APPENDIX E

Sea Level Rise Analysis

moffatt & nichol

SHORELINE VILLAGE REDEVELOPMENT

Sea Level Rise Analysis

REPORT

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1. Introduction

Shoreline Village is a popular destination among locals and visitors in Long Beach, providing public access to the waterfront and a variety of amenities. The proposed Shoreline Village Redevelopment Project (Project) seeks to improve the site and increase its capacity so that it may continue to serve the community for many years to come. The Project site plan is illustrated in Figure 1-1.

The scope of the Project removal and additions as proposed involves no net change in the total area. The renovation of three building exteriors is also included. The current parking lot will be repaved and restriped and a parking deck will be added, resulting in 80 new parking stalls to serve the Project, 24 of which will serve electric vehicles. Public outdoor spaces and viewing areas will also be enhanced with paving and seating, and updated signage will be provided throughout the Project area. Updated landscaping will add new trees to the site and provide aesthetic, water tolerant planting.

A new bike path connection is also proposed between the existing path along Rainbow Harbor and the Marina Green bike path. 28 short-term bike racks will be added to the site, and pedestrian circulation routes throughout the site will also be improved.

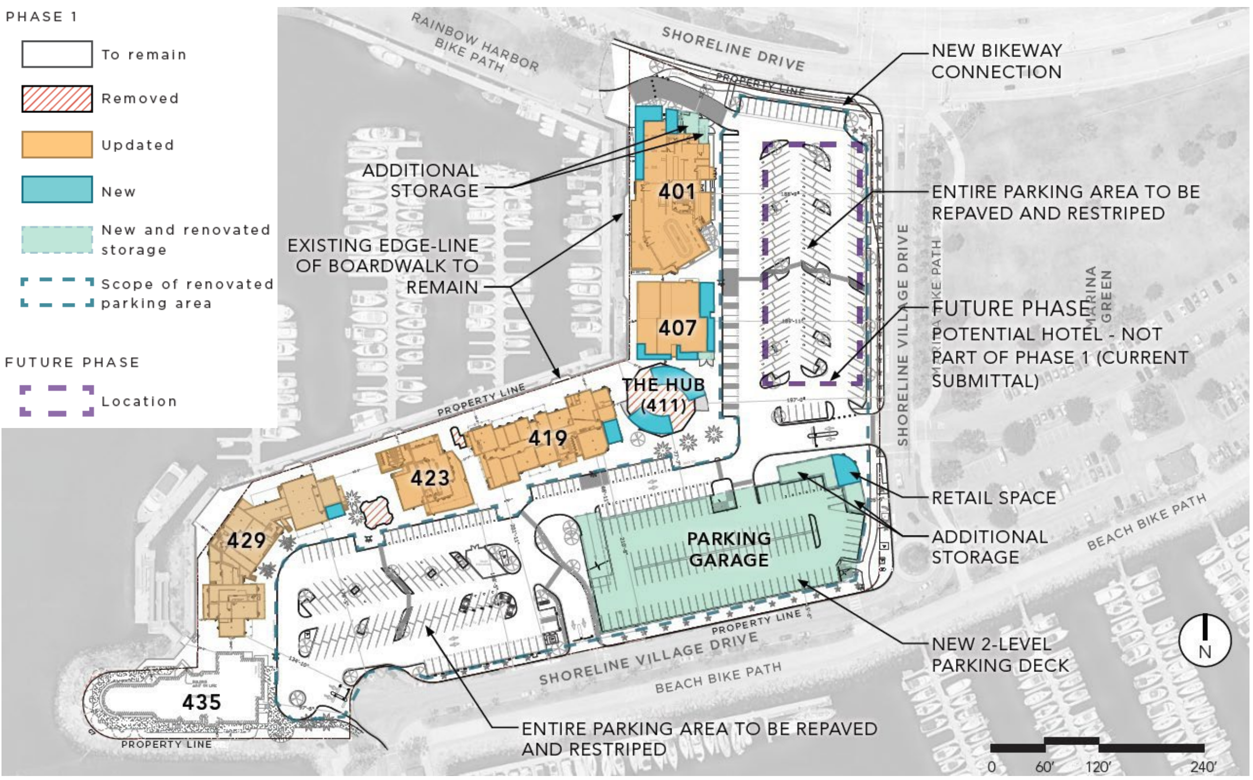

FIGURE 1-1: PROJECT SITE PLAN

1.1. Study Approach

This Sea Level Rise Analysis for the Shoreline Village Redevelopment Project assesses potential impacts to the Project area across multiple sea level rise scenarios. Analyses first focus on the extent to which local coastal hazards change under multiple sea level rise scenarios. The overlap of projected future hazard zones and the Project area is then used to identify potential future vulnerabilities and the sea level rise thresholds at which the Project could be impacted. Key questions that guide the Sea Level Rise Analysis are illustrated in Figure 1-2.

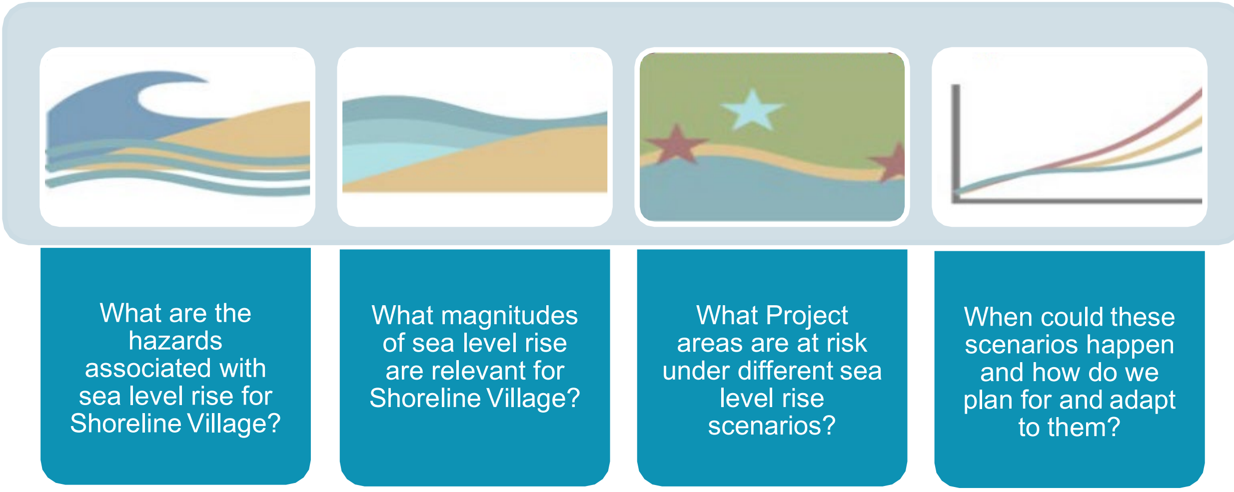

FIGURE 1-2: KEY QUESTIONS USED TO GUIDE THE SEA LEVEL RISE ANALYSIS.

The vulnerability of the Project area to future sea level rise hazards is evaluated through an analysis of hazard exposure, sensitivity, and adaptive capacity. Within this assessment, exposure refers to the type, duration, and frequency of coastal hazards a specific resource is subject to under a given sea level rise scenario. Sensitivity represents the degree to which a resource is impaired by exposure to coastal hazards. Adaptive capacity refers to the ability of a resource to cope with changes in coastal hazards over time. The sea level rise projections are discussed in Section 2. A discussion of the specific coastal hazard analysis methodologies used within the study can be found in Section 3. Sea level rise hazard vulnerability concepts are discussed in more detail in Section 4.

1.2. Coastal Setting

The Shoreline Village is located in the southern portion of Long Beach, California within Rainbow Harbor (Figure 1-2). Engineered shoreline structures are present throughout the Project area, featuring a combination of rock revetment and concrete seawalls. Directly to the south of the Project area is the Long Beach Shoreline Marina and breakwater. Shoreline Drive lies to the north of the Project Area, which provides access to Shoreline Village via Shoreline Village Drive.

FIGURE 1-3: LOCATION OF SHORELINE VILLAGE

1.2.1. Water Levels

The nearest tidal gauge with long-term sea level records is the Los Angeles Outer Harbor gauge, Station Number 9410660, operated by the National Oceanic and Atmospheric Administration (NOAA). The gauge has been operational for over 90 years. Tides in the region are semidiurnal in nature meaning two highs and two lows occurring daily. Tidal datums of the latest published tidal epoch from the gauge are used for this analysis and are provided in Table 1-1.

TABLE 1-1: TIDAL DATUMS AT LOS ANGELES OUTER HARBOR (1983-2001 TIDAL EPOCH)

Description	Datum	Elevation (ft, NAVD88)
Highest Observed Water Level (1/10/2005)	HOWL	7.7
Highest Astronomical Tide	HAT	7.1
Mean Higher-High Water	MHHW	5.3
Mean High Water	MHW	4.6
Mean Tide Level	MTL	2.6
Mean Sea Level	MSL	2.6
Mean Diurnal Tide Level	DTL	2.5
Mean Low Water	MLW	0.7
North American Vertical Datum of 1988	NAVD88	0.0
Mean Lower-Low Water	MLLW	-0.2
Station Datum	STND	-4.0
Lowest Astronomical Tide	LAT	-2.2
Lowest Observed Water Level (12/17/1933)	LOWL	-2.9

1.2.2. Wave Climate

The Shoreline Village is securely protected from open ocean wave impact due to its location in the interior of Rainbow Harbor. In addition to protection provided by the Shoreline Marine breakwater, offshore federal breakwaters installed to protect the Port of Long Beach from wave impacts also diminish wave energy at the site. This protection can be seen in wave modeling results obtained from the USGS Coastal Storm Modeling System (Figure 1-3), which show minimal wave energy arriving at the Project area even under severe, 100-year return period coastal storm conditions.

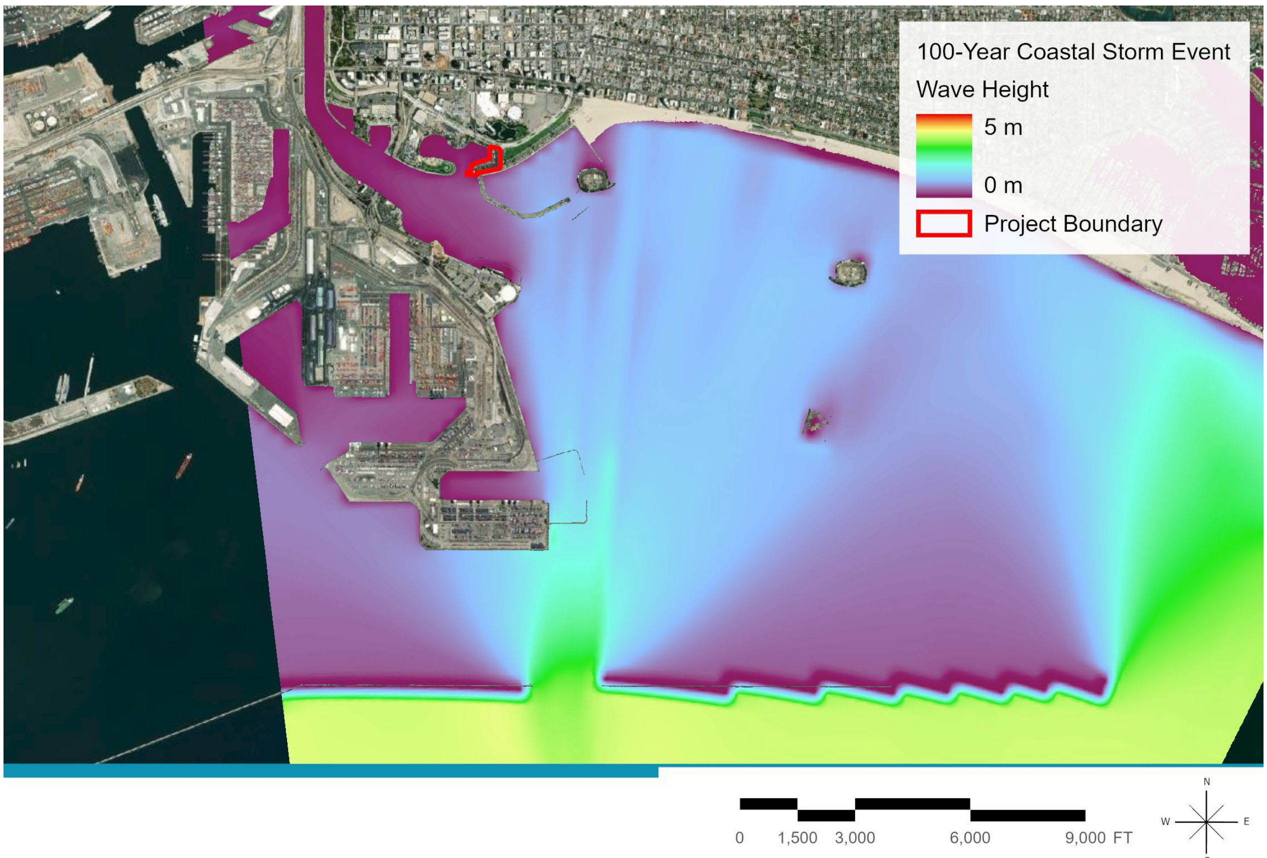

FIGURE 1-4: 100-YEAR COASTAL STORM WAVE HEIGHTS IN AREAS SURROUNDING SHORELINE VILLAGE.

2. Sea Level Rise Projections

Sea level rise science involves analysis of both global and local physical processes, as illustrated in Figure 2-1. Global climate and oceanographic processes are complex and dynamic. Numerical models are created based on the best scientific understanding of these global and local processes to provide predictions of future sea level rise. Hence, modelling efforts and predictions are periodically updated to reflect any changes in scientific knowledge. At the state level, the California Coastal Commission (CCC) recommends using the best available sea level rise science, discussed in Section 2.1, which is expected to be updated approximately every 5 years.

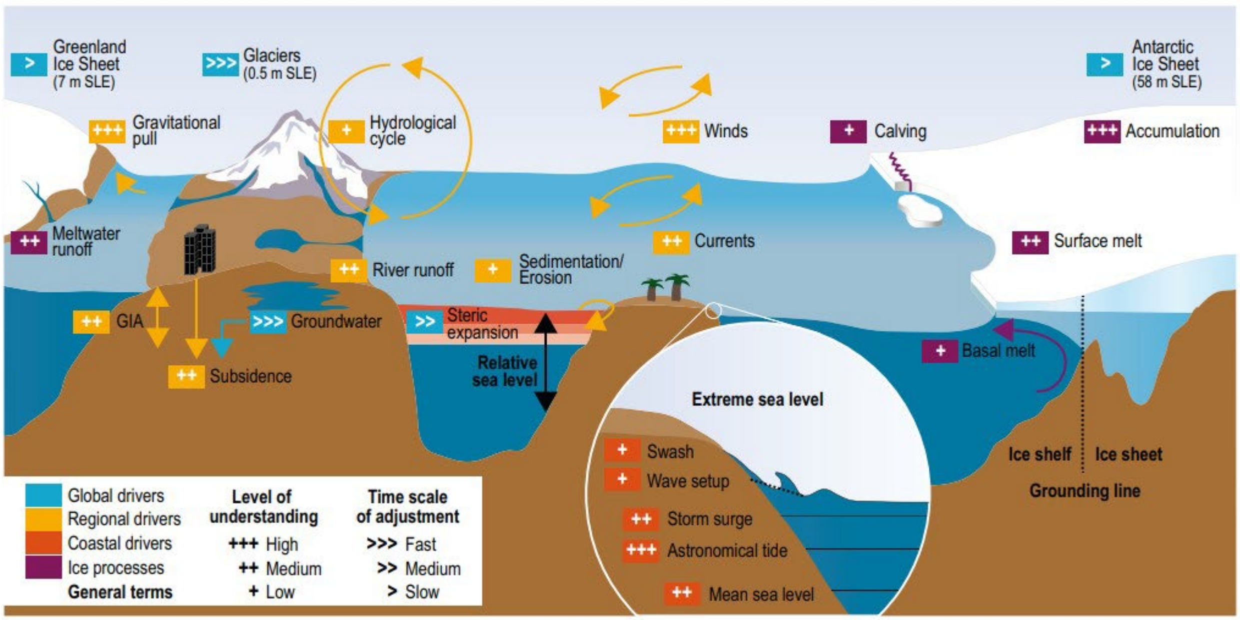

FIGURE 2-1: GLOBAL AND REGIONAL FACTORS THAT CAN CONTRIBUTE TO CHANGES IN SEA LEVEL (IPCC, 2019).

2.1. Probability and Timing

The State of California Ocean Protection Council (OPC) Science Advisory Taskforce compiled the best available sea level rise 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 Sea Level Rise Guidance in 2018 (California Ocean Protection Council, 2018). The 2018 OPC Sea Level Rise Guidance is now referenced as the best available science throughout updated CCC Sea Level Rise policy guidance documents (California Coastal Commission, 2018).

The 2018 OPC guidance includes sea level rise projections for multiple 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 projections for the Los Angeles tide gauge under a high-emissions scenario are referenced in this section. The CCC sea level rise policy guidance recommends using projections associated with a high-emission future to provide a conservative estimate of future hazard conditions.

The OPC sea level rise guidance defines the likely range of sea level rise 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. The upper end of the likely range is recommended by the CCC for use in low risk aversion situations, or when considering projects that would have limited consequences or have a higher ability to adapt, such as sections of unpaved coastal trail, public accessways, and other small or temporary structures that are easily removable and would not have high costs if damaged. This low risk aversion curve is shown in orange in Figure 2-2. At a given time horizon there is a 17% chance that sea level rise will meet or exceed these values based on current sea level rise projections and guidance.

For medium-high risk aversion situations the use of more conservative, or lower probability, sea level rise projections is recommended by OPC sea level rise Guidance. At a given time horizon there is a 0.5% chance that sea level rise meets or exceeds these levels, making them appropriate for use on projects where damage from coastal hazards would carry a high consequence or in cases where the ability to adapt is limited, such as when dealing with residential and commercial structures. The medium-high risk aversion curve is shown in red in Figure 2-2 and is most applicable for major upland development.

The OPC guidance also includes a singular extreme sea level rise scenario, referred to as H++. It is based on projections by Sweet et al., 2017 that incorporate findings of Pollard & Deconto, 2016 related to potential Antarctic ice sheet instability, which could make extreme sea level rise outcomes more likely than indicated by Kopp et al., 2014 (Griggs et al., 2017). Because the H++ scenario is not a result of probabilistic modelling, the likelihood of this scenario cannot be determined. Due to the extreme and uncertain nature of the H++ scenario, it is most appropriate to consider when planning for development with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur (OPC, 2018). The H++ extreme risk aversion curve is shown in purple in Figure 2-2.

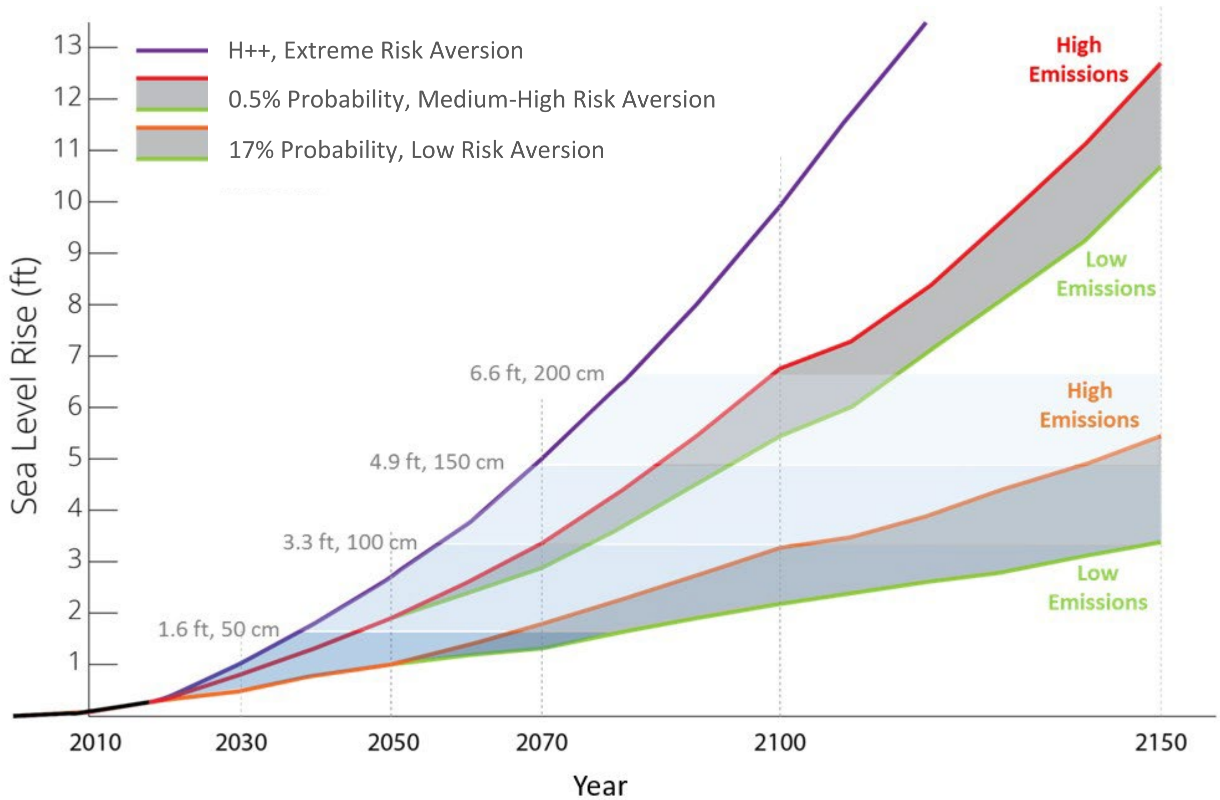

FIGURE 2-2: APPROXIMATE SEA LEVEL RISE PROJECTIONS FOR LOW, MEDIUM-HIGH, AND EXTREME RISK AVERSION LEVELS (OPC, 2018)

2.2. Selected Sea Level Rise Scenarios

Climate science is a constantly changing field, often with high degrees of uncertainty. In the case of sea level rise in California, the OPC has high confidence in estimates to approximately year 2050, after which increased uncertainty in modeling efforts cause predictions to diverge. Due to the high degree of uncertainty associated with predicting when and at what rate sea level rise will occur, this study looks at a range of sea level rise values starting with present day conditions and including low-probability sea level rise scenarios at the end of the century. Buildings within the Project area were constructed in the 1980s. Assuming a 75 - 100 year useful life for those structures and a 50 year design life for the updates, small additions, and parking structure proposed as part of this Project, 2080 is used as the time horizon for sea level rise hazard analyses.

Three scenarios have been selected for analysis within this study that consider projected sea level rise from 3.3 ft to 6.6 ft to capture potential hazards during, at the end of, and after the Project's useful life. Selected sea level rise scenarios also consider available hazard data for the region, which is available in 0.8 ft increments. All sea level rise projections and their corresponding recommendations for use based on time horizons and level of risk are described below and in Table 2-1. Due to the 0.8ft increment of available data, minor approximations with regard to the exact timing and probability of selected sea level rise scenarios have been made as needed to align with risk aversion designations in OPC sea level rise guidance. Coastal hazards under each increment of sea level rise are evaluated under non-storm, 1-year, and 100-year coastal storm conditions. The non-storm condition is the high spring tide condition, which usually occurs twice a month.

1. Sea level rise of 3.3 ft (100 cm) is representative of the medium-high risk aversion projection for 2070 and the low risk aversion projection for 2100.

2. Sea level rise of 4.9 ft (150 cm) is representative of the medium-high risk aversion projection for the 2080-2090 time horizon. If using projections for low risk aversion conditions, this level of sea level rise corresponds to a time horizon beyond 2100.

3. Sea level rise of 6.6 ft (200 cm) is representative of the medium-high risk aversion projection for 2100. Low risk aversion sea level rise projections do not reach this level until beyond 2150.

TABLE 2-1: PROBABILITY AND POTENTIAL TIMING ASOCIATED WITH SELECTED SEA LEVEL RISE SCENARIOS

Sea Level Rise Scenario (ft)	Probability and Timing for Each Sea Level Rise Scenario	
	Low Risk Aversion (17% probability)	Medium-High Risk Aversion (0.5% probability)
3.3	2100	2070
4.9	2100+	2080-2090
6.6	2150+	2100

3. Sea Level Rise Hazard Analysis

Coastal hazards due to sea level rise are analyzed under three separate baseline conditions:

- **Non-storm:** High spring tide and background wave conditions. Refers to USGS Coastal Storm Modeling System (CoSMoS) model results under average conditions (discussed in Section 3.1).
- **1-Year Storm:** 99% annual chance coastal storm event in conjunction with a high spring tide. Refers to CoSMoS model results under 1-year storm conditions.
- **100-Year Storm:** 1% annual chance coastal storm event in conjunction with a high spring tide. Refers to CoSMoS model results under 100-year storm conditions.

3.1. USGS Coastal Storm Modeling System

The effects of sea level rise on storm and non-storm related flooding were evaluated using results of the CoSMoS Version 3.0, Phase 2 (the latest version), a multi-agency modeling effort led by the United States Geological Survey (USGS) designed to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for Southern California. Other sea level rise hazard viewers such as the NOAA Sea Level Rise Viewer are also available, but these tools lack the regional focus and depth of information provided in CoSMoS modeling results.

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

Hazard analyses within this assessment focus primarily on coastal flood modeling results given no erodible shoreline and bluffs within the study area. The hazards depicted in this report are presented solely based on the assumptions and limitations accompanying the CoSMoS data available at the time of this study. No additional numerical modeling or independent verification of the CoSMoS data was performed.

3.1.1. Wave Modeling

Available CoSMoS storm scenarios include annual, 20-year, and 100-year return period storm events. Future storm conditions are downscaled from winds, sea-level pressures, and sea surface temperatures of an established global climate model (Erikson et al., 2017). The CoSMoS study includes additional modeling to propagate projected deep-water waves to shore and to include additional regional and local wave growth. Due to the large geographic extent of CoSMoS modeling efforts, the same representative storm events are used across southern California in wave impact modeling. Each of the selected representative storm events produces waves from a W-NW direction typical of winter storms (Table 3-1). As discussed in Section 1.2.2, CoSMoS wave modeling results show minimal nearshore wave heights (less than 0.5 ft) along the Project shoreline in the interior of Rainbow Harbor (Figure 1-3).

TABLE 3-1: WAVE CONDITIONS ASSOCIATED WITH EACH COSMOS MODELED STORM SCENARIO.

Scenario	Significant Wave Height (ft)	Wave Period (s)	Wave Direction (degrees)	Maximum wind speed (m/s)
non-storm	5.7	12	286	NA
1-year storm #1	14.4	16	284	22.8
20-year storm #1	19.2	18	281	22.3
20-year storm #2	20.1	18	292	28.7
100-year storm #1	20.3	16	264	26.6
100-year storm #2	22.3	18	287	30.3

3.1.2. Coastal Flood Projections

CoSMoS coastal flooding projections simulate the effects of erosion, wave runup, and overtopping during storm events. Coastal flood extents are calculated and mapped at profiles spaced approximately 300ft along the shoreline. The projected coastal water levels used in flood mapping consider future shoreline change, tides, sea level anomalies like El Niño, storm surge, and sea level rise. Future wave conditions used in the model are based on forecasted conditions out to year 2100. All flood events are modeled in conjunction with a high spring tide (Erikson et al., 2017). Specific water elevations associated with each selected sea level rise scenario and storm condition are presented in Table 3-2.

CoSMoS coastal flood modeling results assume that future shoreline retreat will be halted at the existing development line. This assumption is unlikely to affect flood modeling results within the study area due to the engineered nature of the existing shoreline. Projected coastal flood extents are permitted to extend beyond the line of development. Upon verification of the topographic data used in the model, existing seawalls and revetments fronting the Project are captured within topographic data. Flood projections under each sea level rise and storm scenario are presented in Figure 3-1, Figure 3-2, Figure 3-3, and Figure 3-4.

Minor changes to CoSMoS flood projections were made along the shoreline of buildings 401 and 407 based on 2015 LiDAR elevation data from the Los Angeles Region Imagery Acquisition Consortium. Topographic data utilized within the CoSMoS model showed a slight discrepancy in these areas, reporting lower grade elevations than currently present, that caused flood projections to extend further inland. The extent of flood projections was adjusted to reflect the current shoreline position and elevation.

TABLE 3-2: COSMOS WATER LEVELS ASSOCIATED WITH EACH SELECTED SEA LEVEL RISE AND STORM SCENARIO.

Sea Level Rise Scenario	Non-Storm Water Elevation (ft, NAVD88)	1-Year Storm Water Elevation (ft, NAVD88)	100-Year Storm Water Elevation (ft, NAVD88)
0 ft	6.9	7.1	7.4
3.3 ft	10.2	10.3	11.5
4.9 ft	11.8	11.9	13.0
6.6 ft	13.4	13.6	17.3

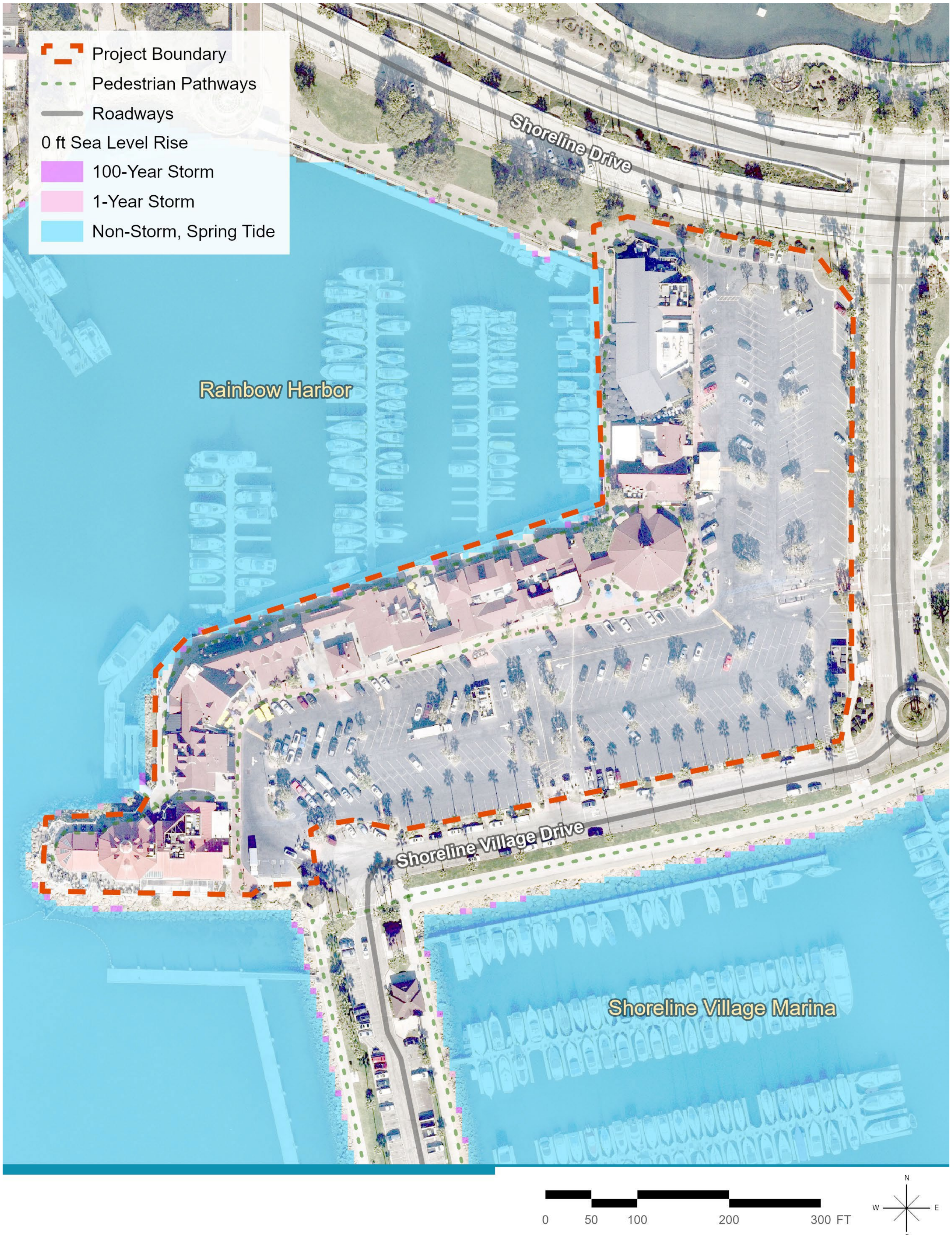

FIGURE 3-1: FLOOD PROJECTIONS WITHIN SHORELINE VILLAGE, 0 FT SEA LEVEL RISE

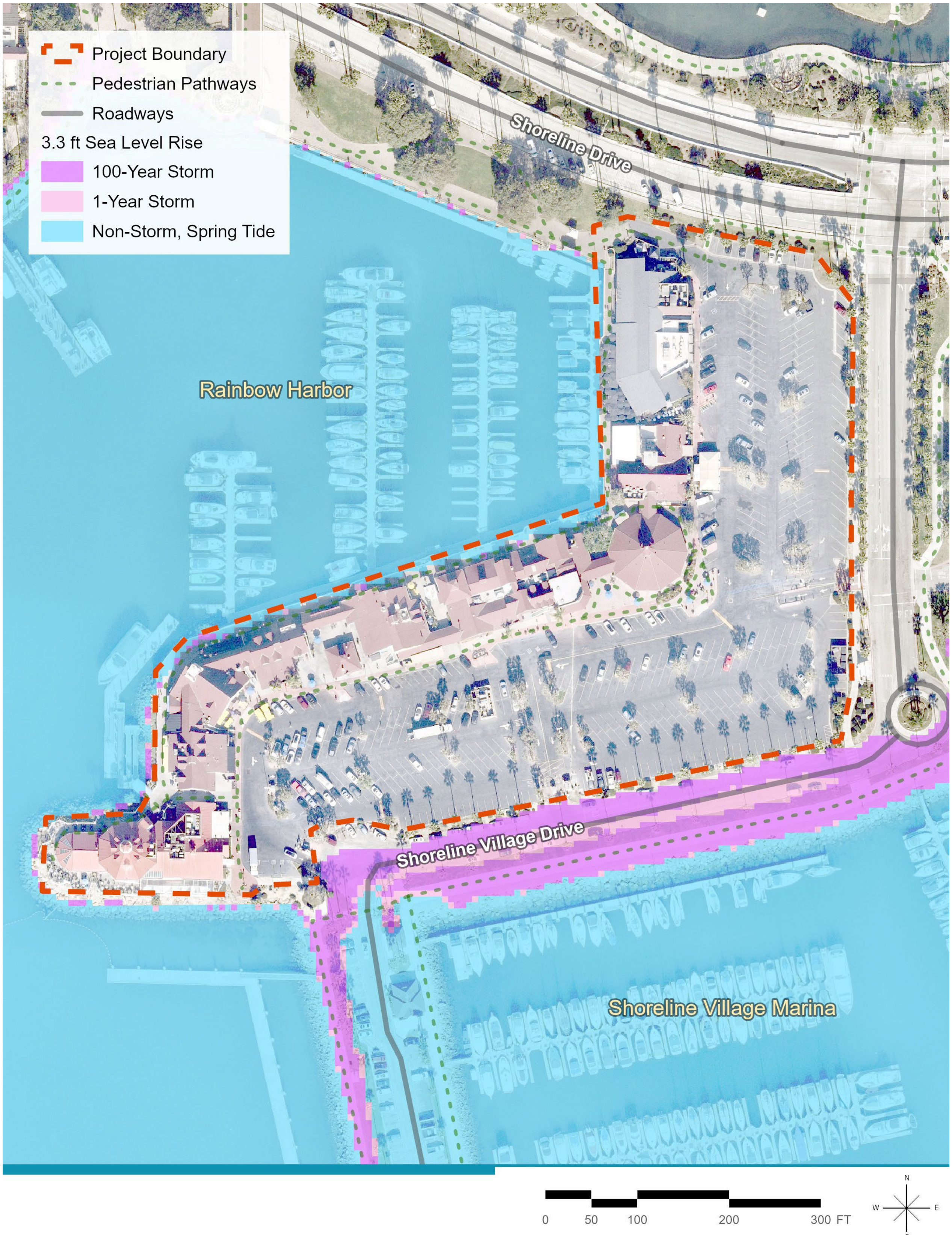

FIGURE 3-2: FLOOD PROJECTIONS WITHIN SHORELINE VILLAGE, 3.3 FT SEA LEVEL RISE

FIGURE 3-3: FLOOD PROJECTIONS WITHIN SHORELINE VILLAGE, 4.9 FT SEA LEVEL RISE

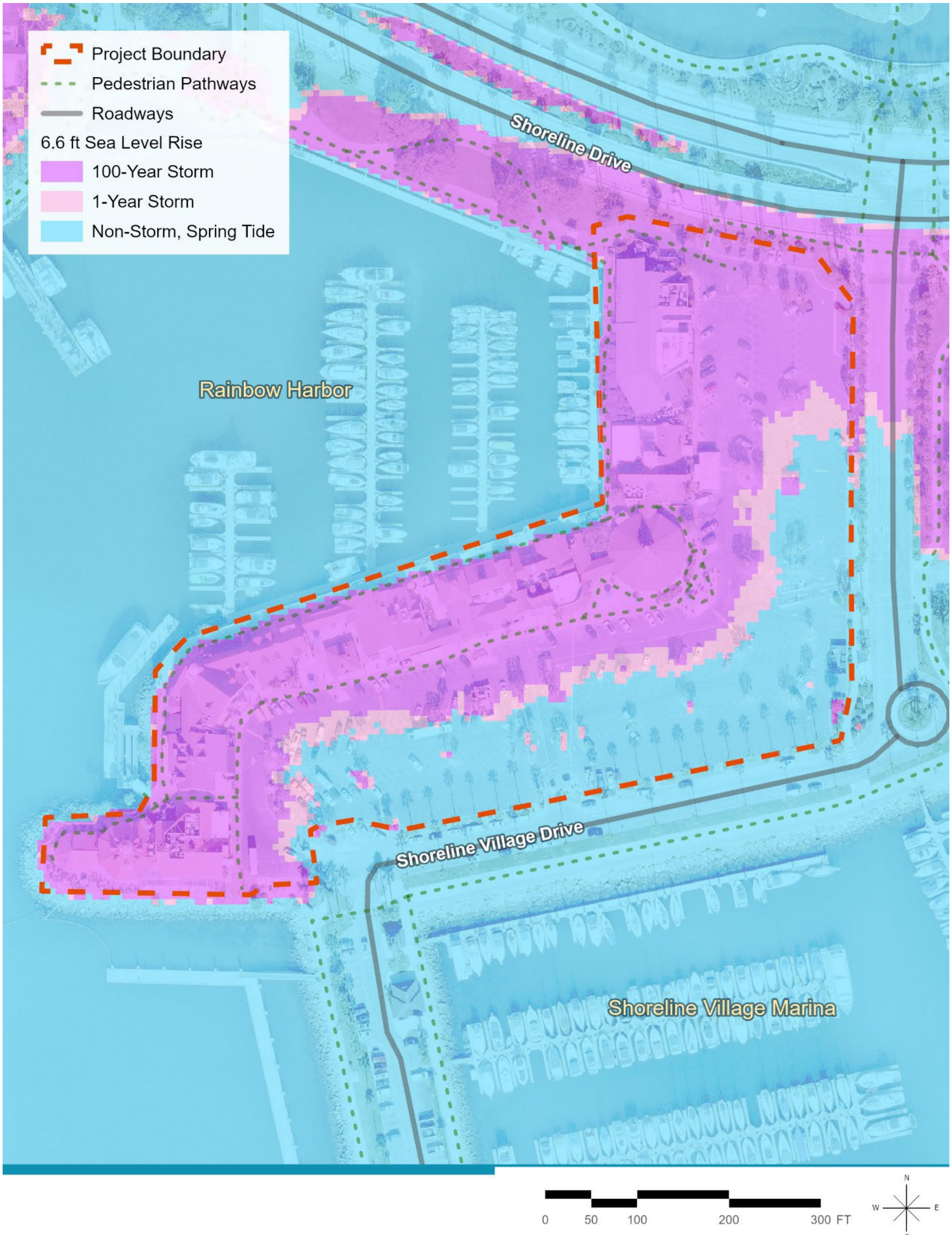

FIGURE 3-4: FLOOD PROJECTIONS WITHIN SHORELINE VILLAGE, 6.6 FT SEA LEVEL RISE

4. Sea Level Rise Vulnerability Analysis

This sea level rise analysis provides a qualitative evaluation of potential vulnerabilities in the Project area due to future sea level rise hazards. The intersection of potential sea level rise hazard zones and the Project area was determined using Geographic Information System (GIS) software. Methodology 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 sea level rise planning guidelines (California Coastal Commission, 2018), sea level rise vulnerability within different areas of the project is assessed as a function of exposure, sensitivity, and adaptive capacity. These concepts, in the context of how they are used within this sea level rise analysis, are illustrated in Figure 5-1.

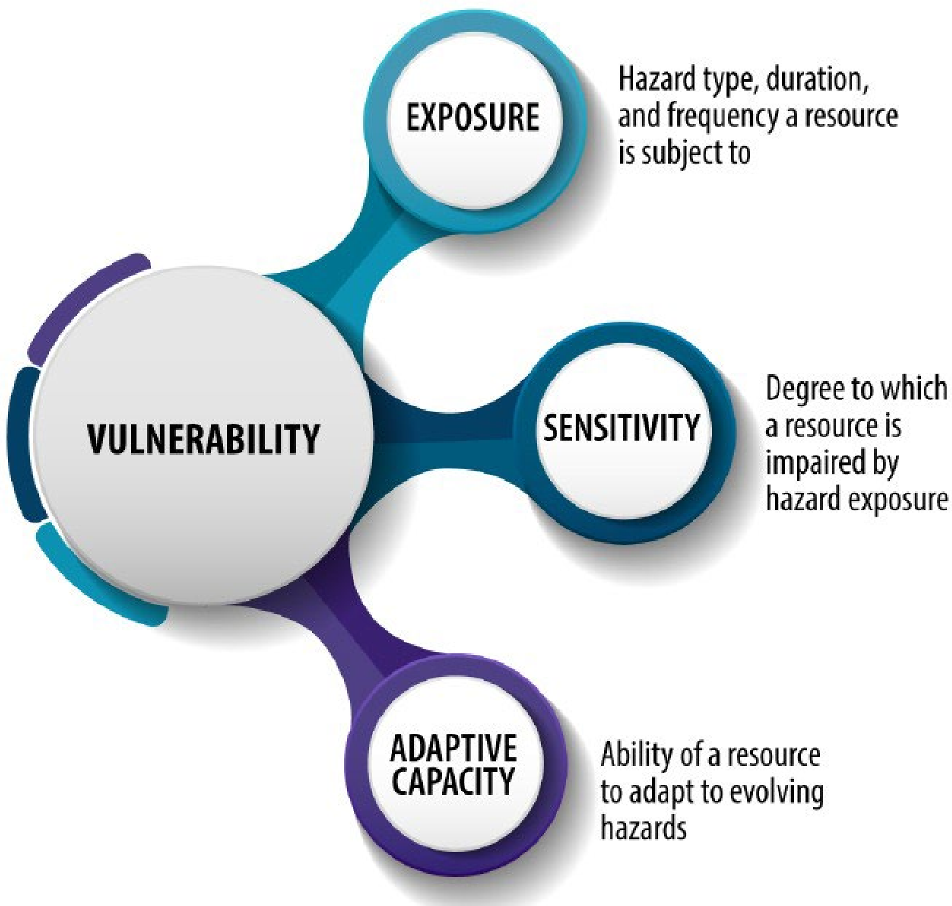

FIGURE 4-1: COMPONENTS OF SEA LEVEL RISE VULNERABILITY AS DEFINED WITHIN THIS STUDY.

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

In addition to the guidance documents discussed above, the vulnerability assessment approach used within this report is also consistent with the proposed City of Long Beach Climate Action and Adaptation Plan (CAAP) (City of Long Beach, 2020). The Long Beach CAAP analyzed sea level rise scenarios up to 66'' in 2100 based on best-available science (National Research Council, 2012) at the time of report preparation. The Long Beach CAAP also utilized results from the USGS CoSMoS to examine future coastal hazard projections and discusses vulnerabilities in terms of hazard exposure, sensitivity, and adaptive capacity, noting potential flooding along the edges of Shoreline Marina and Rainbow Harbor under higher levels of sea level rise projected by 2100.

4.1. Hazard Exposure

Flood hazard exposure is relatively low within the Project area. Interior bulkhead elevations within Rainbow Harbor sit at approximately +15 ft NAVD88, above flood scenarios projected within the Project's useful life (Table 3-2). However, Shoreline Village Drive along Shoreline Village marina is lower, ranging from 10 to 11 ft NAVD88 and is more susceptible to flooding. Hazard exposure for the Project is summarized below. The time horizons for sea level rise projections are based on the 2018 OPC Guidance medium-high risk aversion scenario, which has only a 1 in 200 chance of being exceeded for a given time horizon. Time horizons for sea level rise projections based on the 2018 OPC Guidance low risk aversion scenario, which represent the upper end of the likely range of projections, are also included in Table 2-1.

<u>Current Conditions</u>

Flood hazard exposure is not present at the Project site for current conditions. CoSMoS modeling results show no flood projections within Shoreline Village, including during a 100-year coastal storm event (Figure 3-1). As discussed previously, the wave protection provided by nearby breakwaters greatly reduces the wave impacts at the site, preventing potential flooding during major storm events.

<u>3.3 ft Sea Level Rise (2070 Time Horizon, Near End of Useful Life)</u>

The 3.3 ft sea level rise scenario is not projected until a time horizon approaching the end of the Project's useful life. Flood projections are absent from the Project site itself (Figure 3-2), although flood hazard exposure increases slightly in areas surrounding the Project site. CoSMoS flood projections cover a limited area of the southern portion of Shoreline Village Drive under 1-year storm conditions and more extensive under a 100-year coastal storm event.

<u>4.9 ft Sea Level Rise (2080 – 2090 Time Horizon, End of Useful Life)</u>

The 4.9 ft sea level rise scenario, projected to occur at the end of or slightly after the Project's useful life, represents the first case in which flood hazard exposure is present within the Project site itself. Under this scenario, CoSMoS modeling results indicate that the southern portion of Shoreline Village Drive, located outside of the Project site, will be susceptible to flooding under non-storm, spring tide conditions. Flood projections for a 100-year storm event extend further north along Shoreline Village Drive and cover limited portions of parking areas within Shoreline Village (Figure 3-3).

<u>6.6 ft Sea Level Rise (2100 Time Horizon, Beyond Useful Life)</u>

Flood hazard exposure is projected to increase substantially within the Project site for a 6.6 ft sea level rise scenario, though this scenario is not projected to occur until after the useful life of the Project. While flood hazard exposure increases, projected flooding of commercial structures remains limited to 100-year storm conditions. Non-storm spring tide flood projections extend across significant portions of parking areas and roadways surrounding Shoreline Village. The extent of flood projections increases slightly for a 1-year storm event but remains limited to Project parking areas and surrounding roadways. Under 100-year storm conditions in combination with 6.6 ft sea level rise, CoSMoS modeling results show flooding across the entirety of Shoreline Village (Figure 3-4).

4.2. Hazard Sensitivity

Commercial structures within the Project area are most sensitive to flood hazards. Temporary flooding of such structures as projected under 100-year storm conditions with 6.6 ft sea level rise can cause significant damage and prevent use of the structure as any necessary repairs are made. Any inundation on a regular basis would severely reduce the utility of any Project commercial structures, though this is not projected under sea level rise scenarios examined within this analysis.

Parking areas and similar paved roadways are less sensitive to flood hazards, though impacts can still be significant if flooding occurs on a frequent basis. Such structures are generally resilient to temporary flooding during 1-year or 100-year coastal storm events, especially in the absence of significant wave impacts, as floodwaters are free to wash over and recede from paved areas with little overall structural damage. If inundated more regularly, as projected for Shoreline Village Drive under a 4.9 ft sea level rise scenario and Project parking areas under a 6.6 ft sea level rise scenario, parking areas and roadways can experience increased damage and loss of utility as visitors become unable to access or park safely within the Project area.

4.3. Adaptive Capacity

The adaptive capacity of Shoreline Village is bolstered by the relative absence of flood projections up to 4.9 ft sea level rise, not projected to occur until the end of the Project's useful life, and non-storm flood projections remaining absent in Project commercial development areas across all sea level rise scenarios examined. Within the Project area, raising the elevation of paved areas and floodproofing commercial structures are options to address projected increases in coastal hazards over time as needed, though floodproofing is not projected to be needed until after the Project's useful life. Given current sea level rise projections as discussed in Section 2.1, it is highly unlikely that any adaptation actions would become necessary until after 2070, allowing for significant time to monitor hazard conditions and plan for implementation accordingly.

A summary of potential adaptation measures within the Project site for each sea level rise scenario and associated time horizon is presented below. Further discussion of the potential advantages and challenges associated with different types of adaptation strategies are included in Sections 4.3.1 and 4.3.2. Adaptation options discussed within this report were chosen to align with long-term sea level rise and flooding adaptation actions outlined in the Long Beach CAAP (City of Long Beach, 2020), which include:

- Expand beach nourishment
- Construct living shoreline/berm
- Elevate street hardscapes
- Elevate streets/pathways
- Retreat/realign parking lots
- Extend/upgrade existing seawalls

<u>Current Conditions</u>

No adaptation measures required within Project site or surrounding areas. Flood hazard exposure is not projected at the Project site.

<u>3.3 ft Sea Level Rise (2070 Time Horizon, Near End of Useful Life)</u>

No adaptation measures required within Project site. Projected flood hazard exposure remains absent from the Project site. Impacts to site access at the southern portion of the Project site would be temporary and would only occur under severe storm conditions which are predictable. Access at the eastern portion of the Project site is available and is not projected to experience any flood hazard.

4.9 ft Sea Level Rise (2080 – 2090 Time Horizon, End of Useful Life)

Adaptation measures are potentially needed to address temporary, storm driven flood impacts within parking areas. Projected flood hazards could be mitigated through a slight increase in elevation within low-lying parking areas and floodproofing retrofits of the proposed parking garage. It is also possible that the Project could accommodate these impacts as they are limited to infrequent, temporary flooding of parking areas during predictable severe storm events. Given the lack of wave energy at the Project site, it is possible that floodwaters would enter and recede from these areas without any major structural damage to parking surfaces or the proposed parking garage.

6.6 ft Sea Level Rise (2100 Time Horizon, Beyond Useful Life)

Adaptation measures would be needed to address projected spring tide flooding within parking areas and the proposed parking garage, as well as projected flooding of commercial structures during severe storm events. Site elevation can be employed within parking areas to raise parking surfaces above extreme tidal elevations. The first floor or entrance of the proposed parking garage could also be increased to match any increased elevation of surrounding parking surfaces. In addition to site elevation, floodproofing retrofits can be applied to commercial structures exposed to temporary storm flooding to mitigate flood hazards.

4.3.1. Site Elevation

Site elevation can be used to directly reduce projected sea level impacts throughout the Project area by increasing the height of paved parking lots relative to flood projections over time as necessary. Dependent on cost considerations and elevation requirements, elevation can be increased throughout the parking areas or in targeted areas along the border of the Project site to reduce hazard exposure. Entrances or first floor elevations of structures such as the proposed parking garage can also be raised to reduce flood hazard exposure. If implemented effectively over time, site elevation represents a potential long-term, low cost maintenance method to significantly mitigate potential sea level rise hazards throughout the Project area and preserve coastal access over the life of the Project.

Advantages

- Once implemented, provides effective, long-term flood mitigation with little need for maintenance.
- Elevation reduces risk directly as opposed to barriers or other structures that have a level of residual risk due to potential damage or failure under conditions beyond those considered in design.

Challenges

- Grade transitions to adjacent infrastructure, such as Shoreline Drive.
- Temporary loss of parking areas while under construction.

4.3.2. Dry Floodproofing

Dry floodproofing refers to building techniques or retrofit measures that prevent flooding from entering a building. Dry floodproofing can provide a redundant layer of flood damage protection for buildings sensitive to flooding, such as commercial structures. A number of methods are available for dry floodproofing, including waterproof coatings or installation of removable shields at structure openings as shown in Figure 4-2 and Figure 4-3. All dry floodproofing efforts must consider the potential depth of flooding to properly account for hydrostatic pressure applied to walls and floors.

Advantages

- No additional space needs to be dedicated to flood protection.
- Can be used to improve resilience of existing structures vulnerable to storm related flooding.
- Measures can be applied to buildings at a future date in response to sea level rise or other flood hazards.

Challenges

- Effectiveness may be limited by potential flood duration, flow velocity, wave action, or debris. Measures are typically feasible for flood depths of up to three feet.
- Adequate warning time prior to installation may be required depending on type of measure employed.
- Ongoing maintenance efforts are often required to maintain watertight connections.

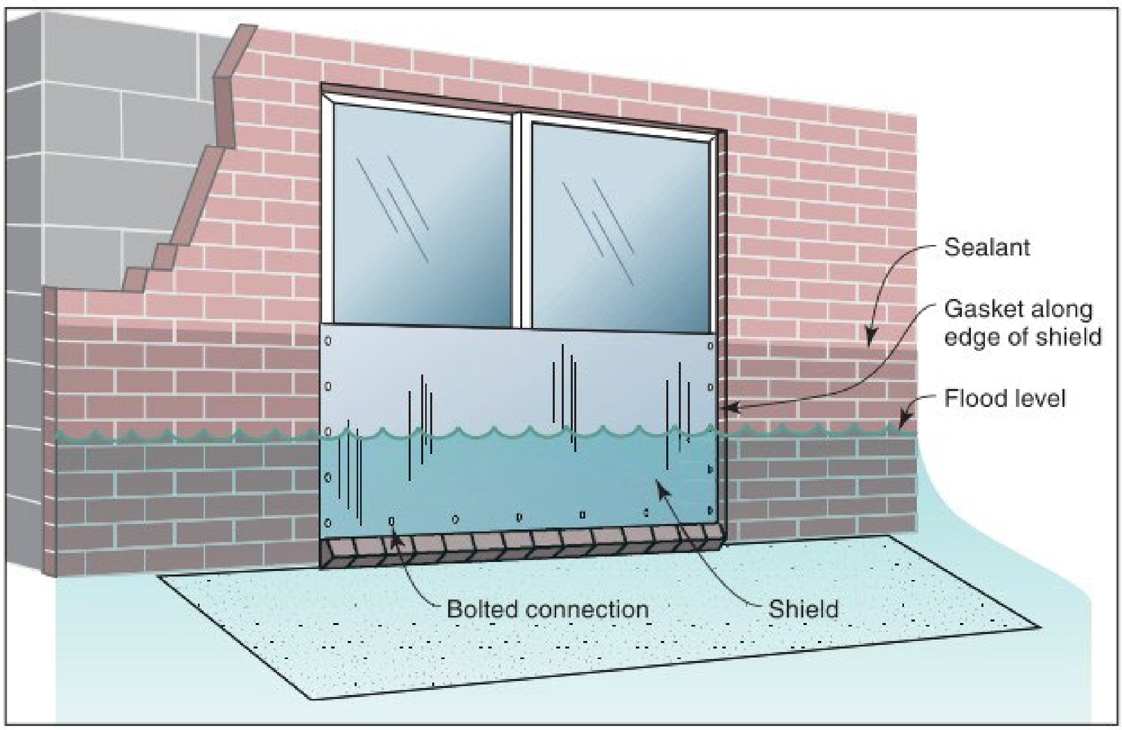

FIGURE 4-2: CONCEPTUAL EXAMPLE OF DRY FLOODPROOFING MEASURES USING BOLTED CONNECTIONS (FEMA, 2014).

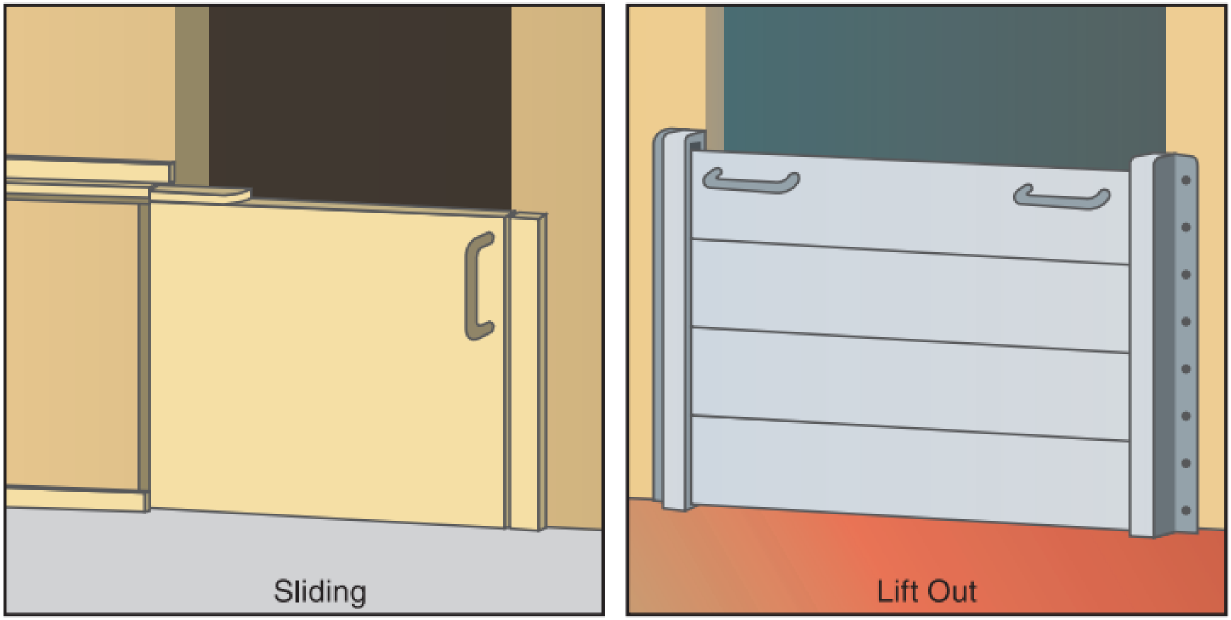

FIGURE 4-3: CONCEPTUAL EXAMPLE OF SLIDING AND LIFT-OUT FLOOD SHIELDS FOR BUILDING ENTRANCES (FEMA, 2013).

5. Impacts to Coastal Resources

5.1. Public Access and Recreation

Public access to the Project area and adjacent docks within Rainbow Harbor is projected to experience impacts due to sea level rise over time, though access to the Project site remains in place over the useful life of the Project. The Project has two access points, one at the western portion of Shoreline Drive and one at the southern portion of shoreline drive.

Current Conditions: There is no access issue.

3.3 ft Sea Level Rise (2070 Time Horizon, Near End of Useful Life)

The access point southern portion of Shoreline Village Drive is projected to experience flooding under 1-year and 100-year storm conditions, potentially limiting access to the Project site while flooding is present. The western access point provides an alternative access point under these conditions.

4.9 ft and greater Sea Level Rise (2080 – 2090 Time Horizon, End of Useful Life and Beyond)

At 4.9 ft and greater sea level rise scenarios, southern portions of Shoreline Village Drive are projected to flood during non-storm, spring tide conditions, impacting the southern access point to the Project site on a more frequent basis. The western access point would again provide an alternative access point under a 4.9 ft sea level rise scenario, as it is only projected to experience temporary flooding under 100-year storm conditions.

Other public access and recreation resources such as public access easements, beaches, recreation areas, public trust lands, and trails are not present within the Project area. These impacts are solely due to projected sea level rise hazards and are not influenced by proposed Project or conceptual adaptation measures as discussed in Section 4.3.

5.2. Coastal Habitats

The proposed Project does not contain and is not near any existing coastal habitats of special biological or economic significance that would be at risk given the influence of sea level rise over time.

5.3. Natural Landforms

The proposed Project does not contain and is not near any natural landforms such as coastal caves, rock formations, bluffs, terraces, ridges, or cliffs that would be at risk with sea level rise influence over time.

5.4. Agricultural Resources

The proposed Project does not contain and is not near any existing agricultural resources that would be at risk given the influence of sea level rise over time.

5.5. Water Quality and Groundwater

The proposed Project does not support an on-site wastewater treatment system and involves no significant changes to existing on-site drainage patterns that would be at risk with sea level rise influence over time.

5.6. Scenic Resources

The proposed project does not include any scenic resources that would be at risk given the influence of sea level rise over time.

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