AB 691 Sea Level Rise Assessment

County of San Mateo Tide Lands Grant S1893 Chapter 24

Photo: Bean Hollow Beach, California Coastal Records Project

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ACRONYMS AND ABBREVIATIONS

CCC	California Coastal Commission
CSLC	California State Lands Commission
DEM	Digital elevation model
MHW	Mean high water[1]
MLW	Mean low water[2]
NRC	National Research Council
OPC	California Ocean Protection Council
SLR	Sea level rise
WTP	Willingness to pay

[1] Average of all high water elevations observed over 19 years.

[2] Average of all low water elevations observed over 19 years.

EXECUTIVE SUMMARY

The State of California granted the intertidal resources along the San Mateo County Pacific Coast from Pescadero Creek to Bean Hollow (S1893) in 1893 through the California State Lands Commission (CSLC) to the County of San Mateo. To meet requirements of Assembly Bill No. 691 (AB 691), the County has prepared this sea level rise (SLR) assessment. The intent of this document is to identify and characterize the impacts of SLR to intertidal resources in the State Grant Area, and to provide resources, information, and strategies for adaptation.

Assessment and Maps of Impacts of SLR for the Region

An inventory of natural and built resources was developed from Pescadero Creek to Bean Hollow. The impacts of changing shorelines and trends in relative local sea level on vulnerable natural and built resources and facilities, including public trust resources and values such as public access, recreation, and coastal habitats are mapped.

Estimate of Financial Costs To Address the Impacts of SLR

Replacement or repair costs of resources and facilities that could be impacted by SLR, and non-market values associated with recreation and other resources that could be impacted by SLR are presented. Costs of 2030, 2050, and 2100 high SLR projections, including anticipated costs of adaptation/mitigation measures, and potential benefits of such strategies and structures are presented.

Our analysis assumes that hiking, viewing the coastal scenery, kayaking, and fishing will be maintained, although this requires that access to the coast through parking lots and hiking trails (especially for kayaking) be maintained over time. With that assumption, our estimates indicate that, due to loss of areas from SLR, the annual non-market value will substantially decrease over time. By 2100, approximately $5 million per year will be lost in non-market value based on the current annual non-market value due to beach recreation and tide-pooling losses.

The study identifies and evaluates several adaptation strategies. In particular, sections of Highway 1 are subject to erosion and could require armoring or other long-term solutions such as strategic realignment. The cost of armoring (rock revetment) is estimated for each time period. In addition, this study assumes that parking lot size and comfort stations (restrooms) will be maintained in new locations at their present capacity. The total costs of implementing these adaptation strategies are estimated to be $7.3 million in 2030, $18.8 million in 2050, and $9.3 million in 2100 with a total cumulative cost of $35.3 million.

Adaptation Measure	2030	2050	2100	Total
Armoring	$6,602,450	$18,565,410	$8,567,510	$33,735,370
Parking Lot	$587,325	$213,804	$412,675	$1,213,804
Comfort Stations	$100,000	$0	$300,000	$34,949,174
Total	$7,289,775	$18,779,214	$9,280,185	$35,349,174

These adaptation strategies could yield significant economic benefits. The table below provides a qualitative summary of the adaptation costs. Armoring Highway 1 will allow visitors to reach Bean Hollow and Pescadero State Parks and allow other visitors and commuters to use Highway 1. This study also assumes that parking would be maintained, and comfort stations would be replaced, although if attendance is reduced due to beach erosion, maintaining existing parking/facilities may be unnecessary. This study also assumes trails and access would be maintained, although we have not estimated this cost.

Impact Level	Cost to Repair / Adaptation Costs	Value of Lost Use / Adaptation Benefit
Low (2030)	Some armoring required to protect Highway 1. Parking lot repairs required and one park comfort station at Bean Hollow (currently closed) will need replacement if erosion occurs. Trail and vertical access realignment required.	Significant loss in beach recreation and tide-pooling. Significant portions of State Park land lost. Five residential structures lost to erosion and significant loss of residential land.
Medium (2050)	Additional armoring to protect Highway 1 required. Parking lot repairs required due to erosion. Trail and vertical access realignment required.	More loss of State Park land and already diminished beach recreation and tide-pooling disappear. One additional residential structure and significant amount of private property subject to erosion.
High (2100)	Additional armoring to protect Highway 1 required. Parking lot repairs required and three additional comfort stations lost if erosion occurs. Trail and vertical access realignment required.	More loss of State Park land. Additional residential land lost. Small loss of agricultural and multiuse land along with road right-of-way. Protection of Highway 1 in areas will eliminate some parking lot and comfort station repair needs.

1 INTRODUCTION

San Mateo County's location between the San Francisco Bay and the Pacific Coast makes it especially vulnerable to sea level rise (SLR) and flooding. Under the leadership of Supervisor Dave Pine, the Office of Sustainability launched the "Sea Change SMC" initiative in 2015 with the goal of increasing coordination and collaboration on sea level rise planning across the County, and improving awareness and understanding of the issue. As part of the County's Climate Change Preparedness Action Plan the County's goal is to continue to prepare for the impacts of sea level rise, and to evaluate risks from other climate change impacts. In 2018, the County finalized a Sea Level Rise Vulnerability Assessment for most of the County in coordination with cities, agencies, businesses, community groups, and others.

In 2019–2020, with new data from the U.S. Geological Survey, the County is working with the San Mateo Resource Conservation District and Revell Coastal, Inc. to complete the last phase of the County's sea level rise vulnerability assessment for the south coast of the County, from Half Moon Bay south to the Santa Cruz County line. This AB 691 report has been completed in advance of the larger regional study to meet the State of California's deadline. Lessons learned will be used in the development of the South Coast Sea Level Rise Risks and Solutions Study, which will include a comprehensive approach to stakeholder and community engagement. Because of this, vulnerability and economic information and adaptation strategies presented in this AB 691 study should be considered preliminary.

The State of California, administered by the California State Lands Commission (CSLC), granted a lease to the County of San Mateo for the intertidal resources along the San Mateo County Pacific Coast from Pescadero Creek to Bean Hollow (S1893) in 1893. In order to meet requirements of Assembly Bill No. 691 (AB 691), the County has prepared this SLR assessment. The intent of this document is to identify and characterize the impacts to intertidal public trust lands from SLR in the State Grant Area, and to provide resources, information, and strategies for adaptation.

The County land grant area (herein called the study area) is defined in S1893 Chapter 24 as the region of San Mateo County on the Pacific Ocean between Mean High Water and Mean Low Water from Pescadero Creek south to Bean Hollow. Specifically, S1893 defines the lands as all tide lands between the lines of high and low tide along the shore of the Pacific Ocean from the mouth of Pescadero Creek, and running southerly with the shoreline to the mouth of Bean Hollow Lagoon. Thus, the focus of this AB 691 SLR analysis is on the intertidal public trust resources granted by the CSLC to the County of San Mateo. Figure 1 provides an overview of the extent of the land grant and the boundaries of this assessment.

The CSLC provides guidance in planning for SLR impacts in accordance with AB 691. Essentially the assessment begins with an inventory of vulnerable natural and built resources and facilities. Upon development of an inventory, the assessment considers the impacts of SLR

and other dynamic coastal processes (e.g., coastal erosion) as exacerbated by SLR such as coastal storms and high tides on the vulnerable assets identified. To facilitate successful adaptation for San Mateo County, the AB 691 assessment considers some of the costs associated with the impacts of SLR. The costs of general adaptation and mitigation strategies are estimated along with potential benefits of various strategies. This report was developed to meet the requirements of the San Mateo County AB 691 SLR assessment to the CSLC.

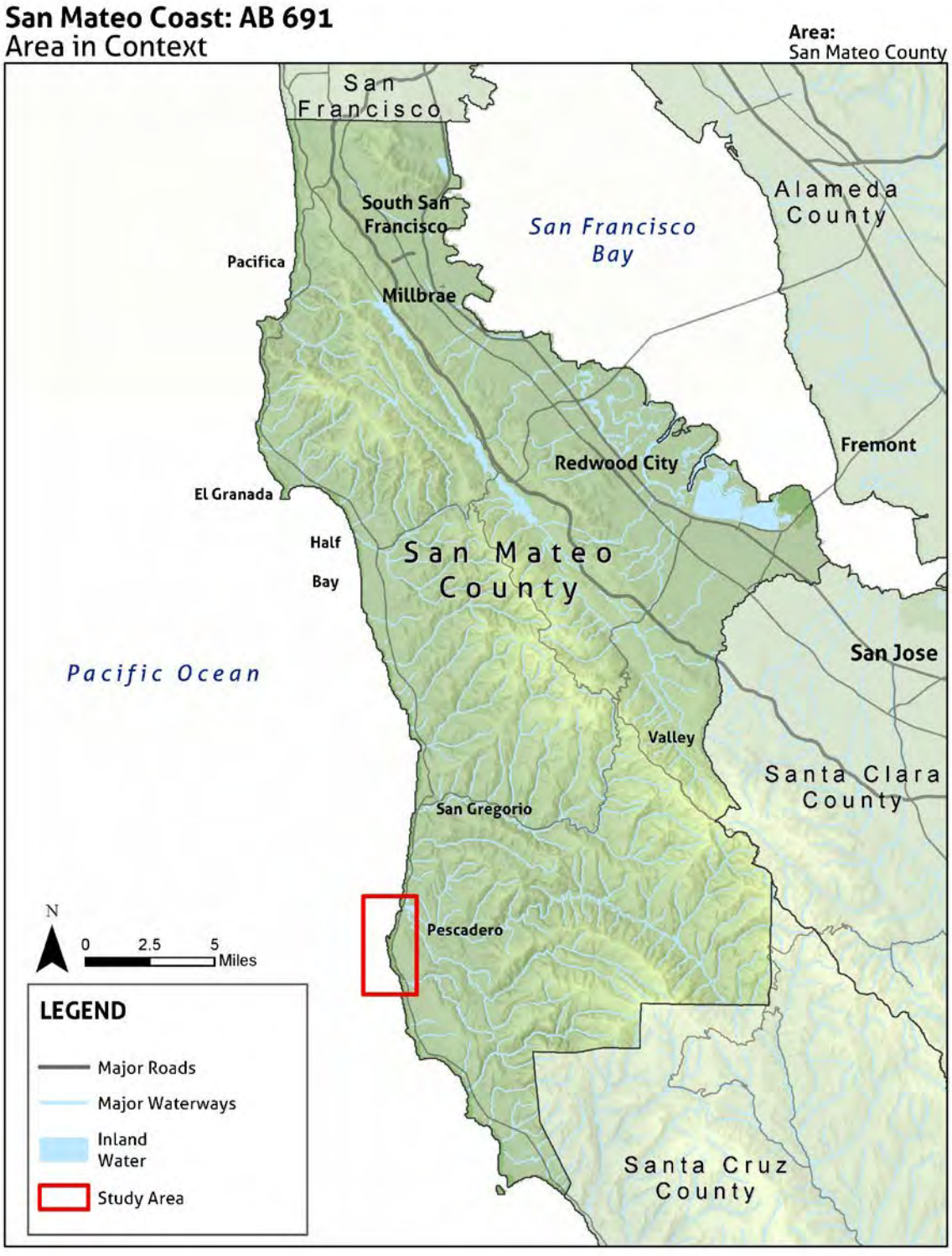

Figure 1. Overview of the San Mateo County S1893 region with the extent of the State Land Grant between mean high water (MHW) and mean low water (MLW), effectively the intertidal resources along this stretch of coast.

2 ASSESSMENT OF SEA LEVEL RISE IMPACTS

The scientific community has reached a strong consensus on the potential for SLR as a result of a changing climate. Climate change impacts include threats not only to our infrastructure but to our health, safety, and the economic vitality of our community. Generally, the coastal science, engineering, and management communities have characterized the three approaches available for addressing the impacts of climate change: protect, accommodate, and strategic re-alignment. There are different costs associated with each of these paths and each strategy could include nature-based options. Thus, incorporating climate resilience into planning allows for taking advantage of opportunities to protect residents, infrastructure, and economic well-being. This document was developed to identify and characterize the impacts of SLR in the State Grant Area, and to provide resources, information, and strategies for adaptation.

The following assessment considers the legislated AB 691 criteria as well as the SLR impacts and recommendations described in the current California Ocean Protection Council's (OPC) State Sea Level Rise Policy Guidance (OPC 2018).[3] While probabilities of sea levels estimated by OPC are anticipated to reach specific levels in the three time horizons evaluated (2030, 2050, and 2100), these time horizons also serve to identify an envelope of impacts that will be used as general guidelines for planning purposes. As SLR rates continue to increase and models become more robust, SLR can be periodically monitored, and observed and projected changes can be incorporated into future updates to the AB 691 assessments. This assessment focuses on the intertidal land grant from the CSLC and focuses primarily on the public trust intertidal resources related to access, recreation and habitats and does not fully consider inland impacts of SLR. The ongoing South Coast SLR Risk and Solutions study will include a full vulnerability and economic assessment of SLR impacts as well as identify potential costs and benefits associated with various adaption approaches. The larger study should be completed by the end of 2020.

2.1 RESOURCE INVENTORY

An inventory of vulnerable natural and built resources and facilities was developed for the AB 691 assessment. The spatially explicit inventory has been developed to consider impacts to public trust resources and benefits, including public access, recreation, and habitats relevant to San Mateo County based on data available at the time of this analysis. The larger San Mateo County South Coast SLR Risks and Solutions study is collecting additional information which will be included in an updated vulnerability assessment and will likely include cultural resources, agricultural lands and more detail on upland land uses. This AB 691 inventory could

[3] http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

be a basis for prioritizing vulnerabilities to be addressed based on SLR and associated coastal hazards (e.g., coastal erosion).

The sectors for assessment identified for the County include land use, recreation, public access, and habitat. Most of the land uses in the study area can be broken down into four land-use categories: intertidal habitat, State Park land, residential land (occupied or vacant), and agricultural or multiuse land. While not occupying large areas, an important consideration in the region are the highways and streets including Highway 1, providing access and running parallel to the coast throughout the region. The market value of each land use depends upon how a sector is zoned and is discussed in the financial assessment. All of the land use categories and data were acquired by San Mateo County. Table 1 provides a summary of the key assets in the study area in terms of acreage and structures. While the study is confined to the intertidal zone and its extension due to SLR, the key assets include all assets bounding the intertidal zone; subsequently, the land uses depicted in Table 1 extends beyond the intertidal study area.

Table 1. Summary of Key Land Uses in or near the Intertidal Land Grant Study Area

Type of Asset	Acreage	Structures
State Park Land	76.84 acres	
State Park Comfort Stations		4 structures
Residential/Vacant Land	44.33 acres	
Residential Structures		6 structures
Agricultural /Multiuse Land	85.73 acres	
Total	206.9 acres	10 structures

2.2 SEA LEVEL RISE PROJECTIONS

Consistent with the updated California Coastal Commission (CCC) 2018 policy guidance, the OPC updated science (2018) and consistent with the approach in the Sea Change SMC Vulnerability Assessment, the County evaluated a range of coastal hazards and SLR scenarios using the best available science. Based on the available science and the nature of the intertidal land grant, two coastal hazards were evaluated – the migration of the intertidal zone and coastal erosion, which may allow for inland migration of the intertidal zone and public trust resources.

The Half Moon Bay tide gage at Pillar Point (NOAA Station 9414131) was used to identify the elevations of Mean High Water (MHW - value of 4.99 ft NAVD88) and Mean Low Water (MLW - 0.04 NAVD88). Rising MHW tide levels and tidal levels used in erosion estimates as described below were used to map projections of tidal flooding along the coast. Table 2 presents the SLR scenarios used for each hazard and the relative probabilities of occurring as identified in OPC (2018). The MHW tide was added to each SLR estimate to account for the SLR-related

inundation of the County granted lease lands. Coastal erosion projections were based on the Pacific Institute cliff and dune erosion data and the high sea level rise estimates used at the time (Heberger et al 2009; Revell et al 2011). Even though these sea level rise projections are lower than those in the intertidal retreat, except for the 2050/2060 projection they fall into similar risk aversion categories (Table 2). Overall, while the erosion projections have differences in the sea level rise estimates, the final mapping relies on the OPC (2018) sea level rise values.

Table 2. Sea Level Rise Scenarios from Pacific Institute (Heberger et al 2009) and OPC (2018)

Scenario	Pacific Institute Coastal Erosion	Risk Aversion	MHW to MLW Intertidal Retreat	Risk Aversion
2025/2030	0.7 ft	Medium high risk	0.8 ft	Medium high risk
2050/2060	1.3 ft	Medium	3.2 ft	High to extreme
2100	4.6 ft	Medium high risk	6.5 ft	Medium high risk

A complete regional digital elevation model (DEM) was developed from the 2017 San Mateo LiDAR project and the NOAA Digital Coast provided from the 2016 USGS West Coast El Nino LiDAR (Washington, Oregon, California). Areas outside of the County DEM were supplemented with the NOAA data. The DEM was used to determine elevation contours of MHW and MLW representing the extents of the existing State Land Grant. Contour values were used to build polygons of the selected SLR elevation horizons. Spatial connectivity was accounted for in all cases in the developed polygons. For example, a known culvert at Bean Hollow Beach was used to assume that connectivity existed between Bean Hollow Beach and Arroyo de los Frijoles under Lake Lucerne to accurately project water levels in the lake.

Figure 2 provides an overview of the areas flooded by rising tides under the increasing SLR scenarios. Generally, the cliff backed shorelines along the region do not allow for significant tidal inundation. Notable exceptions are the beach regions at Bean Hollow and Pebble Beaches and into Pescadero Creek and Lake Lucerne. While further evaluation including erosion is discussed in the following section, it is useful to examine habitat changes here. Figure 4 and Figure 5 map habitat in the north and south sections, respectively. The highlighted regions show the primary habitats flooded by the high rising tide scenario.

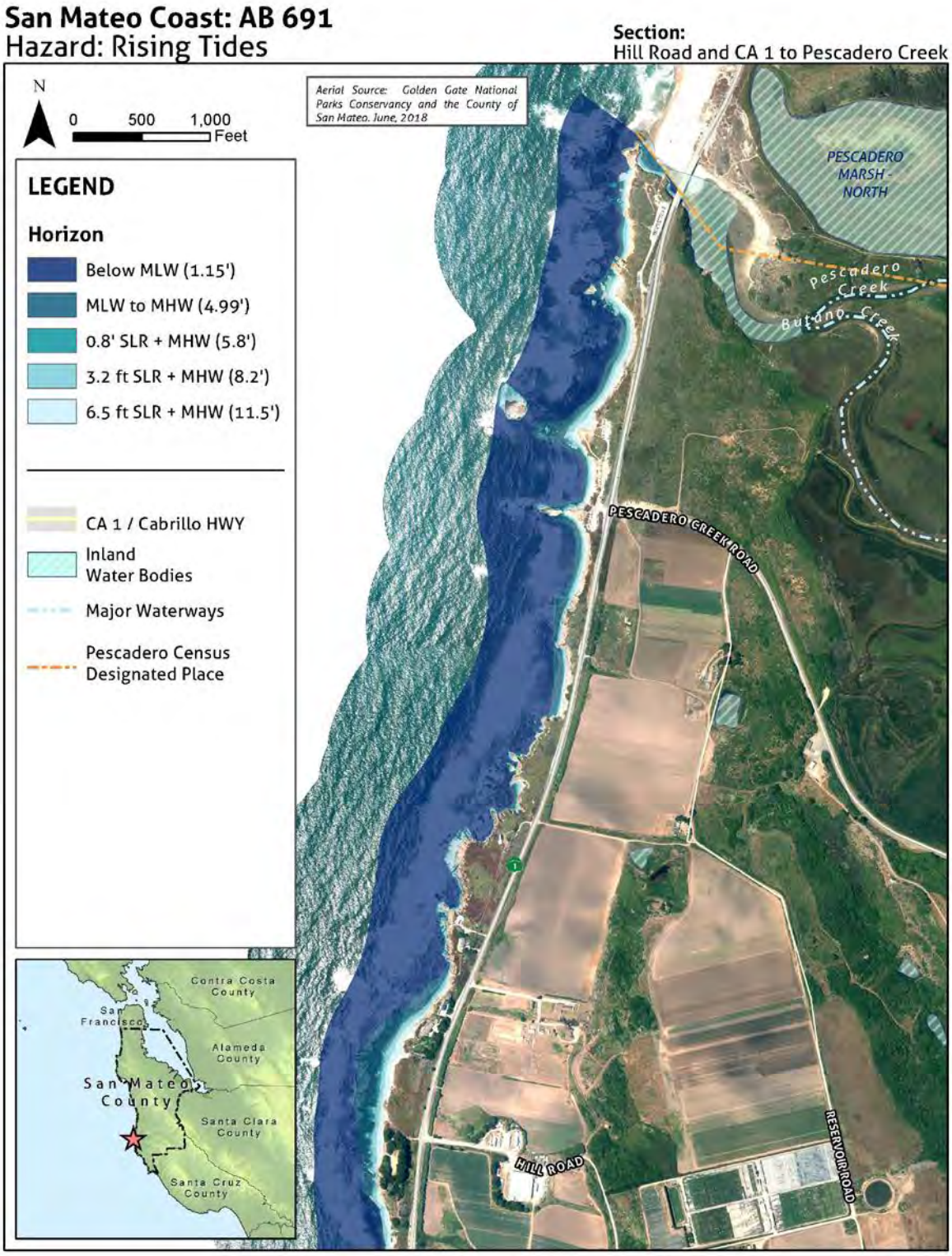

Figure 2. North region of San Mateo Coast with polygons overlaid on flooded areas for the SLR plus MHW scenarios for a total rising tide.

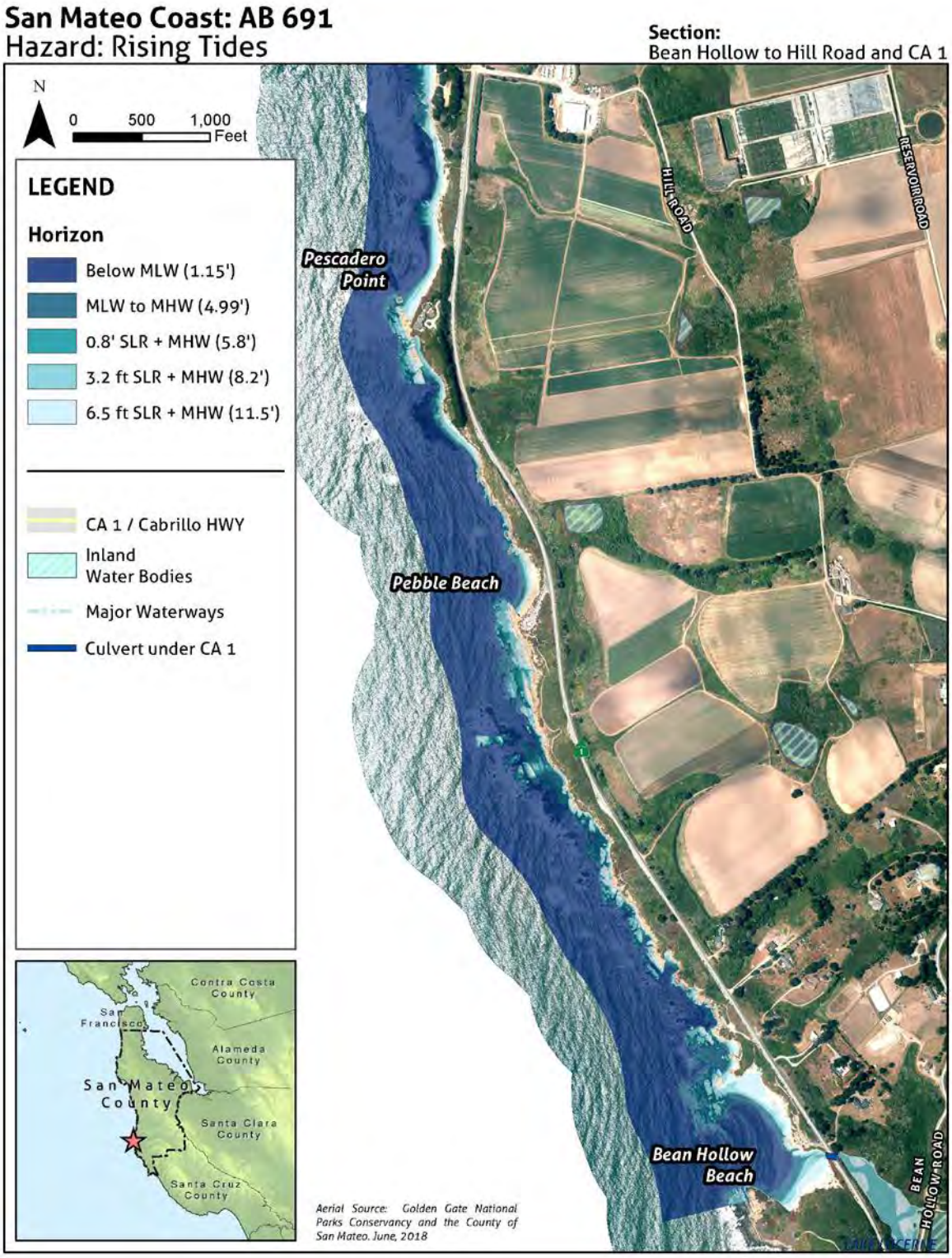

Figure 3. South region of San Mateo Coast with polygons overlaid on flooded areas for the SLR plus MHW scenarios for a total rising tide.

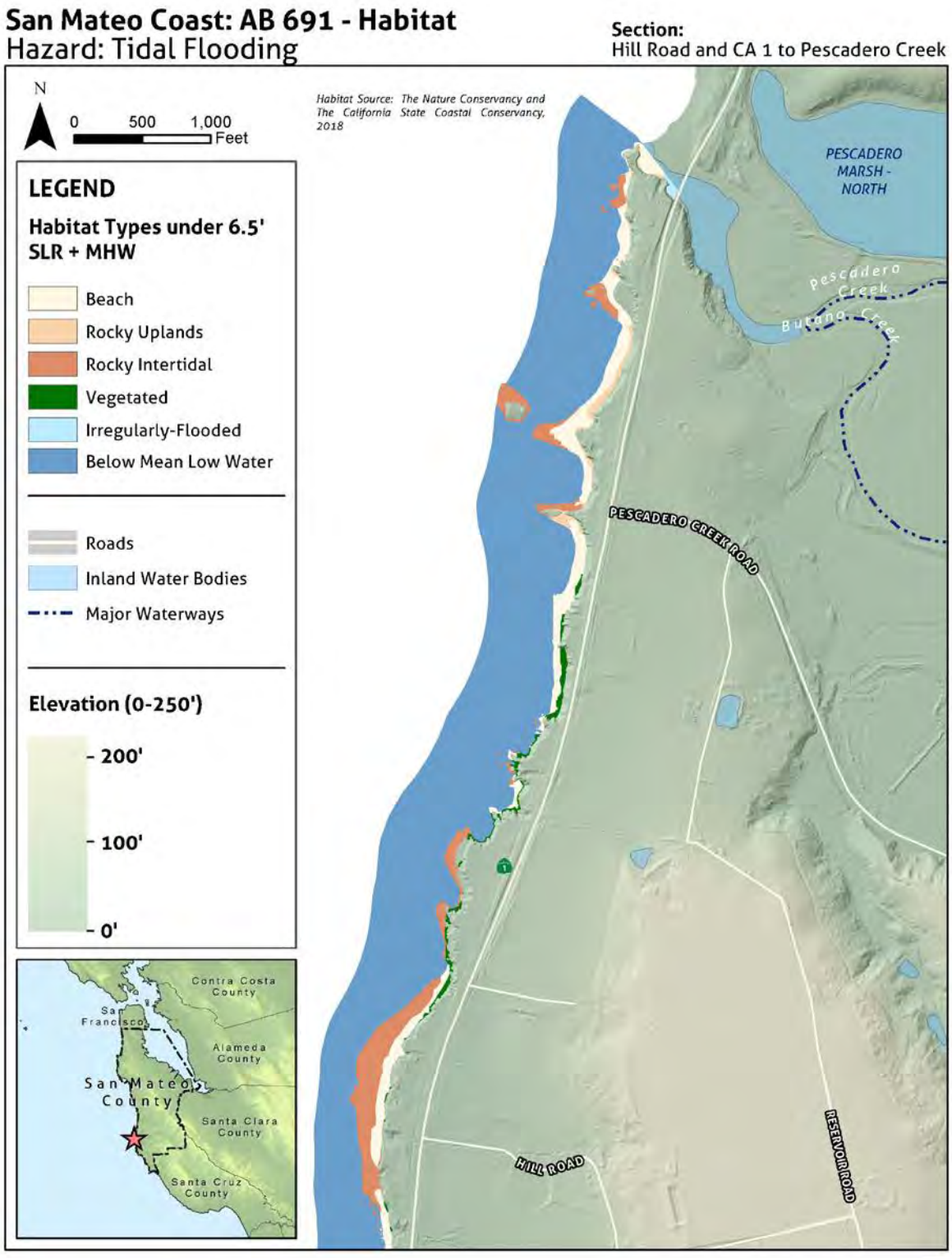

Figure 4. Habitat in the north region vulnerable to inundation under the high SLR scenario.

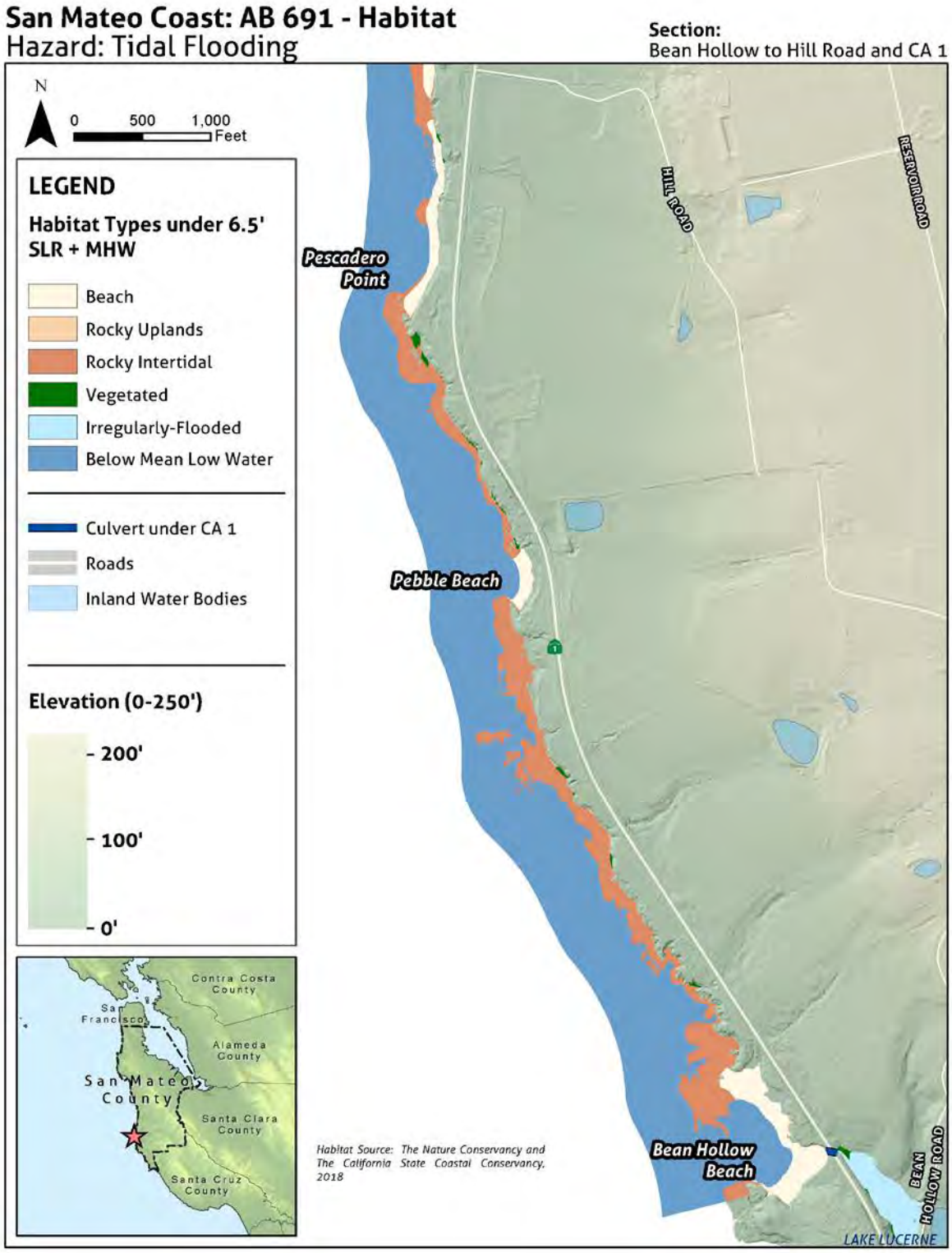

Figure 5. Habitat in the south region vulnerable to inundation under the high SLR scenario.

2.3 SEA LEVEL RISE IMPACTS

The evaluation of total SLR impacts for the coastal sectors include SLR, tidal inundation, and erosion hazards to the natural and built resources. This evaluation has used 2030, 2050, and 2100 as the planning horizons for the assessment for long-term planning purposes based on the available data. The 2100 time frame is the furthermost (or most distant) planning horizon since this is typically last year that the coastal hazard models are available and is consistent with the typical life span of new development built today. Maps projecting ~2030, ~2050, and ~2100 SLR impacts have been developed consistent with San Mateo County mapping resources for use in future planning.

The Pacific Institute has developed projections of coastal hazards and cliff erosion along the California Coast including San Mateo County (Revell et al. 2011; Heberger 2009). The estimates of future coastal hazards are based on scenarios generated from a downscaled regional global climate model, developed as part of the 2nd California Climate Change Assessment (Cayan et al 2008). The erosion model relates shoreline change rates to coastal geology, and applies changes in total water levels in exceedance of the toe elevation to predict future cliff and dune erosion hazards. The Pacific Institute model provides region-specific, consistent information for coastal erosion projections. The assessment here utilized the Pacific Institutes' high SLR scenario associated with a 1% annual storm for both cliff and dune erosion; therefore, the assessment here provides conservatively high erosion extents; however, this Pacific Institute data set represents the most spatially explicit and best available science for this rural region of coastline. The erosion model projections from dune and cliff erosion segments were reconciled into a single erosion layer for inclusion into the analysis. Figure 6 provides an overview of the coastal erosion horizons (2030, 2050, 2100) mapped onto the coastal area. The 2100 results illustrate significant shoreline regression. The following set of figures illustrates the land use impacts of the SLR and associated coastal erosion.

Figure 7 and Figure 8 map the erosion and SLR vulnerabilities to coastal habitat in 2100 for the north and south regions of the coast. Significant erosion into vegetated and rocky upland is projected to occur in both the north and south regions of the area. While a habitat evolution model was not included in the analysis, it is likely that intertidal habitats will migrate as erosion occurs inland. The future habitat composition will be further considered in the larger South Coast SLR Risks and Solutions study. Figure 9 and Figure 10 map the vulnerable state park assets including trails, restrooms, parking lots, and coastal access regions. Parking lots, trails, and restrooms in Bean Hollow Beach have vulnerabilities due to cliff and dune erosion as early as 2030, while by 2100 a large proportion of the trails, restrooms, and parking lots has substantial vulnerability to coastal erosion. Private land vulnerabilities are mapped by parcel and structure and are shown in Figure 11. Affected regions of private parcels are shown in hatched areas. Finally, state highway vulnerability is mapped in Figure 12 and Figure 13. As early as 2030, Highway 1 has vulnerability in the Bean Hollow Beach area and by 2100, multiple vulnerabilities are present for the highway and culverts throughout the region.

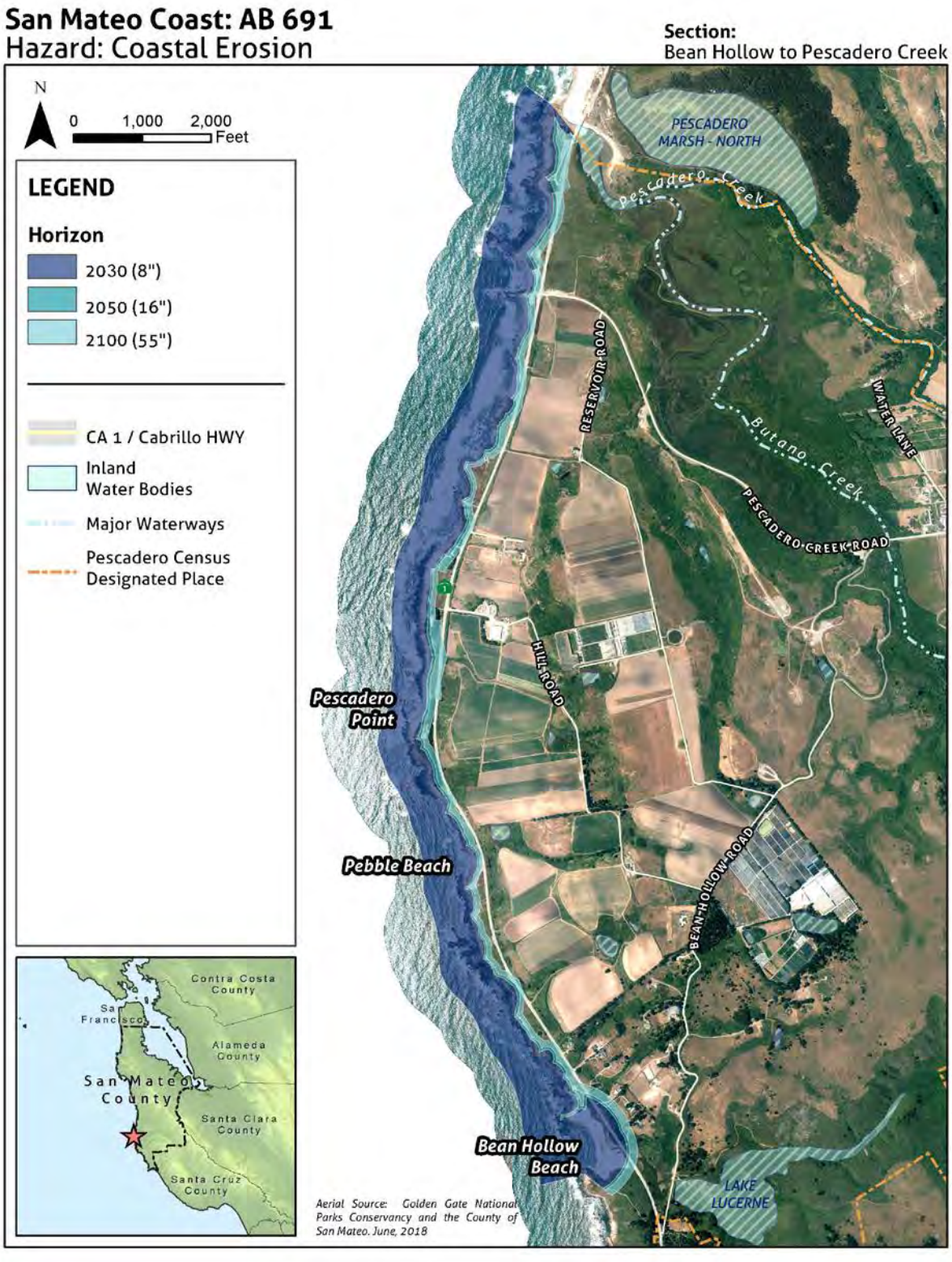

Figure 6. Polygons overlaid on erosion and SLR vulnerabilities at the time periods investigated.

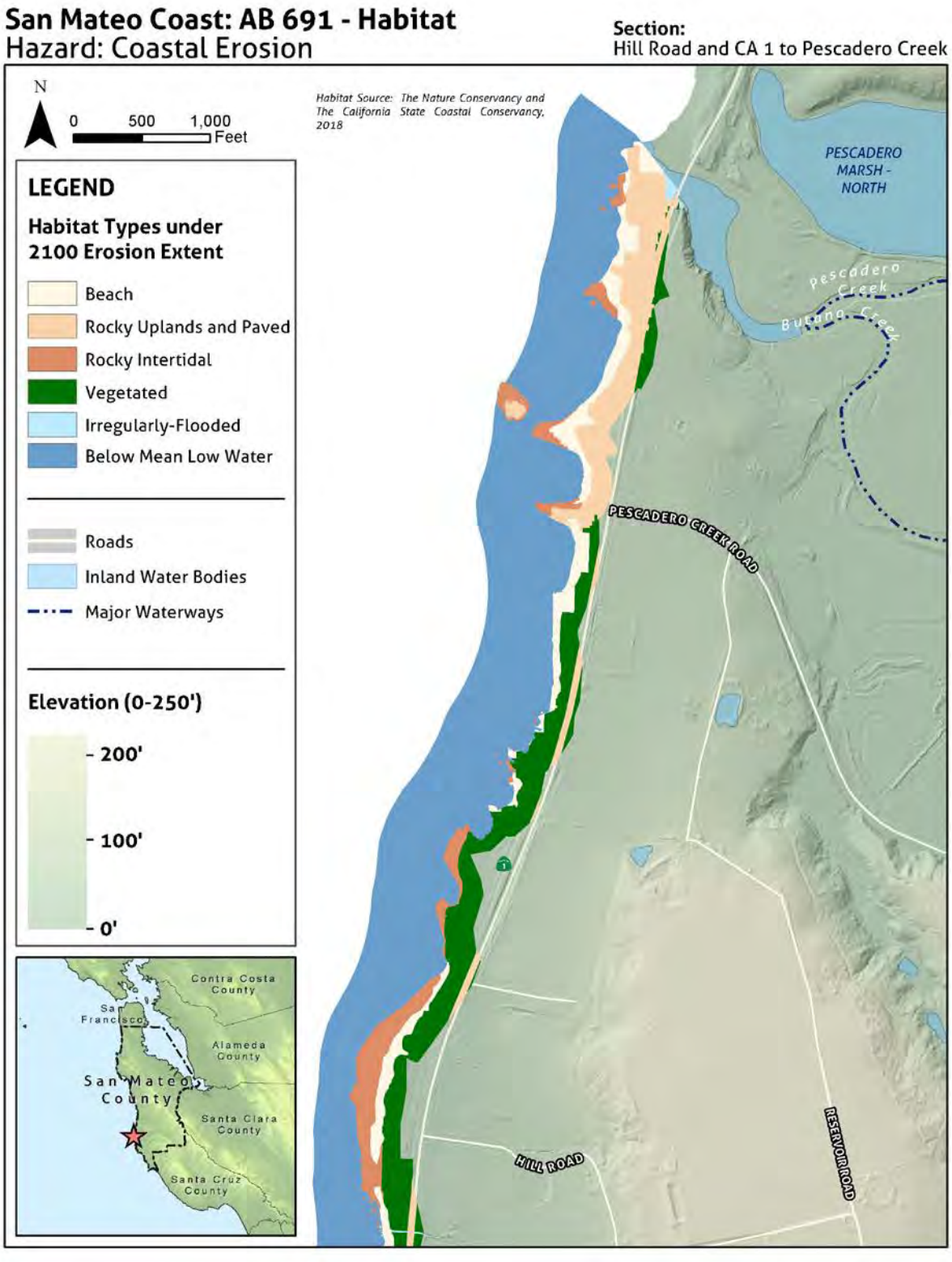

Figure 7. North region showing habitat vulnerabilities in 2100.

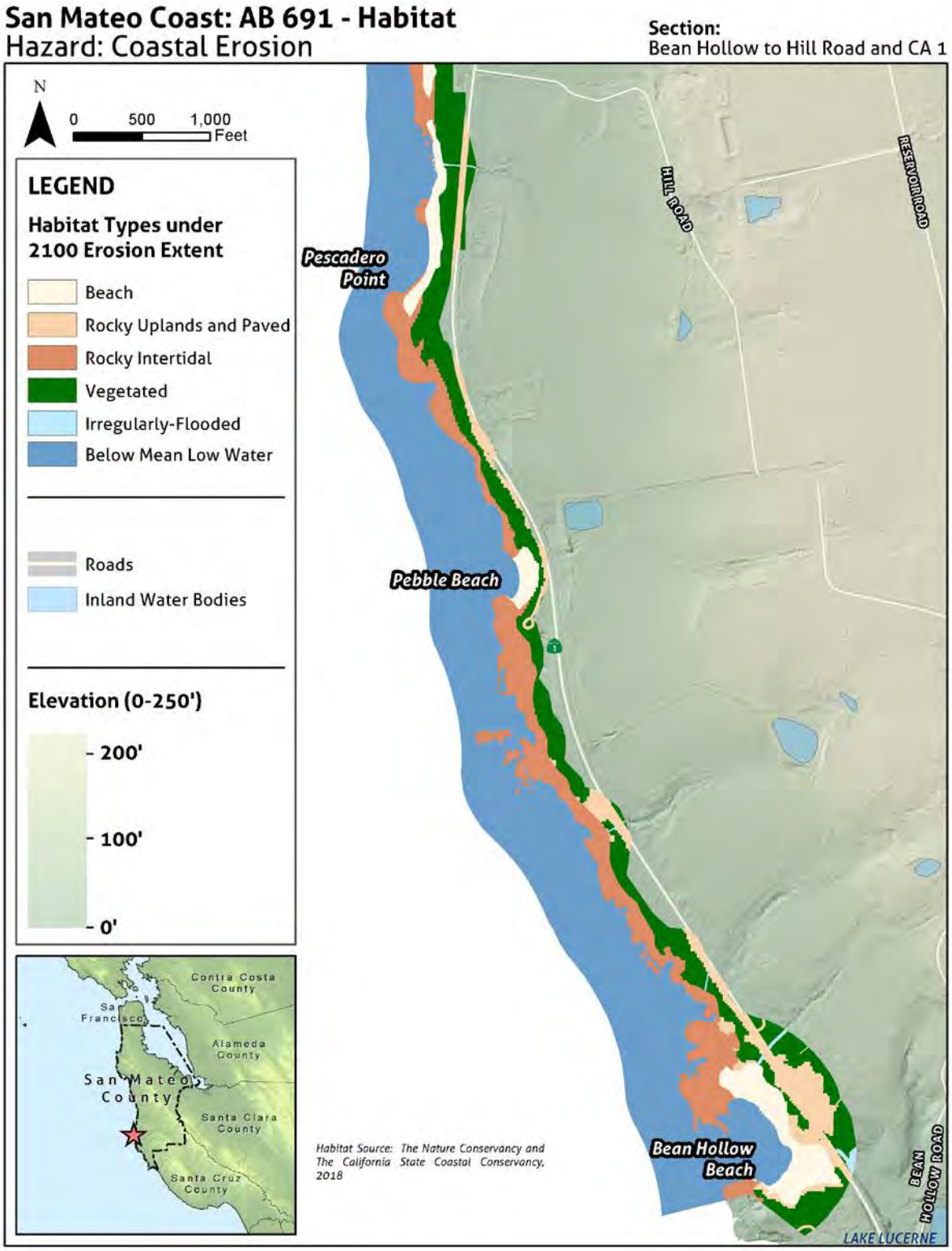

Figure 8. South region showing habitat vulnerabilities in 2100.

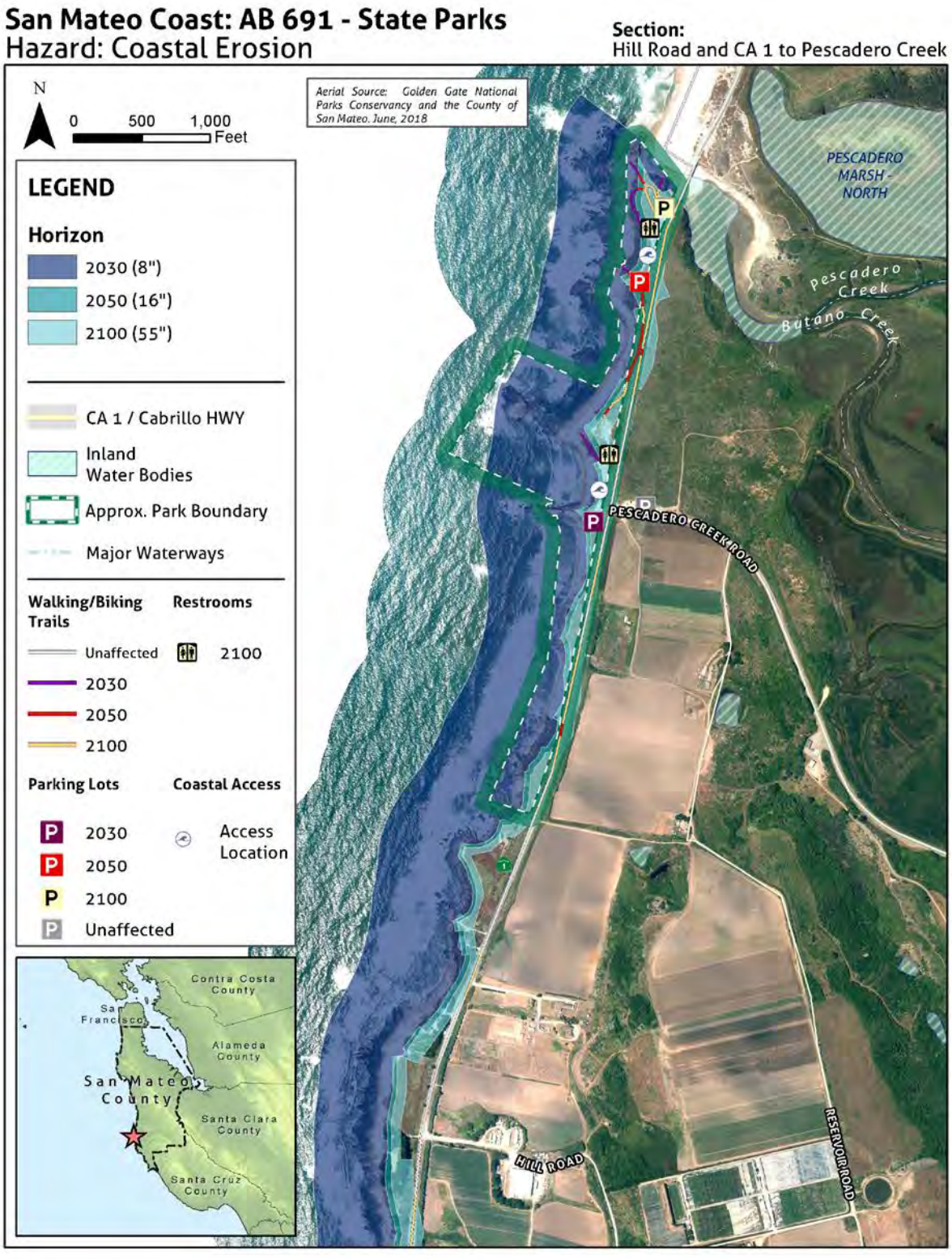

Figure 9. North region showing state park vulnerabilities in 2100.

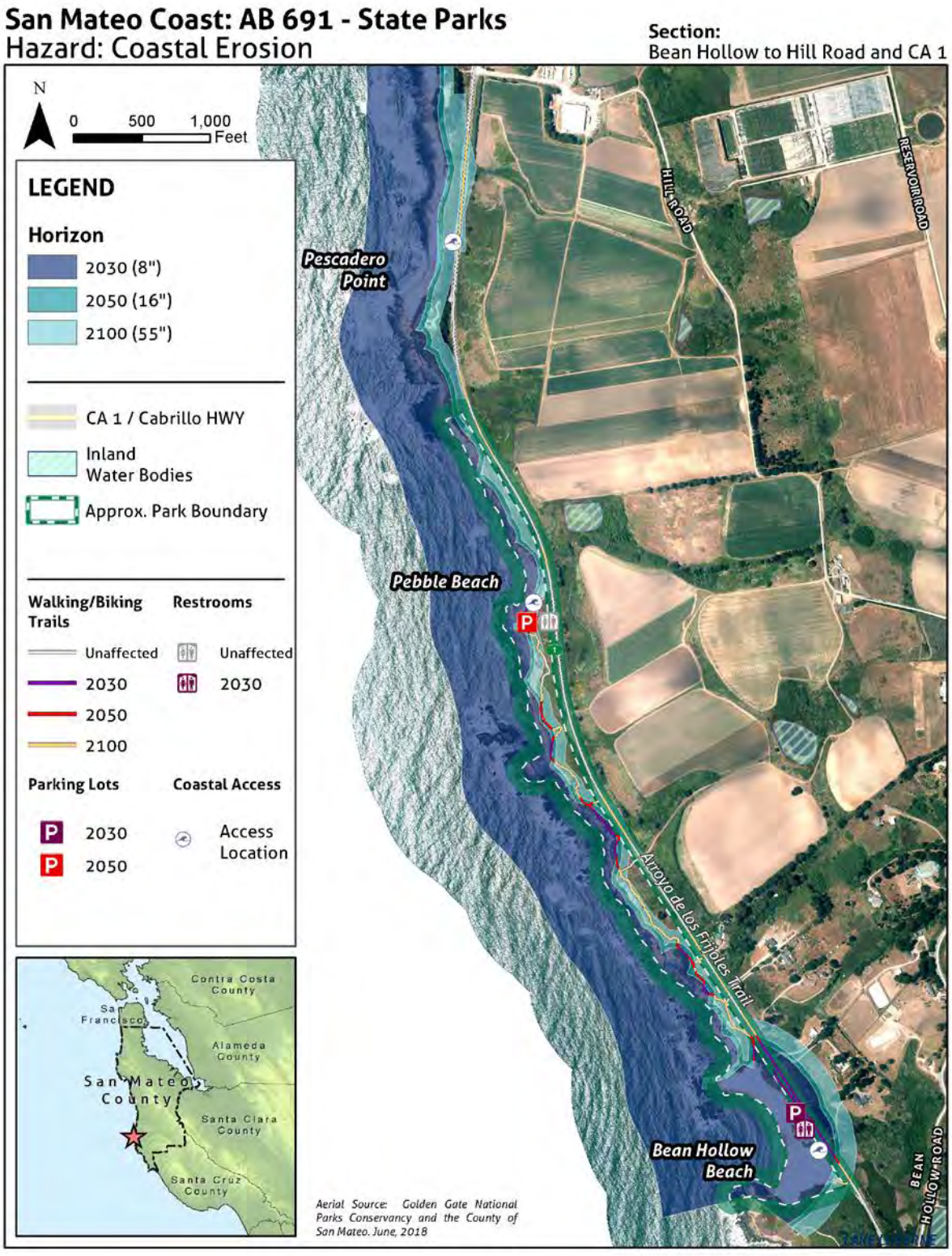

Figure 10. South region showing state park vulnerabilities in 2100.

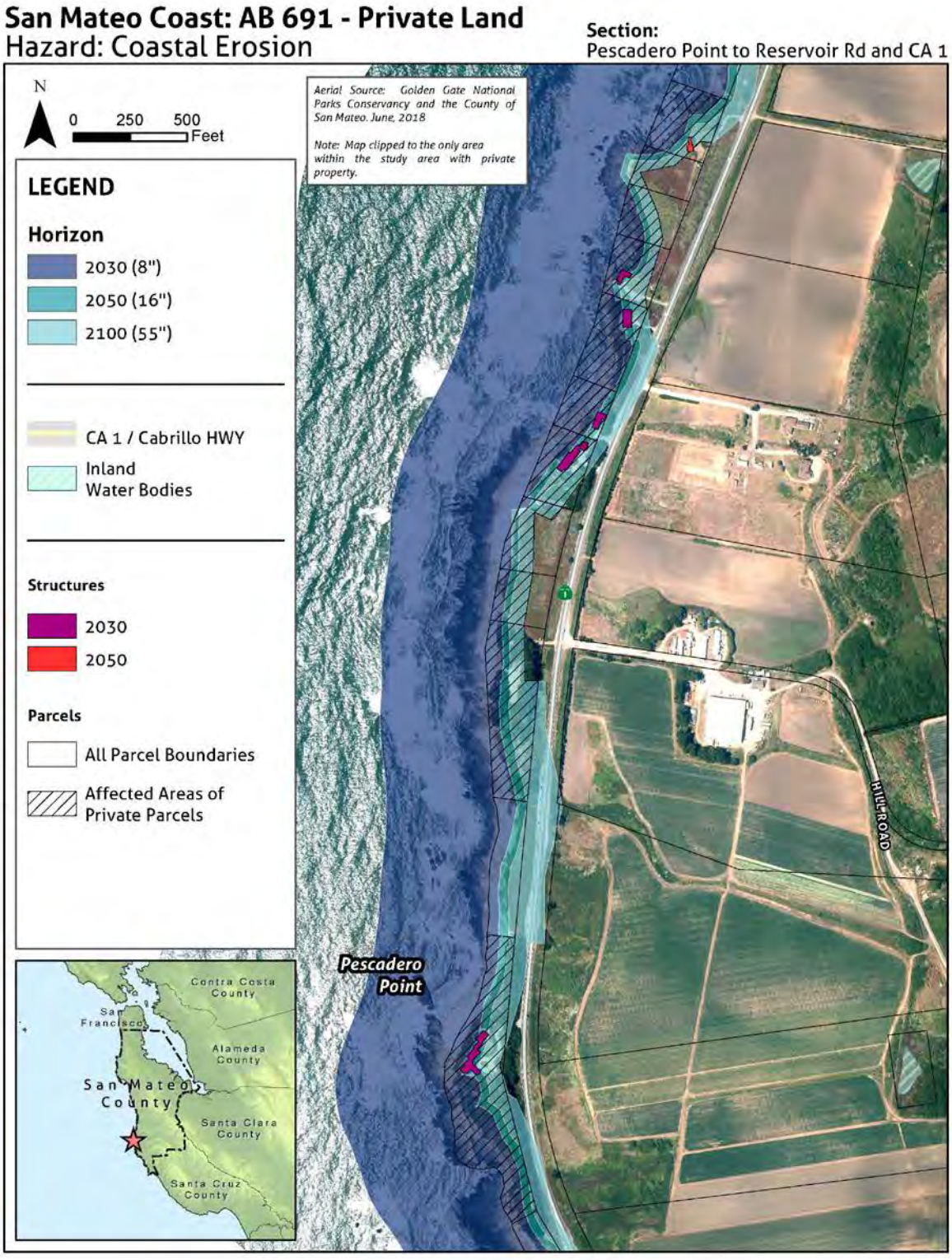

Figure 11. Cropped map showing all private parcel vulnerabilities in 2100 within the study area.

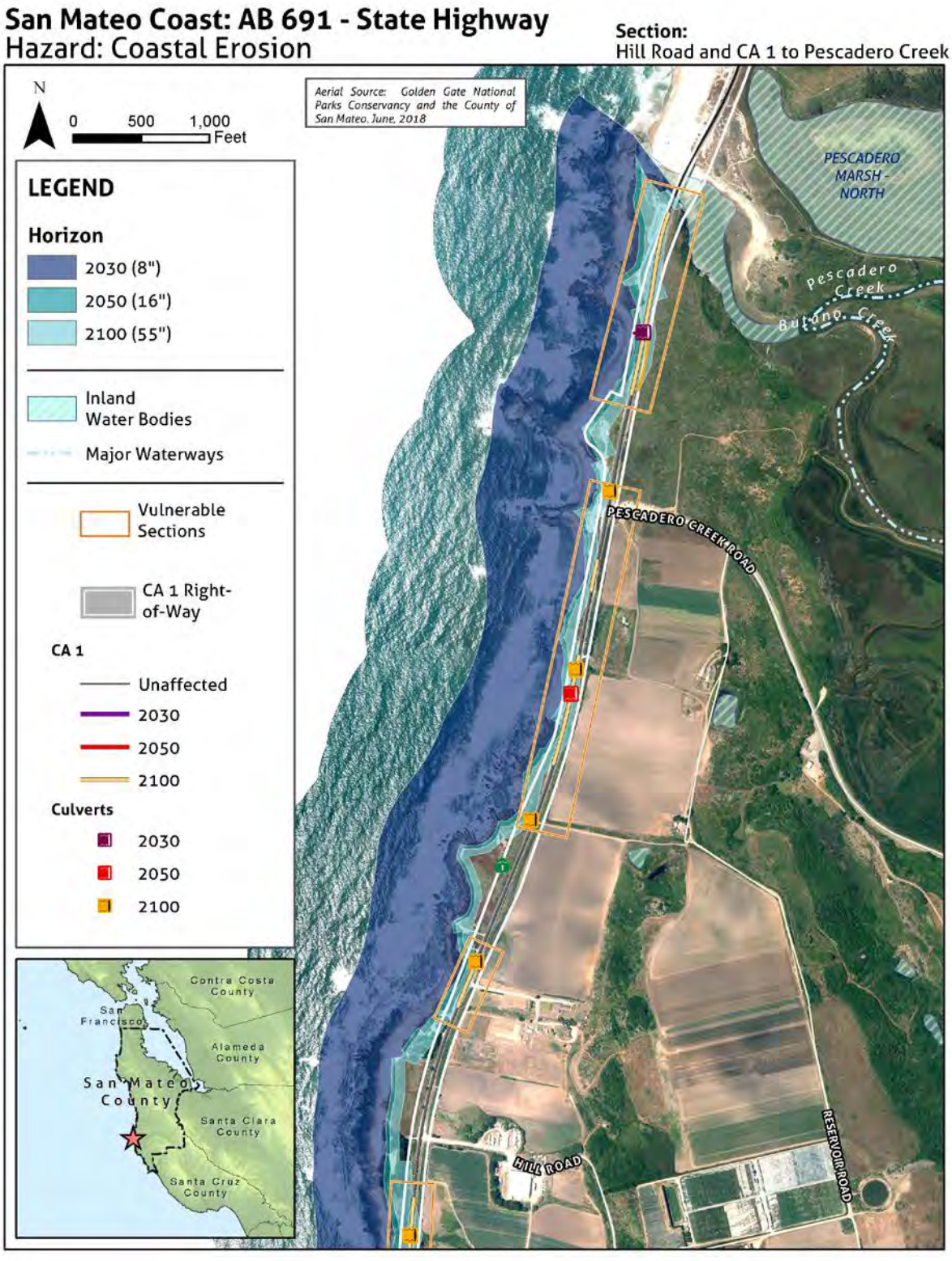

Figure 12. North region showing state highway and culvert vulnerabilities in 2100.

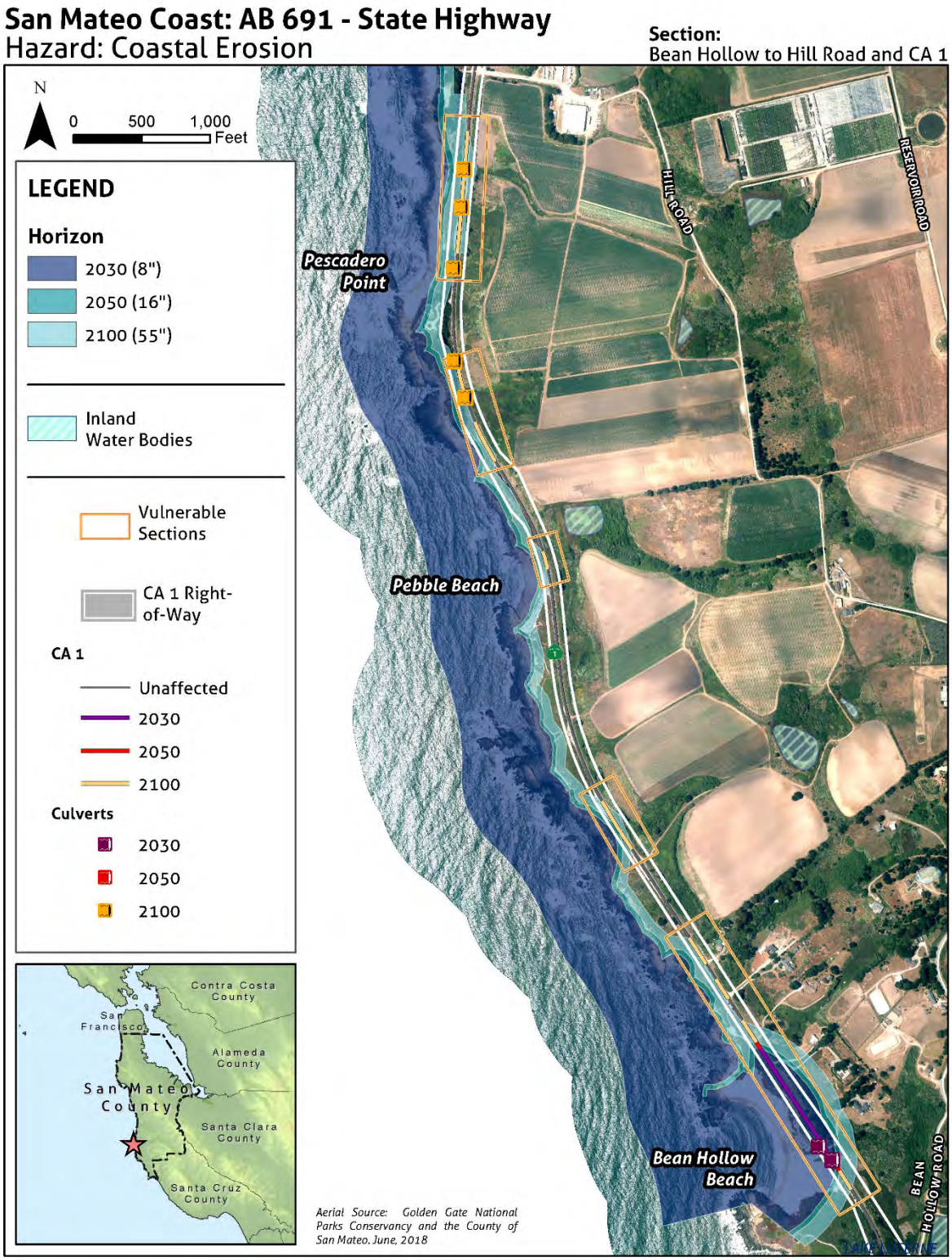

Figure 13. South region showing state highway and culvert vulnerabilities in 2100.

3 FINANCIAL ASSESSMENT

To better quantify the vulnerabilities identified, this section provides estimates of the replacement and repair costs of properties and land at risk due to SLR, coastal erosion, and tidal inundation. The economic analysis provided for this study is based on spatial quantification of the areas identified in the mapping. All of the land, structures, and infrastructure analyzed can be overlaid with the SLR and erosion hazard zones to quantitatively assess impacts from SLR flooding, inundation, and erosion.

The economic analysis used San Mateo County Assessor's parcel data as well as other available geospatial data with information on roadways, access, and various habitat types. The geospatial data were used to identify property boundaries, location, and size of the parcel, along with other information such as zoning and current use. The use of geospatial analysis also allows for the analysis of the length and width of beaches, coastal trails, access points, and other pertinent information about coastal recreation. All of the land use, structures, and infrastructure assessed were overlaid with the hazard zones to determine impacts from coastal flooding, tidal inundation, and coastal erosion.

3.1 REPLACEMENT AND REPAIR COSTS

Most of the land use in areas vulnerable to SLR and erosion is zoned as: State Park land, residential land (occupied or vacant), and agricultural/multiuse land. The market value of the land will depend upon how it is zoned. However, projecting to 2100, it is assumed that zoning may change over time, particularly as adaptation occurs. Consequently, this study assumed that all land was equally valuable. To estimate the market rate of this land, the study examined the county level parcel data within the impacted area. For those parcels having had an assessed value (i.e., private property), the average assessed rate is $212,631 per structure. However, in California, assessed value is often significantly lower than market value for a variety of reasons, in particular Proposition 13, which limits any increase in assessed value to 2% a year. For additional data, this analysis examined recent sales prices through Zillow and estimated a market value of $400,000 per acre. The market value of the land also depends critically upon how it is zoned and also market expectations about future zoning and climate change risk. Given the limited scope and budget, this analysis applied a market value of $400,000 per acre for all property. However, the non-market benefits of this property may far exceed $400,000 per acre.

The economic analysis below estimates erosion losses under three SLR time scenarios (0.7 ft, 1.3 ft, and 4.6 ft corresponding to 2030, 2050, and 2100; Table 2). Table 3 characterizes and values land use and structures potentially at risk to coastal erosion in the study area, including 207 acres of land (approximately 26 acres of which are multiuse land and 34 acres of agricultural

land), six residential structures, and four State Park comfort stations (i.e., restrooms). While only a fraction of these assets are under SLR risk in the intertidal zone, the total assets bounding the intertidal zones are included as potentially at risk. Residential property was valued based on an average from assessed data, but actual costs may be underestimated. Cost estimates for restroom replacement were difficult to acquire, but this study employed an estimate of $100,000 per unit. These facilities all use chemical toilets; the State could save money if it used portable restrooms instead, although that may detract from long-term park goals.

Table 3. Total Value of Land and Assets Within the Study Area

Type of Asset	No. of Acres	Value per Acre	No. of Units	Value per Unit	Total Value
State Park Land	76.84	$400,000			$30,736,209
State Park Comfort Stations			3	$100,000	$300,000
Residential/Vacant Land	44.33	$400,000			$17,731,328
Residential Structures			6	$200,000	$1,200,000
Agricultural /Multiuse Land	85.73	$400,000			$24,114,951
Highways/Streets Land	25.44 (4.3 miles of CA-1)	$400,000			$10,176,535
Total	**206.90 acres**				**$84,259,023**

Table 4 provides estimates for total value of land and structures today (2019) and the estimated cumulative losses due to SLR and erosion for three future time periods/SLR scenarios: 2030, 2050, and 2100. All reported values are in 2019 dollars; no future discount rates have been applied (as would be necessary in a benefit/cost analysis).

As indicated in Table 4, losses to State Park land could be significant in the future, with $20 million (~50 acres) of State Park land potentially eroded by 2030, as well as one State Park's comfort station (estimated value $100,000). By 2050, further erosion of State Park land could lead to financial losses of $23.8 million (~ 60 acres), and by 2100, there could be $28.7 million in erosion losses with approximately 70 acres of land eroding along with three additional comfort stations.

By 2030, approximately 10 acres of residential/vacant land worth just more than $4 million could also be lost along with five residential structures valued at $1 million. By 2050, there could be a total loss of 14 acres ($5.8 million) of residential/vacant land, and one additional residential structure ($200,000). By 2100, 23 acres of residential land valued at $9.3 million

could be lost. By 2100, a small amount of agricultural and multiuse land ($19,486) and approximately three-quarters of an acre of land associated with Highway 1 ($309,526) could also be lost.

Table 4. Cumulative Financial Losses Associated with Three SLR Scenarios Relative to Total Current Value of Land and Structures in the Study Area

Asset Type	Current Value at Risk	Loss by 2030	Loss by 2050	Loss by 2100
State Park Land	$30,736,209	$20,183,789	$23,812,101	$28,694,991
State Park Comfort Stations	$300,000	$100,000	$100,000	$300,000
Residential/Vacant Land	$17,731,328	$4,092,169	$5,790,298	$9,283,340
Residential Structures	$1,200,000	$1,000,000	$1,200,000	$1,200,000
Agricultural /Multiuse Land	$24,114,951	$0	$0	$19,486
Highways/Streets Land	$10,176,535	$0	$0	$309,526
Total	$84,259,023	$25,375,958	$30,902,399	$39,807,343

3.2 NON-MARKET LOSS VALUE

In this section, some potential non-market losses due to SLR are estimated for recreational activities, as well as public trust resources that could be impacted by future sea levels and shoreline conditions. Economists classify recreation and ecosystem services as non-market. The non-market value cannot be determined from a market price, which is for services and goods that can be bought and sold. The valuation of ecosystem services is complex and will be addressed in more detail in the larger South County SLR Risks and Solutions study.

To determine the non-market values, economists suggest using the concept of willingness to pay (WTP), which is defined as the value of an individually consumed non-market good as the amount that an individual consumer would be willing to pay to consume the good or use the service (e.g., see Raheem et al. 2009 and Barbier et al. 2011). The analysis below relies on numerous studies of non-market value discussed below.

In California, beaches below the high water line are in public trust, and there is no market value for them. The recreational value of beaches in California has been studied extensively. This non-market value is typically measured in terms of WTP for a trip to the beach. Economists can measure WTP by estimating the travel cost to and from the site (revealed preference) or by

asking visitors how much they would be willing to pay (stated choice). Most of the studies utilized here and cited in Table 5 are travel cost models (e.g., see Parsons 2003). This WTP is typically expressed as a "day-use value."

Table 5. Estimates of Day-Use Value for California Beaches

Region	Counties	Usage Level*	Studies	Consumer Surplus Values ($2018)
Southern	San Diego Orange Los Angeles Ventura Santa Barbara	High	12	$15.66[a]
				$22.63[b]
				$25.39[c]
				$29.06[b]
				$31.81[b]
				$35.24[a]
				$36.42[d]
				$39.88[b]
				$47.31[e]
				$99.67[a]
				$109.98[f]
				$116.67[f]
		Low	0	
Central	San Luis Obispo Monterey Santa Cruz San Mateo San Francisco	High	1	$50.29[f]
		Low	0	
CA Average		N/A		$50.13
Midpoint Kildow & Pendleton (2006)		N/A		$41.87[g]

[a] Leeworthy and Wiley (1993)
[b] King (2001)—midpoint between two methods
[c] Chapman and Hanemann (2001)—corrected for inflation using the Consumer Price Index
[d] Lew and Larson (2005)
[e] Lew (2002)
[f] Leeworthy (1995)
[g] Midpoint of Pendleton and Kildow (2006) adjusted for inflation ($2015)

As indicated in Table 5, estimates of day-use value vary by study and by beach with valuations ranging from $15 to $116 per consumer surplus per day (2019 dollars), with an average valuation of $50.13 (2019 dollars). However, following Kildow and Pendleton (2006) this study used the median value of $41.87 per visitor per day (in 2015 dollars) rounded to $40 per person per day. This method is also consistent with a recent California Coastal Commission decision in Solana Beach (CCC 2017). In addition, the study area provides many other ecosystem services

and public trust resources (sensitive natural and cultural resources) beyond beach recreation, which have not been estimated due to budget limitations. Future studies should account for all additional ecosystem values in addition to recreation.

This study relied on attendance estimates for Bean Hollow State Beach and for Pescadero State Beach, provided by State Parks, which encompasses much of the beach in the study area. The study area comprises approximately half of Pescadero State Beach area, so our analysis applied 50% of Pescadero attendance to this study. The study area also includes Pebble Beach, a small pocket beach north of Bean Hollow; however, given the limited availability of parking, the estimates for Bean Hollow and Pescadero State Beach are reasonable. One might also assume that attendance would grow over time (e.g., along with population growth). However, given the projected erosion in the study area, this analysis focused on current attendance.

Table 6 summarizes State Park's attendance estimates at Bean Hollow and Pescadero State Beaches for the past five years. For most years, the estimated study area attendance was in a relatively small range of 220,500 to 236,000 visitors per year; however, 2015/2016 was an outlier, with 391,203 visitors estimated. Given the relative consistency of other years, this study chose to use the median attendance for the last five years (228,820) rather than the average (260,053), which is heavily skewed by one year. Applying a non-market value of $40 per visitor per day yields a total recreational (non-market) value of $9.2 million (Table 6 below).

Table 6. California State Parks Annual Attendance Estimates

Year	Bean Hollow Attendance	Pescadero Attendance	50% Pescadero Attendance	Est. Study Area Attendance	Non Market Value
2016/17	115,123	227,393	113,697	228,820	$9,152,780
2015/16	220,141	342,123	171,062	391,203	$15,648,10
2014/15	109,044	223,023	111,512	220,556	$8,822,220
2013/14	127,737	191,753	95,877	223,614	$8,944,540
2012/13	121,329	229,477	114,739	236,068	$9,442,700
Average 2012-2017	138,675	242,754	121,377	260,052	$10,402,068
Median 2012-2017	121,329	227,393	113,697	228,820	$9,152,780

Because the potential impacts to recreation vary significantly by the type of recreation, this analysis breaks down the visitor's primary recreational activity into several different types depicted in Table 7. These estimates of estimated attendance percentage are based on conversations with park rangers, our own experiences, and other local officials and only represent approximate usage, with a wide error band. The non-market value per year for each recreational activity is based on the estimated number of visitors and the value of $40 per visitor per day.

Table 7. Annual Non-market Value of Various Activities

Category	Estimated Percentage of Users by Type	Estimated Annual Use	Non-market Value per Year
Beach Recreation	50%	114,410	$4,576,390
Viewing Scenery	10%	22,882	$915,278
Kayaking	5%	11,441	$457,639
Fishing	5%	11,441	$457,639
Hiking	20%	45,764	$1,830,556
Tide-Pooling	10%	22,882	$915,278
Total	100%	228,820	$9,152,780

Analysis of beach erosion indicates that most of the beach in the study area (94%) is vulnerable to seasonal erosion by 2030, and all of the beach has significant vulnerability for permanent loss by 2100. Similarly 96% of all rocky intertidal habitat will be submerged or inaccessible by 2030 due to rising tides. Consequently, one can expect a significant reduction in both beach-going and tide-pooling activities. On the other hand, the parks are also used for hiking along the cliff top trails. Although our analysis indicates that approximately half of the existing trails could be lost by 2100, we assume that these (relatively simple dirt) trails will be replaced on non-eroded access ways, so that hiking may not diminish. However, there may be challenges associated with moving trails inland due to land ownership, permitting, and access. In addition, the quality of the experience may diminish because the current trails take visitors through coastal bluff vegetation and wildflowers. The experience of hiking without these features will likely be less enjoyable, though this study did not attempt to estimate this loss. Similarly, although the dry beach could disappear, our analysis assumes that access to the shore will be maintained for hiking and that fishing and viewing the coast can still occur.

Table 8 estimates the annual non-market value today and at the three SLR horizons based on the type of recreation from the assumptions above. The non-market value loss due to SLR was estimated by applying a capacity constraint such that the number of visitors decrease as the beach width narrows and access to beach recreation activities diminishes. By 2030, beach recreation could be diminished substantially due to loss of beach, reducing the non-market value from $4.5 million to $1.8 million; similarly tide-pooling could also be reduced from $915,000 to $40,000 by 2030. Tide-pooling is an important activity in this area. The best current geomorphological and ecological data indicate that the rocky-intertidal habitat necessary for tide-pooling will experience significant inundation by 2050. However, it is possible that new habitat eroded from formerly upland areas would migrate over time as long-term coastal erosion continues. This analysis assumes that this habitat will disappear, but efforts to allow rocky intertidal habitat to "retreat" would maintain significant non-market value. Our

estimates indicate close to a half million dollars ($500,000) a year in non-market value is currently generated in the study area from tide-pooling.

Our analysis assumes that hiking, viewing the coastal scenery, kayaking, and fishing will be maintained, although this requires that access to the coast through parking lots and hiking trails (especially for kayaking) be maintained over time. With that assumption, our estimates indicate that, due to loss of areas from SLR, the annual non-market value will substantially decrease over time. By 2100, approximately $5 million per year will be lost in non-market value based on the current annual non-market value due to beach recreation and tide-pooling losses.

Table 8. Estimates of Annual Non-market Value[4]

Category	Current Non-market Value per Year	2030 Estimated Non-market Value	2050 Estimated Non-market Value	2100 Estimated Non-market Value
Beach Recreation	$4,576,390	$1,830,556	$915,278	$457,639
Viewing Scenery	$915,278	$915,278	$915,278	$915,278
Kayaking	$457,639	$457,639	$457,639	$457,639
Fishing	$457,639	$457,639	$457,639	$457,639
Hiking	$1,830,556	$1,830,556	$1,830,556	$1,830,556
Tide-Pooling	$915,278	$40,437	$5,947	$0
Total Non-market Value	**$9,152,780**	**$5,532,105**	**$4,582,337**	**$4,118,751**
Annual Loss in Non-market Value from Current Value		**$3,620,675**	**$4,570,443**	**$5,034,029**

[4] The estimated future non-market value for recreational activities assumes that the reduction in the number of visitors for recreational activity will be proportional to the loss of area. For instance, beach recreation non-market value reduction is proportional to the decrease in beach area with SLR.

4 ADAPTATION AND MITIGATION STRATEGIES

While a more in depth analysis of adaptation options will be developed through a stakeholder driven process with the larger South Coast SLR Risks and Solutions study, the initial recommendations from the study identify several adaptation strategies. In particular, a few sections of Highway 1 are subject to erosion and could require armoring. The cost of armoring (rock revetment) is estimated for each time period. In addition, this study assumes that parking lot size and comfort stations will be maintained in new locations at their present capacity. The total costs of these adaptations are estimated to be $7.3 million in 2030, $18.8 million in 2050, and $9.3 million in 2100 (Table 9). However, given the limitations of this study and the difficulty in identifying all adaptation costs, these estimates should be considered lower bounds.

Table 9. Incremental Adaptation Costs

Adaptation Measure	2030	2050	2100
Armoring	$6,602,450	$18,565,410	$8,567,510
Parking Lot	$587,325	$213,804	$412,675
Comfort Stations	$100,000	$0	$300,000
Trail/Access Realignment	Unknown	Unknown	Unknown
Total Costs	$7,289,775	$18,779,214	$9,280,185
Cumulative Costs	$7,289,775	$26,068,989	$35,349,174

Approximately half of the current hiking trail and significant coastal access could be eliminated due to erosion. This study assumes that the trail will be maintained, either informally (i.e., a dirt path) or more formally (e.g., trail markers). Similarly, the existing vertical access points will erode, but this study does not assume a cost for establishing vertical access points. The costs of these adaptations may not be negligible and depend on choices by State Parks and other stakeholders and are therefore beyond the scope of this study. The costs of replacement and maintenance of vertical access locations will be factored into the larger County vulnerability assessment. However, these expenses should be relatively small compared to the significant non-market value generated by access down the bluff to the shoreline. In particular, kayaking and fishing only require access to the shore. While a sandy beach might improve the experience, this study assumes that visitors will continue to engage in these activities as long as coastal access is maintained.

These adaptation strategies could yield significant economic benefits. Table 10 provides a qualitative summary of the adaptation costs. Armoring Highway 1 will allow visitors to reach Bean Hollow and Pescadero State Parks and allow other visitors and commuters to use Highway 1. This study also assumes that parking would be maintained, and comfort stations

would be replaced, although if attendance is reduced due to beach erosion, maintaining existing parking/facilities may be unnecessary. This study also assumes trails and access would be maintained, although we have not estimated this cost.

Table 10. Qualitative Summary of Adaptation Costs

Impact Level	Cost to Repair / Adaptation Costs	Value of Lost Use / Adaptation Benefit
Low (2030)	Some armoring required to protect Highway 1. Parking lot repairs required and one park comfort station at Bean Hollow (currently closed) will need replacement if erosion occurs. Trail and vertical access realignment required.	Significant loss in beach recreation and tide-pooling. Significant portions of State Park land lost. Five residential structures lost to erosion and significant loss of residential land.
Medium (2050)	Additional armoring to protect Highway 1 required. Parking lot repairs required due to erosion. Trail and vertical access realignment required.	More loss of State Park land and already diminished beach recreation and tide-pooling disappear. One additional residential structure and significant amount of private property subject to erosion.
High (2100)	Additional armoring to protect Highway 1 required. Parking lot repairs required and three additional comfort stations lost if erosion occurs. Trail and vertical access realignment required.	More loss of State Park land. Additional residential land lost. Small loss of agricultural and multiuse land along with road right-of-way. Protection of Highway 1 in areas will eliminate some parking lot and comfort station repair needs.

Other potential adaptation strategies may be available that are not evaluated as a part of this assessment. A habitat evolution model was not included in the analysis and that it is likely that intertidal habitats will migrate as erosion occurs inland. The future habitat composition and adaptation strategies that can enhance habitat evolution will be further considered in the larger South Coast SLR Risks and Solutions study. From a broader economic perspective, maintaining Highway 1 is *critical* for access to these beaches and access for many other uses including commuting and the present adaptation strategy assumes armoring of the highway. Realignment of the Highway 1 corridor to accommodate SLR vulnerabilities is a potential strategy that would eliminate the need for armoring; however, evaluation of realignment is beyond the scope of the present assessment, but could be explored in the broader South Coast SLR Risks and Solutions study.

One other important finding from this analysis is that the anticipated inundation and erosion of Bean Hollow, Pebble, and South Pescadero beaches could lead to a significant loss in non-market value, close to $2 million a year by 2030 and close to $3 million by 2100. Periodic nourishment and dune restoration plans could be developed to maintain valuable beaches. However, the challenges of identifying reliable sand resources and permitting an ongoing

nourishment program present significant project hurdles. It is anticipated that expense and likely interference with ecosystem function in the area may eliminate nourishment as an option. The Surfers Beach Sand Replacement Project in San Mateo County provides a proxy for the challenges associated with nourishment in the region. However, if beach width could be maintained in an ecologically sound fashion, the (non-market) benefits would be substantial—$2 million per year by 2030. In addition, maintaining access to the shoreline is also critical for the preservation of non-market value.

The adaptation portion of this study is based on currently available data, so the analysis and recommendations herein should be considered preliminary, and could change with future work associated with the larger regional County study. Engineering estimates are approximations and are based on experience of the economics team.

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