

Plan Half Moon Bay



Sea Level Rise Vulnerability Assessment

April 2016



planhmb.org

Plan Half Moon Bay

Sea Level Rise Vulnerability Assessment

April 2016

Prepared for
City of Half Moon Bay

by



and

DYETT & BHATIA
Urban and Regional Planners

Funded in part by the California Ocean Protection Council

Table of Contents

Foreword	iv
1 Introduction	1
1.1 Purpose.....	1
1.2 Setting	2
1.3 Regional Planning Efforts	2
2 Sea Level Rise Impacts	3
2.1 Methodology.....	3
2.2 Flood Impacts.....	9
2.3 Tsunami Impacts.....	17
2.4 Erosion Impacts	25
2.5 Combined Impacts	33
3 Vulnerability and Potential Risks	41
4 Recommendations for Next Steps	61
5 Coordination and Outreach	63
5.1 Coastal Commission.....	63
5.2 Public Outreach.....	63
Appendix A: California Coastal Commission Policy Guidance: Options and Strategies	65
A.1 Categories of Adaptation Strategies.....	65
A.2 Strategies	66

List of Figures

Figure 2-1: FEMA Flood Zone Comparison.....	7
Figure 2-2: Potential Sea Level Rise and Flooding – Planning Area.....	11
Figure 2-3: Potential Sea Level Rise and Flooding – Reach 1.....	12
Figure 2-4: Potential Sea Level Rise and Flooding – Reach 2.....	13
Figure 2-5: Potential Sea Level Rise and Flooding – Reach 3.....	14
Figure 2-6: Potential Sea Level Rise and Flooding – Reach 4.....	15
Figure 2-7: Flood-Prone Low-Lying Areas	16
Figure 2-8: Potential Tsunami Inundation – Planning Area	19
Figure 2-9: Potential Tsunami Inundation – Reach 1	20
Figure 2-10: Potential Tsunami Inundation – Reach 2.....	21
Figure 2-11: Potential Tsunami Inundation – Reach 3.....	22
Figure 2-12: Potential Tsunami Inundation – Reach 4.....	23
Figure 2-13: Potential Coastal Erosion – Planning Area	27
Figure 2-14: Potential Coastal Erosion – Reach 1	28
Figure 2-15: Potential Coastal Erosion – Reach 2.....	29
Figure 2-16: Potential Coastal Erosion – Reach 3.....	30
Figure 2-17: Potential Coastal Erosion – Reach 4.....	31
Figure 2-18: Combined Impacts – Planning Area	35
Figure 2-19: Combined Impacts – Reach 1	36
Figure 2-20: Combined Impacts – Reach 2	37
Figure 2-21: Combined Impacts – Reach 3	38
Figure 2-22: Combined Impacts – Reach 4	39
Figure 3-1: Sea Level Rise and Tsunami Affected Areas and Habitats – Planning Area	51
Figure 3-2: Sea Level Rise and Tsunami Affected Areas and Habitats – Reach 1	53
Figure 3-3: Sea Level Rise and Tsunami Affected Areas and Habitats – Reach 2.....	54
Figure 3-4: Sea Level Rise and Tsunami Affected Areas and Habitats – Reach 3.....	55
Figure 3-5: Sea Level Rise and Tsunami Affected Areas and Habitats – Reach 4.....	56
Figure 3-6: Coastal Erosion Affected Areas and Habitats – Planning Area.....	57
Figure 3-7: Coastal Erosion Affected Areas and Habitats – Reach 1	58
Figure 3-8: Coastal Erosion Affected Areas and Habitats – Reach 2	59
Figure 3-9: Coastal Erosion Affected Areas and Habitats – Reach 3	60

List of Tables

Table 2-1: Sea Level Rise Projections.....4

Table 2-2: Cliff Retreat Projected Ranges 26

Table 3-1: Habitats Vulnerable to Flood Hazards 45

Table 3-2: Habitats Vulnerable to Tsunami Hazards 46

Table 3-3: Habitats Vulnerable to Erosion Hazards..... 47

Foreword

Sea level rise is a global phenomenon affecting areas far beyond the planning area boundaries from both jurisdictional and practical perspectives. Planning for sea level rise is a relatively new practice with emerging science and guidance for how it should be approached. The California Coastal Commission (CCC) and Monterey Bay National Marine Sanctuary (MBNMS) have significant jurisdiction over the policies and implementation for sea level rise adaptation and mitigation within Half Moon Bay. Comprehensive implementation of adaptation and mitigation strategies will require coordination and support from these agencies as well as many others including San Mateo County, Caltrans, and the Army Corps of Engineers. Funding and collaboration will become more critical as time passes and adaptation options become more limited. Within the framework of regional efforts and direct reliance on the CCC's recently adopted Sea Level Rise Policy Guidance (August 2015), the intention of this document is to identify the primary vulnerabilities within Half Moon Bay and set forth next steps that the City and other involved agencies may take to further assess and address these vulnerabilities in a timely and comprehensive fashion.

This Sea Level Rise Vulnerability Assessment is a reference document. It is intended to support policy discussion and development. However, in and of itself, this document does not represent policy or regulations of the City of Half Moon Bay. Key findings indicate the following:

- There is a need for additional studies on the impacts of sea-level rise. The effect of sea level rise on the rate of coastal bluff erosion is especially important to better ascertain implications in the near term.
- Both public infrastructure and private development are vulnerable to the future effects of sea level rise and erosion.
- Providing protection from and adapting to sea level rise will be challenging for vulnerable public infrastructure and private development.
- The policies and implementation measures for “hard” and “soft” shoreline protection, managed retreat, designating existing development as nonconforming, establishing evolving bluff setbacks, establishing amortization policies for vulnerable assets, and designating habitat retreat areas are all policy considerations requiring future consideration by the City, CCC and other regulatory agencies.
- The City's planning and implementation strategies for sea level rise will be iterative over time as the science, guidance and the actual significance of its effects become further developed.

This assessment represents a significant initial step in Half Moon Bay's understanding of sea level rise vulnerabilities and identifies conditions needing additional future study. The assessment further presents potential policies and implementation measures that may be most appropriate in the context of Half Moon Bay's natural and built environment pursuant to the CCC's Sea Level Rise Policy Guidance.

I Introduction

I.1 Purpose

Half Moon Bay's Local Coastal Program (LCP) was adopted in 1993, and is being updated, together with the City's General Plan, to ensure that it reflects current conditions, information, and community priorities. This document assesses the City of Half Moon Bay's vulnerability to sea-level rise (SLR). Information in this document will inform the development of SLR adaptation policies related to land use, habitat conservation, recreation and coastal access, and hazards.

This work has been funded in part by a grant from the Ocean Protection Council to incorporate SLR adaptation strategies in the update to Half Moon Bay's LCP, and constitutes Task 1 of the work program. Requirements for this task include determining a range of SLR projections relevant to the LCP Planning Area using best available science; identifying potential physical SLR impacts in the Planning Area; assessing the vulnerability of and potential risks to coastal resources and development; identifying potential adaptation measures and policy options; coordinating with the California Coastal Commission; and enacting public outreach and stakeholder involvement.

Half Moon Bay's coastal setting impacts all aspects of the city's long-term development—from land use and the economy to infrastructure planning, environmental resources and habitat protection, recreation, water quality and sourcing, hazard mitigation, and agricultural practice. This vulnerability assessment considers coastal resources such as public access and recreation areas, environmentally sensitive habitats, agriculture, commercial fishing and recreational boating facilities, and other land-based resources and coastal-dependent uses. It will also consider indirect or secondary impacts on critical facilities such as Highway 1, the city's natural resources, and existing and planned development.

For effective long-range planning, Half Moon Bay needs an understanding of its vulnerability to SLR and its adaptive capacity to respond to a changing environment. This understanding can then be considered alongside potential population and economic impacts to inform planning policies, as embodied in the LCP and the General Plan, to promote safe and sustainable coastal development in the face of climate change. This vulnerability assessment draws from available information to provide a reference for policy development as well as a basis for prioritizing future in-depth analysis. Thus, while it is useful in supporting the City's LCP update process, it is not intended to be the final word on the subject of SLR in the Planning Area.

1.2 Setting

Half Moon Bay is situated along the San Mateo County coastline, approximately 23 miles south of downtown San Francisco and at the western edge of the Bay Area region. It is connected to Pacifica and San Francisco to the north and Santa Cruz to the south by Highway 1, and connected to San Mateo, the Peninsula, and the East Bay by Highway 92.

The City's General Plan/LCP Planning Area extends approximately six miles along the Pacific coast, and encompasses approximately 4,267 acres. It comprises the city limits of Half Moon Bay, as well as some unincorporated land along the Highway 92 corridor east of the City, land primarily used as nurseries located directly east of Highway 1 and north of Miramontes Point Road bordering the City's southeastern edge, and the Moonridge neighborhood of affordable farm labor housing on the south side of Miramontes Point Road. These areas are included for consideration because they are directly related to planning for Half Moon Bay. The Planning Area is located entirely within the California Coastal Zone.

1.3 Regional Planning Efforts

San Mateo County is undertaking a concurrent effort to address SLR impacts throughout the county. Sea Change San Mateo County is the County's initiative to provide resources to local governments and agencies on the issue of SLR. The County is cooperating with a number of local jurisdictions in carrying out this work, including the City of Half Moon Bay. As part of this effort, the County is conducting its own SLR vulnerability assessment, which will provide a regional context for the impacts presented in this assessment. When complete, both vulnerability assessments are expected to be compatible, with information from each complementing the other. Thus, the County's vulnerability assessment is expected to be an additional resource to inform the City's understanding of near-, mid-, and long-term vulnerability along the Midcoast and throughout the county as a whole.

2 Sea Level Rise Impacts

2.1 Methodology

Mapping of SLR was conducted by Noble Consultants, Inc. (NCI). NCI's tasks included: (1) determining a range of SLR projections relevant to the LCP Planning Area or segment using the best-available science; and (2) identifying and mapping potential physical SLR impacts in the LCP planning area/segment, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.

NCI staff collected and reviewed the existing data resources and information that have previously been commissioned by the City, San Mateo County, the National Research Council (NRC), and other agencies. This information was used to provide the basis for assessing significant issues of inundation, flooding, saltwater intrusion, shoreline erosion and bluff retreat under the existing baseline and future sea-level-rise conditions.

The analysis was based on existing available information and mapping and modeling tools; no new fieldwork or investigations were performed, and no engineering analysis was performed under this task.

PROJECTIONS

The NRC's SLR projections for the California coast (currently considered the best available science by the California Coastal Commission¹) and tools recommended in the California Coastal Commission's Sea-Level Rise Guidance Document were used to assess the potential physical impacts of sea level rise.

Based on the National Research Council's (NRC) 2012 report² on sea level rise for the coasts of California, Oregon, and Washington; the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT) developed SLR guidance³ to advise California in planning efforts. Using the range of SLR presented in the NRC (2012) report, CO-CAT selected SLR values based on agency and context-specific considerations of risk tolerance and adaptive capacity. These SLR projections were also unanimously adopted for use by the Coastal Commission on August 12, 2015.⁴ The NRC's SLR predictions for the project site are listed in Table 2-1.

¹ California Coastal Commission, 2015. California Coastal Commission, Sea Level Rise Policy Guidance, unanimously adopted on August 12, 2015.

² National Research Council (NRC), 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389.

³ CO-CAT, 2013. State of California Sea-Level Rise Guidance Document, March 2013 update.

⁴ California Coastal Commission, 2015. California Coastal Commission, Sea Level Rise Policy Guidance, unanimously adopted on August 12, 2015.

Table 2-1: Sea Level Rise Projections

<i>Time Period</i>	<i>Sea Level Rise</i>
By 2030	2-12 inches (4-30 cm)
By 2050	5-24 inches (12-61 cm)
By 2100	17-66 inches (42-167 cm)

Sources: National Research Council, 2012; NCI, 2015.

SCENARIOS

The California Coastal Commission recognizes uncertainty in SLR science, and recommends that this uncertainty be addressed through scenario planning. Given the uncertainty in the magnitude and timing of future SLR, particularly over longer time periods, the Coastal Commission encourages the use of scenario-based analysis to examine a range of possible shoreline changes and SLR risks.⁵ This vulnerability assessment explores 100-year storm scenarios under four different sea levels: 0 cm, 25 cm, 50 cm, and 91 cm; a tsunami scenario; and three shoreline erosion scenarios as described below. The 0 cm scenario is a baseline scenario, and represents sea levels in the year 2000. The 25 cm scenario corresponds to a rise of 25 centimeters from year 2000 baseline levels, and represents the upper range of SLR projected by 2030 and the lower range of sea level rise projected by 2050. The 50 cm scenario represents the upper range of SLR projected by 2050 and the lower range projected by 2100. The 91 cm represents the middle range of SLR projected by 2100. Projections at the upper end of a range correspond to projections based on a higher rate of SLR. Similarly, projections at the lower end of a range correspond to a lower rate of SLR.

It is important to note that the 91-centimeter scenario corresponds to worst-case scenario projections for approximately the year 2065, and is in the mid-range of SLR projected by the year 2100, as shown in Table 2-1. Thus, actual SLR by 2100 has the potential to be greater than the 91-centimeter rise discussed in this document, and resulting impacts and vulnerabilities may be more extreme. The vulnerability analysis being conducted for Sea Change San Mateo County examines SLR scenarios of 0 feet, 3.3 feet (100 cm), and 6.6 feet (200 cm), and may be referenced for additional information regarding potential flooding impacts at those levels.

Flood Mapping

The flood hazard maps were produced by combining the coastal flood inundation maps, which were developed by Our Coast Our Future (OCOF) for the coastal area, with the Federal Emergency Management Agency’s (FEMA’s) Flood Insurance Rate Map (FIRM) for the Planning Area. The OCOF flood maps show the inundation due to SLR, waves, and storm surge for coastal areas. The flood maps for the 100-year storm event combined with three SLR scenarios: no SLR, 25 cm SLR, and 50 cm SLR were downloaded directly from the OCOF website. The flood map for the 100-year

⁵ Ibid.

storm event combined with 3 ft. SLR was manually interpolated between the 75 cm SLR and the 100 cm SLR scenarios downloaded from the OCOF website.

FEMA's preliminary draft FIRM, dated 9/14/2015, was used to represent the 1 percent annual chance (100-year) inundation boundary for inland creeks. For information purposes, Figure 2-1 shows the 100-year inundation map that is delineated in the preliminary draft FIRM. This map covers both the coastal storm flooding and the inundation boundaries of the inland creeks. It is noted that the impact of SLR is not included in the FIRM. However, SLR will only impact the estuary of Frenchmans Creek, and the inundation of this estuary area is already included in the OCOF's (coastal) flood map. The impact of SLR on riverine flooding decays as the distance upstream from the river mouth increases, and is negligible for other inland creeks in the City of Half Moon Bay.

It is noted that the initial intent of this study was to use the 0 cm SLR king tide scenario as a baseline for comparison against projected SLR impacts. However, OCOF only provides flood inundation maps associated with the king tide scenario for San Francisco Bay, and not for the open Pacific coast, including the coastal shoreline within the Planning Area. As a result, the flood inundation maps for the king tide scenario are not generated in this study. Alternatively, the inundation map for the 100-year storm event without SLR, or the FEMA preliminary draft FIRM dated 9/14/2015, is recommended to be used as the current flooding baseline condition. Figure 2-1 shows the preliminary draft FIRM in comparison to the current adopted FIRM; the preliminary draft shows more pronounced coastal flooding in multiple areas along the coast, and less pronounced flooding in the northern coastal neighborhoods. These two maps are more conservative than the inundation condition associated with the king tide scenario. The 100-year tide event, not including wave contribution, would be approximately one foot higher than the king tide. These two maps also include the wave impact, resulting in a still greater difference from the 0 cm SLR king tide scenario.

It is also noted that OCOF does not provide inundation conditions for a small area of coastline at the southern end of the city, including Ocean Colony (southerly down the coast to the golf course). The potential flood hazard for this area is thus not mapped in this study. The FEMA's inundation map, or the erosion and inundation map prepared by ARCADIS for the County of San Mateo,⁶ can be used as a reference for this area.

Tsunami Mapping

The tsunami hazard maps were reproduced based on the tsunami inundation map developed by the California Emergency Management Agency (CalEMA), the California Geological Survey (CGS), and the University of Southern California (USC) dated June 15, 2009. Based on the notes on the published tsunami inundation map this map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region. For this reason, all of the inundation region shown for a particular area will not likely be inundated during a single tsunami event.

⁶ San Mateo County Vulnerability Assessment – Ocean Side 1% Annual Chance Storm (ACS) with Three SLR Scenarios, Prepared by ARCADIS for County of San Mateo and Coastal Conservancy.

It is noted that the SLR impact is not included in the USC tsunami modeling and the resulting tsunami inundation map. The tsunami combined with SLR may result in a more severe tsunami hazard. However, considering the limited accuracy of the tsunami modeling, the impact of SLR on tsunami inundation may be less than the errors in the tsunami modeling itself.

Erosion Mapping

The OCOF website provides projected shoreline ranges for the years 2010, 2030, 2050, and 2100. Cliff retreat ranges are also presented in the OCOF website at three different locations. However, these data sets could not be directly downloaded from the OCOF website. Based on NCI's communication with USGS,⁷ the shoreline retreat shown in the OCOF website is a "simple extrapolation of historical rates" based on the USGS National Shoreline Assessment.⁸ The USGS National Shoreline Assessment derived its historical erosion rates from National Ocean Service topographic maps from the 1920s and 1930s and Lidar (Light Detection and Ranging) data from 1998 and 2002. The study was unable to quantitatively evaluate the impact of coastal protection structures on cliff retreat and erosion rates.⁹ The shoreline retreat data was downloaded from the USGS National Shoreline Assessment website.

Shoreline erosion hazard maps show shoreline variation and cliff retreat ranges in 2010, 2030, 2050 and 2100. The variation in range of cliff retreat are shown relative to the 2010 condition. These maps were produced based on the shoreline and cliff retreat data from OCOF and the U.S. Geological Survey (USGS). Projections for future shoreline and cliff locations are shown as a range to capture potential variations.

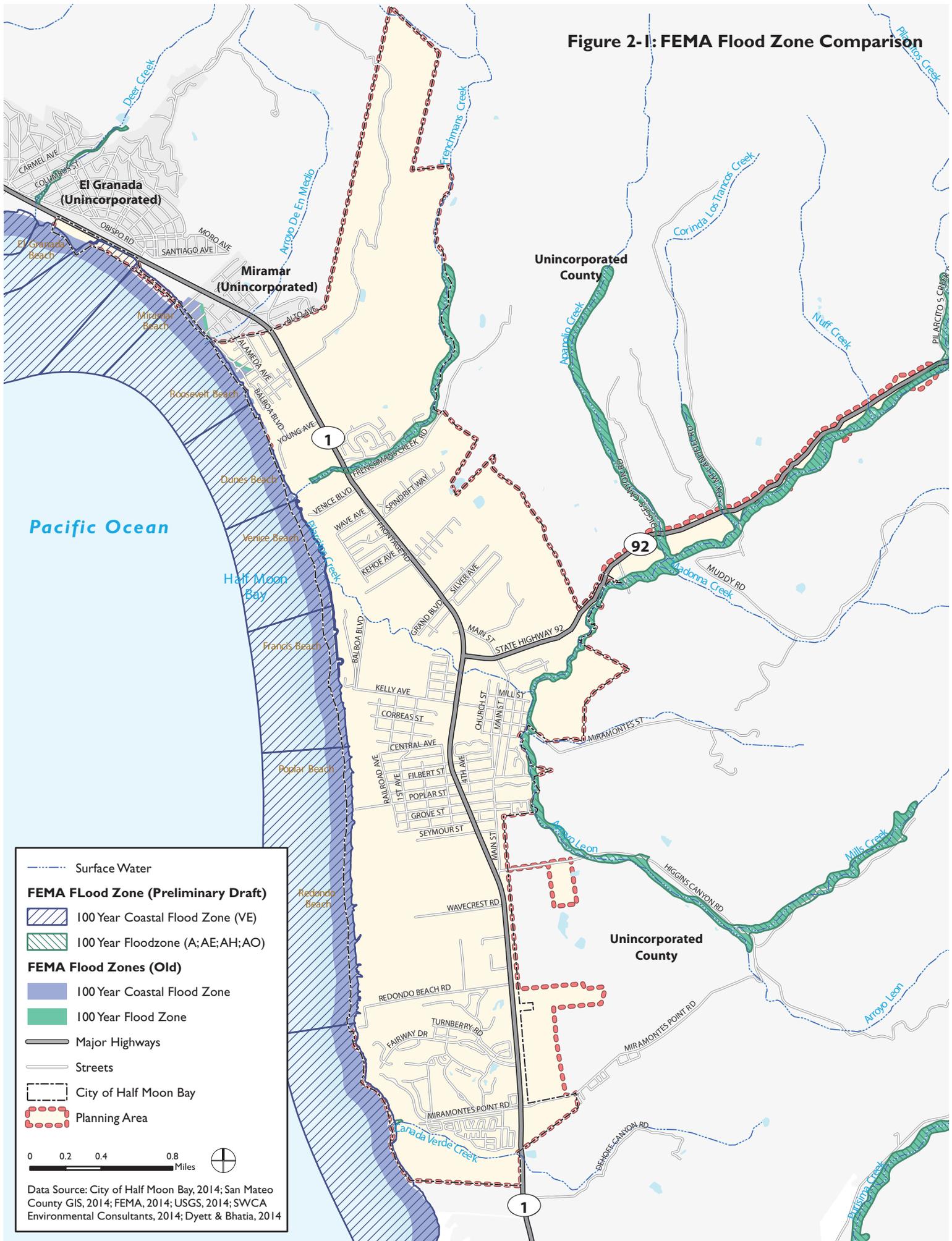
The shoreline erosion and cliff retreat depend on the water level, waves, nearshore currents, and site geologic, soil type, and exposure conditions. As discussed, the shoreline erosion and cliff retreat, which were projected by USGS, and that are presented in the OCOF website, are "simple extrapolations of historical rates." In other words, the impact of SLR is not included in the future shoreline erosion and cliff retreat data. SLR will accelerate shoreline erosion and cliff retreat, but without reliable engineering or geologic analysis, more specific projections cannot be stated at this time. It is recommended to quantify this impact in future analysis and re-map the shoreline erosion hazard when this information becomes available. The impact of tsunamis on shoreline erosion and cliff retreat is not included either. This impact can vary from insignificant to extremely significant depending on the tsunami event and shoreline area, and without reliable analysis for the project site, anticipated relationships between tsunami and seismic impacts on coastal or bluff erosion cannot be provided.

⁷ Personal communication with Dr. Li Erikson of, Research Oceanographer, USGS Pacific Coastal and Marine Science Center.

⁸ USGS St. Petersburg Coastal and Marine Science Center. National Assessment of Shoreline Change Project. <http://coastal.er.usgs.gov/shoreline-change/>

⁹ Hapke, C.J., and Reid, D., 2007, National Assessment of Shoreline Change, Part 4: Historical Coastal Cliff Retreat along the California Coast: U.S. Geological Survey Open-file Report 2007-1133.

Figure 2-1: FEMA Flood Zone Comparison



— · — · — Surface Water
FEMA Flood Zone (Preliminary Draft)
 100 Year Coastal Flood Zone (VE)
 100 Year Floodzone (A;AE;AH;AO)
FEMA Flood Zones (Old)
 100 Year Coastal Flood Zone
 100 Year Flood Zone
 Major Highways
 Streets
 City of Half Moon Bay
 Planning Area

0 0.2 0.4 0.8
 Miles

Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; FEMA, 2014; USGS, 2014; SWCA Environmental Consultants, 2014; Dyett & Bhatia, 2014

This page intentionally left blank.

Additionally, no cumulative sedimentation occurs along Half Moon Bay's coastal shoreline, which differs from the shoreline sedimentation that can occur along the San Francisco Bay. Thus, while the City of Half Moon Bay is not vulnerable to hazards associated with sedimentation, the lack of sedimentation to replenish shorelines affected by erosion is a concern.

It is also noted that the USGS and OCOF do not provide shoreline erosion data for a small area of coastline at the southern end of the city, including from Ocean Colony (southerly down the coast to the golf course). The data is also missing for two gaps in Reach 2 (Figure 2-15) and in Reach 4 (Figure 2-17). As a result, the shoreline erosion hazard is not mapped for these areas without data. In practice, it can be interpolated or extrapolated based on the information in adjacent areas, or can be approximated with the erosion hazard map that was prepared by ARCADIS for the County of San Mateo as part of its own vulnerability assessment.

Saltwater Intrusion

In the Planning Area, three small creeks, Frenchmans Creek, Pilarcitos Creek, and Cañada Verde Creek flow into the ocean. Arroyo de en Medio, on the Planning Area's northern boundary, also releases into the ocean. These creeks are separated from the ocean by berms and beaches and have little water flow during most days. As a result, saltwater intrusion for these three freshwater resources would be considered negligible. Over time and under certain conditions, it is possible that saltwater from the ocean may enter habitats at the mouths of the waterways. This could occur as a result of failure of the protection provided by the berms and beaches due to erosion, damage from coastal hazards, or extreme tides or flooding combined with higher sea levels. To fully understand the potential for saltwater intrusion and any impacts on the habitats in those areas, further study would be required of the strength and elevation of the berms and the channels, potential frequency of occurrence given tides and storm strengths, and whether saltwater would subsequently flow out of the waterways or remain in them. Additionally, further study would be required to understand the sensitivity of coastal habitats, groundwater, and the potential use of wells exposed to potential saltwater intrusion to that impact. Thus, while saltwater intrusion impacts are expected to be negligible over the planning period, further study is required to understand the potential for saltwater intrusion in the long term.

2.2 Flood Impacts

SLR can result in flood impacts in low-lying coastal areas and cause the inland extents of 100-year floods to increase. Higher water levels at the coast may cause water to back up along waterways and drainages and cause upstream or inland flooding.¹⁰

Flood hazards in the Planning Area are typically associated with storms or other events resulting in coastal flooding from waves or tsunamis. Several creeks and drainages pass through the city and are also subject to fluvial flooding. Fluvial flooding can be exacerbated by coastal flooding as wave run-up reduces discharge capacity and increases flood extents.

¹⁰ Heberger, Matthew et. al., 2009. The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center.

The flood hazard maps showing the combination effects of the 100-year flood and SLR are shown in Figure 2-2 through Figure 2-6 for the Planning Area and four reaches along the City of Half Moon Bay shoreline. The maps are broken into four figures for better resolution. OCOF does not provide inundation conditions for the segment of coastline between the northern portion of the Ocean Colony development and the southern City limits. The potential flood hazard for this area is thus not mapped in this study. This segment of the coastline is characterized by bluffs with narrow tidal beaches, a golf course along the bluffs, and the Ocean Colony and Cañada Cove neighborhoods set back from the bluffs. The California Coastal Trail is located near the edge of the bluff top. Only one structure—the Ritz-Carlton Hotel—is located within close proximity of the bluff top. The mouth of Cañada Verde Creek is located along this coastal segment, and creates a break in the bluffs. Impacts in this area are likely to be similar to those affecting other blufftops in the Planning Area, though more information would be required in order to map and understand specific impacts.

As shown, a 100-year flood event under the three sea level rise scenarios would mainly impact the Planning Area’s beaches. Some inundation at the outlets of waterways and drainages will likely be more pronounced with higher sea levels, particularly the outlet of Pilarcitos Creek. Flooding along the waterways under the sea level rise scenarios was not mapped, because OCOF does not provide inundation conditions along inland creeks. However, data from FEMA regarding current conditions shows flood potential along waterways such as Frenchmans Creek that could be exacerbated with higher sea levels.

The OCOF tool also showed “Flood-prone Low-lying Areas” on and around the Sewer Authority Mid-Coastside (SAM) Wastewater Treatment Plant site at 0 cm SLR, which increase in size as SLR increases. These are shown in green on Figure 2-7 but are not included in the flood impacts mapping as they are not defined as flood inundation areas and are disconnected from other flooding areas.

As previously stated, over time, SLR is expected to surpass the 91 cm analyzed in this vulnerability assessment. Therefore, the extents of SLR-related flooding may eventually impact more areas than are discussed here, including areas inland of impacts shown in the 25, 50, and 91 cm scenarios, including creeks and the SAM Wastewater Treatment Plant. San Mateo County is also preparing a sea level rise vulnerability assessment which will provide mapping and more information about a longer term, more extreme condition.

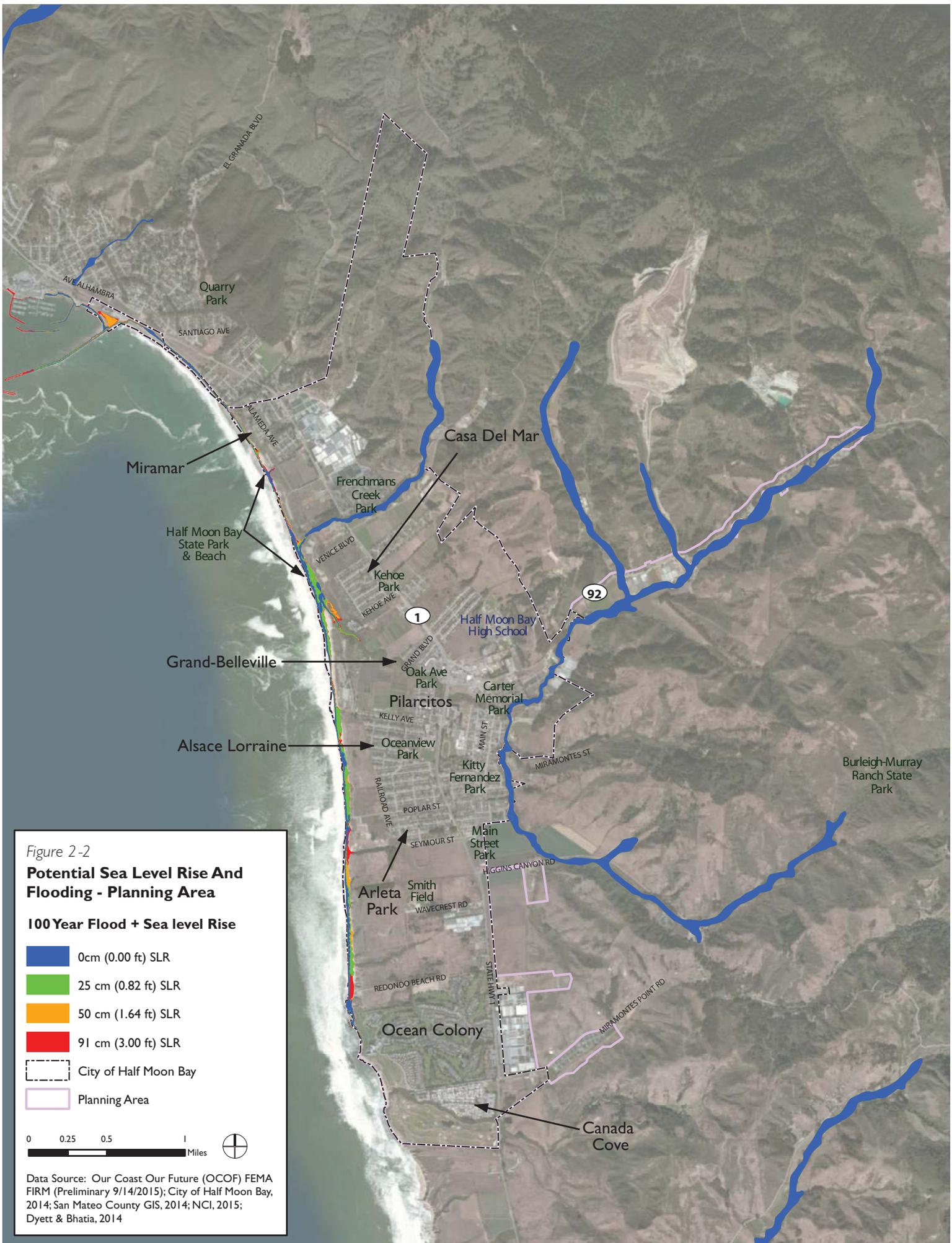




Figure 2-3
**Potential Sea Level Rise And
 Flooding - Reach I**

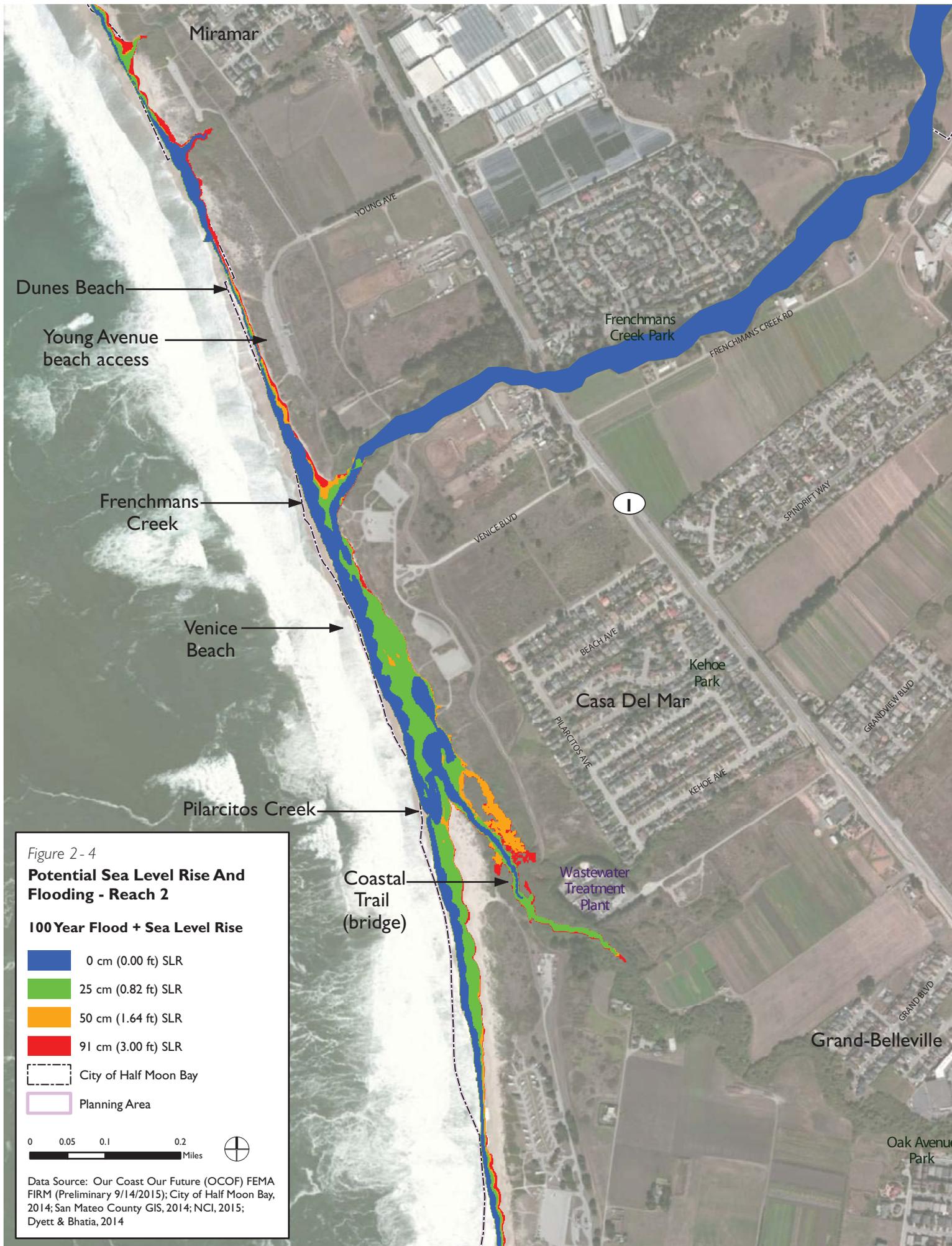
100 Year Flood + Sea Level Rise

- 0 cm (0.00 ft) SLR
- 25 cm (0.82 ft) SLR
- 50 cm (1.64 ft) SLR
- 91 cm (3.00 ft) SLR

- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF) FEMA FIRM (Preliminary 9/14/2015); City of Half Moon Bay, 2014; San Mateo County GIS, 2014; NCI, 2015; Dyett & Bhatia, 2014



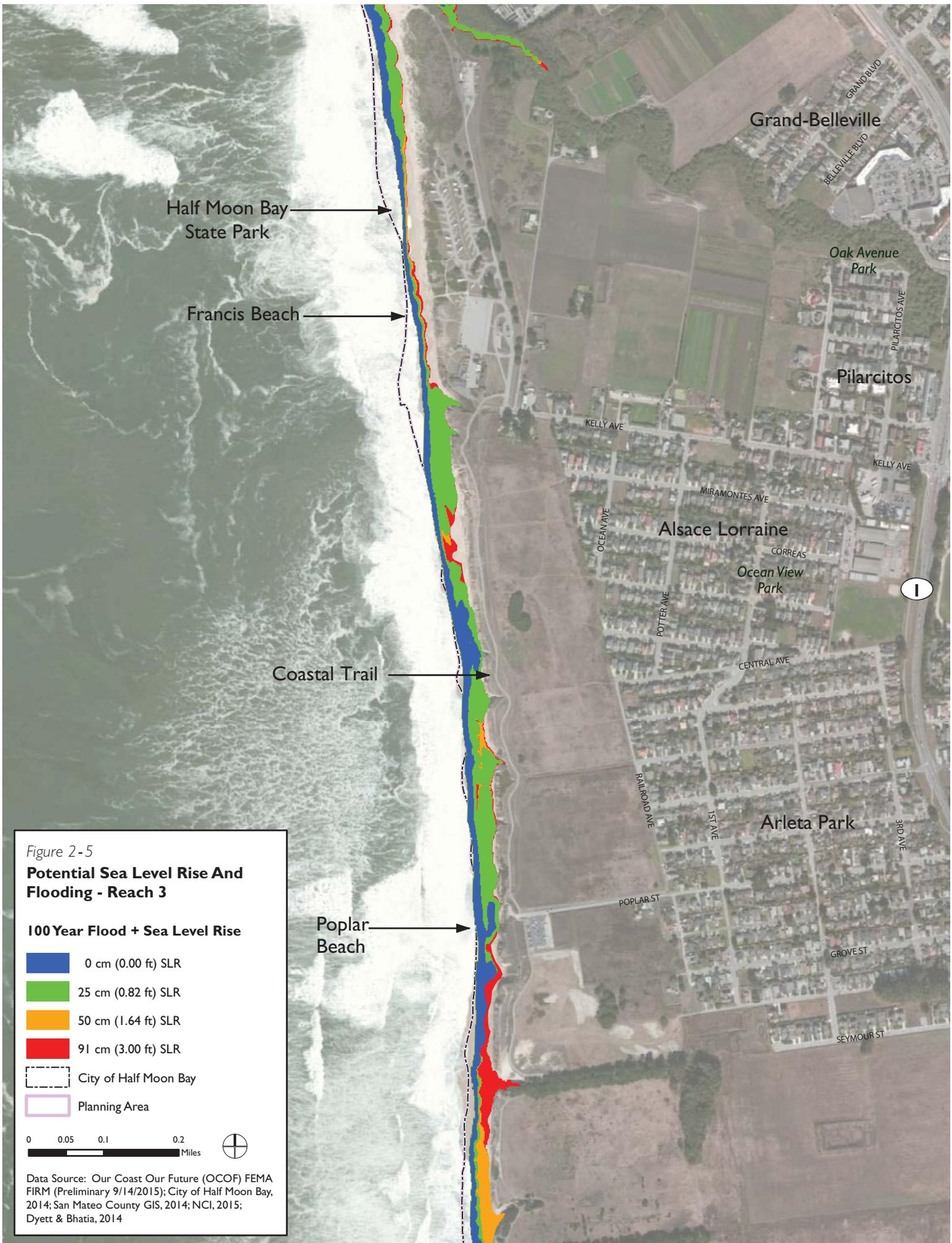


Figure 2-5
**Potential Sea Level Rise And
 Flooding - Reach 3**

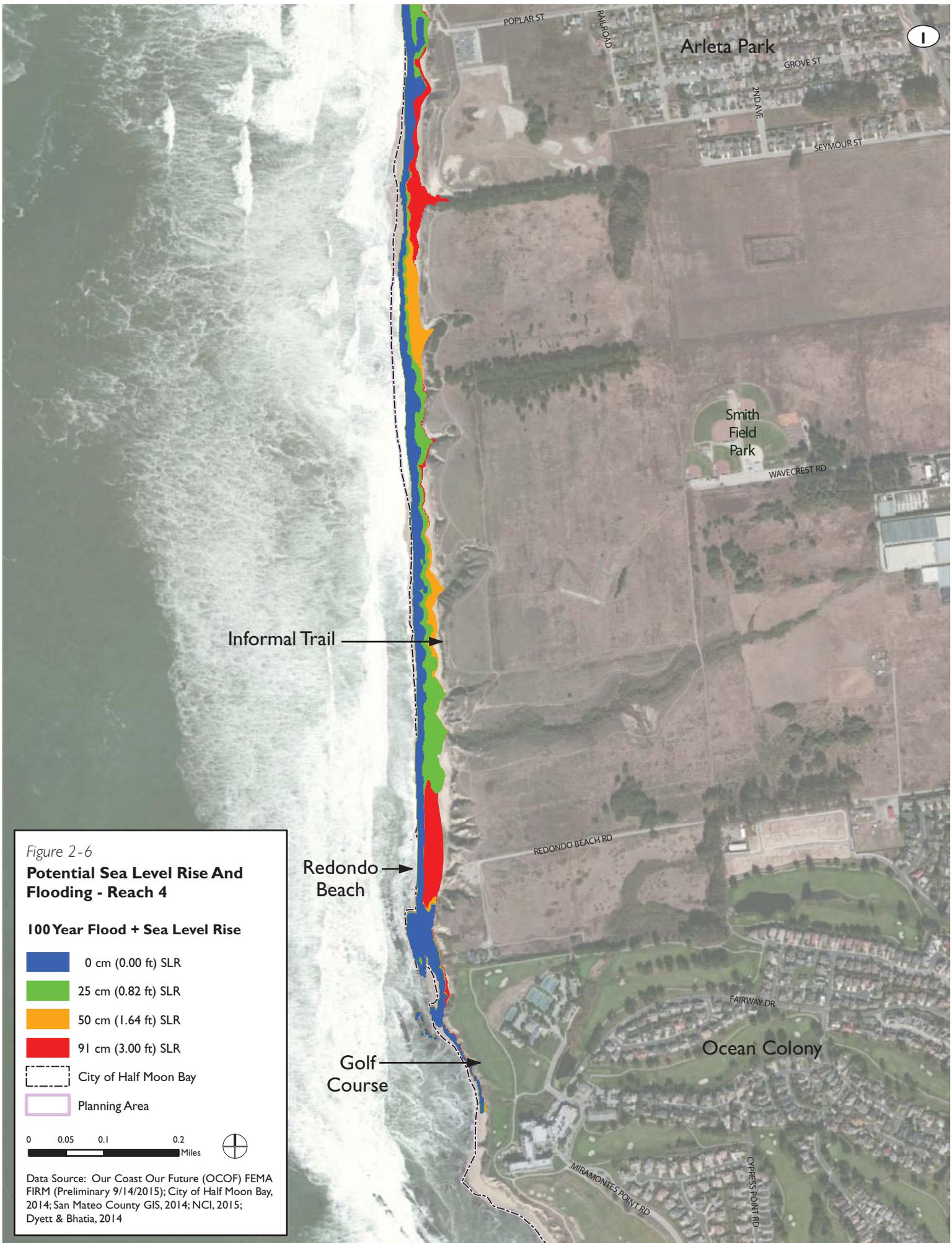
100 Year Flood + Sea Level Rise

- 0 cm (0.00 ft) SLR
- 25 cm (0.82 ft) SLR
- 50 cm (1.64 ft) SLR
- 91 cm (3.00 ft) SLR

- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF) FEMA FIRM (Preliminary 9/14/2015); City of Half Moon Bay, 2014; San Mateo County GIS, 2014; NCI, 2015; Dyett & Bhatia, 2014



POPLAR ST

RAILROAD

Arleta Park

GROVE ST

2ND AVE

SEYMOUR ST

Smith Field Park

WAVECREST RD

Informal Trail

Redondo Beach

REDONDO BEACH RD

Golf Course

Ocean Colony

FAIRWAY DR

MIRAMONTES POINT RD

CYPRESS POINT RD

1

Figure 2-7: Flood-Prone Low-Lying Areas



 Flood-Prone Low-Lying Areas

0 200 400
Feet 

Data Source: Our Coast Our Future (OCOF)

2.3 Tsunami Impacts

Tsunamis are large waves caused by seismic or landslide events in the ocean floor. Tsunamis can result from off-shore earthquakes near the coastline or from far distant events. Although tsunamis are more typically generated by subduction faults (Washington and Alaska) local tsunamis may result from strike-slip faults along the San Andreas fault running along the coast of the San Francisco Peninsula.¹¹ In general, tsunamis along the west coast of the United States and the Planning Area, in particular, are considered to be rare. Most of the recorded tsunami events in the vicinity of the Planning Area have been small with many possibly misinterpreted from other wave-related phenomena such as storm-generated waves or seiches.¹²

Potential tsunami hazards are shown in figures 2-8 through 2-12 for the Planning Area and four reaches along the City of Half Moon Bay shoreline. The mapping shows that a tsunami could result in waves impacting areas as much as 3,000 feet inland in low-lying parts of the Planning Area. This includes substantial portions of the Miramar and Casa del Mar neighborhoods as well as open space and agricultural land between these neighborhoods and along Pilarcitos Creek. The Wastewater Treatment Plant is also located within the potential tsunami area., While the beaches would likely be inundated, a tsunami would not be anticipated to penetrate the coastal bluffs from Kelly Avenue southward. Though data was not available for tsunami impacts under sea level rise scenarios, it would be expected that a tsunami would impact areas farther inland with higher sea levels.¹³

¹¹ Association of Bay Area Governments (ABAG), 2010, Taming Natural Disasters, Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area, Publication Number: P09001EQK.

¹² Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

¹³ California Coastal Commission, 2015. California Coastal Commission, Sea Level Rise Policy Guidance, unanimously adopted on August 12, 2015.

This page intentionally left blank.

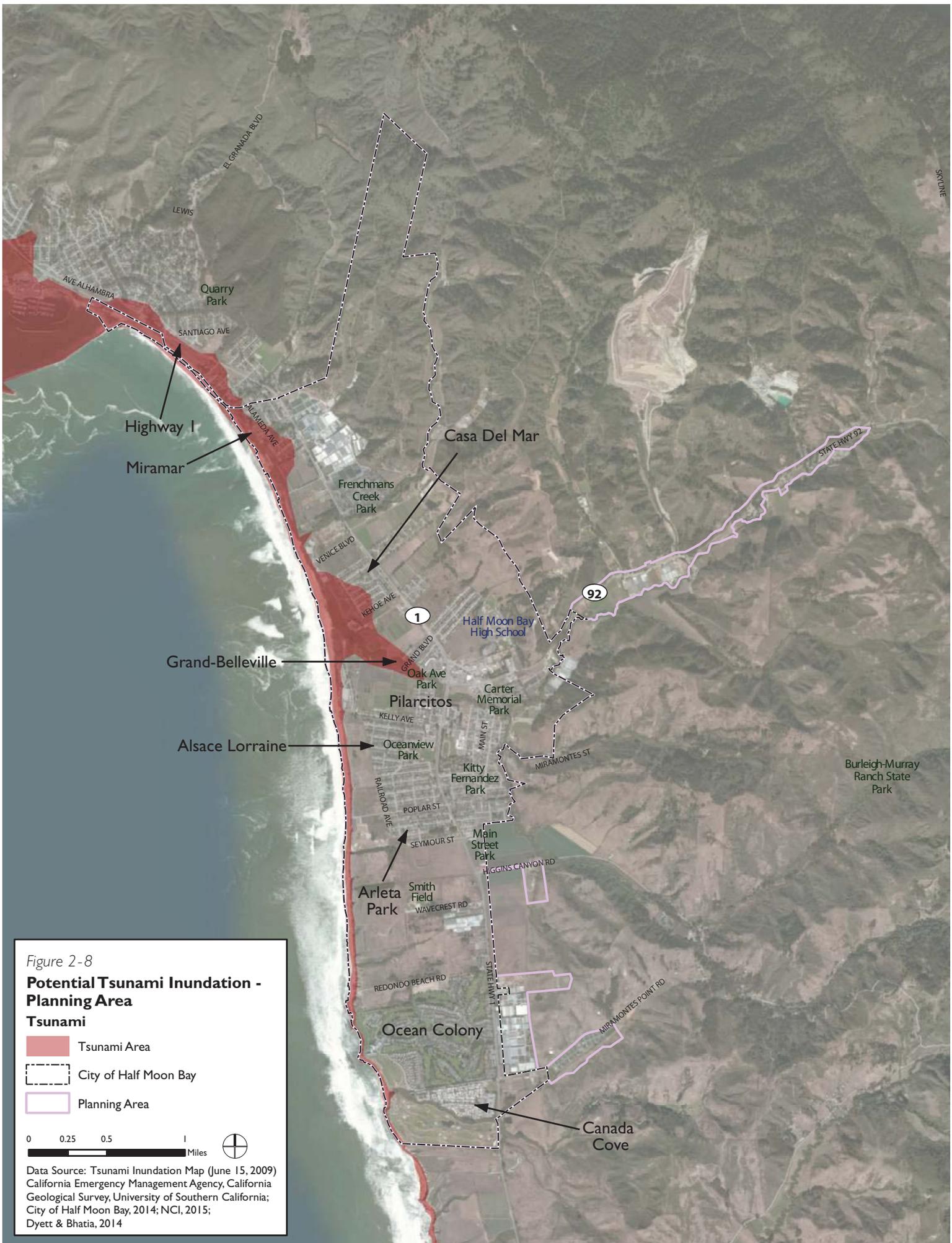


Figure 2-8

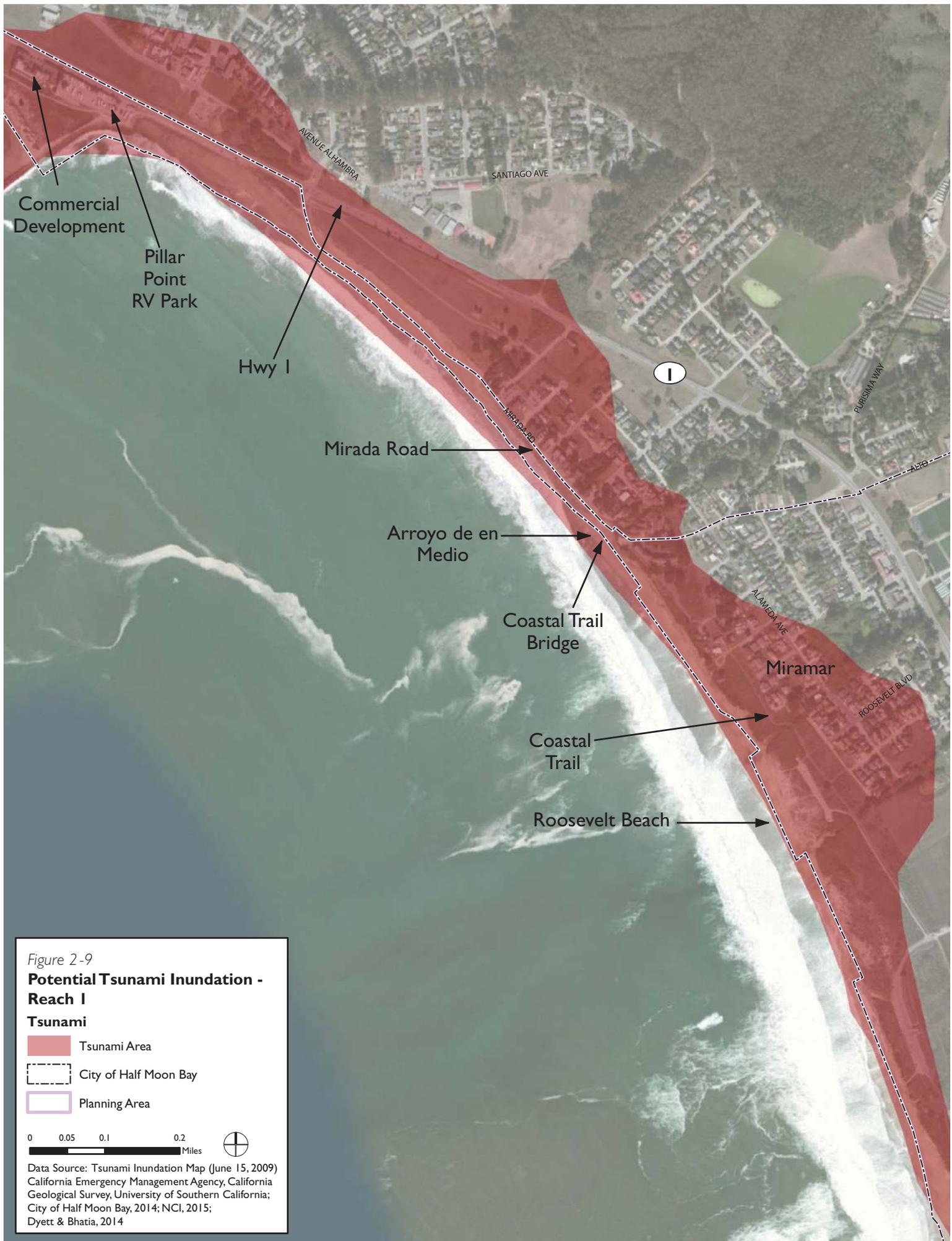
Potential Tsunami Inundation - Planning Area

Tsunami

- Tsunami Area
- City of Half Moon Bay
- Planning Area



Data Source: Tsunami Inundation Map (June 15, 2009)
 California Emergency Management Agency, California
 Geological Survey, University of Southern California;
 City of Half Moon Bay, 2014; NCI, 2015;
 Dyett & Bhatia, 2014



Commercial Development

Pillar Point RV Park

Hwy 1

Mirada Road

Arroyo de en Medio

Coastal Trail Bridge

Coastal Trail

Roosevelt Beach

Miramar

AVENUE ALHAMBRA

SANTIAGO AVE

HERRING RD

ALAMEDA AVE

ROOSEVELT BLVD

PURISIMA WAY

1

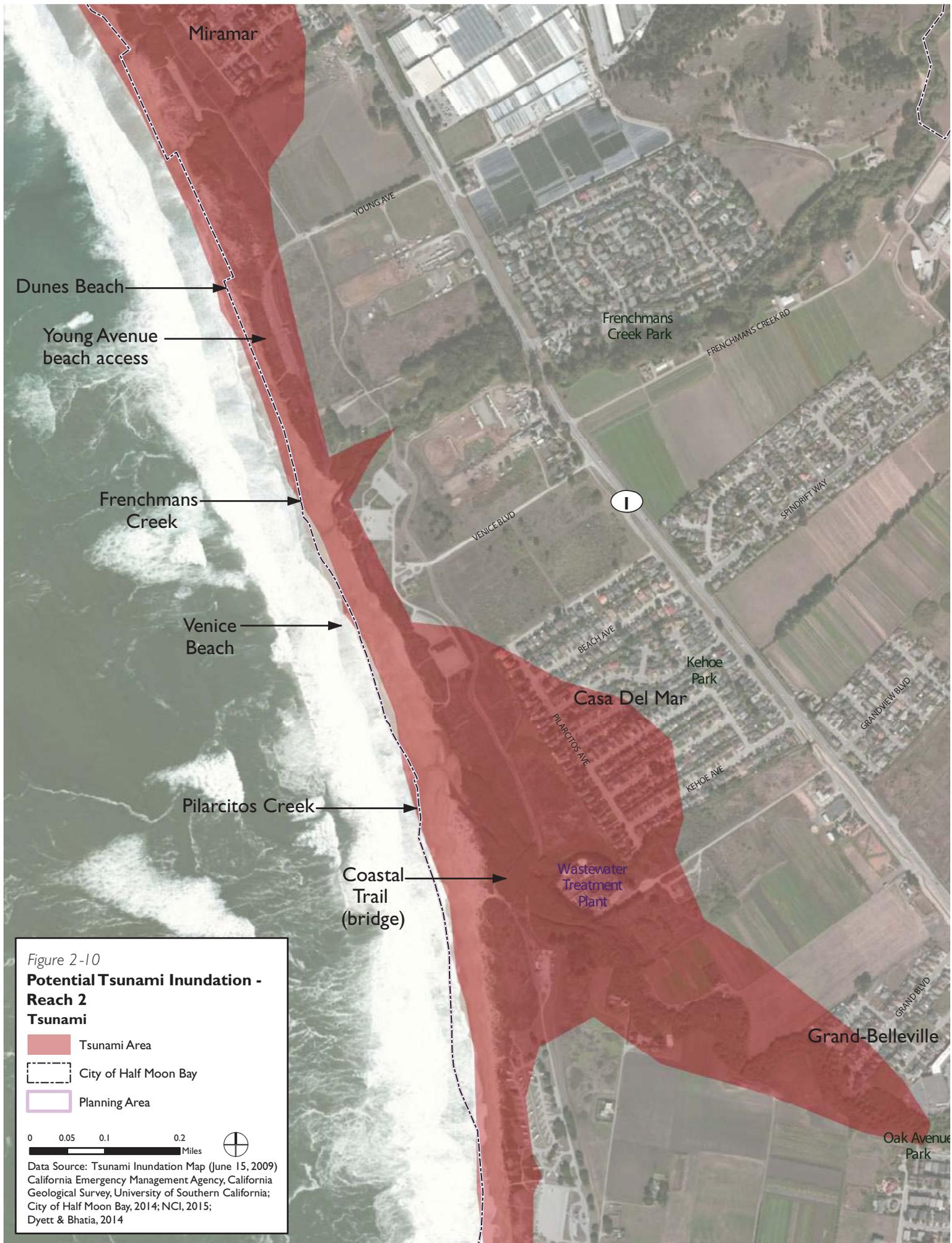


Figure 2-10

Potential Tsunami Inundation - Reach 2
Tsunami

- Tsunami Area
- City of Half Moon Bay
- Planning Area

0 0.05 0.1 0.2 Miles



Data Source: Tsunami Inundation Map (June 15, 2009)
 California Emergency Management Agency, California
 Geological Survey, University of Southern California;
 City of Half Moon Bay, 2014; NCI, 2015;
 Dyett & Bhatia, 2014



Figure 2-11
Potential Tsunami Inundation - Reach 3

Tsunami

- Tsunami Area
- City of Half Moon Bay
- Planning Area



Data Source: Tsunami Inundation Map (June 15, 2009)
 California Emergency Management Agency, California
 Geological Survey, University of Southern California;
 City of Half Moon Bay, 2014; NCI, 2015;
 Dyett & Bhatia, 2014



Figure 2-12

Potential Tsunami Inundation - Reach I

Tsunami

- Tsunami Area
- City of Half Moon Bay
- Planning Area

0 0.05 0.1 0.2 Miles

Data Source: Tsunami Inundation Map (June 15, 2009)
 California Emergency Management Agency, California
 Geological Survey, University of Southern California;
 City of Half Moon Bay, 2014; NCI, 2015;
 Dyett & Bhatia, 2014

This page intentionally left blank.

2.4 Erosion Impacts

Erosion is a natural process by which wind and water move across soils and break down existing features and structures. Human alteration of the natural environment can accelerate the pace of erosion, and/or create unnatural patterns of erosion. Accelerated erosion can cause instability in geologic structures, and water quality concerns in receiving waters. The NRC stated that higher sea levels would result in an increase in wave heights, producing greater wave energy to erode the coastline at a higher rate.¹⁴ Such erosion in turn could destabilize the landforms and threaten blufftop development and man-made structures along the coast.¹⁵ Higher sea levels could also cause the landward migration of beaches over time.¹⁶ Open space for recreation, habitat, and agriculture may also be affected, resulting in a need to allow for relocation of infrastructure and land for habitat retreat.

The western edges of the Planning Area consist of coastal bluffs and sandy shoreline. There are different sources of and risks related to erosion along the coast and within the interior of the Planning Area. Along the coast, sources of erosion are related to waves acting upon the steep bluff features. Evidence of wave related erosion has been documented along the shoreline and bluff areas along the southern shoreline of the Planning Area.

Shoreline erosion hazard maps for the City of Half Moon Bay are shown in figures 2-13 through 2-17. As discussed in Section 2.1, these maps depict extrapolations of historical rates of shoreline erosion and cliff (bluff) retreat projected by USGS, as data on the impact of SLR on future shoreline erosion and bluff retreat was not available. The 2010 base shoreline, and the projected 2030, 2050, and 2100 shorelines, are shown in each of these figures. The variation ranges of cliff retreats (from 2010) are also shown in these figures for three cliff locations. Projections for future shoreline and cliff locations are shown as a range to capture all potential variations.

Potential coastal erosion is anticipated to reach the western portion of Miramar by 2100, as well as parking areas for Half Moon Bay State Beach, portions of the Coastal Trail south of Kelly Avenue, and portions of the informal trails along the coast in the Wavecrest area. OCOF modeled cliff retreat near the Miramar neighborhood and in two locations in the West of Railroad area. Potential ranges for cliff retreat at these points are shown in Table 2-2. Though data on erosion from SLR was not available, it is understood that higher sea levels are likely to accelerate shoreline and bluff erosion and retreat due to increased wave attack.¹⁷ Therefore, actual shoreline erosion rates, when combined with the impacts of SLR, may in fact be higher than what existing studies indicate.

¹⁴ National Research Council (NRC), 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389.

¹⁵ California Coastal Commission, 2015. California Coastal Commission, Sea Level Rise Policy Guidance, unanimously adopted on August 12, 2015.

¹⁶ National Research Council (NRC), 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389.

¹⁷ Heberger, Matthew et. al., 2009. The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center.

Table 2-2: Cliff Retreat Projected Ranges

<i>Location</i>	<i>2030 Range (feet)</i>	<i>2050 Range (feet)</i>	<i>2100 Range (feet)</i>
Miramar	35.69	70.34	156.95
West of Railroad (northern point)	35.17	70.34	158.26
West of Railroad (southern point)	35.17	71.12	161.01

Source: USGS, 2015; NCI, 2015; Dyett & Bhatia, 2015

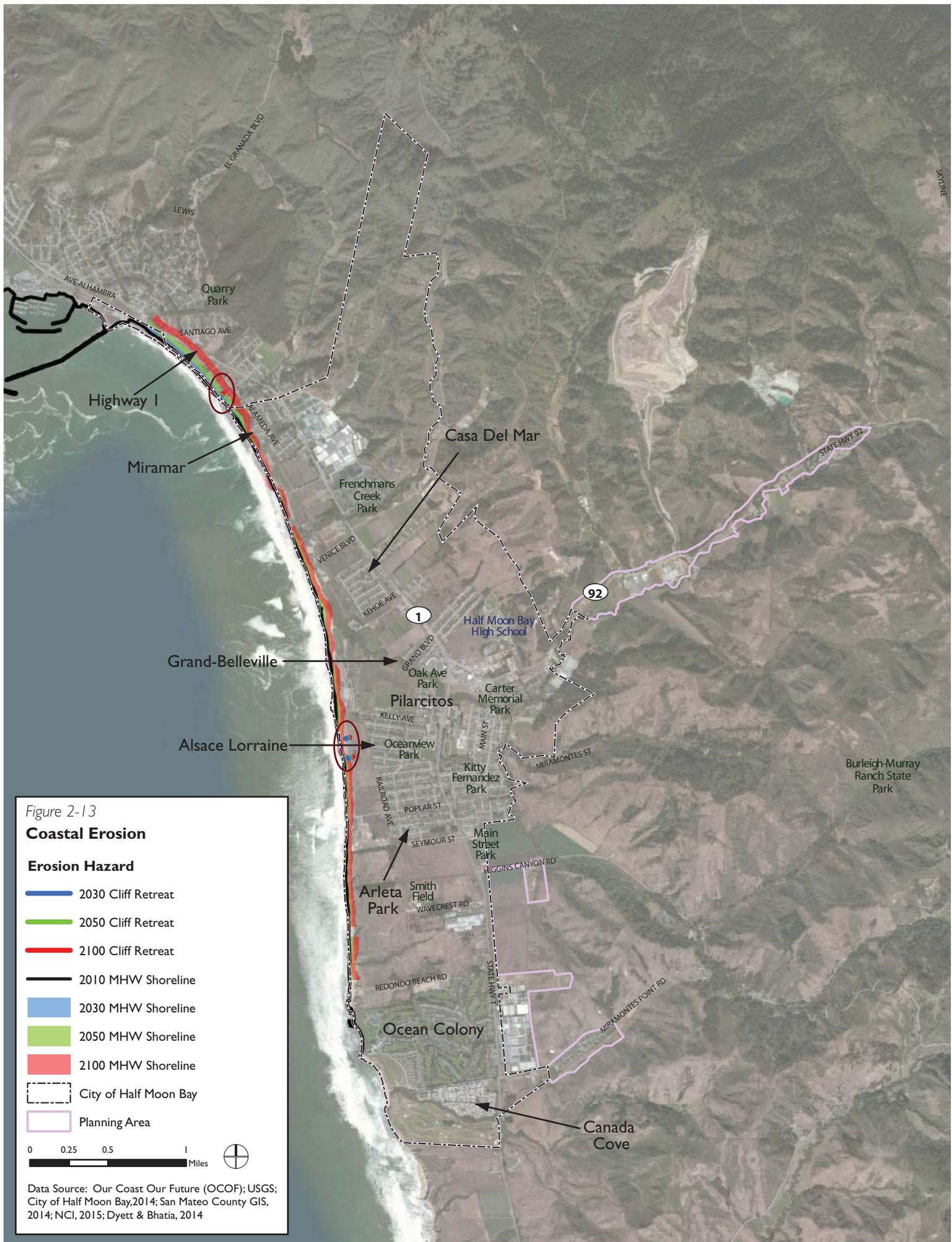




Figure 2-14
Coastal Erosion - Reach I

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF); USGS; City of Half Moon Bay, 2014; San Mateo County GIS, 2014; NCI, 2015; Dyett & Bhatia, 2014

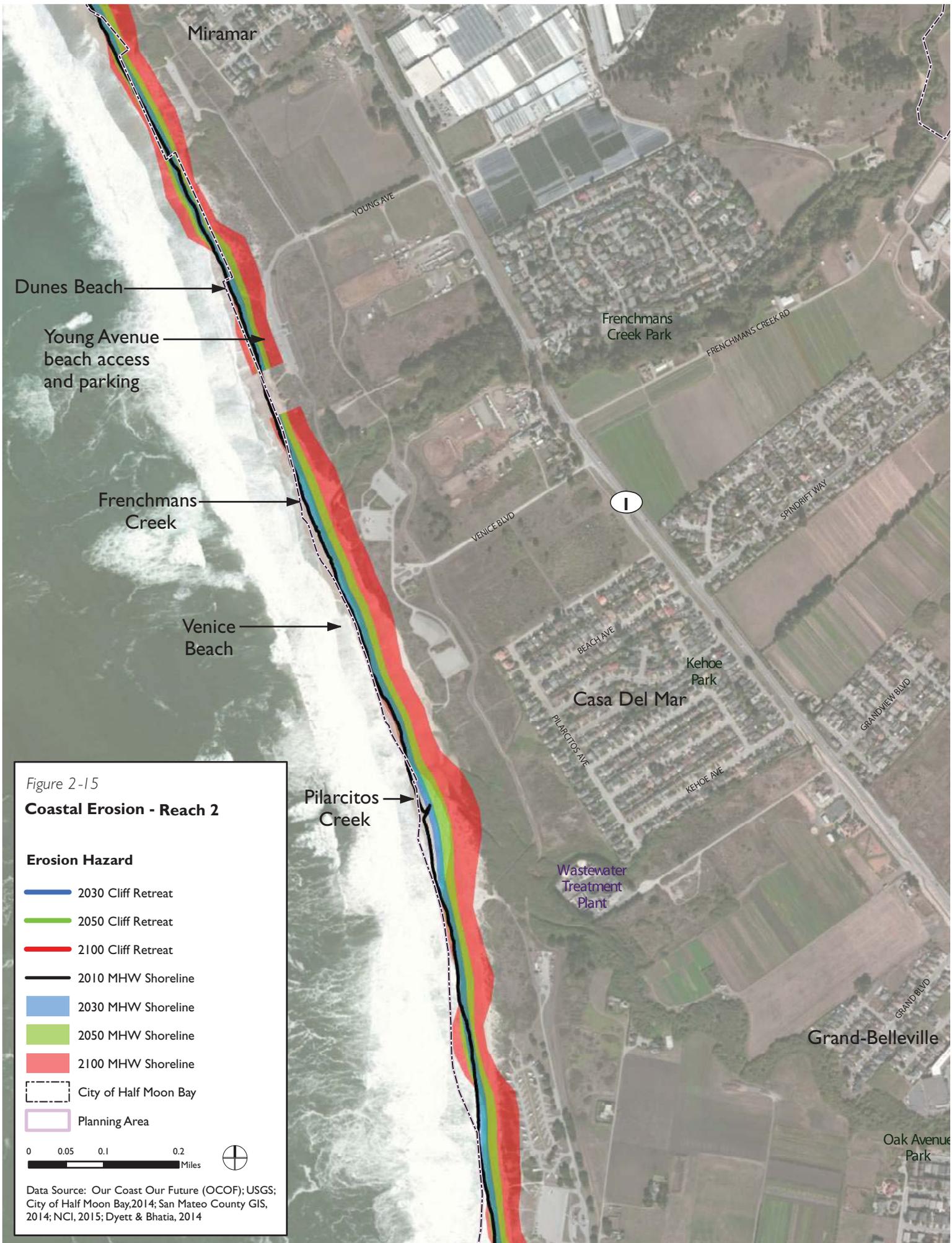


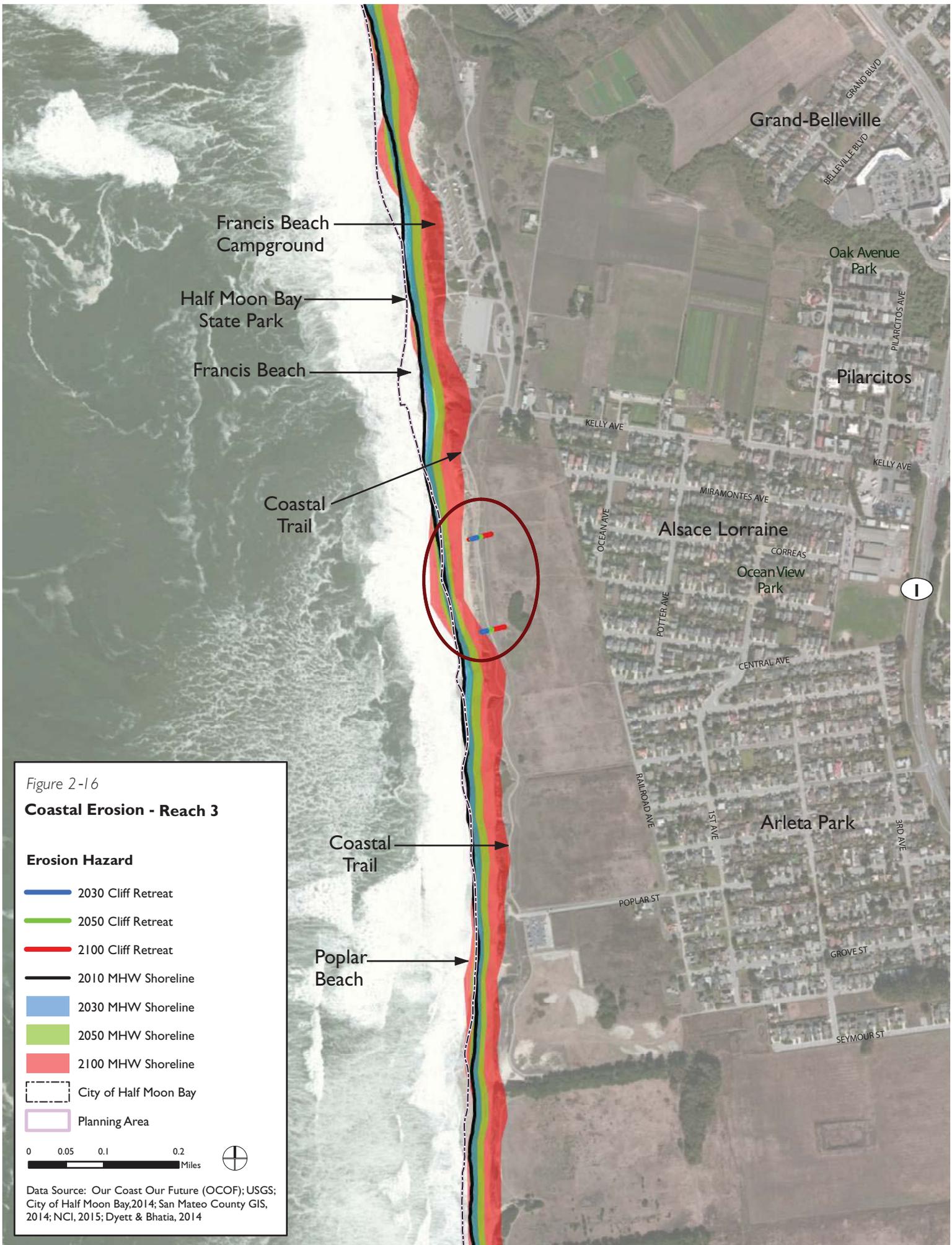
Figure 2-15
Coastal Erosion - Reach 2

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF); USGS; City of Half Moon Bay, 2014; San Mateo County GIS, 2014; NCI, 2015; Dyett & Bhatia, 2014



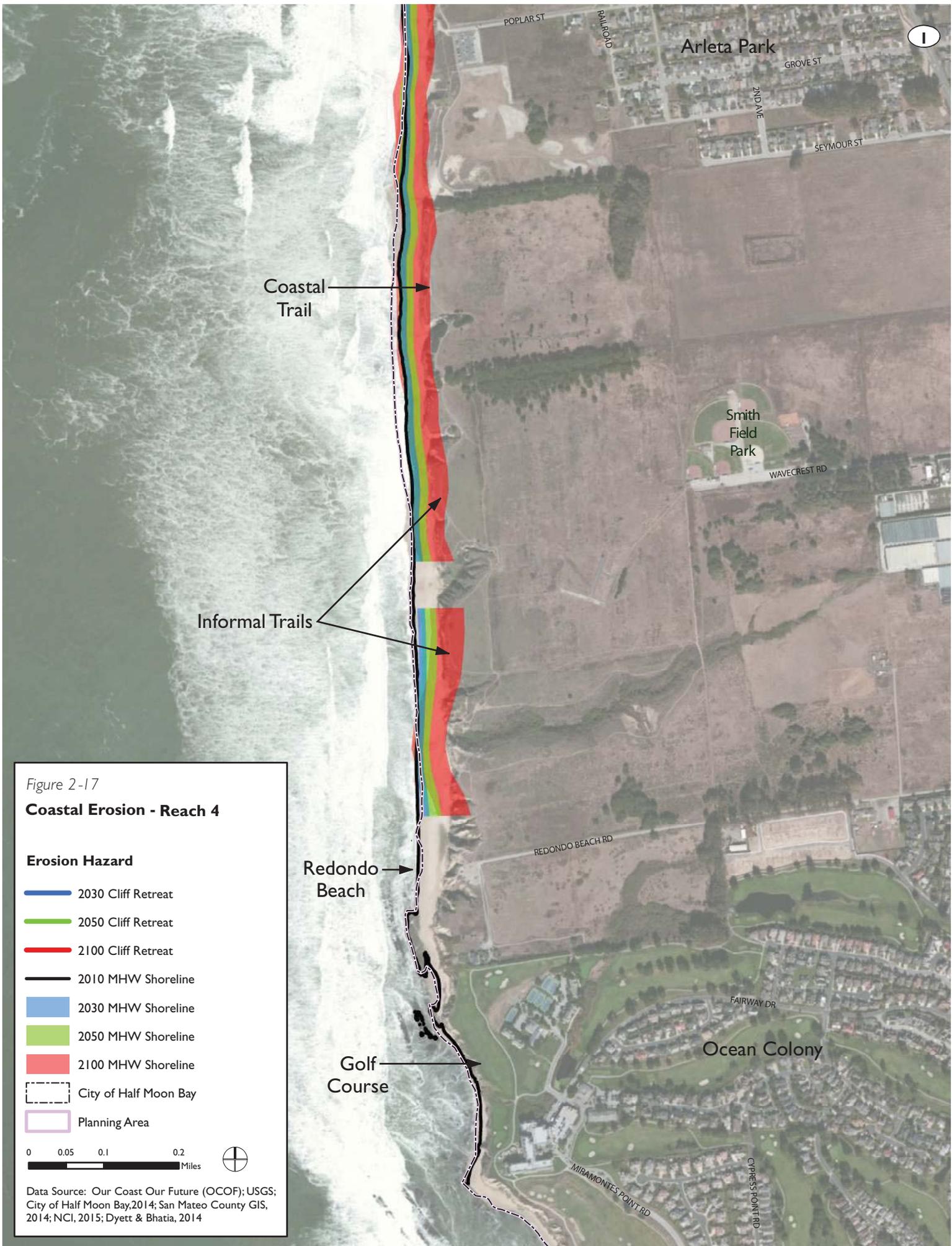


Figure 2-17

Coastal Erosion - Reach 4

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



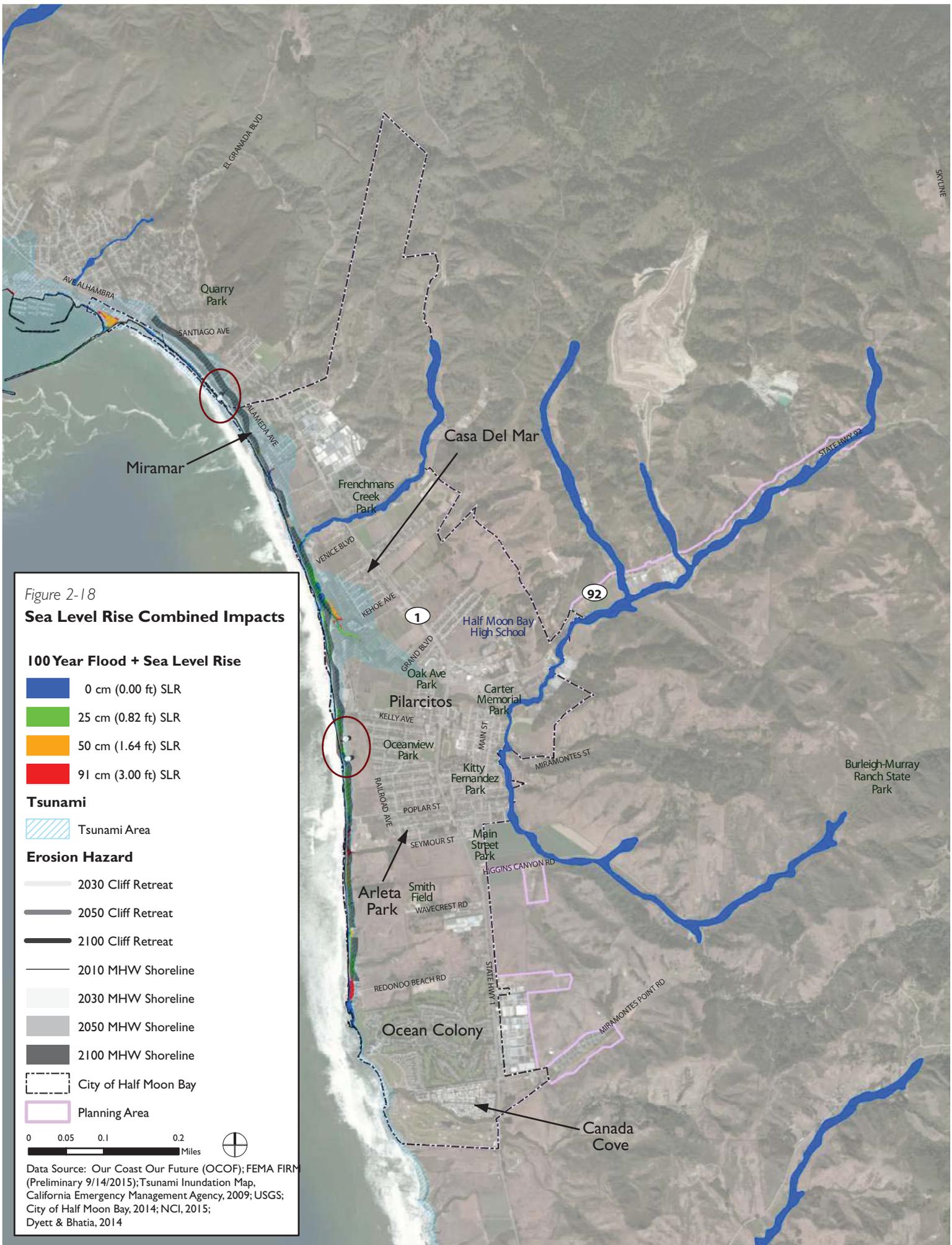
Data Source: Our Coast Our Future (OCOF); USGS; City of Half Moon Bay, 2014; San Mateo County GIS, 2014; NCI, 2015; Dyett & Bhatia, 2014

This page intentionally left blank.

2.5 Combined Impacts

Figure 2-18 through Figure 2-22 plot areas vulnerable to the combined threat of any of the aforementioned hazards. As shown, all areas impacted by flooding at all levels of SLR are also located within the tsunami inundation zone. In many cases along the coast, retreating shoreline ranges coincide with flooding from SLR, including the Frenchmans Creek outlet, Venice Beach, the Pilarcitos Creek outlet, and the segment of coastline from Francis Beach to Ocean Colony. It is important to note that flooding and erosion impacts have the potential to influence one another. Flooding in an area could contribute to erosion in that area over the course of the flooding event. Similarly, erosion along the coast could lead to a larger flooding extent.

This page intentionally left blank.



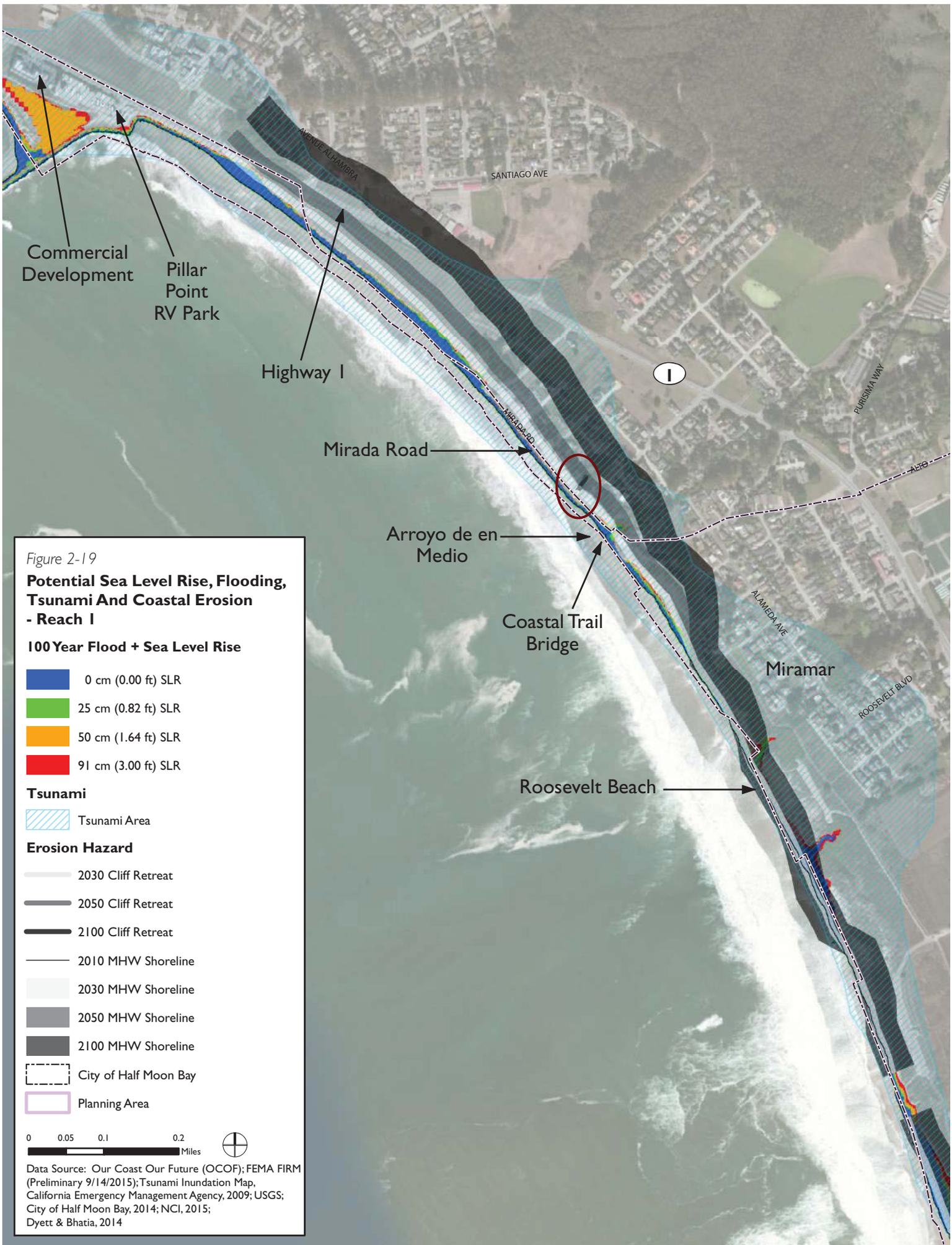


Figure 2-19

Potential Sea Level Rise, Flooding, Tsunami And Coastal Erosion - Reach I

100 Year Flood + Sea Level Rise

- 0 cm (0.00 ft) SLR
- 25 cm (0.82 ft) SLR
- 50 cm (1.64 ft) SLR
- 91 cm (3.00 ft) SLR

Tsunami

- Tsunami Area

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF); FEMA FIRM (Preliminary 9/14/2015); Tsunami Inundation Map, California Emergency Management Agency, 2009; USGS; City of Half Moon Bay, 2014; NCI, 2015; Dyett & Bhatia, 2014

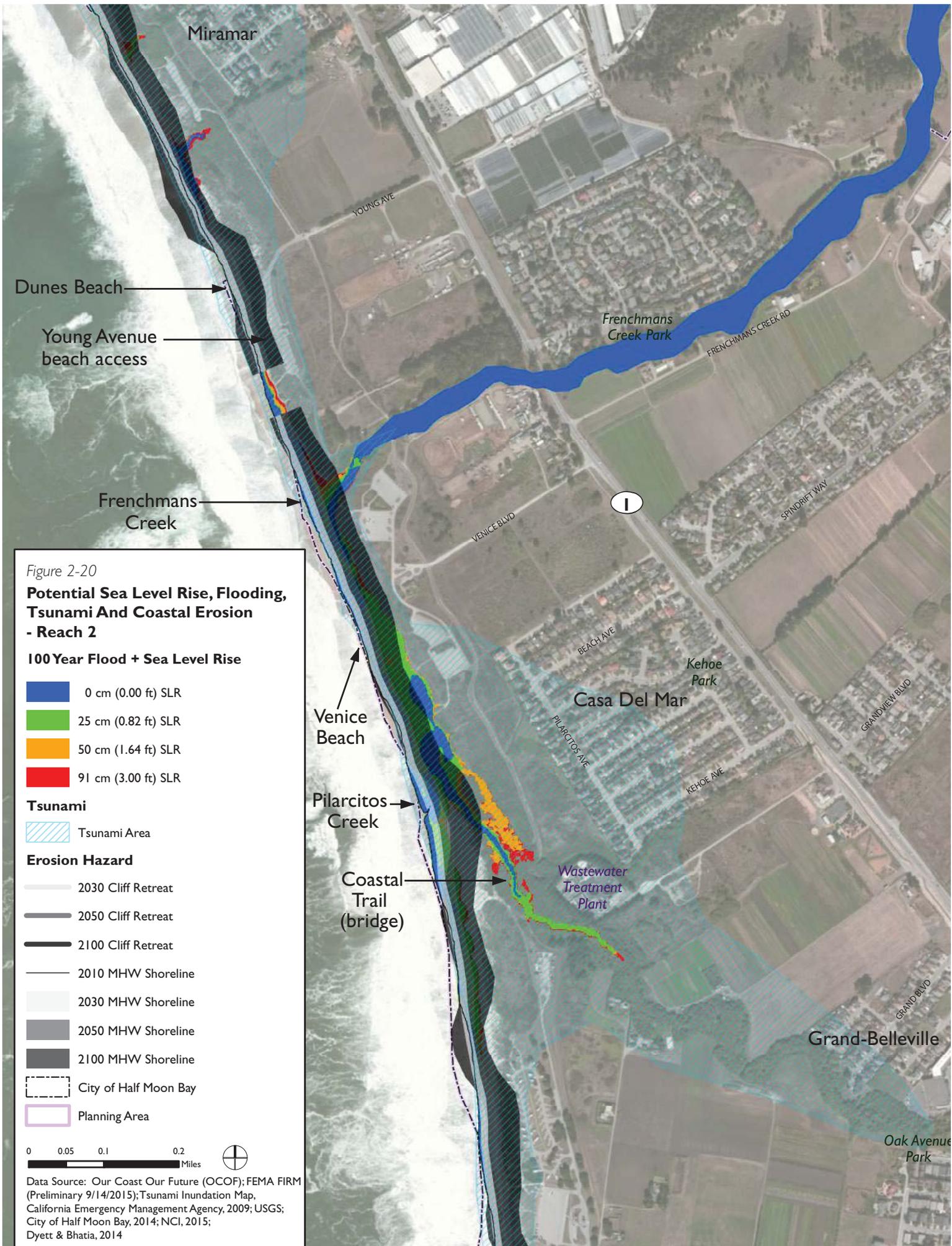


Figure 2-20

Potential Sea Level Rise, Flooding, Tsunami And Coastal Erosion - Reach 2

100 Year Flood + Sea Level Rise

- 0 cm (0.00 ft) SLR
- 25 cm (0.82 ft) SLR
- 50 cm (1.64 ft) SLR
- 91 cm (3.00 ft) SLR

Tsunami

- Tsunami Area

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF); FEMA FIRM (Preliminary 9/14/2015); Tsunami Inundation Map, California Emergency Management Agency, 2009; USGS; City of Half Moon Bay, 2014; NCI, 2015; Dyett & Bhatia, 2014

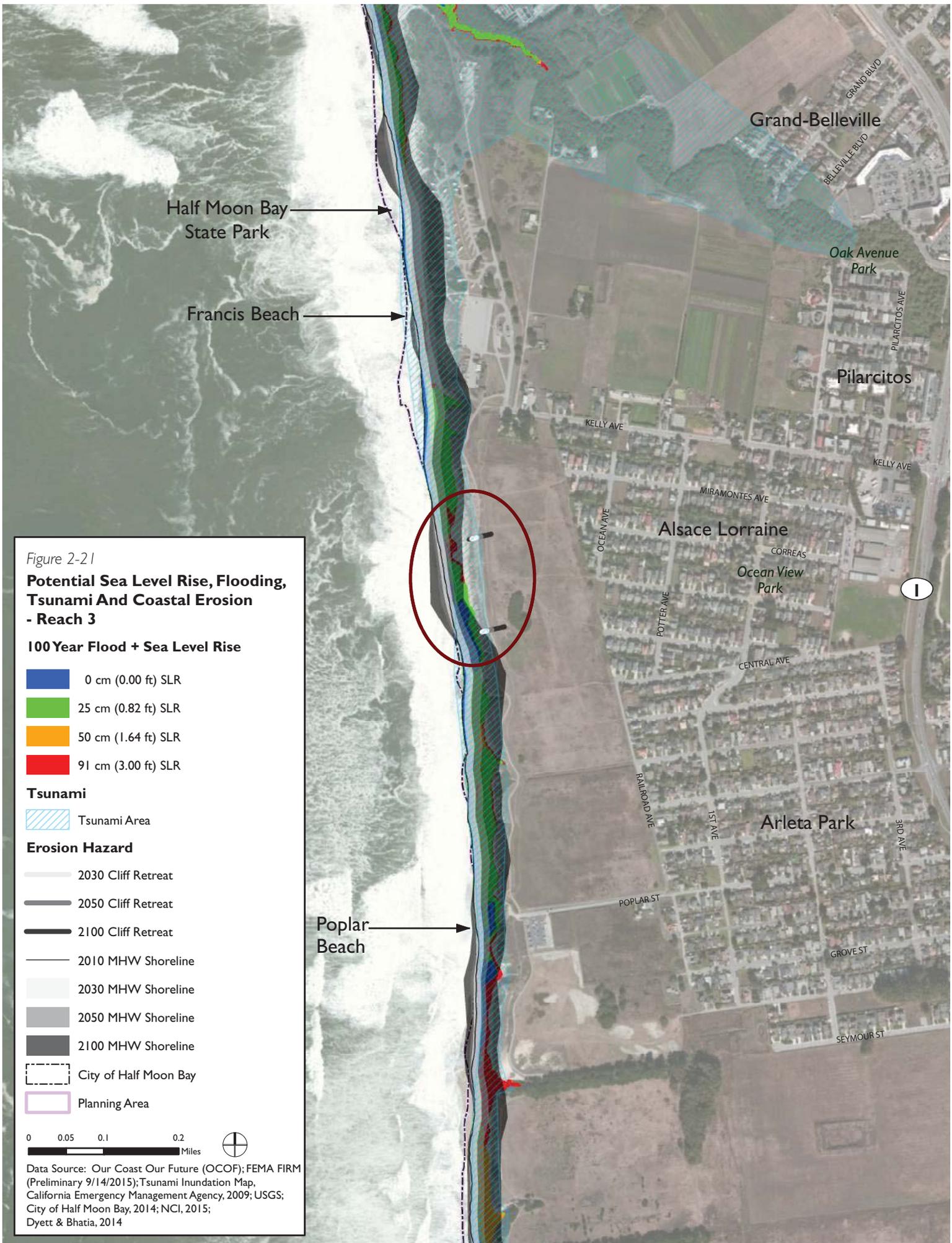


Figure 2-21

Potential Sea Level Rise, Flooding, Tsunami And Coastal Erosion - Reach 3

100 Year Flood + Sea Level Rise

- 0 cm (0.00 ft) SLR
- 25 cm (0.82 ft) SLR
- 50 cm (1.64 ft) SLR
- 91 cm (3.00 ft) SLR

Tsunami

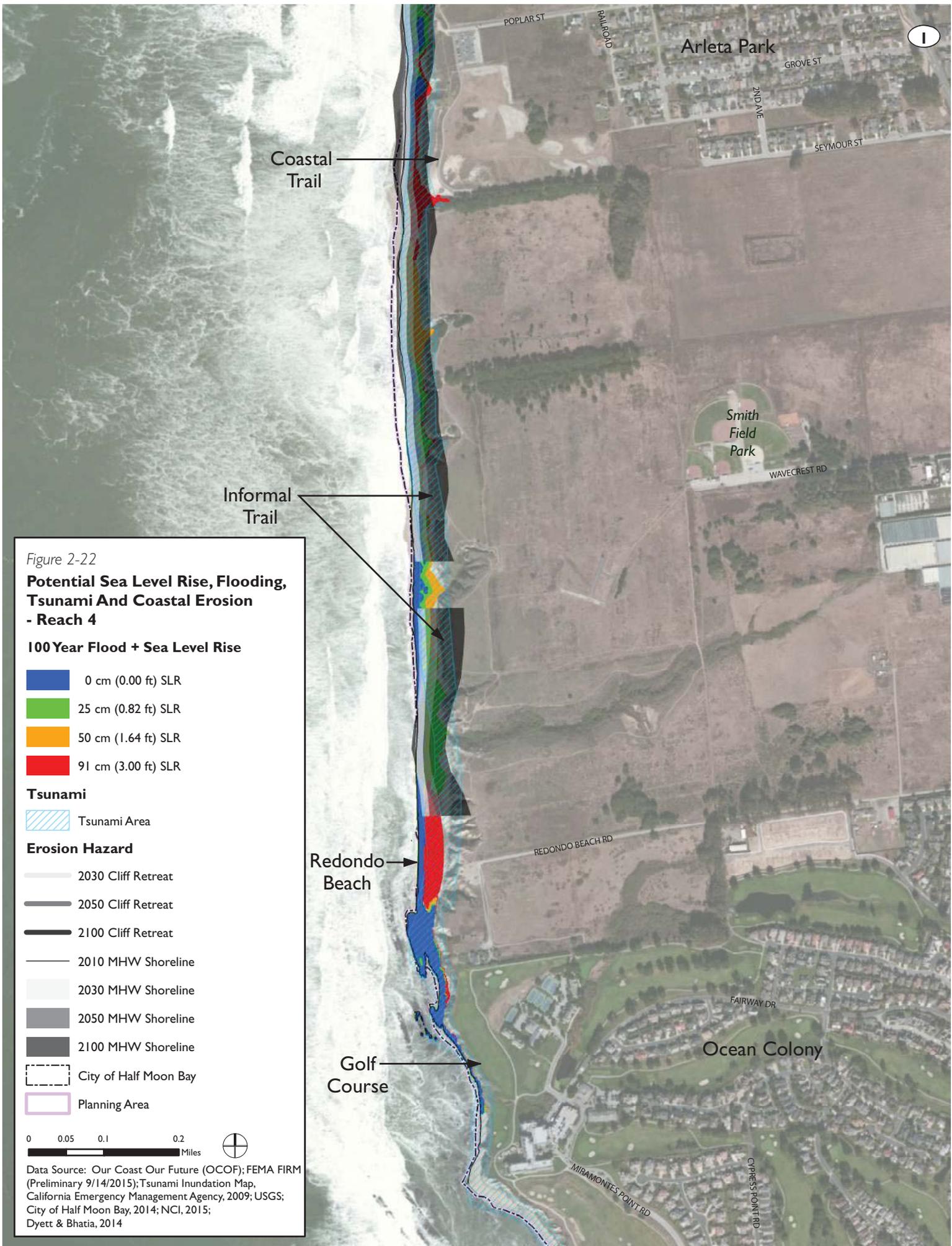
- Tsunami Area

Erosion Hazard

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline
- City of Half Moon Bay
- Planning Area



Data Source: Our Coast Our Future (OCOF); FEMA FIRM (Preliminary 9/14/2015); Tsunami Inundation Map, California Emergency Management Agency, 2009; USGS; City of Half Moon Bay, 2014; NCI, 2015; Dyett & Bhatia, 2014



This page intentionally left blank.

3 Vulnerability and Potential Risks

Features in the Planning Area that may be vulnerable to flooding impacts are shown on figures 2-2 through 2-6; features that may be vulnerable to tsunami impacts have been identified on figures 2-8 through 2-12; and features that may be vulnerable to erosion impacts have been identified on figures 2-13 through 2-17. These features are described below.

This assessment is intended to provide a general discussion of potential SLR vulnerabilities and is not for predictive purposes. For any single one of the features or areas assessed here, further engineering analysis is required to determine specific risks from SLR impacts. In all cases, it is important to acknowledge uncertainties inherent in SLR mapping and modeling efforts. The tools and data used in this analysis are based on model simulations that are subject to revision and do not take into account all variables that may have substantial effects on flood extents and depths.¹⁸ Uncertainty in the NRC's SLR projections arises from a number of factors, including the variability of the climate system, the inability of replicating complex systems using a mathematical model, and variations in the drivers of change within the climate system, and is reflected in the ranges for each projection year.¹⁹ Actual sea levels, SLR impacts, and vulnerabilities to impacts may differ from those included in this assessment. As previously stated, actual sea level rise may be greater than 91 centimeters by the year 2100, and more extensive impacts may result, including impacts to areas not discussed in this assessment. Thus, further investigations regarding local conditions including oceanographic conditions, geologic composition, elevation, vegetation, and the impacts of surrounding development are recommended to verify the extent of vulnerabilities discussed here.

Agricultural Resources

The analysis did not show any agricultural resources at risk of impacts from SLR or coastal erosion. As noted in Section 2.1, saltwater intrusion into the creeks in the Planning Area is negligible, however saltwater intrusion into groundwater supplies is not currently understood. Further study conducted by water purveyors of potential groundwater impacts is recommended. Tsunami affected areas do include agricultural land in northern Half Moon Bay and to the north and south of Pilarcitos Creek.

Roadways

Potential vulnerabilities resulting from SLR, coastal erosion, and/or tsunami hazards were identified for two roadways:

- **Highway 1.** Highway 1 is vulnerable to impacts from tsunami inundation and shoreline erosion. This vulnerability is particularly acute in the northern portion of the Planning Area near Pillar Point Harbor and the unincorporated community of El Granada. Tsunami inundation poses a number of risks related to the highway—if the roadway is damaged or blocked, one of the city's main regional connections could be disabled with no convenient

¹⁸ Our Coast Our Future. <http://data.prbo.org/apps/ocof/>

¹⁹ National Research Council (NRC), 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389.

bypass to divert travelers around the vulnerable area. A tsunami would also pose a risk to those using the roadway, as Highway 1 is a major route accommodating north-south traffic along the coast. Midcoast residents and recreational visitors may also rely on the highway as a tsunami evacuation route.

The erosion hazard map shows potential impacts to Highway 1 as early as 2030. Should the shoreline retreat as projected by OCOF, a solution would be necessary to maintain north-south connectivity through this portion of the Midcoast.

The flood hazard map does not indicate any vulnerability due to flood impacts along Highway 1. However, the segment of Highway 1 adjacent to Surfer's Beach in the northern part of the Planning Area is protected by newly restored shoreline protection, and it is unclear how SLR or SLR in combination with erosion may impact that protection over time. Protective structures in that area may need to be maintained and enhanced over time in order to ensure the safety of the highway and surrounding development, or the roadway may need to be relocated inland at a future time.

- **Mirada Road.** Mirada Road, located in the unincorporated community of Miramar, is at the edge of the Planning Area near the northern border of the city. This roadway is vulnerable to flooding impacts at 0 cm of SLR, with slightly more pronounced flooding impacts at higher levels. It is also vulnerable to tsunami and erosion impacts. In January 2016, a section of the bluff along Mirada Road eroded leaving a portion of the roadway at risk. Emergency repairs were completed and the City and San Mateo County are currently contemplating a long-term solution acceptable to the California Coastal Commission.²⁰

Numerous other roadways in the Miramar and Casa del Mar neighborhoods are also within the Tsunami Inundation Zone.

Waterways

Because the Planning Area's waterways and drainages drain to the ocean, these outlets are susceptible to flooding during storm events, with more pronounced impacts at higher sea levels. They are also susceptible to tsunami inundation. Coastal flooding at these outlets, and along the length of the waterways as storm surges cause flooding farther inland, may damage riparian habitats as well as the structural integrity of the banks and any infrastructure (such as bridges) that may span the waterways. Intrusion of saltwater during coastal flooding events may also impact riparian habitats, though these impacts are not currently quantifiable and require further study. Erosion, particularly incision or cutting of banks, of a number of these waterways already takes place under current conditions. With SLR, there is the potential for accelerated erosion farther upstream and more pronounced erosion closer to the coast. Frenchmans Creek and Pilarcitos Creek, for example, show more pronounced intrusion from coastal flooding with higher sea levels. Additionally, because the creeks and drainages act as stormwater conveyances for the city, flood conditions could lead to more sedimentation and debris entering the waterways and being carried to the ocean. Mapping of projected shoreline retreat shows that the outlets for these waterways and drainages may move inland. Potentially affected waterways include the following:

²⁰ Weigel, Samantha, 2016. "Cliff's edge: San Mateo County, Half Moon Bay seeking solutions for Mirada Road coastal erosion problem." San Mateo Daily Journal. January 20, 2016.

- Arroyo de en Medio
- Roosevelt Creek
- Frenchmans Creek
- Pilarcitos Creek
- Seymour Drainage

Mapping is not available for Cañada Verde Creek for SLR or erosion impacts; however, similar vulnerabilities are likely to exist there. Thus, potential vulnerability to tsunami impacts are indicated for Cañada Verde Creek's outlet area.

California Coastal Trail

The Coastal Trail is an important component of Half Moon Bay's and the Midcoast's circulation and recreational infrastructure. It runs nearly the length of the city, with a gap between the Coastside Land Trust's property in the Wavecrest area and Redondo Beach Road (a trail connection is being planned for this segment). Through much of Half Moon Bay, the trail is a paved facility that provides alternative transportation options and recreational opportunities west of Highway 1. It is a means of accessing the beaches, experiencing the city's open spaces, and providing regional connections along the Midcoast. In general, the Coastal Trail is not affected by 100-year flooding under the SLR scenarios, with the exception the trail's crossings at Arroyo de en Medio and Pilarcitos Creek. While sea level rise would be expected to affect the creeks themselves, the bridges would be anticipated to remain above the level of SLR. The trail is also vulnerable in the northern portion of the Planning Area near Pillar Point Harbor.

The trail is more vulnerable to erosion and eventual shoreline retreat. In the northern portion of the Planning Area, the trail could be vulnerable to damage as early as 2030. In the West of Railroad area farther south, portions of the trail are vulnerable by 2100. However, even today the segment of the trail between Kelly Avenue and Poplar Street are experiencing erosion from drainages.

The trail is also vulnerable to tsunami inundation in northern Half Moon Bay adjacent to the Miramar and Casa del Mar neighborhoods, and lies very close to the anticipated extent of the Tsunami Inundation Zone as it follows the top of the bluff south of Kelly Avenue.

Coastal Access and Recreation

Along the length of the Planning Area, beaches and coastal recreational facilities are generally vulnerable to SLR impacts, including flooding and erosion, as well as tsunami due to their necessary proximity to the ocean. All of the city's beaches are affected, including:

- Roosevelt Beach
- Dunes Beach
- Venice Beach
- Francis Beach
- Poplar Beach

- Redondo Beach

Along with the beaches, existing coastal access points are also vulnerable. These include:

- **Access from Young Avenue.** Access from the parking lot at the end of Young Avenue would be vulnerable to 100-year flood events in all four scenarios (with vulnerability to inundation and/or storm impacts increasing with higher sea levels) and tsunami, and the parking lot is also vulnerable to erosion by 2100.
- **Access from Venice Beach.** Access trails from the parking lot at Venice Beach are vulnerable to erosion by 2100.
- **Access from Francis Beach Campground.** Access to Francis Beach is vulnerable to tsunami and erosion by 2050.

Recreational facilities may also be at risk, including the following:

- **Pillar Point RV Park.** Located in the northern portion of the Planning Area, this lower-cost lodging option is vulnerable to tsunami.
- **Half Moon Bay State Park.** Located at the western end of Kelly Avenue, the state park's beaches are vulnerable to flooding from a 100-year storm in all four scenarios (with vulnerability to inundation and/or storm impacts increasing with higher sea levels), though less so than other nearby beaches. A slightly larger area of the beach is vulnerable to tsunami. The beach and other amenities would be vulnerable to shoreline retreat and erosion, including a portion of the picnic area that would be vulnerable by 2100.
- **Francis Beach Campground.** Part of Half Moon Bay State Park, this campground would be vulnerable to erosion by 2100.
- **Informal trails in Wavecrest area.** A number of informal trails cross the Wavecrest area south of the Coastal Trail. Portions of these may be vulnerable to erosion by 2100.

Other Coastal Dependent Land Uses

Coastal-dependent land uses could include fishing or boating facilities or water-oriented recreation uses. Other than the beaches and State Park facilities identified above, no coastal-dependent uses were identified as vulnerable.

Sensitive Habitats

SLR impacts can alter or damage habitats through flooding and erosion. Half Moon Bay's coast is home to a variety of habitats, some of which are or may be considered environmentally sensitive habitat areas (ESHAs) by the California Coastal Commission. Table 3-1 summarizes the habitats that may be vulnerable to 100-year flood events in the various SLR scenarios, Table 3-2 summarizes habitats that may be vulnerable to tsunami, and Table 3-3 summarizes habitats that may be vulnerable to erosion. Figures 3-1 through 3-5 show habitats vulnerable to 100-year flood events in the SLR scenarios and tsunami. Figures 3-6 through 3-9 show habitats vulnerable to coastal erosion and shoreline retreat. Some ESHA and potential ESHA are potentially vulnerable to flood hazards under the SLR scenarios. It is possible that such flood events could contain saltwater. The impact of saltwater on various habitats over different periods of exposure would need to be better

understood in order to evaluate the vulnerability of these habitats. No wetlands as identified by the Bay Area Aquatic Resource Inventory (BAARI) are vulnerable to sea level rise impacts for the map scenarios within the Planning Area (a small wetland area north of the Planning Area adjacent to El Granada falls within the Tsunami Inundation Area). For these analyses, ESHA refers to those habitats determined to be ESHA by the 1993 Half Moon Bay LCP, and Potential ESHA refers to those habitats that may be considered ESHA should a site-specific survey determine that habitat conditions consistent with the 1993 Half Moon Bay LCP definition of ESHA. Habitat mapping is current as of 2014 based on literature review, database review, and prior field reconnaissance.

Table 3-1: Habitats Vulnerable to Flood Hazards

<i>Habitat</i>	<i>0 cm SLR</i>	<i>25 cm SLR</i>	<i>50 cm SLR</i>	<i>3 feet SLR</i>
ESHA				
Central coast riparian scrub	✓	✓	✓	✓
Central dune scrub	✓	✓	✓	✓
Coastal and valley freshwater marsh	—	—	—	—
Open Water	✓	✓	✓	✓
Sea cliff	✓	✓	✓	✓
Vernal marsh	—	—	—	—
Potential ESHA				
Agriculture	✓	✓	✓	✓
Eucalyptus forest	✓	✓	✓	✓
Monterey cypress forest	—	—	—	—
Monterey pine forest	✓	✓	✓	✓
Non-native grassland	✓	✓	✓	✓
Northern coastal scrub	✓	✓	✓	✓
Ruderal/landscaped	✓	✓	✓	✓
Sandy beach	✓	✓	✓	✓
Notes:				
✓ Affected				
— Not Affected				

Source: OCOF, 2015; FEMA, 2015; SWCA Environmental Consultants, 2014; NCI, 2015; Dyett & Bhatia, 2015

Table 3-2: Habitats Vulnerable to Tsunami Hazards

<i>Habitat</i>	<i>Tsunami Risk</i>
ESHA	
Central coast riparian scrub	✓
Central dune scrub	✓
Coastal and valley freshwater marsh	✓
Open Water	✓
Sea cliff	✓
Vernal marsh	✓
Potential ESHA	
Agriculture	✓
Eucalyptus forest	✓
Monterey cypress forest	✓
Monterey pine forest	—
Non-native grassland	✓
Northern coastal scrub	✓
Ruderal/landscaped	✓
Sandy beach	✓
Notes:	
✓	Affected
—	Not Affected

Source: CEMA 2009; SWCA Environmental Consultants, 2014; NCI, 2015; Dyett & Bhatia, 2015

Table 3-3: Habitats Vulnerable to Erosion Hazards

<i>Habitat</i>	<i>2030</i>	<i>2050</i>	<i>2100</i>
ESHA			
Central coast riparian scrub	—	—	—
Central dune scrub	✓	✓	✓
Coastal and valley freshwater marsh	—	—	—
Open Water	—	—	—
Sea cliff	✓	✓	✓
Vernal marsh	—	—	—
Potential ESHA			
Agriculture	—	—	—
Eucalyptus forest	—	—	—
Monterey cypress forest	—	✓	✓
Monterey pine forest	—	—	—
Non-native grassland	—	—	✓
Northern coastal scrub	—	—	✓
Ruderal/landscaped	—	—	—
Sandy beach	✓	✓	✓
Notes:			
✓ Affected			
— Not Affected			

Source: USGS, 2015; SWCA Environmental Consultants, 2014; NCI, 2015; Dyett & Bhatia, 2015

Utilities and Infrastructure

The SAM Wastewater Treatment Plant is located within the current tsunami inundation zone. It is not within vulnerable areas for either the 100-year flood zones for the SLR scenarios or erosion through 2100. Although there may not be direct flooding impacts for the SAM plant, it is located within what OCOF terms a “flood-prone low-lying area.” In addition, flood events do impact the city’s sewer system. SAM’s Annex to the 2010 Association of Bay Area Governments Local Hazard Mitigation Plan states that sanitary sewer overflows (SSOs), which occur during rain events, are locally significant incidents that can negatively impact public health and sensitive habitats.²¹ More pronounced flood events due to SLR could contribute to future SSO events, which can impact the city’s residents, infrastructure, marine and riparian habitats, and recreational areas. The potential impacts of flooding and tsunami hazards on the Wastewater Treatment Plant will be important to address.

Additionally, utility lines serving residential, commercial, and public uses in vulnerable areas (as described in the following section) may be impacted. These would include power lines supplying residences, businesses, and coastal parking lots; and water and sewer pipes and hookups. This infrastructure may be vulnerable to 100-year flooding, erosion, and tsunami, and would be most exposed in the areas described below under Residential and Commercial Uses.

Residential and Commercial Uses

Based on GIS analysis using OCOF data and data from the San Mateo County Assessor’s office, one existing residential property on Mirada Road is within the 100-year coastal flood zone, even with no sea level rise. The same property would also be affected by coastal erosion, falling within the Mean High Water (MHW) line in 2010 and all later modeled years. No other residential properties are anticipated to be affected by sea level rise at any of the thresholds modeled, up to 91 centimeters. Mapping indicates that several townhomes (also on Mirada Road) could be affected by coastal erosion by 2050, and three additional single-family residences could be affected by 2100. Recent storm events have been directly affecting this area and may result in nearer term consequences than existing projections and maps indicate. Coastal erosion may also affect the Ritz-Carlton Hotel and golf course and the Cañada Cove community, though modeling data are not available for this segment of the coast. It is important to keep in mind the uncertainties inherent in the projections and the possibility that sea level rise may surpass the 91 cm mapped for this assessment, and that additional structures may be vulnerable that are not indicated here.

The flood hazard map does not indicate any vulnerability due to flood impacts to the commercial properties at the north end of the Planning Area (including the Pillar Point RV Park and the Half Moon Bay Beach House). However, this area has existing shoreline protection, and it is unclear how SLR or SLR in combination with erosion may impact that protection over time. Protective structures in that area may need to be maintained and enhanced over time in order to ensure the safety of the development.

In some areas, residential and commercial uses may be vulnerable to tsunami hazards, including:

²¹ Sewer Authority Mid-Coastside, 2010. Annex to 2010 Association of Bay Area Governments Local Hazard Mitigation Plan Taming Natural Disasters. Sewer Authority Mid-Coastside.

- **Sam’s Chowder House and Half Moon Bay Beach House.** These uses exist at the northern end of the Planning Area and are vulnerable to tsunami impacts.
- **Miramar neighborhood.** The Miramar neighborhood is located in the northern portion of the Planning Area, adjacent to the unincorporated community of Miramar. Portions of both the neighborhood and the unincorporated community are within the modeled Tsunami Area.
- **Casa del Mar neighborhood.** Houses in the western portion of the Casa del Mar neighborhood in central Half Moon Bay are located within the Tsunami Area.
- **Grand-Belleville neighborhood.** A small number of houses along Grand and Belleville Boulevards are also located within the Tsunami Area.
- **Ocean Colony and Half Moon Bay Golf courses.** The two golf courses in the southern part of the city are vulnerable to tsunami impacts.

Altogether, based on GIS data, some 252 residential parcels totaling 60 acres are within (or partly within) the Tsunami area in Half Moon Bay. Another 67 commercial or hotel properties totaling 17 acres are also within the Tsunami Area, along with two golf course properties totaling 126 acres. The Tsunami Area is mapped based on a scenario in which a combination of source events occurs simultaneously, but does not account for potential sea level rise.

Hazardous Materials

Known and potential hazardous materials sites may be subject to impacts from sea level rise. The Half Moon Bay Landfill, a closed Class III landfill owned by San Mateo County, is located on approximately 14 acres along Railroad Avenue between Metzgar and Seymour streets. The landfill accepted primarily inert material, yard waste, and residential waste from 1962 to 1976, and was capped in 1978. The marine terrace on which the landfill is located is subject to erosion from wave action, and a portion of landfill waste was exposed in the early 1990s. The eroded area was repaired by the County through regrading and the installation of a concrete block and steel chain mat.²² Further study regarding the impacts of sea level rise on the erosion of this site is recommended.

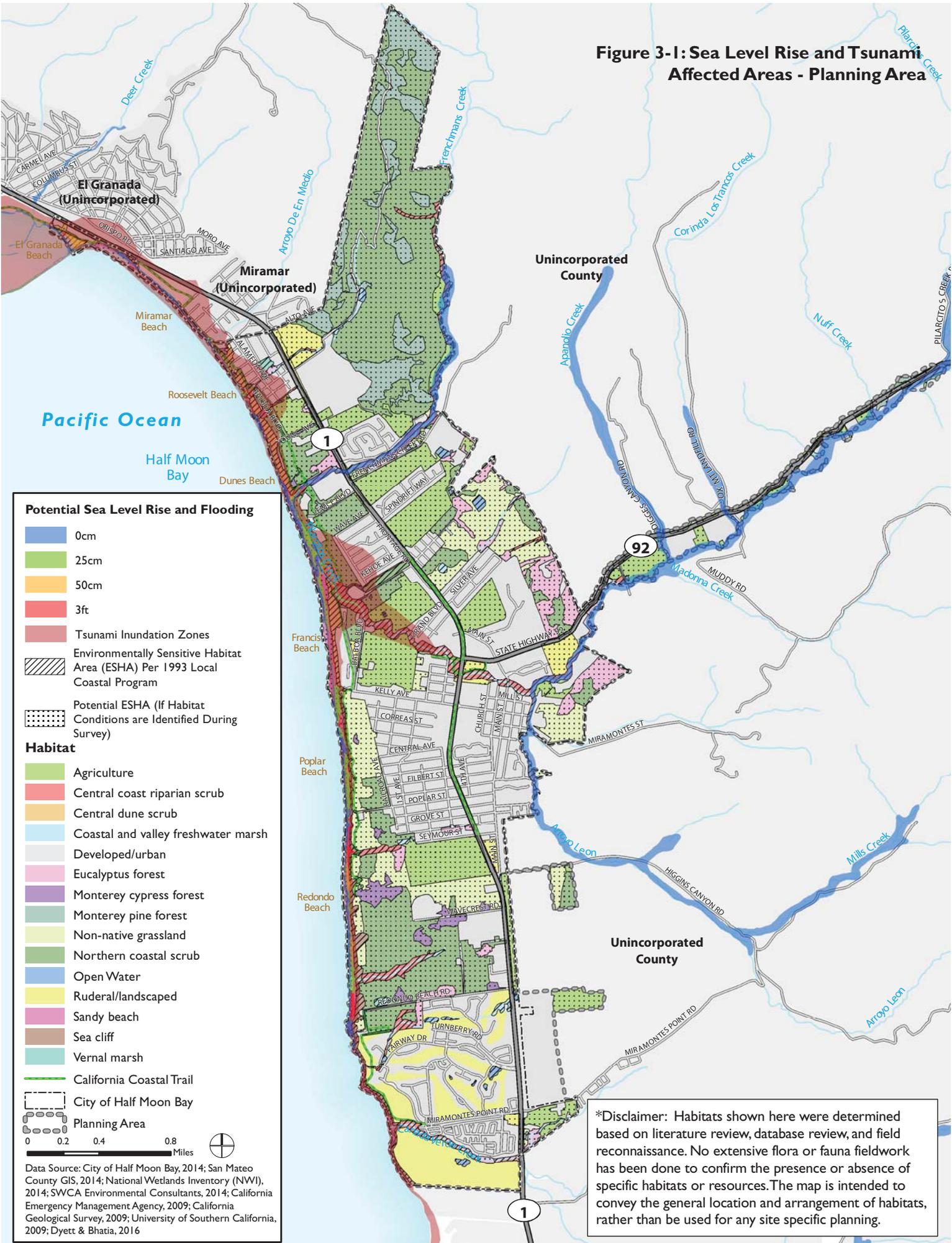
Additionally, a closed Leaking Underground Storage Tank (LUST) site is located near the SAM Plant in the tsunami inundation area, and in the vicinity of a Caltrans mitigation site with the potential to contain sensitive habitat. The LUST site is designated as “closed,” meaning that it has met clean-up criteria,²³ though further study on its vulnerability to impacts may be desirable.

²² County of San Mateo Department of Public Works, 2010. Request for Proposals for Environmental Consulting Services for Conducting Groundwater and Landfill Gas Monitoring at the Closed Half Moon Bay and Pescadero Landfills.

²³ State Water Resources Control Board (SWRCB), 2016. Geotracker data. Accessed 2/3/2016 at <http://geotracker.waterboards.ca.gov/>.

This page intentionally left blank.

Figure 3-1: Sea Level Rise and Tsunami Affected Areas - Planning Area



Potential Sea Level Rise and Flooding

- 0cm
- 25cm
- 50cm
- 3ft
- Tsunami Inundation Zones

Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program

Potential ESHA (If Habitat Conditions are Identified During Survey)

Habitat

- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh
- California Coastal Trail

City of Half Moon Bay Planning Area

Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; National Wetlands Inventory (NWI), 2014; SWCA Environmental Consultants, 2014; California Emergency Management Agency, 2009; California Geological Survey, 2009; University of Southern California, 2009; Dyett & Bhatia, 2016

*Disclaimer: Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site specific planning.

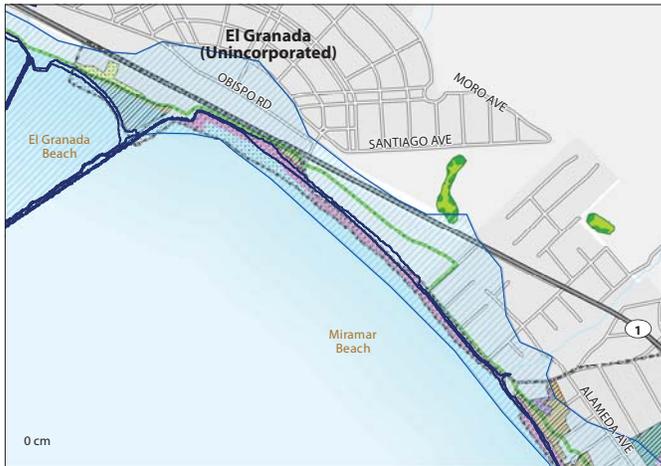
This page intentionally left blank.

Figure 3-2

Sea Level Rise and Tsunami Affected Areas - Reach I

Potential Sea Level Rise and Flooding

- 0cm
- 25cm
- 50cm
- 3ft
- Tsunami Inundation Zones
- BAARI Mapped Wetlands*
- Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program
- Potential ESHA (if Habitat Conditions are Identified During Survey)
- Habitat****
- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh
- California Coastal Trail
- City of Half Moon Bay Planning Area



*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site specific planning.

0 0.05 0.1 0.2 Miles
 Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; National Wetlands Inventory (NWI), 2014; SWCA Environmental Consultants, 2014; California Emergency Management Agency, 2009; California Geological Survey, 2009; University of Southern California, 2009; Dyett & Bhatia, 2016

Figure 3-3

Sea Level Rise and Tsunami Affected Areas - Reach 2

Potential Sea Level Rise and Flooding

- 0cm
- 25cm
- 50cm
- 3ft
- Tsunami Inundation Zones
- BAARI Mapped Wetlands*
- Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program
- Potential ESHA (if Habitat Conditions are Identified During Survey)

Habitat**

- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh
- California Coastal Trail
- City of Half Moon Bay Planning Area

*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site-specific planning.

0 0.05 0.1 0.2 Miles
 Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; National Wetlands Inventory (NWI), 2014; SWCA Environmental Consultants, 2014; California Emergency Management Agency, 2009; California Geological Survey, 2009; University of Southern California, 2009; Dyett & Ghazio, 2016



Figure 3-4

Sea Level Rise and Tsunami Affected Areas - Reach 3

Potential Sea Level Rise and Flooding

- 0cm
- 25cm
- 50cm
- 3ft
- Tsunami Inundation Zones
- BAARI Mapped Wetlands*
- Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program
- Potential ESHA (if Habitat Conditions are Identified During Survey)

Habitat**

- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh
- California Coastal Trail
- City of Half Moon Bay
- Planning Area

*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site-specific planning.

0 0.05 0.1 0.2 Miles
 Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; National Wetlands Inventory (NWI), 2014; SWCA Environmental Consultants, 2014; California Emergency Management Agency, 2009; California Geological Survey, 2009; University of Southern California, 2009; Dyess & Bhasia, 2016



Figure 3-5

Sea Level Rise and Tsunami Affected Areas - Reach 4

Potential Sea Level Rise and Flooding

- 0cm
- 25cm
- 50cm
- 3ft
- Tsunami Inundation Zones
- BAARI Mapped Wetlands*
- Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program
- Potential ESHA (if Habitat Conditions are Identified During Survey)

Habitat**

- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh
- California Coastal Trail
- City of Half Moon Bay
- Planning Area

*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site-specific planning.

0 0.05 0.1 0.2 Miles
 Data Source: City of Half Moon Bay, 2014; San Mateo County GIS, 2014; National Wetlands Inventory (NWI), 2014; SWCA Environmental Consultants, 2014; California Emergency Management Agency, 2009; California Geological Survey, 2009; University of Southern California, 2009; Dyett & Ghosia, 2016

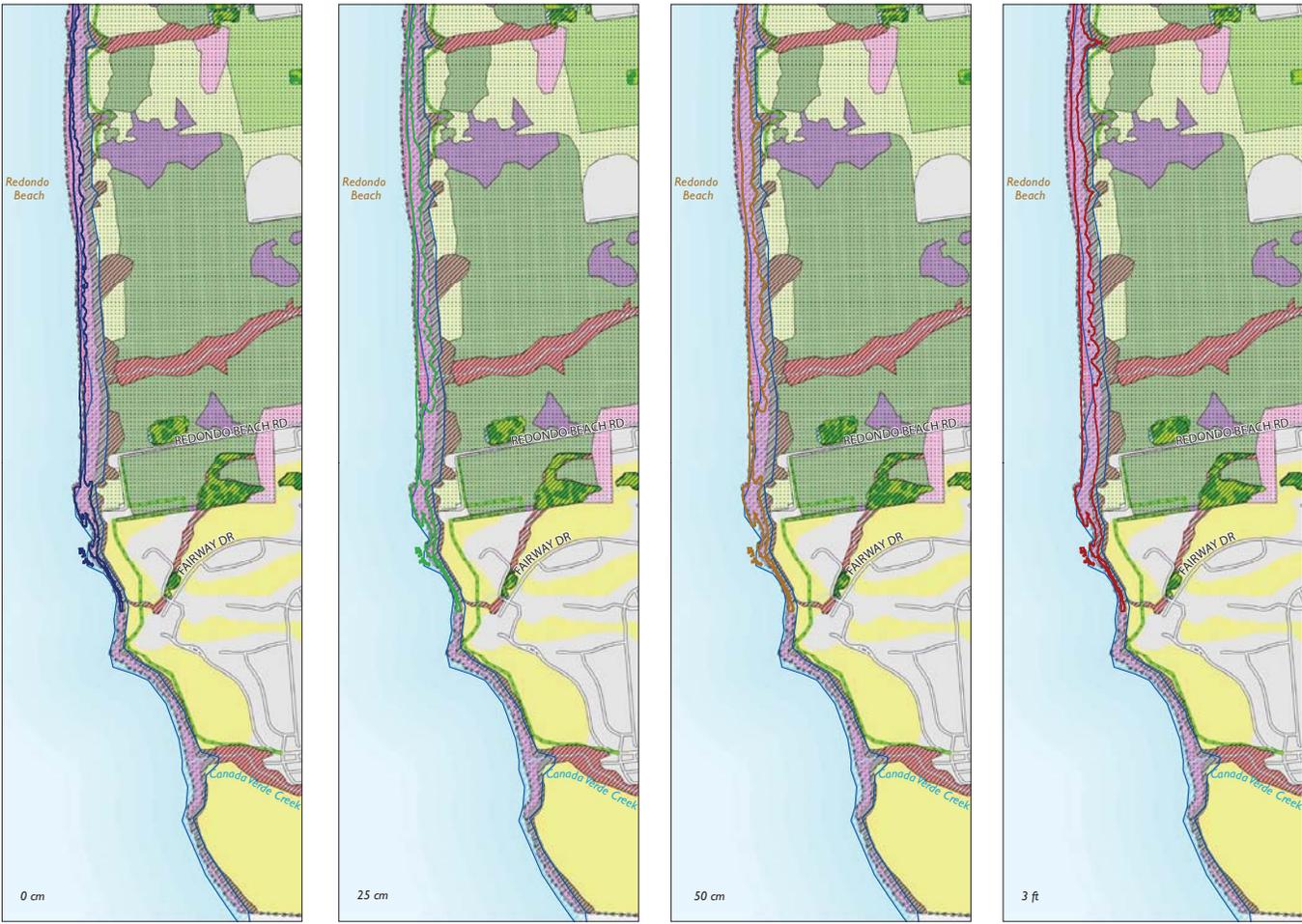
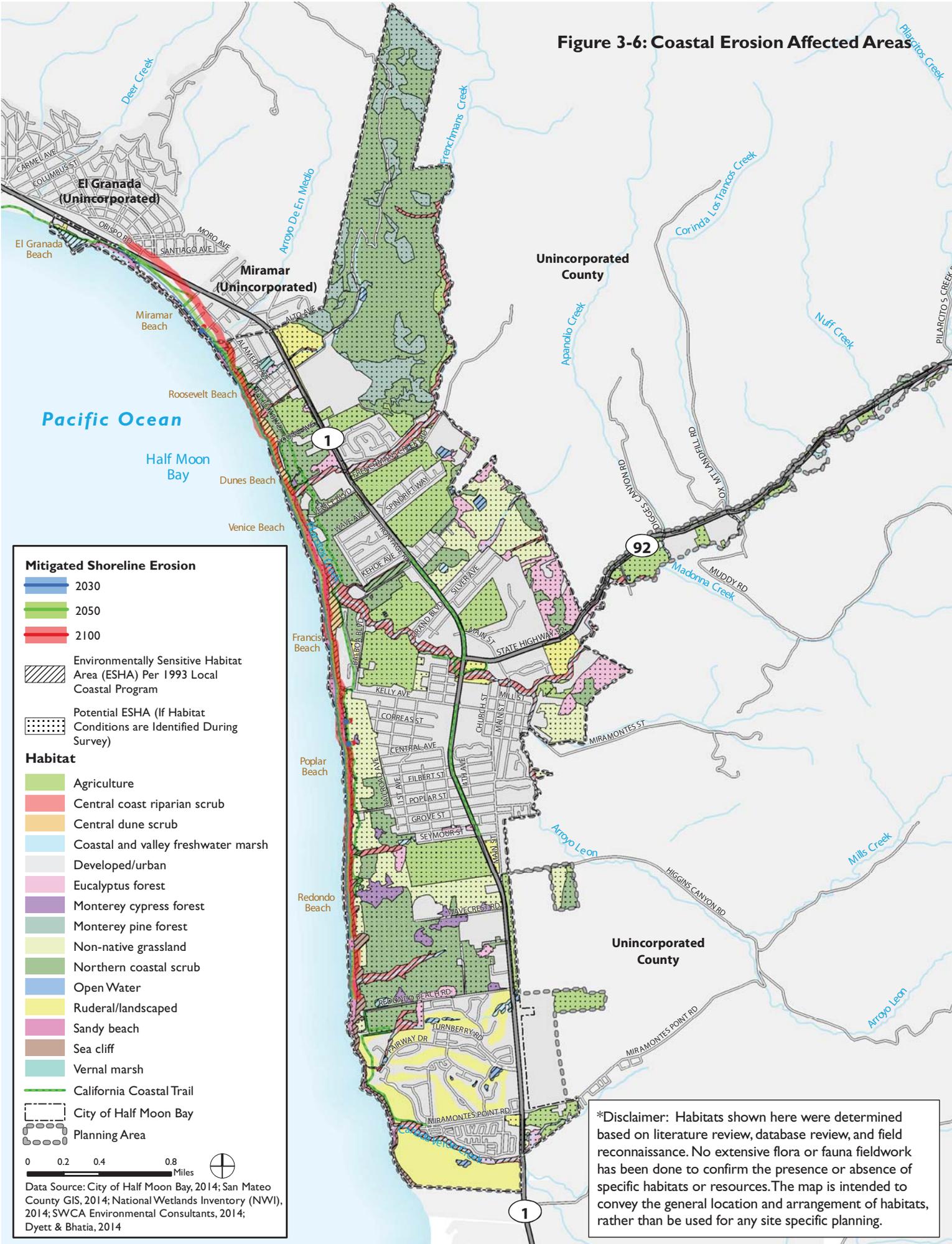
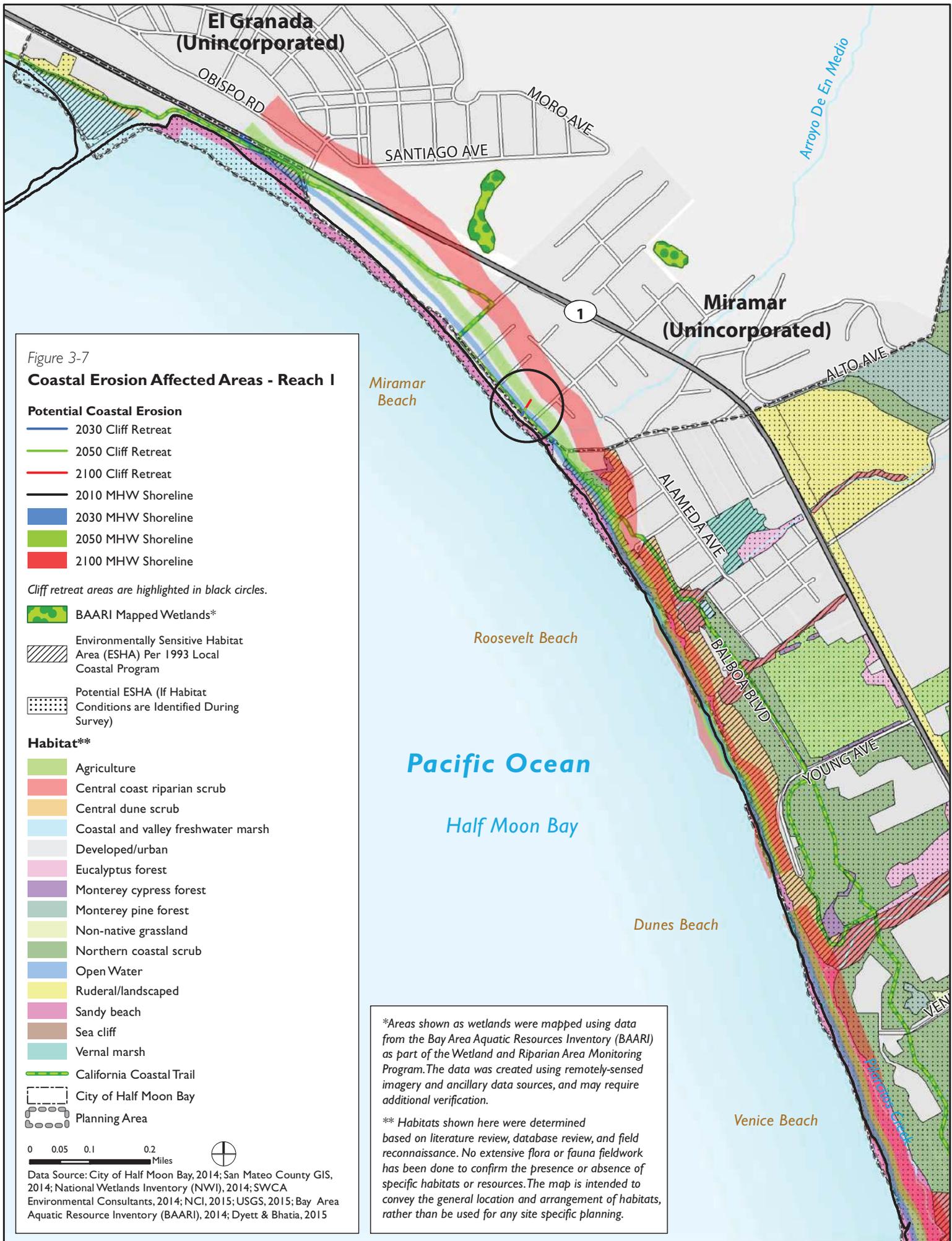


Figure 3-6: Coastal Erosion Affected Areas





*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site specific planning.

Figure 3-8

Coastal Erosion Affected Areas - Reach 2

Potential Coastal Erosion

- 2030 Cliff Retreat
- 2050 Cliff Retreat
- 2100 Cliff Retreat
- 2010 MHW Shoreline
- 2030 MHW Shoreline
- 2050 MHW Shoreline
- 2100 MHW Shoreline

Cliff retreat areas are highlighted in black circles.

BAARI Mapped Wetlands*

Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program

Potential ESHA (If Habitat Conditions are Identified During Survey)

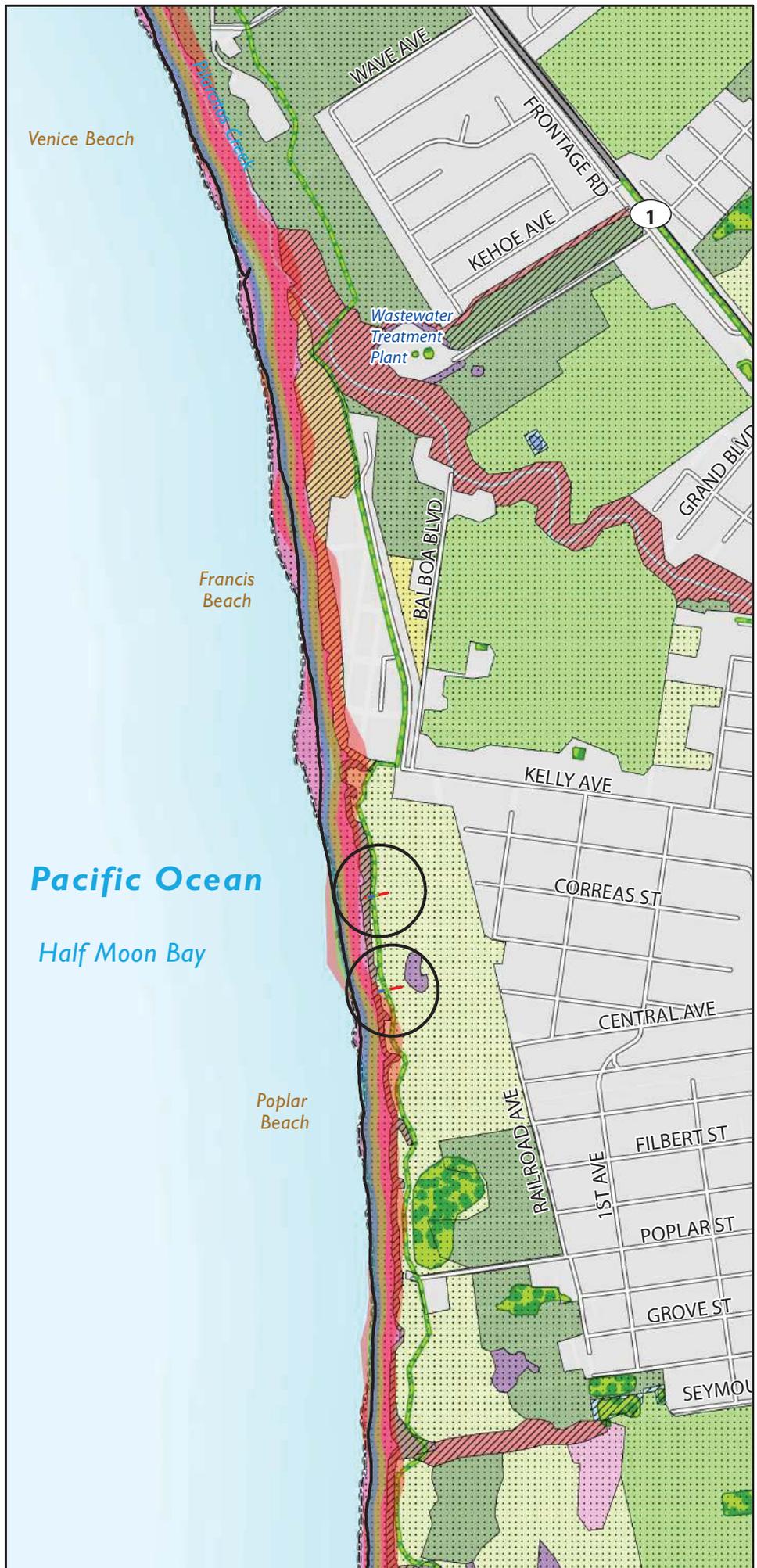
Habitat**

- Agriculture
- Central coast riparian scrub
- Central dune scrub
- Coastal and valley freshwater marsh
- Developed/urban
- Eucalyptus forest
- Monterey cypress forest
- Monterey pine forest
- Non-native grassland
- Northern coastal scrub
- Open Water
- Ruderal/landscaped
- Sandy beach
- Sea cliff
- Vernal marsh

California Coastal Trail

City of Half Moon Bay

Planning Area



*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site specific planning.



Figure 3-9

Coastal Erosion Affected Areas - Reach 3

Potential Coastal Erosion

-  2030 Cliff Retreat
-  2050 Cliff Retreat
-  2100 Cliff Retreat
-  2010 MHW Shoreline
-  2030 MHW Shoreline
-  2050 MHW Shoreline
-  2100 MHW Shoreline

Cliff retreat areas are highlighted in black circles.

 BAARI Mapped Wetlands*

 Environmentally Sensitive Habitat Area (ESHA) Per 1993 Local Coastal Program

 Potential ESHA (If Habitat Conditions are Identified During Survey)

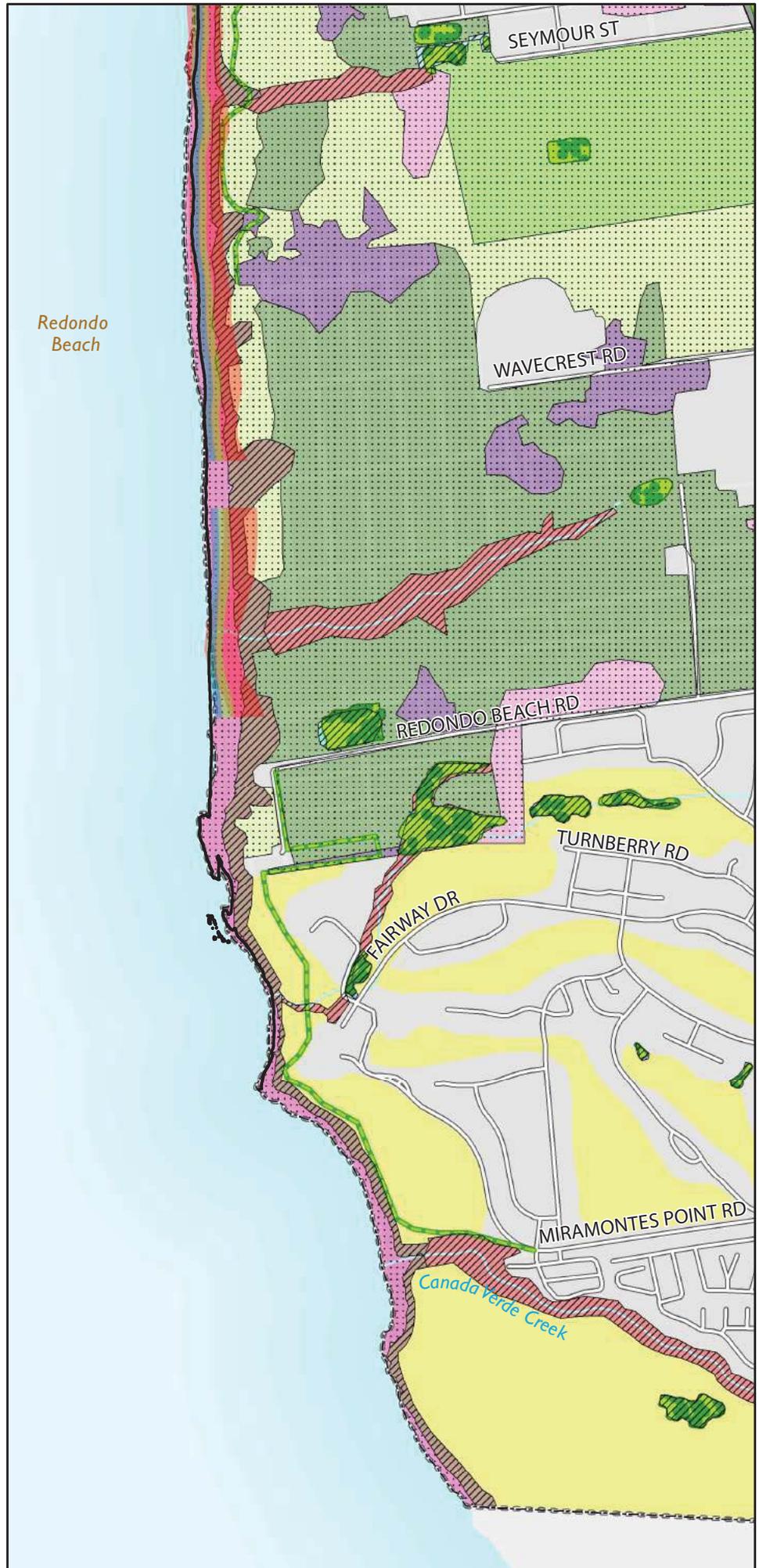
Habitat**

-  Agriculture
-  Central coast riparian scrub
-  Central dune scrub
-  Coastal and valley freshwater marsh
-  Developed/urban
-  Eucalyptus forest
-  Monterey cypress forest
-  Monterey pine forest
-  Non-native grassland
-  Northern coastal scrub
-  Open Water
-  Ruderal/landscaped
-  Sandy beach
-  Sea cliff
-  Vernal marsh

 California Coastal Trail

 City of Half Moon Bay

 Planning Area



*Areas shown as wetlands were mapped using data from the Bay Area Aquatic Resources Inventory (BAARI) as part of the Wetland and Riparian Area Monitoring Program. The data was created using remotely-sensed imagery and ancillary data sources, and may require additional verification.

** Habitats shown here were determined based on literature review, database review, and field reconnaissance. No extensive flora or fauna fieldwork has been done to confirm the presence or absence of specific habitats or resources. The map is intended to convey the general location and arrangement of habitats, rather than be used for any site specific planning.



4 Recommendations for Next Steps

This vulnerability assessment analyzes a range of potential SLR for Half Moon Bay based on existing information. Due to the current state of available information, there are still many gaps in our understanding of how SLR may affect the city's coastal resources. Additionally, because adaptation planning for SLR is a relatively new concept, the efficacy of various adaptation strategies is still being tested. Sea level rise science and adaptation are continually evolving fields, and over time, more in-depth studies and opportunities to conduct further analyses are expected to emerge. Thus, the City of Half Moon Bay should continue to develop its understanding of potential SLR hazards, conducting additional analysis to augment the information presented in this report. Future assessments may take the form of commissioned studies, site-specific investigations conducted as part of the development process, monitoring programs, interagency collaborations, etc. Suggested areas for further study include the following.

- **Flood Risk.** The City should stay apprised of future updates to FEMA's FIRM for the region and update its data on coastal flood hazards accordingly. Additionally, as discussed above, the uncertainty involved in tsunami modeling makes it challenging to identify areas that may be at risk during a tsunami event under any given SLR scenario. The City should stay updated on the best available science and mapping for tsunami hazards and continue to plan for the worst case scenario.
- **Sea Level Rise Impacts on Erosion.** Increased wave action has the potential to accelerate erosion along the city's shoreline and bluffs. Although this study maps cliff retreat ranges based on historic data, there is no information currently available that projects erosion rates for the three SLR scenarios. The City should support efforts to establish these projections in order to better prioritize and phase its adaptation strategies.
- **Other Impacts on Erosion.** Other severe events, such as groundshaking and tsunami may impact the rate of erosion along the city's coastline, which, while independent of SLR impacts, may have a cumulative effect along with SLR impacts on coastal resources. The City should support any efforts by others to increase understanding of any such cumulative effects.
- **Best Practices.** As Half Moon Bay and other jurisdictions within the California Coastal Zone develop and implement SLR adaptation strategies, it will be possible for the City to learn from its own experience and the experience of others which strategies are most appropriate for the Half Moon Bay community, and how best to execute those strategies. The City already participates in a number of forums that facilitate information sharing about SLR among California coastal communities. It should continue to be an active participant in these forums to ensure that its adaptation strategies represent current best practices.
- **Saltwater Intrusion.** Based on existing information and current conditions, saltwater intrusion as a result of SLR is expected to have a negligible impact in the Planning Area. However, the City should continue to monitor its waterways and groundwater supply as conditions change, and encourage further study of the potential for saltwater to intrude into waterways, riparian habitats, underground streams and groundwater basins either as a result of a storm event or failure of protective berms or beaches, the potential frequency of

such events and the expected periods of exposure, and the sensitivity of habitats that may be exposed to such events.

- **Oceanographic Conditions.** Oceanographic conditions include details regarding current, water temperature, seasonal variations, and wave action. These conditions may impact marine habitats, beach habitats and recreation opportunities, and bluff erosion rates. This information can provide a context for shoreline protection and management, marine and coastal habitat management, and hazard assessment.
- **Known and Potential Contaminated Sites.** It is recommended that the City continue to update its inventory of known and potential contaminated sites through data sources such as the State Water Resources Control Board's GeoTracker database and the California Department of Toxic Substances Control's Envirostor database. Further research should also be conducted to determine the extent of the vulnerability of identified sites in hazardous areas, including the Half Moon Bay Landfill and LUST site discussed above, as well as any secondary impacts affected known and potential contaminated sites may have on sensitive and marine habitats and other coastal resources in the vicinity.

5 Coordination and Outreach

5.1 Coastal Commission

The City has been coordinating with the Coastal Commission on its LCP update process and in the development of this vulnerability assessment. The work program for this assessment was scoped in cooperation with both Ocean Protection Council and Coastal Commission staff. Over the course of the project, the City has met with the Coastal Commission to review the status of the update. Coastal Commission staff provided guidance to the City and its consultants in selecting the scenarios studied in this vulnerability assessment. Half Moon Bay has also received a grant from the Coastal Commission to fund the LCP update. Ongoing coordination is a requirement of the grant, and is conducted through quarterly reports and other communications.

5.2 Public Outreach

In May, 2015 the City of Half Moon Bay began a multi-pronged outreach program based on the four Building Blocks topics of Recreation, Conservation, and Open Space; Climate Action Plan and Healthy Community; Transportation; and Land Use. Considerations related to SLR were included as part of the Climate Action Plan and Healthy Community Building Block.

The goals of the outreach program were to extend outreach to a large cross-section of the community, including community members who have not participated in the past, to inform them of the planning process, encourage them to participate, and capture their feedback on important topics; promote an in-depth dialogue among community members on key policy topics; and gather feedback on proposed policy directions to arrive at a preferred plan. Outreach meetings included Neighborhood Listening Sessions, Open Houses, and Community Workshops.

NEIGHBORHOOD LISTENING SESSIONS.

In May and June, 2015, the City held listening sessions in each of Half Moon Bay's 13 neighborhoods. The meetings were conducted in an open house format, inviting neighborhood residents to learn more about the General Plan and LCP updates, share ideas and concerns related to the Building Blocks, and read the ideas and concerns shared by their neighbors. Most took place outdoors on public property at locations visible and convenient to each neighborhood. Approximately 400 community members participated.

OPEN HOUSES

Two open houses were held in June, inviting community members to learn about the Building Blocks topics, converse with City staff and consultants, and leave feedback about issues and ideas related to the topics. Materials at the open houses presented a snapshot of ideas and issues that had been identified throughout the planning process so far. Community members had the opportunity to engage with staff, learn about, and comment on issues of habitat conservation, coastal access, recreation, coastal hazards, sea level rise, and other topics relevant to LCP policy development. The City presented preliminary mapping for SLR along the Half Moon Bay coast, and provided

information about the vulnerability assessment project and tasks. The open houses each presented the same content, but on different days to allow community members to attend whichever was most convenient.

COMMUNITY WORKSHOPS

The City held three public workshops covering the Building Blocks topics, and two Synthesis workshops to present draft policy concepts for public discussion and feedback. The first three workshops focused on small-group discussions in which participants were asked for their ideas and concerns on specific issues related to the Building Blocks in order to inform policy development. Sea-level rise issues were discussed at the second workshop, Climate Action Plan and Healthy Community, held on July 30, 2015.

The Synthesis workshops presented draft policies for Conservation, Open Space, and Safety (September 10, 2015) and Land Use and Circulation (December 3, 2015). These workshops invited participants to ask questions and leave feedback in an open house format. A take-home form was provided, and an online feedback form was made available for additional comments up to two weeks after each workshop. Topics relevant to SLR adaptation options were included in the draft policies, including coastline preservation, public land acquisition, and hazard avoidance and mitigation. Comments were received on these topics and will be used in conjunction with this vulnerability assessment in developing LCP policies.

Appendix A: California Coastal Commission Policy Guidance: Options and Strategies

Adaptation strategies are means by which the City can manage risks from SLR impacts and reduce the exposure of people, property, and coastal resources to SLR hazards. This appendix presents a range of adaptation strategies and a general framework of policies from the California Coastal Commission's SLR Guidance document that may address the vulnerabilities identified in Half Moon Bay. The California Coastal Commission document is a resource for local jurisdictions in their planning for SLR. The guidance identifies options to address a wide range of conditions that may occur along the state's coastline. This appendix is provided as a resource for potential policy approaches relevant to Half Moon Bay. Community input will lead to Half Moon Bay policies and implementation strategies to be incorporated into the LCP update.

A.1 Categories of Adaptation Strategies

The Coastal Commission's Sea Level Rise Guidance document identifies three general categories of adaptation strategies: protection, accommodation, and retreat. Descriptions of each category as provided in the guidance document are as follows:

- **Protection.** Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into "hard" and "soft" defensive measures or armoring.

"Hard" armoring refers to engineered structures such as seawalls, revetments, and bulkheads that defend against coastal hazards like wave impacts, erosion, and flooding. Such armoring is a fairly common response to coastal hazards, but it can result in serious negative impacts to coastal resources, particularly as sea level rises. Most significantly, hard structures form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise. Other detrimental impacts may include negative visual impacts or interference with other ecosystem services.

"Soft" armoring refers to the use of "green" (natural) infrastructure like beaches, dune systems, wetlands, and other systems to buffer coastal areas.²⁴ Soft armoring includes strategies like beach nourishment, dune management, and the construction of "living shorelines" (an approach that uses structural and organic materials such as plants and sand)²⁵ that capitalize on the natural ability of these systems to protect coastlines from coastal hazards while also providing benefits such as habitat, recreation area, more pleasing

²⁴ Green infrastructure in general refers to natural systems that are implemented to provide critical services for communities. The term is most closely associated with stormwater management, but can be applied more widely to include the use of natural systems to ensure a livable environment, safety, clean air and water, and healthy biodiversity.

²⁵ NOAA Habitat Conservation Restoration Center. Living Shorelines. <http://www.habitat.noaa.gov/restoration/techniques/livingshorelines.html>

visual environment, and the continuation or enhancement of ecosystem services. The engineering of green infrastructure is a somewhat newer concept in some cases, and because of this, the effectiveness of different strategies in different types of environments is not necessarily well-known or tested.

- **Accommodation.** Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of SLR. On an individual project scale, these accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or using extra setbacks. On a community-scale, accommodation strategies include any of the land use designations, zoning ordinances, or other measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas even as development is protected. As with protection strategies, some accommodation strategies could result in negative impacts to coastal resources. Elevated structures may block coastal views or detract from community character; pile-supported structures may, through erosion, develop into a form of shore protection that interferes with coastal processes, blocks access, and, at the extreme, results in structures looming over or directly on top of the beach.
- **Retreat.** Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include land use designations and zoning ordinances that encourage building in more resilient areas or gradually removing and relocating existing development. Acquisition and buy-out programs and removal of structures where the right to protection was waived (i.e., via permit condition) are examples of strategies designed to encourage managed retreat.

The updated LCP will almost certainly contain strategies from all three categories, as well as hybrid strategies that balance components of more than one category in order to meet the specific needs of the community, the California Coastal Act, and the Monterey Bay National Marine Sanctuary.

A.2 Strategies

The Coastal Commission's Sea Level Rise Guidance document contains a series of recommended adaptation measures and policy options for addressing SLR impacts. These measures and options are not considered checklists that must be fully incorporated in all local coastal programs, nor do they represent all potential adaptation methods. Each community must determine its own priorities and capabilities in adopting strategies for its adaptation plan. To identify the appropriate strategies for implementation, the City is anticipated to consider the following factors:

- Projected timeframe for SLR impacts
- Time required to plan and implement adaptation strategies
- Benefits
- Negative impacts

- Costs and funding
- Equitability²⁶
- Potential for leveraging existing frameworks and tools

This section draws relevant policy suggestions from the Coastal Commission’s examples and organizes them into strategies. The City may reference the following strategies as a basis for developing the policies that it will include in its LCP update.

ZONING AND OVERLAYS

This strategy involves establishing a zoning district or overlay district that clearly identifies areas exposed to SLR hazards to set development conditions intended to limit development, preserve landforms and viewsheds, and protect sensitive habitats. The city’s Zoning Code is the legal framework used to implement the community’s land use policies and regulates development within the City’s jurisdiction. The Zoning Code contains specific provisions for development, such as permitted uses, building height and bulk, densities and intensities, setbacks, and requirements for permit approval. An overlay zone is an area applied over one or more underlying zoning districts in which additional development criteria may be established. SLR hazard zones or overlays may reflect projected inundation and/or erosion areas and establish requirements for siting and design, planned retreat or removal programs, redevelopment restrictions, ecological buffers or geologic setbacks, limitations on septic systems and hazardous materials, and site-specific analysis of potential SLR impacts.

Policy Options

- **Hazard Zones or Overlays.** Update land uses and zoning requirements to minimize risks from sea level rise in identified hazard zones or overlay areas in current and future sea level hazard zones as determined through inundation and erosion risks.
- **Sea Level Rise Hazards Analysis.** Specify zones or overlays where a closer analysis of sea level rise is necessary at the permit application stage to avoid or minimize coastal hazards and impacts to coastal resources. Ensure that the most up-to-date information on sea level rise is incorporated in such analyses.
- **Bluff Setbacks.** Incorporate sea level rise into calculations of a Geologic Setback Line or bluff setback. Update geotechnical report requirements for establishing the Geologic Setback Line (bluff setback) to include consideration of bluff retreat due to sea level rise
- **Limit Development.** Limit construction of new development in zones or overlay areas that have been identified or designated as hazardous areas to avoid or minimize impacts to coastal resources and property from sea level rise impacts. Concentrate development away from hazardous areas.
- **Septic Systems.** In hazardous areas, limit new development dependent on septic systems.

²⁶ Equitability here is related to the concept of environmental justice, or “the fair treatment of people of all races, culture and income with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies.” (Based on the definition of “environmental justice” from the California Coastal Commission’s Sea Level Rise Policy Guidance).

- **Scenic Communities.** Designate areas with significant visual resources that could be negatively impacted by adaptation responses as scenic communities with special protections.

SITING AND DESIGN

Siting and design requirements can be established for new development that limits the exposure of people and property to hazards by limiting development in at-risk areas and encouraging development that can accommodate SLR impacts while preserving safety. LCP policies and implementation tools can limit or prohibit development in setback or flood zones where structures may be exposed to erosion or inundation impacts or in areas critical to the long-term viability of sensitive habitats. They can require that new development plan for eventual removal and/or relocation and ensure that property owners understand the assumed risk. Siting and design requirements can also apply to critical facilities and infrastructure such as water or wastewater treatment and roadways, as well as public access facilities, should any new facilities be required to replace or augment existing facilities.

Policy Options

Hazard Mitigation for New Development

- **Setbacks.** Ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced erosion) over the life of the structure, without the use of a shoreline protective device. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Require detailed, site-specific analyses through LCP policies and CDPs to determine the size of the setback, taking into consideration sea level rise and establish the expected life of the structure (for example, the time period over which the setback should be effective).
- **Subdivisions.** Limit subdivisions in areas vulnerable to sea level rise by prohibiting any new land divisions, including subdivisions, lot splits, lot line adjustments, and/or certificates of compliance that create new beachfront or blufftop lots unless the lots can meet specific criteria that ensure that when the lots are developed, the development will not be exposed to hazards or pose any risks to protection of coastal resources.
- **Building Codes and Standards.** Establish and implement building codes and standards for building siting and construction that avoid or minimize risks from flooding and erosion and increase resilience to extreme events within sea level rise hazard zones. Provide additional development controls in areas that are identified in the LCP as hazard areas.
- **Flood Protection.** Require new development located in areas subject to current or future flood/wave action to be sited and designed to be capable of withstanding such impacts in compliance with both FEMA and Coastal Act requirements. Ensure that implementation of adaptation measures such as elevation of habitable areas, break-away walls, etc. will be consistent with both LCP and FEMA provisions. Where applicable, in areas likely to be subject to current or future flood/wave action, revise residential building standards to prohibit habitable space at elevations subject to wave/flood risk.

- **Options for Removal.** For new development in high hazard areas or resource-constrained areas where managed retreat might be an appropriate option at some time in the future, ensure that foundation designs or other aspects of the development will not preclude future incremental relocation or managed retreat. Alternative design options should be considered, and employed if site conditions allow.
- **Foundations and Basements.** In locations where foundation or building elements, such as deepened perimeter foundations, caissons or basements may be exposed to wave action through rising sea level or erosion, require analysis of less extensive foundation or building options.
- **Assumed Risk.** Establish standards, permit conditions, and deed restrictions that ensure that current and future risks are assumed by the property owner. Consider policies that would encourage or require property owners to set aside money, such as in the form of a bond, as a contingency if it becomes necessary to modify, relocate, or remove development that becomes threatened in the future.
- **Real Estate Disclosure.** Require sellers of real estate to disclose permit conditions related to coastal hazards, or property defects or vulnerabilities, including information about known current and potential future vulnerabilities to sea level rise, to prospective buyers prior to closing escrow.
- **Community Outreach and Support.** Ensure that information regarding potential risks and vulnerable areas is accessible to all community members (including new renters/owners, non-English speaking residents, low-income residents, seniors, and disabled residents), and that support is available to aid community members in addressing risks and complying with hazard mitigation regulations.

Habitat Conservation

- **Development near ESHA.** Restrict the construction of new development in areas that are adjacent to wetlands and ESHA in order to preserve buffers and open areas to allow for habitat migration.
- **Clustered Development.** Cluster development away from land where wetlands and other coastal habitats and dispersal areas could migrate with sea level rise.
- **Limit Subdivisions.** Require provision for inland migration of natural resource areas or to require lots to be configured in a way that allows such migration. Lot line adjustments may sometimes be appropriate if they facilitate locating physical development further away from hazards or sensitive resources.

Scenic Resource Preservation

- **Visual Design Standards.** Update design standards to ensure that adaptation measures protect visual resources while minimizing hazards. Adaptation strategies such as shoreline armoring or elevation techniques should be designed such that the visuals are subordinate to, and in character with, the surrounding visual resources of an area.
- **Height Limits.** Avoid modifications to height limits in scenic areas and provide for options to modify roof-lines or elevate the lowest flood elevation for flood protection in a manner

that is consistent with scenic character. In some cases, it may be appropriate to update height limitations to allow for elevation in response to sea level rise hazards.

- **Scenic Resource Protection.** Emphasize the use of adaptation strategies that will not impact visual resources. Such strategies may include short-term retrofits with plans for longer term relocation or removal.

Critical Facilities

- **Worst Case Scenario.** Ensure that critical facilities are designed to function even if the highest projected amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts. Require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation. Note that the highest level of sea levels projected for the year 2100 is 167 cm, as shown in Table 2.1.
- **Wastewater.** Ensure that wastewater treatment and disposal systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts. This would require coordination with the Sewer Authority Mid-Coastside and other applicable agencies.
- **Outfalls and Treatment Facilities.** Ensure that new ocean outfalls, wastewater treatment facilities, and other facilities that could negatively impact water quality if flooded or inundated, are sited and designed to minimize impacts from sea level rise. Avoid construction of new stormwater outfalls and direct stormwater to existing facilities with appropriate treatment and filtration where feasible. Where new outfalls cannot be avoided, plan, site, and design stormwater outfalls to minimize adverse impacts on coastal resources, including consolidation of existing and new outfalls where appropriate. Consolidate new and existing outfalls where appropriate.
- **Transportation Planning and Design.** Ensure that transportation networks are designed to function even if the highest projected sea level rise amounts occur. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, and LCP planning efforts, and individual projects will be implemented through CDPs.

Public Access

- **Access Sites and Facilities.** Require public access sites, segments of the Coastal Trail, and recreation and visitor-serving facilities to be sited and designed to avoid impacts from sea level rise, while maximizing public access and recreation opportunities. Where facilities

can be safely sited for the near term but future impacts are likely, require an adaptive management plan detailing steps for maintenance, retrofitting, and/or relocation.

- **Mitigation.** For unavoidable impacts to public access or recreation from shoreline armoring or other development, require mitigation of impacts through the addition of new public access, recreation opportunities, visitor-serving accommodations, or Coastal Trail segments, or payment of fees to fund such improvements. Mitigation measures should be planned in such a way that, if possible, sea level rise will not impair their efficacy over time.
- **Transportation Planning and Design.** Ensure that transportation networks are designed to function even if the highest projected sea level rise amounts occur. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, and LCP planning efforts, and individual projects will be implemented through CDPs.

REDEVELOPMENT

The Coastal Commission recommends incorporating SLR adaptation into development policies in the form of limitations on expansions, additions, or substantial renovations to structures exposed to SLR hazards. The purpose of this strategy is to discourage the expansion or perpetuation of existing structures in at-risk locations. It is implemented through the regulation of nonconforming structures through the Zoning Code. A nonconforming use or structure is an existing use or structure that does not conform to current zoning regulations, but which conformed to all regulations in place at the time it was implemented. Such uses or structures are allowed to continue provided that it meets certain criteria established in the Zoning Code. As an SLR adaptation strategy, uses and structures that are nonconforming in regards to hazard setbacks and/or overlay requirements would face limitations on redevelopment.

Policy Options

- **Non-conforming Structures.** Consider a structure non-conforming when the seaward portion of the structure no longer meets the standards or setback that would be required for new development. Allow non-exempt repair and maintenance and modifications only if they do not increase the size or degree of non-conformity of the existing structure. Acknowledge that additions to existing structures should be considered new development that must conform to the standards for new development including but not limited to avoiding future protective devices. Consider limitations on the size of additions unless non-conforming portions of the structure are removed.
- **Redevelopment in At-Risk Locations.** Limit expansions, additions, or substantial renovations of existing structures in danger from erosion. Require removal of non-conforming portions of the existing structure, when possible, when a remodel or renovation is proposed.
- **Foundations.** Limit new or replacement foundations or substantial improvements, other than repair and maintenance, to the existing foundation when located seaward of an established Geologic Setback Line or bluff setback. Approve significant new foundation work only when it is located inland of the setback line for new development and when it will not interfere with coastal processes in the future.

- **Redevelopment Standards.** Require that renovations meeting the threshold for redevelopment should not be approved unless the entire structure meets the standards for new development, including but not limited to a waiver of right to protection. Specify that if any existing non-conforming elements are permitted to remain, those non-conforming elements are not subject to rights to protection pursuant to Coastal Act Section 30235.
- **Shoreline Protection Removal.** On properties with existing shoreline protective devices, require removal of the protective device when the structure requiring protection is redeveloped or removed. If removal is not possible, require a waiver of any rights to retain the protective device to protect any structure other than the one that existed at the time the protective device was constructed or permitted.

MANAGED RETREAT AND RETROFIT

Managed retreat is a strategy that accepts that encroaching hazards from SLR may eventually reduce the safety of new or existing development below an acceptable level. The overall aim of this strategy is to plan for the eventual and/or incremental removal, replacement, or relocation of uses away from hazardous areas. In cases where a use is location-dependent and cannot be moved, such as coastal access or recreation facilities, retrofitting is an alternative that can mitigate risk. Retrofitting may involve upgrading the strength of building materials, elevating portions of the facility, modifying drainage infrastructure, and other techniques. This strategy may be applied to private development, critical facilities such as the wastewater treatment plant and outfalls, and public access and recreation facilities such as the California Coastal Trail, and sensitive coastal habitats. This strategy may involve incentives or other programs to facilitate the public acquisition or dedication of vulnerable land.

Policy Options

Planned Retreat and Removal

- **Retreat.** Require new development authorized through a CDP that is subject to wave action, erosion, or other hazards to be removed or relocated if it becomes threatened in the future.
- **Incremental Removal.** When a lot is not large enough to accommodate development that avoids coastal hazards for the expected life of the development, develop a project option that minimizes hazards from the identified sea level rise scenarios for as long as possible, and then requires incremental retreat once certain triggers are met.

Triggers for relocation or removal of the structure would be determined by changing site conditions such as when erosion is within a certain distance of the foundation; when monthly high tides are within a certain distance of the finished floor elevation; when building officials prohibit occupancy; or when the wetland buffer area decreases to a certain width.

- **Foundation and Structure Removal.** If no less damaging foundation alternatives are possible, ensure that the foundation design allows for incremental removal as the foundation elements become exposed, and develop pre-established triggers, for example when the bluff edge or shoreline comes within a certain distance of the foundation, for incremental or complete removal that will avoid future resource impacts.

- **Rolling Easements.** Establish a program of rolling easements to allow coastal lands and habitats including beaches and wetlands to migrate landward over time as the mean high tide line and public trust boundary moves inland with sea level rise. Such policies often restrict the use of shoreline protective structures (such as the “no future seawall” limitation sometimes used by the Commission), limit new development, and encourage the removal of structures that are seaward (or become seaward over time) of a designated boundary. Despite the term “rolling easements,” not all of the strategies related to rolling easements actually involve the use of recorded easements.

Land Acquisition

- **Relocation Incentives.** Provide incentives to relocate development out of hazardous areas and to acquire oceanfront properties damaged by storms, where relocation is not feasible. Consider creating a relocation fund through increased development fees, in lieu fees, or other funding mechanisms.
- **Acquisition and Buyout Programs.** Establish an acquisition plan or buyout program to acquire property at risk from flooding or other hazards. Acquisition includes the acquiring of land from the individual landowner(s). Structures are typically demolished or relocated, the property is restored, and future development on the land is restricted. Such a program is often used in combination with incentives for relocation. Undeveloped lands are conserved as open space or public parks.

Critical Facilities and Infrastructure

- **Critical Facilities.** Establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Identify critical infrastructure that is vulnerable to SLR hazards, such as the SAM Wastewater Treatment Plant, establish a plan for managed relocation of at-risk facilities, and ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms.
- **Repair and Retrofit.** In instances where relocation is not an option, repair damage and/or retrofit existing structures to better withstand sea level rise impacts through measures such as using stronger materials, elevating bridges or sections of roadways, and building larger or additional drainage systems to address flooding concerns.
- **Loss of Access and Recreation Areas.** Identify replacement opportunities or otherwise plan ahead for how to replace recreation areas and accessways that will be lost due to inundation or damage associated with sea level rise.

All beaches in Half Moon Bay are subject to potential loss from erosion and rising sea levels. Additionally, access points including the parking lot and pathways at Half Moon Bay State Beach and Dunes Beach, and Venice Beach may be affected. Some segments of the Coastal Trail, including bridges at Pilarcitos Creek and Wavecrest, as well as informal trails along the coast at Wavecrest, are also subject to potential loss.

- **Open Space Protection for Coastal Habitats.** Plan for future coastal recreational space and parkland by protecting open space adjacent to coastal habitats so that beaches and other habitats can migrate or so that there is open space available as parkland or other areas are lost.

- **Open Space Protection for Recreation.** Protect open space to ensure available space to replace parkland that is lost to sea level rise. Protect open space adjacent to beaches and coastal habitats to allow for inland migration.

All beaches in Half Moon Bay face potential loss from erosion and rising sea levels, based on mapping conducted for the 2016 Half Moon Bay Sea Level Rise Vulnerability Assessment.

- **Water Quality Risks.** Establish a program to retrofit, relocate, or eliminate ocean outfalls and other wastewater infrastructure deemed at risk. Alternatives include modifications to outfall lines, the use of green infrastructure, and redesign of waste and stormwater systems.
- **Outfalls.** Identify areas where sea level rise could affect flow of wastewater from outfalls and lead to backup and inland flooding, and plan to retrofit, relocate, or eliminate these outfalls to prevent damage and impacts to water quality.

The San Mateo County Harbor District and the US Army Corps of Engineers are currently undertaking a study of erosion at Surfers Beach that has occurred at an increasing rate following construction of the east arm of the Pillar Point Harbor breakwater. The project is focused on identifying the feasibility of solution(s) to the problem that will have no or minimal environmental impacts on natural resources. Solutions may include transferring sediment trapped behind the breakwater onto Surfers Beach. The study does not cover any portion of the shoreline within the Half Moon Bay Planning Area, but could result in an infrastructure-related strategy that may affect the Planning Area over the long term.

Public Access and Recreation

- **Removal of Structures.** Plan for removal and relocation of structures that limit inland migration of beaches.
- **Replace Visitor and Recreation Facilities.** Develop a plan to replace any visitor-serving facilities that are lost due to impacts from sea level rise, maximizing continued provision of affordable options and an appropriate mix of accommodations over time.
- **Safe Access.** Identify areas where accelerated erosion due to sea level rise may affect the stability of formal and informal coastal accessways and seek to address hazardous accessways through strategies including establishing alternative formal accessways in less hazardous areas.
- **Retrofit and Relocation of Public Access and Recreation Areas.** Require all new public access and recreation areas, sections of the Coastal Trail, visitor-serving accommodations, or related recreation facilities to be retrofitted or relocated if they become threatened from erosion, flooding, or inundation.
 - Consider options to retrofit existing recreation and visitor-serving facilities to better accommodate sea level rise impacts. Such retrofits could include use of different building materials and/or relocating facilities.
 - Consider options to retrofit existing accessways to reduce impacts from sea level rise. Such retrofits could include using different materials that can better withstand impacts, or re-orienting the layout or other features of accessways to lessen damage and other

impacts. Also begin to plan for and identify triggers and options for relocating accessways over time as conditions change.

- Use boardwalks, bridges, and/or other design features to ensure continuity of the Coastal Trail in sections that are vulnerable to SLR hazards. Some sections may need to be relocated over time. Identify vulnerable sections of the Coastal Trail and establish a phased approach to relocate sections of the trail in such a way that is consistent with provisions of the Coastal Act and ensures that the Coastal Trail remains within sight, sound, and/or smell of the sea.
- Develop a phased plan for realigning, re-siting, and/or protecting the Coastal Trail to ensure safety, stability, and minimal interruptions to access over the long term.

SHORELINE PROTECTION AND MANAGEMENT

Shoreline protection and management are interrelated strategies that the City will need to balance in order to provide for the stability of existing coastlines and ensure the health of the Planning Area’s beaches and coastal habitats. Shoreline protection refers to the judicious placement of “hard” shoreline protection where deemed necessary to ensure the safety of critical location-dependent facilities, as well as the deliberate removal of such existing protection over time. This follows the Coastal Commission’s guidance to avoid permanent “hard” shoreline armoring along the coast in order to avoid the adverse impacts on natural shorelines typically associated with such armoring, and to gradually relocate development reliant on armoring away from hazardous areas.²⁷ It is appropriate for LCP policies to encourage “soft” armoring to protect the natural coastline. Shoreline management as a strategy combines “soft” armoring techniques as part of a comprehensive approach to preserve the shoreline as a recreational and ecological resource, and may involve planning at a regional level to control erosion and sedimentation.

Policy Options

Shoreline Protection

- **Shoreline Protection.** Require CDPs for new development in hazardous locations to include as a condition of approval a waiver of rights to future shoreline protection that would substantially alter natural landforms or cause other adverse coastal resource impacts. Allow for the protection or relocation of critical infrastructure and public facilities, including the SAM Wastewater Treatment Plant and the Half Moon Bay State Beach campgrounds that may require shoreline protection in order to continue providing needed services to the community.
- **Soft Protection.** Under appropriate shoreline conditions, require or encourage development to use soft armoring techniques, including green infrastructure and “living shorelines” as an alternative to the placement of hard shoreline protection in order to protect development or other resources and to enhance natural resource areas. Examples of soft solutions include vegetative planting, dune restoration, and sand nourishment.
- **Hard Protection.** Allow hard protection only if no feasible less damaging alternative exists. Shoreline protection for existing critical infrastructure and public facilities in danger from

²⁷ California Coastal Commission, 2013. Local Coastal Program Update Guide, Part I - Section 8. Coastal Hazards.

erosion may be allowed if coastal resource impacts are avoided or minimized and fully mitigated where unavoidable.

- **Existing Protection.** If the removal of armoring would put existing development at risk and not otherwise result in significant protection or enhancement of coastal resources, allow properly designed shoreline armoring to remain for the foreseeable future, subject to conditions that provide for potential future removal in coordination with surrounding development.
- **Protection Monitoring.** Require periodic monitoring of the shoreline protective device to examine for structural damage, excessive scour, or other impacts from coastal hazards and sea level rise. Ensure that the structures remain within the initial footprint and that they retain functional stability.
- **Shoreline Monitoring.** Require as a condition of approval monitoring of impacts to shoreline processes and beach width both at the project site and the broader area and/or littoral cell as feasible, and provide for such actions as removal or modification of armoring in the future if it is no longer needed for protection or if site conditions change.
- **Protection Permit.** Require permits for bluff and shoreline protective devices to expire when the currently existing structure requiring protection is redeveloped, is no longer present, or no longer requires a protective device, whichever occurs first.
- **Impact Reassessment.** Reassess the impacts from protective devices at specific trigger points, including when substantial improvement or redevelopment of the structure requiring protection is proposed, or when existing armoring is being modified or expanded. Reassessment should consider the effect any significant improvement to a structure requiring protection will have on the length of time the protective device will remain, and if the existing armoring is still required, acknowledge that it is authorized to protect the existing structure only.
- **Retention.** On lots with existing pre-Coastal Act or permitted armoring, require a waiver of rights to retain such protection for any structures other than the structure that existed at the time the armoring was constructed or permitted.
- **Removal of Shoreline Protection Structures.** Specify priority areas where shoreline protection structures should be removed if they are no longer needed or in a state of great disrepair, including areas where structures threaten the survival of wetlands and other habitats, beaches, trails, and other recreational areas.

Shoreline Management

- **Shoreline Management Planning.** Establish a shoreline management plan to address long-term shoreline change due to sea level rise. Include the short and long term goals for the specified area, the management actions and policies necessary for reaching those goals, and any necessary monitoring to ensure effectiveness and success. Incorporate strategies necessary to manage and adapt to changes in wave, flooding, and erosion hazards due to sea level rise.
- **Beach Nourishment.** Identify locations where nourishment may be appropriate and establish a beach nourishment program and protocols for conducting beach nourishment; establish criteria for the design, construction, and management of the nourishment area;

and/or establish measures to minimize adverse biological resource impacts from deposition of material, such as sand compatibility specifications, timing or seasonal restrictions, and identification of environmentally preferred locations for deposits. Beach nourishment programs should also consider how nourishment options may need to change over time as sea level rises.

- **Sediment Management.** Identify natural sediment supplies and remove and/or modify existing structures or actions that impair natural sand supply, such as dams or sand mining. Support nature-based responses to sea level rise by maintaining and restoring natural sand supply. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.
- **Regional Sediment Management.** Develop a Regional Sediment Management (RSM) program including strategies designed to allow the use of natural processes to solve engineering problems. The program should be periodically updated to address on-going changes from sea level rise. Regional cooperation may be needed for best implementation.
- **Dune Management.** Identify existing dune systems and develop or encourage management plans to enhance and restore these areas, including consideration of ways that the system will change with rising sea level.
- **Public Access and Recreation Mitigation.** For unavoidable impacts to public access or recreation from shoreline armoring or other development, require mitigation of impacts through the addition of new public access, recreation opportunities, visitor-serving accommodations, or Coastal Trail segments, or payment of fees to fund such improvements. Mitigation measures should be planned in such a way that, if possible, sea level rise will not impair their efficacy over time.
- **Beach Management.** Update or develop a new comprehensive beach management strategy to address loss of beach areas, including loss of lateral access, or changes in beach management due to sea level rise. Establish a program to minimize loss of beach area through, as may be appropriate, a beach nourishment program; restoring sand and sediment supply to the littoral cell; removal, adjustments, or maintenance to shoreline protection structures; use of man-made structures such as terminal groins or artificial reefs to retain sediment; or other actions.
- **Sediment Restoration.** Restore natural hydrodynamic systems to help ensure the ability of wetlands to persist with sea level rise by ensuring that sediment is available for wetland accretion. Such actions may include restoring natural channels in streams and waterways that have been armored or channelized. Organizing and coordinating such efforts may be accomplished through a Regional Sediment Management Plan. Consider facilitating the delivery of clean, dredged sediment to areas where former wetlands have subsided or to areas where existing wetlands are or may become sediment-limited as sea levels rise.

INTERAGENCY COOPERATION

The strategy addresses the reality that many coastal resources and facilities are managed by or of concern to other agencies and that planning for SLR impacts will require coordination and consultation. This is particularly clear in the case of Highway 1, a Caltrans facility, which is a critical route along the Coastside and one of the only regional connections available to Half Moon Bay

residents; though the City may determine that addressing the highway’s vulnerabilities is a priority for the community, it would need to work with Caltrans in order to do so. This strategy is also a means of leveraging the resources and expertise of other agencies in adaptation planning. The strategy also involves cooperating with other organizations in the preservation of coastal resources, including cultural, historic, and biologic and open space resources.

Policy Options

- **Transportation Priorities.** Carry out vulnerability analyses to identify chronic problem areas that are highly subject to erosion, wave impacts, flooding, or other coastal hazards or that maybe become so in the near future. Coordinate with Caltrans and local public works/transportation agencies to address high priority areas and increase monitoring efforts of chronic problem areas.

Areas of concern based on the 2016 Half Moon Bay Sea Level Rise Vulnerability Assessment include a segment of Highway 1 along the northern coast of the Planning Area, bordering the unincorporated community of El Granada which is subject to erosion and utilizes shoreline protection, and Mirada Road in the Miramar neighborhood, which has experienced severe erosion.

- **Interagency Coordination.** Coordinate with Caltrans and local public works/transportation agencies to establish new alternative transportation routes or a plan to ensure continued alternative transportation and parking is available that allows for continued access to beaches and other recreation areas.
- **Harbor Linkages.** Coordinate with relevant stakeholders (such as the San Mateo County Harbor District) to ensure that linkages between nearby harbor infrastructure and overland transportation networks will be resilient to future sea level rise impacts.
- **Water Protection.** Coordinate with the regional water quality control board and San Mateo County Resource Conservation District to add policies to reduce water pollution from runoff should agricultural lands become flooded or inundated due to sea level rise. Agricultural practices that are designed to minimize water quality impacts, such as those designed to minimize runoff, may need to be updated or enhanced to ensure water quality protection if sea level rise results in more frequent flooding of agricultural lands.
- **Wastewater Treatment.** Coordinate with the Sewer Authority Mid-Coastside to develop a retrofit strategy to manage impacts from sea level rise-related coastal flooding to ensure continued function of the facility while minimizing risks to sensitive coastal habitats and water quality from damage or overflows.
- **Tribal Consultation.** If resources are at risk, coordinate with the appropriate entity or Native American tribe(s) to develop a coordinated management plan for artifacts.
- **State Coordination.** Work with the State Historic Preservation Officer to identify actions to protect archaeological and paleontological resources.
- **Partnerships for Open Space Conservation and Habitat Management.** Coordinate with San Mateo County, the State of California, the San Mateo County Resource Conservation District, and conservation and environmental organizations to strategically acquire and manage lands to be conserved as open space for hazard avoidance and habitat protection.

OPEN SPACE ACQUISITION AND CONSERVATION

Open space designation can serve a number of planning purposes, including prohibiting development in hazardous areas, including those subject to erosion and inundation; preserving natural resources and providing space and corridors for the inland migration of coastal habitats in response to SLR; and providing space for outdoor recreation and coastal access as well as reserving sites for the eventual retreat or relocation of recreation and access facilities away from areas at risk from SLR. Public acquisition of open space lands can be accomplished through a variety of tools, including easements, incentives, cooperation with local land trusts.

Policy Options

- **Open Space Preservation and Conservation.** Preserve land for its ecological or recreational value through limiting or prohibiting development and any uses that conflict with ecological preservation goals. Potential strategies include transfer of development rights programs to offset reduced development potential, open space management plans that evaluate and consider the impacts of sea level rise, establishing open space and conservation areas through land use designations and zoning, redevelopment restrictions, acquisition and easement programs, and setback and buffer requirements.
- **Public Acquisition.** Establish a program to partner with state, federal, and non-profit organizations to acquire and protect natural resource areas for public use, including areas that could serve as refugia for species impacted by sea level rise, or areas that could be appropriate sites for coastal habitat creation or restoration.
- **Open Space Requirements.** Require permit conditions for new development in certain areas that buffers around natural resource areas be protected through a conservation easement, deed restrictions, or other comparable mechanism.
- **Development Restrictions.** Establish a formalized program to identify, acquire, and manage areas appropriate for some form of conservation protection. Easements or other strategies may be used to limit or restrict development on portions of a lot parcel that are most vulnerable to SLR impacts. The program might develop standard agreements to be used for easements and identify the entities that could hold the easements.

HABITAT MANAGEMENT PLAN

The City may consider developing a habitat management plan to serve as a comprehensive guide outlining Half Moon Bay's approach to acquiring, restoring, preserving, monitoring, and maintaining open space for the conservation of biological resources. If so, the plan should incorporate SLR adaptation strategies to protect sensitive habitats and provide sites and corridors for inland migration of those threatened by SLR.

Policy Options

- **Habitat Management Plans.** Address effects of sea level rise in any management plans for coastal habitats.
 - Use an adaptive management approach in ecosystem management, restoration, or design. Habitat management plans and/or other habitat projects should establish an adaptive management approach, with clearly defined triggers for adaptive actions.

Such an approach would allow for and ensure that coastal habitats are able to migrate and transition with changes in sea level.

- **Environmentally Sensitive Habitat Areas.** Establish measures to ensure the continued viability of (ESHA), such as protection of migration zones, habitat corridors, and other applicable adaptation strategies where at risk from sea level rise.
 - Preserve open areas that are adjacent to wetlands to allow for migration of these habitats as sea levels rise.
 - Protect refugia, or areas that may be relatively unaltered by global climate change and thus can serve as a refuge for coastal species displaced from their native habitat due to sea level rise or other climate change impacts.
 - Enable identification of important animal movement corridors. Develop regulations to protect these corridors for present and future conditions, taking into account habitat shifts from climate change. Require that new structures such as highways, medians, bridges, culverts, and other development are designed to facilitate movement of animals.
 - Reserve space for a “habitat migration corridor” or areas into which wetlands and other habitats could migrate as sea level rise induced inundation of existing wetland areas occurs. These areas could be reserved through land acquisition, use designations, zoning buffers, setbacks, conservation easement requirements, and clustering development. Consider developing a plan for acquisition of important habitat migration corridors.
- **New or Restored Coastal Habitat.** Require new coastal habitat to be provided or for degraded areas to be restored to account for the expected loss of existing habitat that will occur when development blocks the necessary upland migration due to sea level rise.
- **Site-Specific Evaluation.** Require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise where appropriate. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion).
- **Habitat Restoration, Creation, or Enhancement.** Ensure that habitat restoration, creation, or enhancement projects are designed to withstand impacts of sea level rise and adapt to future conditions.
- **Ecosystem Function.** Pursue strategies to protect ecosystem function under a range of future sea level rise or climate change scenarios. Recommend coastal habitat management strategies that strive to protect ecosystem function in the future. Strategies include protecting a wide range of ecosystem types, protecting refugia, protecting wildlife and habitat corridors, and establishing methods to monitor ecosystem change over time.
- **Monitoring.** Establish a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time. Such a protocol would also help identify triggers at which additional adaptation options are necessary.
- **Ecological Buffers.** Establish requirements for ecological buffers and provide guidance on how to establish or adjust these buffers to accommodate sea level rise. Require buffers to

be designed, where applicable, to provide “habitat migration corridors” that allow sensitive habitats and species to migrate inland or upland as sea level rises.

AGRICULTURAL DESIGNATION

The California Coastal Act provides for the preservation of agricultural production in the Coastal Zone. Though SLR impacts are not anticipated for Half Moon Bay’s agricultural resources, the cumulative effects of SLR and tsunami could affect agricultural lands in the city. Thus, the City may consider a strategy of identifying sites where agricultural operations may retreat and continue to support the continuation of agricultural uses in the community and/or in the surrounding region.

Policy Options

- **Agricultural Designation.** Identify any non-sensitive open or developed areas, both within and outside of the Coastal Zone, which could potentially be used to replace agricultural land that is lost to sea level rise. Update LCP designations and/or policies to protect these identified areas for agricultural production and, as applicable, to provide for their conversion to agricultural use. Encourage and support regional coordination as feasible and applicable.
- **Agricultural Protection.** Establish a formal program to identify, acquire, incentivize, and manage areas appropriate for new/renewed agricultural use and/or for protection of current and/or future agricultural uses. Such program should target key areas and properties where agricultural conversion threats are highest, and should dovetail with existing agricultural protection programs. Easements and other legal restrictions may be used as part of such program to help limit or restrict development in areas where agricultural land and production are most vulnerable to sea level rise impacts. The program might develop standard language and/or legal documents that can be used for easements or other property restrictions.

RESEARCH, MONITORING, AND EVALUATION

Policy Options

Research, monitoring, and evaluation are methods of information gathering that can assist the City in filling in gaps in existing data, identifying priorities for adaptation, and developing more effective adaptation policies. These can be implemented at the citywide level, by ensuring that generalized hazard mapping is up to date and supporting further studies on SLR impacts, and at a project level through site-specific evaluations and monitoring programs in hazardous areas. In this way, site-specific evaluations of vulnerability to SLR hazards and coastal resource vulnerability can provide a baseline for evaluating the effectiveness of its adaptation strategies over time.

- **Sea Level Rise Impacts.** Support research on impacts to recreation and public access, including impacts to recreational activities like surfing or other coastal recreational uses.
- **Coastal Flood Hazard Mapping.** Maintain and update coastal hazard maps, including areas subject to wave action and flooding due to sea level rise.
- **Water Quality Hazards.** Prioritize low-lying contaminated sites for remediation and restoration.

- **Contaminated Sites.** Maintain an updated inventory of hazardous materials sites in the Planning Area (including the closed San Mateo County owned and managed Half Moon Bay Landfill and underground storage tank sites), monitor the status of those sites, and work with property owners and state agencies to ensure proper and timely cleanup of all sites.
- **Site-Specific Hazard Evaluation.** Require site-specific evaluation of coastal hazards due to sea level rise over the full projected life of any proposed development. Analyses should be conducted by a certified Civil Engineer or Engineering Geologist with expertise in coastal processes.
- **Site-Specific Resource Evaluation.** Require site-specific evaluation of potential sea level rise impacts to archeological and paleontological resources on a development site. Requirements that a monitoring program and plan be established as a condition of approval for development located on a site with artifacts vulnerable to sea level rise. Adaptation or protection strategies used may depend on the significance of the archaeological resources in question.
- **Flood Protection Evaluation.** Evaluate impacts from flood protection measures by requiring new development that must be located in areas likely subject to current or future flood/wave action or elevated groundwater to evaluate potential impacts to adjacent or nearby properties from all proposed structural flood protection measures to ensure that these measures will not create adverse direct and/or cumulative impacts either on-site or off-site.
- **Saltwater Intrusion of Coastal Waterways and Habitats.** Encourage further study of the potential for saltwater to intrude into coastal waterways and habitats either as a result of a storm event or failure of protective berms or beaches, the potential frequency of such events and the expected periods of exposure, and the sensitivity of habitats that may be exposed to such events.

STORMWATER MANAGEMENT

Stormwater management is a key strategy when addressing flooding impacts. The City can incorporate SLR impacts on coastal flooding into its stormwater pollution prevention program as well as in its capital improvements program for the stormwater system. Updates that would address SLR-related issues include Best Management Practices (BMPs), or green infrastructure²⁸ and devices designed to improve stormwater quality and flow rates, and stormwater infrastructure that can manage any increases in capacity or runoff pollutants associated with sea level rise-induced flows.

Policy Options

- **Stormwater Management.** Include sea level rise and extreme storms in stormwater management plans and actions.

²⁸ Green infrastructure in the context of stormwater management and water quality refers to an approach to water management that protects, restores, or mimics the natural water cycle (definition from American Rivers).

- **Best Management Practices.** Evaluate and update BMPs to account for changes in water quality and supply issues due to sea level rise, as applicable.
- **Stormwater Infrastructure.** Reduce impacts from higher water levels through measures such as widening drainage ditches, improving carrying and storage capacity of tidally-influenced streams, installing larger pipes and culverts, adding pumps, converting culverts to bridges, creating retention and detention basins, and developing contingency plans for extreme events. Encourage infrastructure that prioritizes or restores natural drainage patterns.
- **Retrofit.** Identify and prioritize development in low-lying or other at-risk areas with inadequate stormwater infrastructure and take steps to retrofit these systems to better accommodate sea level rise driven changes, prioritizing methods that utilizes natural drainage patterns and systems.

GROUNDWATER MANAGEMENT

The purpose of groundwater management as an adaptation strategy is to ensure the quality of the city's groundwater in light of potential saltwater intrusion from rising sea levels (currently, not enough information is available to determine the risk of saltwater intrusion into Half Moon Bay groundwater supplies). This strategy is connected to the goal of agricultural preservation as farming operations may use groundwater for irrigation purposes. It is important to note the majority of the Planning Area's water, supplied by Coastside County Water District, comes from Pilarcitos Lake and Upper Crystal Springs Reservoir, part of the San Francisco Public Utilities Commission's Hetch Hetchy water system. About 28 percent of CCWD's water supply is from surface and groundwater from the District's Pilarcitos well field and Denniston Project.

Policy Options

- **Groundwater Management.** Plan and coordinate monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of fostering long-term sustainability of the resource. Specify limits or establish other standards for the use of groundwater and sensitive aquifers. Coordinate with other regional water planning efforts.
- **Agricultural Water Supply.** Protect water supply for priority coastal agriculture, including policies to address any potential saltwater intrusion, such as limits on groundwater withdrawal or diversification of water supplies. Strategies to pump freshwater and/or highly treated wastewater into aquifers to reduce saltwater intrusion should be minimized in areas with limited freshwater resources.
- **Saltwater Intrusion of Groundwater Supply.** Establish a long-term strategy for addressing saltwater intrusion in aquifers, including limiting development that would use sensitive aquifers as applicable. Identify the local information needs and promote the establishment of a research program to increase understanding of the vulnerability of coastal aquifers.
- **Water Conservation.** Enhance standards related to water conservation and/or to identify opportunities for water recycling, dual plumbing systems, and the like. Establish a program to identify alternate water sources for agriculture.

- **Groundwater Extraction.** Regulate development to limit or prevent extraction and avoid overdraft from aquifers vulnerable to saltwater intrusion. Encourage measures to recharge shallow aquifers that are depleted.
- **Wells and Water Intake Facilities.** Identify opportunities to relocate wells and water intake facilities away from hazards and/or areas where saltwater intrusion may be a problem. Require new water wells to be sited away from areas where saltwater intrusion could occur.
- **Water Supply.** Limit or restrict new development in areas that are dependent on water supplies that are or will become susceptible to saltwater intrusion. When siting and designing new development, ensure that adequate and sustainable water sources are available for the lifetime of the development and suitable for the intended use of the development, considering potential impacts of sea level rise and saltwater intrusion upon groundwater supplies.

HAZARD MANAGEMENT PLANNING

This strategy involves updating and maintaining the city's hazard management protocols with current information on the impacts of SLR. Half Moon Bay may update its Local Hazard Mitigation Plan to include an assessment of SLR risks and adaptation strategies. It may also coordinate with local public safety agencies such as the San Mateo Sheriff's Department, the Coastside Fire Protection District, and emergency response operators to establish policies and protocols in response to potential geologic and flooding hazards. This would include determining emergency access and egress routes for evacuation and emergency response purposes, including access in a scenario in which Highway 1 has been impacted.

Policy Options

- **Hazard Management Planning.** Include sea level rise impacts in hazard management planning, including its effects on wave runup, storm surge, and tsunami hazards.
- **Transportation Redundancy.** Provide alternative routes, as possible, to allow for access to and along the coast in instances in which sections of roadways may become temporarily impassible as a result of coastal hazards. Ensure that alternate route information is provided to residents and visitors to coastal areas.

DYETT & BHATIA
Urban and Regional Planners

755 Sansome Street, Suite 400
San Francisco, California 94111
☎ 415 956 4300 📠 415 956 7315