishment/ dunes	478	lf	1,000 – 3,000	478,000 – 1,434,000	
Deploy sandbags or other temporary flood barriers around the Community Center, Aquatic Center, City Hall, and Club Room	Sandbagging	2,369	lf	7	17,000	

Action Area 6: Coronado Beach

Action area 6 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Ensure Coronado Beach public restrooms and lifeguard tower are wet flood proofed	Building retrofits	5739	sf	30 – 60	194,000 – 389,000	387,000 – 1,025,000
Install deployable flood gate at intersection of Ocean Blvd and Ocean Dr	Deployable	80	lf	2,000 – 5,500	192,000 – 529,000	
Elevate low beach access points, especially by Sunset Park, to create a low and wide dune for wave runup protection	Beach renourishment/ dunes	212	lf	1,000 – 3,000	212,000 – 636,000	

Action Area 7: Coronado Shores to Avenida Lunar

Action area 7 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Construct additional groins/breakwaters to reduce beach erosion rates	Groins	2,160	lf	2,000 – 5,000	4,320,000 – 10,800,000	10,906,000 - 27,525,000
Extend and/or heighten groins and breakwaters as needed	Groins	2160	lf	2,000 – 5,000	4,320,000 – 10,800,000	
Reinforce the toe of flood walls as needed	Revetment	1,424	lf	1,500 – 4,000	2,136,000 – 5,696,000	
Elevate vulnerable beach parking areas	Raise Parking lot	222	sf	100 – 300	22,000 – 67,000	
Install short flood walls at public access entry areas to block flooding from beach	Flood wall	254	lf	400 – 600	108,000 – 162,000	

Action Area 8: State Route 75 (SR75)

Action area 8 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Extend, raise, and enhance the vegetated dune systems on the open coast, with hard materials (cobble or rip rap)	Beach renourishment/ dunes	13,041	lf	1,000 – 3,000	13,041,000 – 39,123,000	264,041,000 – 541,123,000
Install temporary flood barriers	Sandbagging	10,000	lf	10-20	1,000,000-2,000,000	
Elevate segments of roadway vulnerable to flooding (i.e., embankment or causeway)	Raise Transportation Infrastructure	12,500	lf	20,000 – 40,000	250,000,000 – 500,000,000	

Action Area 9: Coronado Cays Residential Area

Action area 9 cost estimates.

Strategy	Strategy Type	Size	Unit	Cost per Unit (USD)	Cost of Strategy (USD)	Action Area Cost (USD)
Install deployable flood barriers where elevations and seawalls cannot be raised and manage stormwater flooding of roads	Deployable	900	lf	2,000 – 5,500	2,164,000 – 5,951,000	Engineering 621,099,000 – 1,313,875,000
Install additional height to seawalls using special assessment funding in vulnerable areas	Flood wall	30,627	lf	400 – 600	13,027,000 – 19,541,000	
Utilize special assessment funding to further raise seawalls and elevate roads where necessary	Seawall	30,627	lf	2,500 – 7,500	76,568,000 – 229,703,000	
	Raise Transportation Infrastructure	26,467	lf	20,000 – 40,000	529,340,000 – 1,058,680,000	
Install flood walls to block water flow paths to streets	Flood wall	900	lf	400 – 600	383,000 – 574,000	Managed Retreat 383,000 – 574,000

Appendix AP-5: Outreach Results

Public outreach is an essential component in the preparation of the **Sea Level Rise Vulnerability Assessment and Adaptation Plan**. In Fall 2020, the City of Coronado undertook a planning process to understand the potential effects of sea level rise and explore possible adaptation strategies. As part of the planning process, a robust public outreach program was organized to engage residents, stakeholders, and governmental agencies in the development of the plan. The City coordinated closely with residents, the business community, environmental and non-profit stakeholders, and agencies that share jurisdiction over the Coronado coastline. The input collected has played a critical role in developing and informing the **Sea Level Rise Vulnerability Assessment and Adaptation Plan.**

A description of each of outreach effort is described in further detail below.

Stakeholder Interviews

The City held stakeholder meetings throughout the planning process with agencies that have jurisdiction over land in Coronado, or that have a regional interest in sea level rise planning. Specifically, the City met with California State Parks, Caltrans, City of Imperial Beach, Port of San Diego, San Diego Association of Governments (SANDAG), San Diego Regional Climate Collaborative, Tijuana River National Estuarine Research Reserve (TRNERR), and the U.S. Navy. As needed, ongoing check-ins with stakeholders continued throughout the process.

Discussion with stakeholders included reviewing infrastructure that is vulnerable to sea level rise impacts, addressing findings from the stakeholders' own sea level rise planning efforts, key concerns, input on chosen sea level rise scenarios, adaptation strategies that the City may consider as well as strategies being implemented by the stakeholders, and opportunities for how the City can collaboratively address sea level rise with the stakeholders. The following table includes a list of stakeholders and meeting dates.

Virtual Community Workshop #1

On July 29, 2021, the City of Coronado held the first community workshop virtually via Zoom for residents and other participants interested in learning about the Draft Vulnerability Assessment. The purpose of the workshop was to provide an update on the project, review the findings of the Draft Vulnerability Assessment, and encourage attendees to participate in the community survey. A total of 76 people attended. Live polling questions were asked throughout the presentation and are described below. The workshop concluded with a Q&A session giving attendees the opportunities to ask questions that needed further clarification or may have not been addressed during the presentation. Workshop attendees primarily questioned how the sea level rise assumptions and scenarios were developed, the level and extent of inter-agency coordination, and how sea level rise will directly impact Coronado.

For a recording of the workshop, please visit:

https://www.youtube.com/watch?v=6RJpkQjQ2a0&t=1661s

Live polling breaks were held during the virtual workshop via Mentimeter, which is an online engagement tool that allows participants to participate in live polls using an electronic device. Responses were collected and discussed in real-time, creating an informative and interactive presentation. The following questions were asked:

- What is your connection to Coronado?
- What three words would you use to describe your feelings about sea level rise?
- In your opinion, sea level rise: is already impacting Coronado, will impact Coronado in 10 years, will impact Coronado in 50 years, or will not impact Coronado.
- Select your top three priorities the City could choose to protect.
- Should the City prioritize projects that proactively help to mitigate for future sea level rise impacts?

Similar to the participants and input received from the community survey, the majority of respondents live in and/or own property in Coronado and recognize that sea level rise is already impacting Coronado. Many were concerned about sea level rise and recognized that it is inevitable. Respondents prioritized roads, public safety, and critical City-owned infrastructure as the top three priorities that the City could choose to protect. They believed that the City should prioritize projects that proactively help to mitigate for future sea level rise. The City should strongly consider future SLR impacts when investing in public projects and preparing long-range planning projects.

For more details regarding the polling results, please visit:

https://commentcoronado.org/7724/widgets/35535/documents/22669

In-Person Community Workshop #2

On August 12, 2021, an in-person workshop was held at the Library Winn Room with the same presentation from the virtual Community Workshop #1. Approximately 12 people attended.

Community Survey

A community survey was available from July 29 to September 17, 2021, to solicit input on how Coronado should plan for sea level rise. A total of 42 responses were received. The purpose of the survey was to gather input on the types of infrastructure that the community prioritizes, potential support for various adaptation strategies, and ideas regarding potential funding measures.

The survey[11] revealed support for the City to prioritize projects that proactively help to mitigate future sea level rise impacts (81%) and for the City to consider future sea level rise impacts when investing in public infrastructure or facility projects and preparing long-range planning projects (91%).

For the complete results of the survey, please visit:

https://commentcoronado.org/7724/widgets/35535/documents/23546

Sea Level Planning Website

A website was developed for the public consumption. The website provided relevant information about the update process, fact sheets, workshop materials, project timeline and a calendar of events for outreach activities. The website also provided included the community survey as well as the contact information of city staff for residents and community members to send additional comments or request additional information. The website is located at https:/commentcoronado.org/sea-level-rise.

Notifications

The City utilized multiple avenues to promote the workshops, community survey, and the website. The workshops were advertised through paid social media advertisements, newspaper advertisements, emails to residents that signed up through the website, the City Manager weekly video and newsletter, flyers posted throughout the City, updates to the project website, emails to stakeholders, and flyers sent to parents through the Coronado Unified School District. The survey and website were similarly advertised through emails, newsletter updates, and paid advertising.

Future Public Outreach

Upon completion of the draft Sea Level Rise Adaptation Plan and authorization to proceed from City Council, a public review period will commence, and an additional workshop is scheduled for winter 2022.

[11] The public survey received 42 responses, of which 40 people self-identified as living in and/or owning property in Coronado.