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FINAL

City of Pacific Grove Climate Change Vulnerability Assessment

PREPARED FOR

City of Pacific Grove

January 12, 2015

EMC PLANNING GROUP INC.
A LAND USE PLANNING & DESIGN FIRM

301 Lighthouse Avenue Suite C Monterey California 93940 Tel 831·649·1799 Fax 831·649·8399
www.emcplanning.com

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City of Pacific Grove
Anastazia Aziz, AICP, Senior Planner
Community & Economic Development Department
300 Forest Ave, 2nd Floor
Pacific Grove, CA 93950
Tel 831.648.3192

PREPARED BY

EMC Planning Group Inc.
301 Lighthouse Avenue, Suite C
Monterey, CA 93940
Tel 831.649.1799
Fax 831.649.8399
Polaris Kinison Brown
kinisonbrown@emcplanning.com
www.emcplanning.com

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TABLE OF CONTENTS

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 OBJECTIVE

The City of Pacific Grove ("city") is in the process of completing its Local Coastal Program (LCP). LCPs are basic planning tools used by local governments to guide development in the coastal zone, in partnership with the California Coastal Commission ("coastal commission"). The land use and coastal resources policies in the LCP are useful for examining the potential impacts of climate change in the city's coastal zone. The *2009 California Climate Adaptation Strategy* (California Natural Resources Agency 2009) suggests that all LCPs account for the impacts of climate change.

The types and extent of the changes as well as what climate change will actually mean for local communities requires an understanding of the current (and future) condition of the potentially affected local systems. To begin this process, a community must first assess its vulnerability to climate change.

This *City of Pacific Grove Climate Change Vulnerability Assessment* ("vulnerability assessment" or "assessment") provides an evaluation of potential significant impacts of climate change for the city's coastal zone with an emphasis on how anticipated climate change may affect people, resources, and infrastructure along the coast. Pacific Grove has approximately 458 acres of land within the coastal zone. The extent of the city's coastal zone is shown on Figure 1, Pacific Grove Coastal Zone.

The intent of this assessment is to inform and support the city's LCP, specifically the LCP policies related to climate change adaptation and planning.

1.2 CLIMATE CHANGE, VULNERABILITY ASSESSMENT, AND KEY CONCEPTS

1.2.1 Climate Change

According to the United States Environmental Protection Agency (EPA), the earth's average temperature has risen by 1.4 degrees Fahrenheit over the past century, and is projected to rise another two to 11.5 degrees Fahrenheit over the next hundred years (EPA 2014). Even relatively small increases in global temperature can translate to large and potentially dangerous changes in climate and weather (climate change). The specific changes are difficult to predict, but certain effects seem likely: warmer temperatures on average, although some regions may become cooler; greater precipitation overall, although some areas may become dryer; and rising sea levels (NASA 2014). Each of these changes can have profound ramifications to natural and social systems.

The coastal commission has identified several areas of concern for climate change specific to the coastal zone including: storms and flooding; coastal erosion and loss of sandy beaches; coastal habitats; marine ecosystems; land use planning decisions; and shoreline access (California Coastal Commission 2014).

1.2.2 Vulnerability Assessment

Vulnerability assessment is the analysis of the expected impacts, risks and the adaptive capacity of a region or sector to the effects of climate change (Climate - Adapt 2014). Climate change vulnerability assessment encompasses measurement of the potential harm caused by events resulting from climate change and an assessment of the region's or sector's ability to adapt.

In the case of climate change projections, considerable complexities arise in the calculation of the risk. These are associated with assigning probability to certain climate change scenarios and with making assumptions about the resulting impacts to communities.

Given the difficulty in applying vulnerability and risk assessments, the intent of this report is to provide a broad overview of climate change vulnerability and potential impacts that may be considered in the development of coastal policy. A focus on risk, rather than certainty, supports decision-making in the context of climate change (IPCC 2014). This climate change vulnerability assessment is not intended to provide site specific impact data, or certain date of future impacts.

1.2.3 Key Concepts

The following is a list of key terms related to climate change vulnerability assessment as used in this report:

Adaptation: Adjustments one might make in a system to prepare for and deal with the impacts of climate change.

Adaptive capacity: A community's current ability to address the projected climate change impacts.

Climate change impact: An effect of climate change on structures, functions, or populations (impacts).

Exposure: The nature and degree of the climate change effects a community will experience (e.g. higher temperatures, wetter weather, sea level rise, etc.).

Resilience: The ability to bounce back faster and better from an extreme event, or deal with relative ease with changing conditions.

Risk and onset: An adjustment of potential impacts based on uncertainty, timing, and adaptive capacity.

Sensitivity: Key community structures, functions, and populations that are potentially susceptible to each climate change exposure.

Vulnerability: A system's susceptibility to harm or change.

1.3 METHODOLOGY

1.3.1 Climate Change Vulnerability Assessment Process

The *California Adaptation Planning Guide* (APG) (2012), developed by the California Emergency Management Agency and California Natural Resources Agency is a set of four complementary documents that provides guidance to support communities in addressing the unavoidable consequences of climate change. The primary document entitled *APG: Planning for Adaptive Communities* provides a step-by-step process for local and regional climate vulnerability assessments. A companion document entitled *APG: Defining Local and Regional Impacts*, provides a more in-depth understanding of how climate change can affect a community. This report follows the methodology provided by the APG (specifically, methodology presented in *APG: Planning for Adaptive Communities* and *APG: Defining Local and Regional Impacts*) to provide a climate vulnerability assessment of the city's coastal zone.

As identified in the APG, vulnerability assessment involves the following five steps:

1. Exposure: What climate change effects will a community experience?
2. Sensitivity: What aspects of a community (people, structures, and functions) will be affected?
3. Potential Impacts: How will climate change affect the points of sensitivity?
4. Adaptive Capacity: What is currently being done to address the impacts?
5. Risk and Onset: How likely are the impacts and how quickly will they occur?

For the City of Pacific Grove, each of the five steps identified above are used to evaluate vulnerability for the following community sectors: public health and safety; recreational resources and access; water management; biodiversity and habitat; and coastal development and infrastructure. It is recognized that these sectors overlap and interact. The separating of impacts into sectors is simply a way of organizing the planning effort.

1.3.2 Data Used

Based on the APG's identification how California will be affected by climate change (California Emergency Management Agency and California Natural Resources Agency 2012b,page 3), potential climate changes that may affect Pacific Grove's coastal zone include increases in temperature, shifts in precipitation, higher sea level, severe storms, and ocean acidification. Although a secondary impact of climate change, Pacific Grove's coastal zone is also at increased risk of exposure to wildfire.

The APG identifies three types of information required for conducting climate adaptation planning (California Emergency Management Agency and California Natural Resources Agency 2012b, page 8):

- Information from the web-based Cal-Adapt tool (cal-adapt.org) that shows the type, magnitude, and onset of various effects of climate change that a community will experience (e.g., the extent of coastal inundation from sea-level rise expected by 2050).

- Information from local agencies on the types of assets, resources, and populations that will be sensitive to various climate change exposures (e.g., the location of infrastructure in the coastal zone or the types of people in the community prone to heat stress).

- Information from local agencies on their current ability to deal with the impacts of climate change (e.g., firefighting capacity to handle anticipated future changes in wildfire regimes).

Consistent with APG recommendations, for this vulnerability assessment, as available, Cal-Adapt (http://cal-adapt.org/) is utilized to identify historic conditions and model future projections (year 2050 and year 2100) for potential climate change impacts. This assessment also relies on information from the City of Pacific Grove and the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan – Final Draft* (Monterey County Hazard Mitigation Planning Team with Professional Planning Assistance from AECOM 2014) regarding assets, resources, populations and current ability to address potential impacts.

The coastal commission has released its *Draft Sea-Level Rise Policy Guidance Public Review Draft* ("Draft Sea-Level Rise Policy Guidance") (California Coastal Commission 2013) as part of a larger statewide strategy to respond to climate change and to assist in the identification of sea-level exposure and potential impacts. Appendix B of the report presents steps that may be taken to develop projections of potential hazard conditions. For sea level rise, this vulnerability assessment follows Appendix B's basic recommendations and utilizes publically available data and existing resources to complete the assessment of sea level rise.

The coastal commission's Draft Sea-Level Rise Policy Guidance suggests using the materials from the National Research Council's 2012 Report: *Sea Level Rise for the Coasts of California, Oregon and Washington: Past Present and Future* ("NRC report") as the best available science for sea-level rise changes in California. The NRC report projected that sea level may rise by as much as 140-165 centimeters (55-65 inches) in California by 2100 (California Coastal Commission 2013 page 3). However, the coastal commission has also identified that as best available information changes, readers should use their best judgment in applying this guidance for other reports.

The recently released *Monterey County Multi-Jurisdictional Hazard Mitigation Plan – Final Draft ("Multi-Jurisdictional Hazard Mitigation Plan"*) (Monterey County Hazard Mitigation Planning Team with Professional Planning Assistance from AECOM 2014) provides a current evaluation of local hazards including sea level rise.

The sea level rise data included in the Multi-Jurisdictional Hazard Mitigation Plan were created in 2013 as part of the National Oceanic and Atmospheric Administration Coastal Services Center's efforts to create mapping depicting potential sea level rise and its associated impacts on the coastal areas using Lidar derived elevation data and nationally recognized standards. Lidar (light detection and ranging) is an optical remote-sensing technique that uses laser light to densely sample the surface of the earth, producing highly accurate x,y,z measurements. The purpose of the mapping is to provide coastal managers and scientists with a preliminary look at sea level rise and coastal flooding impacts.

Based on discussions with city staff, AECOM and the coastal commission, this information was identified as the best mapping available for illustrating base sea level rise (the inundation area anticipated by a 55-inch sea level rise by the year 2100) as the information is current, consistent with NRC report projections, and is specific to the Monterey area. However, this mapping does not take into account potential compounding impacts (e.g., a 100 year flood event and sea level rise, or erosion and sea level rise). Therefore, for these assessments other mapping was needed.

Publically available mapping for identifying potential sea level rise impacts are identified in Appendix B of the Draft Sea-Level Rise Policy Guidance. Among these resources is Pacific Institute Sea Level Rise maps (California Coastal Commission 2013, Appendix B, Table 12). These maps illustrate the projected sea level rise under a moderate sea level rise scenario (consistent with the lower level 55-inch sea level rise projections identified in the NRC report) and landward extent of flooding and erosion. For flooding, the Pacific Institute maps use FEMA 100-year flood elevations, with a sea-level rise of 55 inches (year 2100) to estimate the impacts of a 100-year coastal flood with a sea-level rise. The erosion hazard zone dataset for the year 2100 represents the areas vulnerable to erosion with a sea-level rise. This dataset is a merge of the dune and bluff hazard datasets created by Philip Williams and Associates with a sea-level rise of 55 inches (year 2100).

The projections for each climate change exposure anticipated for the City of Pacific Grove based on the data sets described above are summarized in the Climate Change Exposure section below.

1.4 CLIMATE CHANGE EXPOSURE

An assessment of a community's vulnerability to climate change begins with an understanding of local exposure to direct impacts. The direct climate change impacts anticipated for Pacific Grove include increases in temperature, shifts in precipitation, higher sea level, severe storms, and ocean acidification. Although a secondary impact of climate change, Pacific Grove's coastal zone is also at increased risk of exposure to wildfire.

The projections for each of these impacts are summarized below.

1.4.1 Temperature

The average historic temperature for Pacific Grove is 56.5 degrees Fahrenheit. The projected change in annual average temperature for Pacific Grove is approximately 2.5 Fahrenheit higher by the year 2050 and between 3.1 and 5.3 degrees Fahrenheit higher by the year 2100 depending on low versus high emissions scenarios, respectively (Cal-Adapt 2014c).

The threshold for an "extreme heat day" for the City of Pacific Grove is considered to be 80 degrees Fahrenheit. The projected number of extreme heat days for the city is anticipated to sharply increase from a historical average of four days per year to potentially between 16 and 28 days per year by 2050 and potentially as many as 71 days per year by 2100 (Cal-Adapt 2014b). See Figure 2, Potential Extreme Heat Days.

There is no history of "heat waves" (extreme heat days lasting five days or more) in Pacific Grove. It is projected that due to climate change the city may experience as many as four heat waves by 2050 and six heat waves *per year* by 2100 (Cal-Adapt 2014d).

1.4.2 Precipitation/Intense Rainfall

Pacific Grove enjoys a Mediterranean-like climate that is characterized by a winter rainy season and cool dry summers. Annual precipitation is approximately 20 inches per year. The Mediterranean seasonal precipitation pattern is expected to continue, however drier winters are projected with a 10 percent decrease in total annual precipitation by 2050 and as much as a 20 percent decrease in total annual precipitation by 2100 (Cal-Adapt 2014a). Expected changes in precipitation patterns include a continued risk of intense rainfall events and associated flooding, with the occasional greater-than-historical flooding events (California Natural Resources Agency 2009).

1.4.3 Sea Level Rise

The two driving processes causing global sea level rise are thermal expansion caused by the warming of the oceans (since water expands as it warms) and the loss of land-based ice (such as glaciers and polar ice caps) due to increased melting. Coastal communities experiencing increases in mean sea level are at greater risk to the effects of coastal flood hazards as natural, protective buffers such as coastal wetlands and dunes are lost and property and infrastructure become more exposed to the frequency and severity of coastal flood and storm surge inundation (AECOM page 4-21). In the case of Pacific Grove, there are not any wetlands or dunes to speak of and the only barrier consists of the rocky shoreline, shallow beach areas, and low elevation uplands.

The *Monterey County Multi-Jurisdictional Hazard Mitigation Plan Final Draft* (September 2014) reports that Monterey County may experience an approximate five-foot rise in sea level by the year 2100 (Monterey County Hazard Mitigation Planning Team 2014, page 4-22). Figure 3, Potential Sea Level Rise, presents the potential inundation area anticipated by a 55-inch sea level rise by the year 2100.

Sea level rise has the potential to amplify the severity of episodic hazard events such as coastal flooding and long-term coastal erosion. The Pacific Institute (2009) has developed a series of coastal hazard maps for the entire coast of California, including in the vicinity of Pacific Grove. These maps illustrate the projected sea level rise and landward extent of flooding and erosion under a moderate sea level rise scenario. As shown on Figure 4, Potential Sea Level Rise and Flooding, (coastal 100-year base flood plus a 55-inch sea level rise scenario) under existing conditions, the 100-year coastal base flood would potentially extend inland approximately 100 feet in beyond the mean high tide line in the vicinity of Ocean View Boulevard; with sea level rise projections, this flood could potentially extend an additional 60 to 100 feet inland (Rincon 2014, page 4.8-8).

Higher sea levels will expose larger areas of the coast to more persistent erosional forces. It has been estimated that a 55-inch sea level rise has the potential to erode 41 square miles of California's coastline by 2100 (Monterey County Hazard Mitigation Planning Team 2014, page 4-8). Rocky cliffs and marine terraces are located along Monterey Peninsula from Pacific Grove to Carmel. Although the granite cliffs have shown very little erosion over the past several years, areas with overlying marine terraces are subject to higher erosion rates, especially during strong storm years. Coastal erosion analysis indicates that average retreat rates for marine terraces are between two to four inches a year (Monterey County Hazard Mitigation Planning Team 2014, page 4-7). The areas within the city's coastal zone anticipated to be potentially affected by coastal erosion in combination with a 55-inch sea level rise by 2100 is illustrated on Figure 5, Potential Sea Level Rise and Coastal Erosion.

Studies conducted in Hawaii determined that sea level rise can lead to increased reach of tidal surges in the event of a tsunami: "…sea level rise may cause increased wave over-topping, tsunami inundation, and hurricane storm surge with negative impacts to low-lying environments, ecosystems, and developed areas including coastal roads and communities" (University of Hawai'i at Manoa 2008). The coastal area of Pacific Grove is potentially vulnerable to tsunami as shown on Figure 6, Potential Tsunami. Although it is beyond the scope of this assessment to determine the extent of impact sea-level rise may have on a tsunami event in Pacific Grove; it is acknowledged that tsunami reach and intensity will increase with increased sea levels.

1.4.4 Severe Storms and Ocean Acidification

Ocean acidification refers to a reduction in the pH of the ocean over an extended period time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere (NOAA 2014). When CO_2 is absorbed by seawater, a series of chemical reactions occur resulting in the increased concentration of hydrogen ions. This increase causes the seawater to become more acidic and causes carbonate ions to be relatively less abundant. Carbonate ions are an important building block of structures such as sea shells and coral skeletons. Decreases in carbonate ions can make building and maintaining shells and other calcium carbonate structures difficult for calcifying organisms such as oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton.

Increase in the occurrence and intensity of severe storm events (e.g. hurricane, tornado, storm surge, etc.) and ocean acidification are direct climate change impacts, but projection data are less easily acquired (California Emergency Management Agency and California Natural Resources Agency, 2012a, page 16) and forecasts for these phenomena are not yet available on Cal-Adapt. A detailed analysis of these impacts is beyond the scope of this assessment; however, it is acknowledged that severe storms and ocean acidification are potential changes that may have an effect on populations and resources in the city's coastal zone.

1.4.5 Wildfire (secondary effect)

Secondary impacts of climate change include increased risk of wildfire. Direct climate change impacts of warmer weather combined with reduced precipitation can be expected to increase wildfire through fuel hazards and ignition risks. Figure 7, Wildfire Severity Zones, illustrates the existing wildfire risk areas within the city's coastal zone. As shown on Figure 7, the areas with the highest risk of wildfire are located in the inland central portion of the city.

1.5 ORGANIZATION OF THE REPORT

1.5.1 Report Organization

This report is organized as follows:

Section 1.0 Introduction

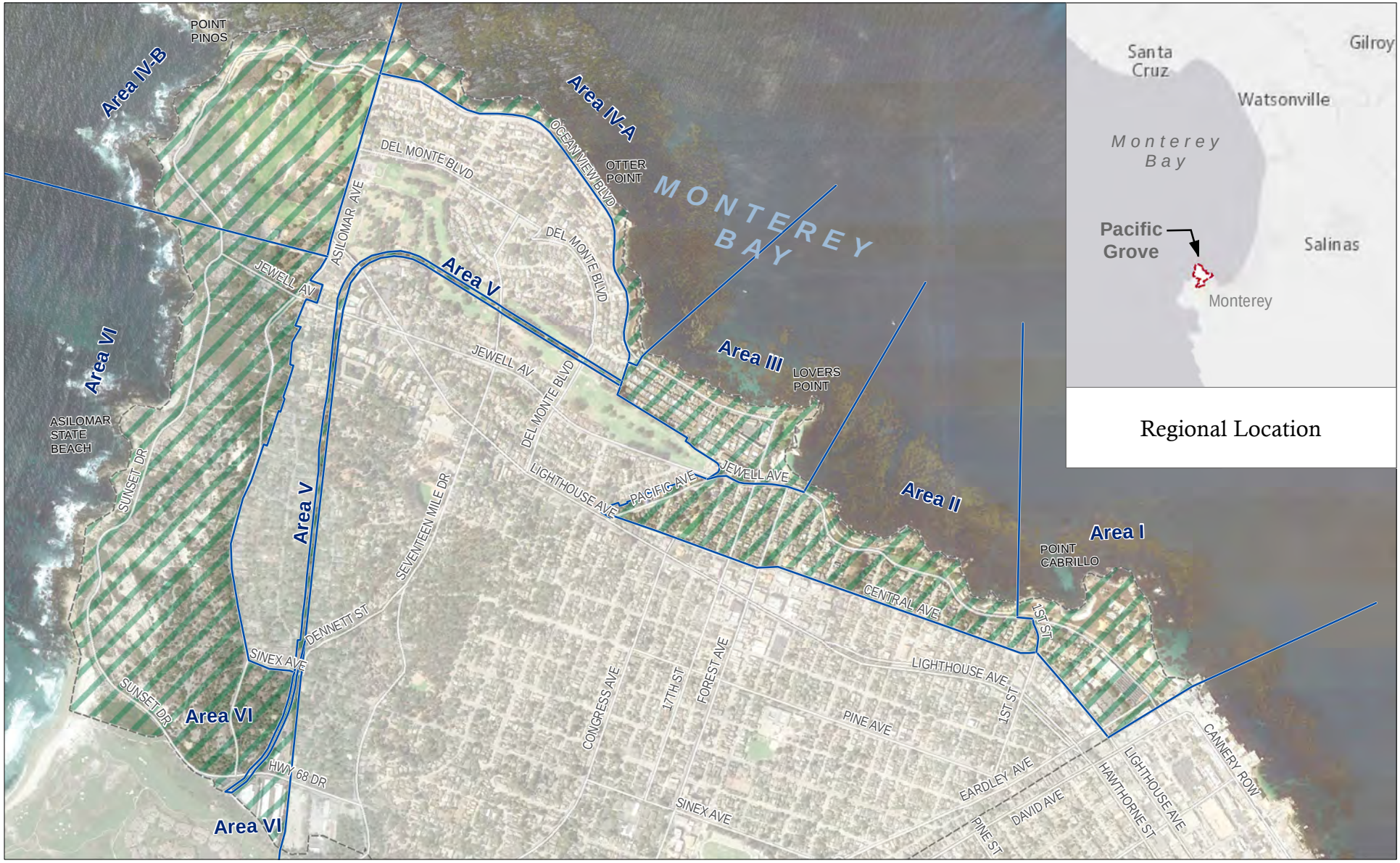
This section contains a brief summary of climate change and vulnerability assessment methodology, key concepts that are central to thinking about climate change and vulnerability, and a summary of climate change exposure (temperature, rainfall, sea-level rise, etc.) for the City of Pacific Grove.

Section 2.0 Vulnerability Assessment

The core of this report will present information applicable to each community sector addressed and provide an evaluation of the climate vulnerability of the sector using the methodology described above.

Section 3.0 Documentation

This section provides a bibliography of sources referenced in the report and locations where they can be obtained or viewed, a list of persons contacted, and a list of report preparers.



0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: City of Pacific Grove, Google Earth 2013

Figure 1

Pacific Grove Coastal Zone

Pacific Grove Vulnerability Assessment

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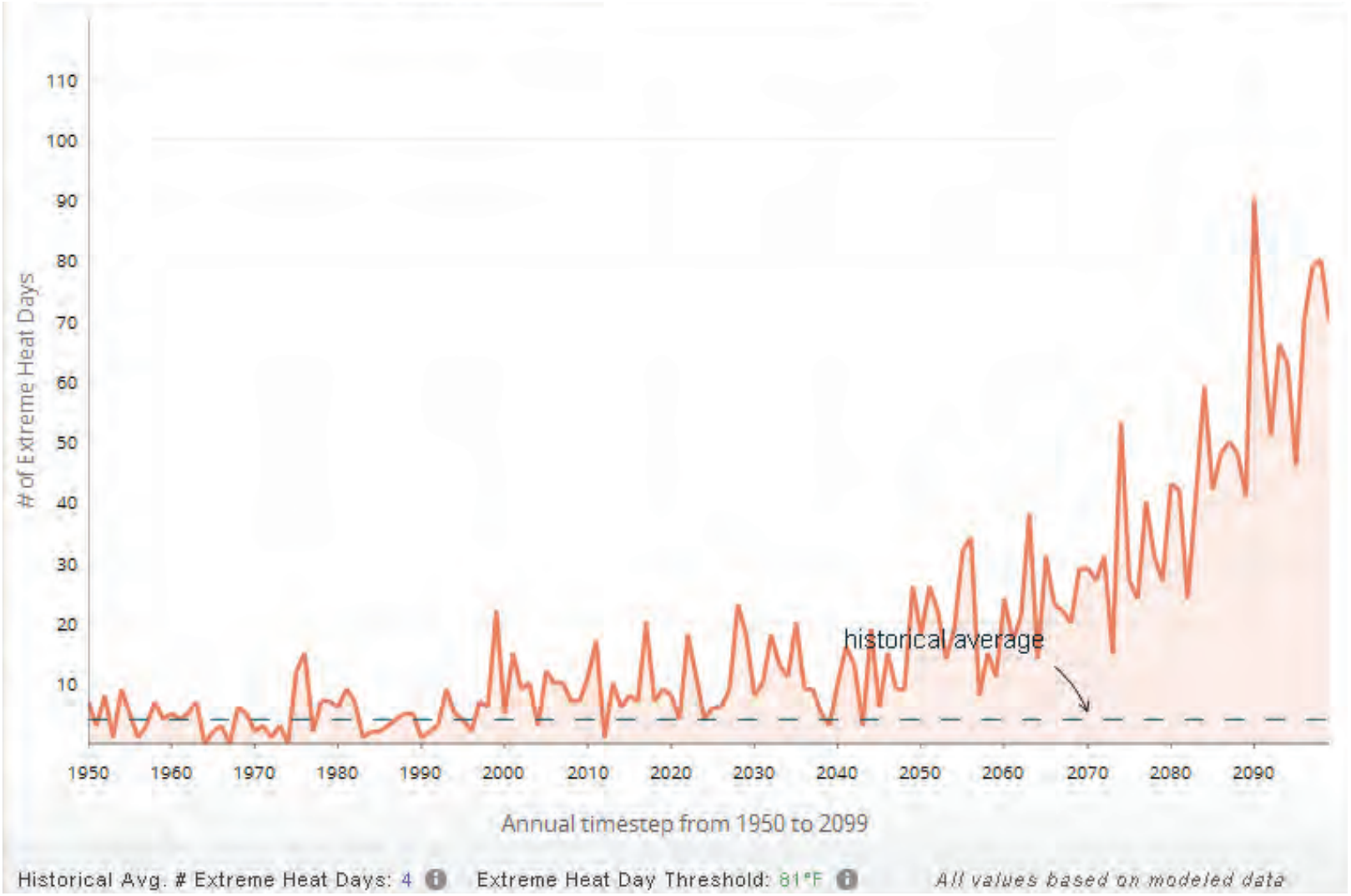

Source: Cal-Adapt 2014

Figure 2
Potential Extreme Heat Days

Pacific Grove Vulnerability Assessment

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Source: AECOM 2014, City of Pacific Grove, Google Earth 2013

Figure 3

Potential Sea Level Rise

Pacific Grove Vulnerability Assessment

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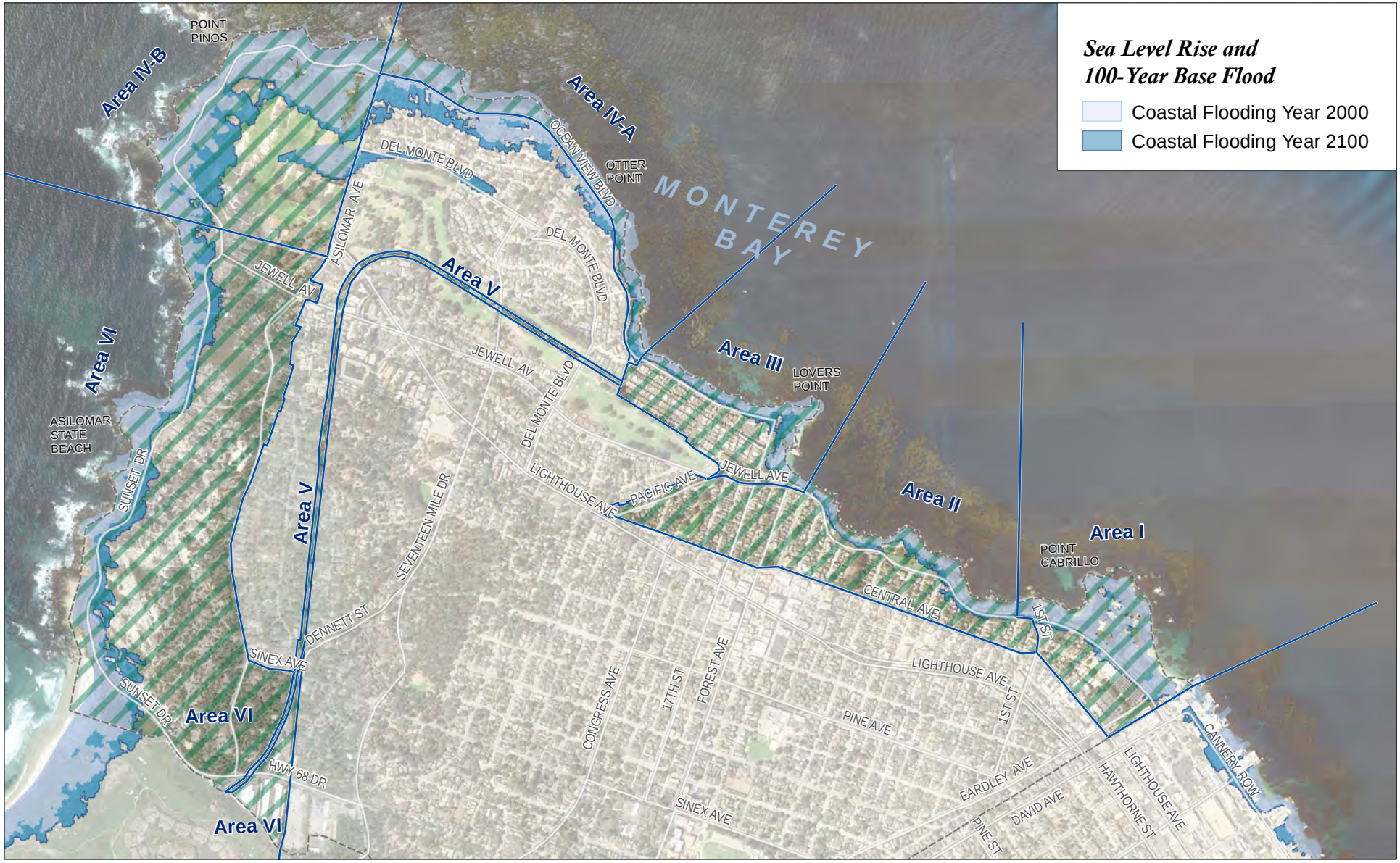

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: Pacific Institute 2014, City of Pacific Grove, Google Earth 2013

Figure 4

Potential Sea Level Rise and Flooding

Pacific Grove Vulnerability Assessment

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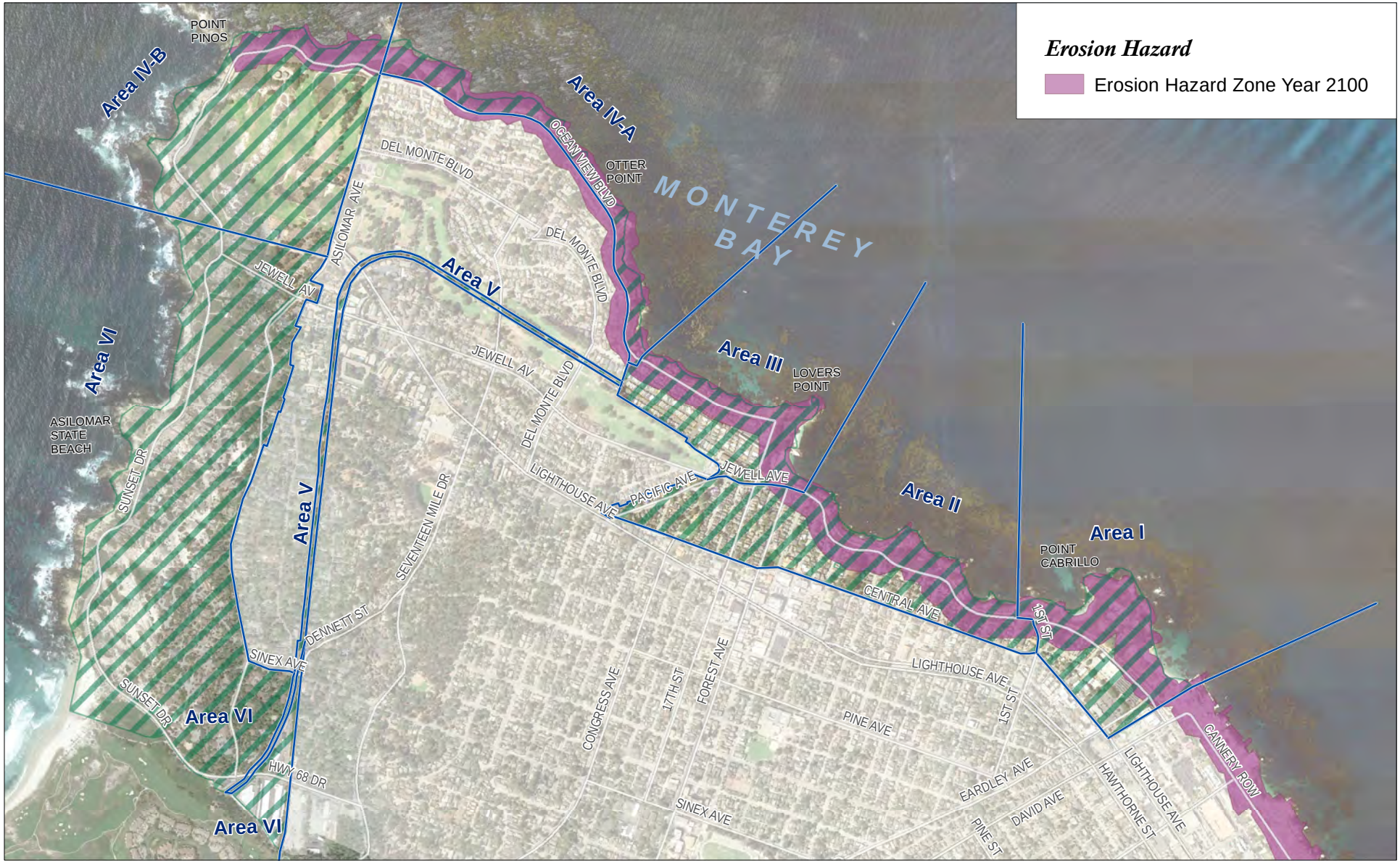

Source: Pacific Institute 2014, City of Pacific Grove, Google Earth 2013

Figure 5

Potential Sea Level Rise and Coastal Erosion

Pacific Grove Vulnerability Assessment

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove, Google Earth 2013

Figure 6

Potential Tsunami

Pacific Grove Vulnerability Assessment

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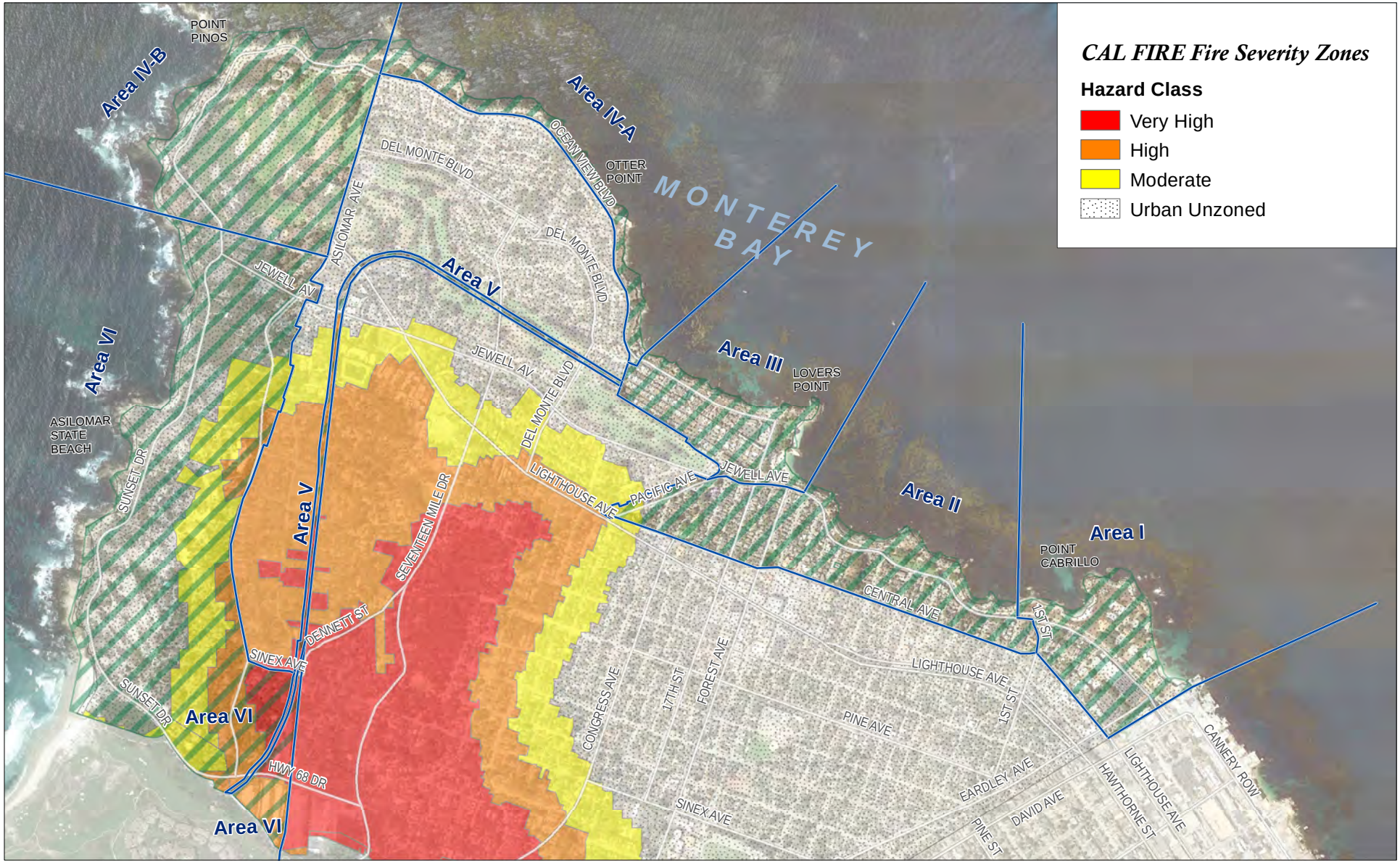

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: CAL FIRE 2007, City of Pacific Grove, Google Earth 2013

Figure 7

Wildfire Severity Zones

Pacific Grove Vulnerability Assessment

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2.0
VULNERABILITY ASSESSMENT

2.1 PUBLIC HEALTH AND SAFETY

This section consists of the public health and safety issues associated with climate change impacts. Public health impacts may include heat events, cardio-respiratory issues, and water contamination. Public safety impacts include flooding, severe storms, and wildfire.

Please refer to section 1.2, Methodology of this report for a discussion the approach and methodology used in this assessment.

2.1.1 Exposure

As described in the introduction to this report (Section 1.5), the direct climate change effects that the city's coastal zone will experience (exposure) include increased temperatures, decreased precipitation, sea level rise, and an increase in severe storm activity and ocean acidification. Wildfire is considered to be a secondary impact. Each of these direct and secondary climate change impacts may affect public health and safety as described below.

Temperature

Short-term extreme temperature changes such as heat events and long-term increases in average temperature are expected to affect public health. Increases in the frequency, intensity, and duration of extreme heat events and heat waves are likely to increase the risk of mortality and morbidity due to heat-related illness and exacerbation of existing chronic health conditions (California Natural Resources Agency 2009, page 39).

Precipitation/Intense Rainfall

Decreased precipitation, as expected for Pacific Grove, may lead to increased likelihood of drought. A reduction in precipitation in combination with an increase in average temperatures may worsen incidence of drought resulting in decreased water supplies which may affect public health. Drought cannot be estimated with tools that are currently available for use in this assessment, such as Cal-Adapt, but is acknowledged as a possible outcome.

Anticipated precipitation patterns include a continued risk of short and intense rainfall events and associated flooding, with the occasional greater-than-historical flooding events. Flooding may affect public safety.

Sea Level Rise

Sea level rise will result in increased flooding and erosion, both of which may have safety implications, including potentially increased risks for drowning, injuries, and traffic accidents. Sea level rise can lead to increased reach of tidal surges in the event of a tsunami, thus exacerbating the safety consequences of a tsunami. Flooding related to sea level rise, or intensified due to sea level rise, could interfere with life and safety response efforts.

Severe Storms and Ocean Acidification

Increased storm activity and ocean acidification cannot be estimated with tools available for this assessment including Cal-Adapt but it is acknowledged that these direct impacts of climate change may affect public health and safety. Severe storm activity can endanger lives of those on or adjacent to the shoreline. Human health effects from ocean acidification are related mainly to possible disruptions to the ocean-sourced food supply (NOAA 2013).

Wildfire (secondary impact)

Increased wildfire risk is considered a secondary impact of climate change as increased temperature and shifts in precipitation patterns (prolonged drought) can increase the probability and intensity of occurrence. Smoke from wildfire makes breathing difficult and can have acute respiratory effects for all populations. Smoke can exacerbate existing chronic health conditions such as asthma, lung disease, or heart disease. Safety concerns include injury or death as a direct result of the fire. Additionally, loss of homes and personal property to wildfire and evacuation of homes during a wildfire cause both physical and emotional stress, stretches health system resources, and can be financially devastating for individuals.

2.1.2 Sensitivity

Identifying points of health and safety sensitivity requires evaluating aspects of the community that may be affected by climate-change exposure. Those most at risk and vulnerable to climate-related health issues are the elderly; individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses; infants; the socially or economically disadvantaged; and those who work outdoors (California Natural Resources Agency 2009, page 39). Those most at risk and vulnerable to climate-related safety risks are segments of the population that live or work in areas at-risk, lack material resources, lack information, are physically disadvantaged, lack basic lifelines, or are at particular risk due to their jobs.

The aspects of the community most likely to be affected by climate-related health and safety issues include: residences, areas of employment, visitor serving areas, hospitals, nursing facilities, and schools. The health and safety points of sensitivity for climate change impacts to the Pacific Grove coastal zone are identified on Figure 8, Health and Safety.

2.1.3 Potential Impacts

Temperature

Extreme and/or prolonged heat can affect cardio-respiratory health and result in mortality; however, temperatures normally need to exceed 90 degrees Fahrenheit to be considered a health threat. In the range of 90 to 105 degrees Fahrenheit, heat cramps and exhaustion may occur. Between 105 and 130 degrees Fahrenheit, heat exhaustion is almost certain, and activities should be significantly limited. An environmental temperature over 130 degrees Fahrenheit is likely to lead to heatstroke (Healthline 2014).

Due to climate change, the annual average temperature in Pacific Grove is expected to increase by as much as 5.3 degrees Fahrenheit by the year 2100. The city is anticipated to experience a sharp increase in extreme heat days (from four to as many as 71 days per year) and heat waves (from zero to six per year) by the year 2100. Although the temperature increase and duration is significant, the average annual temperature is not expected to exceed 61.8 degrees Fahrenheit and an extreme heat day would be 80 degrees Fahrenheit which is far less than temperatures that are considered to be dangerous to human health.

Precipitation/Intense Rainfall

Decreased precipitation may lead to decreased water supplies which may affect public health. It is beyond the scope of this assessment to identify segments of the population with heightened

vulnerability due to health or socioeconomic factors. Therefore, it is conservatively assumed that all segments of the population are at potential risk of health issues due to a potential for reduced availability of water.

Intense rainfall, which could occur even as annual precipitation decreases, presents its own potential safety hazards. For example, intense rain can precipitate automobile accidents, with potentially serious injuries. Flooding increases the risk of drowning. Areas most at risk are in the areas subject to coastal flooding, shown on Figure 9, Health and Safety – Potential Sea Level Rise.

Sea Level Rise

Sea level rise will result in increased flooding and erosion, both of which may have safety implications.

Figure 9, Health and Safety – Potential Sea Level Rise, identifies potential risks due to sea level rise and sea level rise combined with a 100-year flood event. In general, inundation areas and associated impacts are anticipated to increase in the following locations within the city's coastal zone:

- Area I: The 2000 and 2100 flood event inundation areas do not differ much in this area, and there are no noticeable increases in the inundation area.
- Area II: The 2000 and 2100 flood event inundation areas do not differ much in this area, with the most noticeable difference being a slight extension of the inundation area between 4th-10th Streets to residences in the Retreat.
- Area III: The 2100 event increases slightly towards the Beach Tract landward of Ocean View Boulevard, but the most impactful increase would be to Lovers Point Park, the former restaurant property at 631 Ocean View Boulevard, a motel at 635 Ocean View Boulevard (currently Borg's Motel), and an inn at 625 Ocean View Boulevard (currently Lovers Point Inn) which would be inundated by the 2100 event. The 2000 event only covers portions of the Park and does not inundate any of the visitor serving uses mentioned above. In addition, a slight increase in inundation would occur at the south end of the Park, potentially affecting the Beach House, Grill, and other visitor serving uses.
- Area IV-A: Both the 2000 and 2100 flood event inundation areas cover the majority of the area IV-A, with the most noticeable change being at the eastern edge of the area just north of the Beach Tract where the 2100 event abuts Ocean View Boulevard.

- Area IV-B: 2000 and 2100 flood events cross Sunset Drive into the dunes, golf course, water treatment plant, and Crespi Pond. The 2100 event most noticeably increases flooding along the western edge of the golf course along Sunset Drive.
- Area V: None.
- Area VI: 2000 flood event typically remains seaward of Sunset Drive, whereas 2100 flood event crosses Sunset Drive further into the Asilomar Conference Grounds and Asilomar Dunes residential uses.

Figure 10, Health and Safety – Potential Coastal Erosion, illustrates potential risks of coastal erosion combined with sea level rise. Areas at risk within Pacific Grove's coastal zone include the following:

- Area I: Employees of the Hopkins Marine Station and Monterey Bay Aquarium; a portion of residences in the block bound by Dewey Street-Ocean View Boulevard-1st Street-Central Avenue; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.
- Area II: Residents of a swath of properties in the Retreat roughly following the line of the coast reaching Central Avenue around 4th Street; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.
- Area III: All users at Lovers Point Park; a small northeasterly portion of the mobile home park; 631 Ocean View Boulevard, Lovers Point Inn and Borg's Motel; residences along the Beach Tract; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.
- Area IV-A: All users along Ocean View Boulevard and all lands seaward.
- Area IV-B: All users along Sunset Drive and all lands seaward to the east of Point Pinos; however, southwest of the Point, risks are no present.

Figure 11, Health and Safety – Potential Tsunami, identifies risks to the following segments of the population due to tsunami:

- Employees of the Hopkins Marine Station and Monterey Bay Aquarium; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.
- Residents of a swath of properties in the Retreat from approximately 3rd Street to 9th Street; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.

- All users at the Lovers Point Beach and a portion of Lovers Point Park; all users along Ocean View Boulevard and all lands seaward; and all users along the Monterey Bay Recreation Trail.
- All users along Ocean View Boulevard and all lands seaward.
- Golfers along the northern swath of the golf course at the Lighthouse Reservation; future workers at the reclaimed water facility (former wastewater treatment plant); and all users along Sunset Drive and all lands seaward.
- Residents of the two single-family homes seaward of Sunset Drive at Rocky Point; and all users along Sunset Drive and all lands seaward.

Table 1, Historic Tsunamis in Monterey Bay, presents data on historic tsunamis with wave heights recorded at locations within Monterey Bay.

Severe Storm Activity and Ocean Acidification

Increased storm activity and ocean acidification cannot be estimated with tools available for this assessment, including Cal-Adapt, but it is conservatively assumed that these direct climate change impacts have the potential to have health and safety ramifications to populations living along the coast.

Wildfire

Increased wildfire risk is considered a secondary impact of climate change as increased temperature and shifts in precipitation patterns (prolonged drought) can increase the probability and intensity of occurrence. Figure 12, Health and Safety – Potential Wildfire, identifies populations within the city's coastal zone that are at potential risk from wildfire. Additionally, wildfire smoke can have severe effects regionally.

2.1.4 Adaptive Capacity

Assessing the adaptive capacity evaluates the degree to which systems are able to withstand the conditions projected in the future as a result of climate change. Jurisdictions must evaluate their current ability to address the projected impacts, including current management plans for safety and health programs and facilities, future plans, and funding allocations.

Those most at risk and vulnerable to climate-related health issues are the elderly; individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses; infants; the socially or economically disadvantaged; and those who work outdoors (California Natural Resources Agency 2009, page 39). Those most at risk and vulnerable to climate-related safety

risks are segments of the population that live or work in areas at-risk, lack material resources, lack information, are physically disadvantaged, lack basic lifelines, or are at particular risk due to their jobs. Residences, areas of employment, and visitor serving areas are places most at risk in Pacific Grove.

The greatest health and safety vulnerabilities relate to potential coastal flooding and potential wildfire. Response to coastal flooding involves protective measures against flooding and/or evacuation of vulnerable populations. As discussed in Section 2.5, no specific plans are in place to protect vulnerable structures from coastal flooding, so evacuation in the event of coastal flooding would be the necessary approach for the foreseeable future. The City has an established evacuation route network, which includes three major egresses, and significant redundancy. Adequate advanced notice, a good communication system, and adequate coordination would be the most critical factors in successfully evacuating flood-endangered areas. The City of Pacific Grove participates with the Monterey County Office of Emergency Services in development and implementation of the County's regional emergency planning. As identified in the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan Final Draft* (September 2014), the city has recently received grant money to fund watershed flows throughout the city and the city is in the process of implementing this. Note that the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan i*s a "final draft" document that was released in September 2014. The document will not be finalized until review by State of California Office of Emergency Services and the Federal Emergency Management Agency (FEMA). Incorporating watershed measures will not only protect the marine sanctuary, but it will also encourage the alleviation of flood hazards, sea level rise potentials, and storm water runoff issues. (Monterey County Hazard Mitigation Planning Team 2014, Appendix A., Table P-10).

Coastal flooding caused by strong winter storms is generally predictable, and advanced warning is broadcast through the news media at least several days in advance. Coastal flooding caused by tsunami is unpredictable and warning times could range from as much as 12 hours for a distant-source tsunami to as little as 10 minutes for a local-source tsunami. For a local-source tsunami, very rapid communication would be required to alert persons to evacuate, and many would be unable to evacuate in a timely manner. The coastal area of Pacific Grove is marked with tsunami hazard zone warning signs. Other than the emergency broadcast system over the radio, no public warning system is in place, but the County has a telephone messaging system that is intended to alert those homes located within 30 feet of sea level. Working within the time constraints of the particular circumstances, the police department would alert persons in the event of a potential tsunami. Consistent with recommendations identified in the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan Final Draft* (September 2014), the city currently participates in the NOAA Tsunami Ready Program (sponsored by the National Weather Service). In addition, multiple "Tsunami Warning" signs are posted in vulnerable areas throughout the city, and staff is familiar with the tsunami inundation zone. (Monterey County Hazard Mitigation Planning Team 2014, Appendix A., Table P-10).

Most areas in Pacific Grove at direct risk from wildfire are located outside the coastal zone, in wooded upland areas. The area within the coastal zone at greatest risk is within Area VI. All areas of the city are at risk from health effects of wildfire smoke, which can affect the city even from fires many miles away. For direct risks from wildfire, the ability to move equipment and evacuate people is the greatest concern. The city's roadway and evacuation route system can adequately provide these functions, although it may experience congestion. Emergency shelters for displaced persons can be established within or outside of the city. Transportation can be provided for those lacking mobility. For smoke effects, remaining indoors is generally the best approach, so no official response capability is necessary. Persons with chronic conditions susceptible to smoke may need to re-locate during times of heavy smoke.

The city continues to pursue a public outreach program to improve public awareness and knowledge regarding all types of hazards, preparedness and mitigation measures. Signs throughout the city provide photos and information about the potential of specific hazards. (Monterey County Hazard Mitigation Planning Team 2014, Appendix A., Table P-10).

2.1.5 Risk and Onset

The Intergovernmental Panel on Climate Change (IPCC) considers sea level rise to be of high probability, therefore coastal communities should consider the potential impacts of sea level rise to be of higher priority for adaptive planning than other potential effects of climate change (California Emergency Management Agency and California Natural Resources Agency 2012a, IPCC 2007). The current rate of sea level rise over the last decade is about 0.12 inch per year; thus, the current onset of sea level rise is relatively slow. The rate is expected to increase closer to the IPCC's 2100 climate change effects forecast year. Pacific Grove is fortunate in that the bluffs along its coastline are significantly higher than the projected rise in sea level; the greatest risk in Pacific Grove comes from the combined effects of sea level rise with coastal storm flooding and tsunami inundation. Risk of injury or death due to combined effects of sea level rise and coastal flooding are high relative to other health and safety risks.

The IPCC considers temperature increase to be of high probability, therefore, communities should consider the potential impacts of temperature rise to be of high priority for adaptive planning. Cal-Adapt shows expected temperature until 2090. These projections can be used to determine onset and rate of change over time. It is assumed that temperature rises would occur at rates similar to sea level rise. In Pacific Grove, because the climate is cool to begin with, even fairly large rises in temperature would not result in extreme high temperatures. Therefore, the risk of public health or safety effects is low.

The IPCC has not established probabilities for change in storm intensity risk. The IPCC has established changes in precipitation as medium probability and changes in temperature as high probability. Therefore, using the more conservative of the two, it is recommended that changes

in storm intensity be considered to be of medium probability. Increases in storm intensity are of significant concern in Pacific Grove because, combined with sea level rise, intense storms pose one of the most significant climate change threats to Pacific Grove. Sea level rise combined with coastal flooding presents a relatively high risk to public health and safety.

A major tsunami could happen at any time, and the probability over time is high. During a period of more than 100 years, no tsunami has resulted in waves in excess of 1.5 meters (five feet) in height in Monterey Bay. However, a major tsunami combined with sea level rise would have significant adverse health and safety effects. A tsunami generated at a distant location would result from a major earthquake. A tsunami generated within Monterey Bay is considered to most likely to result from an earthquake on the San Geronimo Fault causing an underwater landslide in Monterey Canyon.

2.2 RECREATIONAL RESOURCES AND ACCESS

This section addresses coastal recreation and access that may be affected by climate change.

A significant portion of the City of Pacific Grove lies within, or in proximity to, the coastal zone, and the community is highly dependent on the cultural, social, and economic benefits that access to the coast and ocean provides. Although a socioeconomic analysis is beyond the scope of this assessment, it is noted that impacts to recreational resources and access may have a direct impact on tourism, which is a key industry in Pacific Grove. Significant changes may increase the vulnerability of local populations that rely on the tourism industry.

In this section, consideration will be given to the following: recreational resources and shoreline access; parks; beaches; and shoreline access points and trails, including the California Coastal Trail.

Please refer to section 1.2, Methodology of this report for a discussion the approach and methodology used in this assessment.

2.2.1 Exposure

Three primary climate change impacts will affect recreation and coastal access in Pacific Grove's coastal zone: sea level rise, changed storm frequency and severity, and ocean acidification. Wildfire, as a secondary impact, may also affect coastal zone recreational areas.

Sea Level Rise

Sea level rise may result in impacts to coastal recreation and access through increased coastal inundation and flooding and potential loss of sandy beach and/or coastal trails.

Severe Storm Activity and Ocean Acidification

Increased storm activity and ocean acidification cannot be estimated with tools available for this assessment, including Cal-Adapt, but it is acknowledged that these direct impacts of climate change may affect public health and safety.

Wildfire

Very little of the immediate coastline is susceptible to wildfire, due to the lack of flammable vegetation.

2.2.2 Sensitivity

Recreational Resources

Pacific Grove's Coastal Zone has several existing shoreline and near-shore recreational areas and facilities (e.g., beaches, parks, visitor-serving facilities). These resources are listed in Table 2, Inventory of Existing Recreational Resources, below and shown on Figure 13, Recreational Resources and Access.

Shoreline Access

Several trails and parking areas provide access to Pacific Grove's shoreline and coastal recreational resources. These facilities are listed in Table 3, Shoreline Access Facilities, below and shown on Figure 13, Recreational Resources and Access.

2.2.3 Potential Impacts

As identified earlier in this section, the primary climate change impacts that that have the potential to impact recreational resources and access are: sea level rise, severe storms, ocean acidification, and secondarily, wildfire. The potential impacts are discussed below.

Sea Level Rise

Sea level rise will result in increased flooding and erosion, both of these have the ability to severely limit or eliminate coastal access and/or beach recreation areas. Sea level rise can lead to increased reach of tidal surges in the event of a tsunami.

Figure 14, Recreational Resources and Access – Potential Sea Level Rise, identifies potential risks due to sea level rise and sea level rise combined with 100 year flood event. As identified in the figure, most of the Monterey Peninsula Recreation Trail, all beach access points and trails, and several parks would be inundated under the combined effects of sea level rise and coastal flooding. This type of flooding would occur during winter months when tourist use of facilities is lower, however, Pacific Grove's coastal recreation and access facilities receive heavy use all year. Specific park and recreational facilities at risk of inundation are summarized in Table 4, Park, Recreational, and Access Facilities at Risk from Coastal Flooding.

Figure 15, Recreational Resources and Access – Potential Coastal Erosion, identifies potential risks to recreational resources and access due to sea level rise and coastal erosion. The coastal erosion process would gradually (and sometimes episodically) move the shoreline inland from its present location. This process would affect facilities within about 14 to 28 feet of the existing

shoreline. For the most part, access to tide pool, rock, and beach facilities consist of informal hiking trails. Exceptions include developed access for handicapped persons at Asilomar Beach (a wooden boardwalk) and at Lovers Point (a concrete ramp). In general, although sea level rise and/or cliff retreat may make areas inaccessible, most informal coastal access would remain. The concrete ramp at Lovers Point would withstand the effects of climate change. The wooden boardwalk at Asilomar State Beach is outside the area directly affected by sea level rise and shoreline erosion. Park facilities closest to the shoreline and commercial facilities at Lovers Point Park could be affected, although the shoreline is partially armored in this area.

Figure 16, Recreational Resources and Access – Potential Tsunami, identifies potential risks to recreational resources and access due to tsunami. Although tsunamis are less frequent and potentially more dramatic, areas affected by tsunami would be similar to those areas affected by coastal flooding.

Severe Storms

The extent or frequency of increased storm activity cannot be estimated with tools available for this assessment, including Cal-Adapt, but it is acknowledged that this direct impact of climate change may affect coastal resources and access. Severe storms would interfere with access during the storm and/or immediately following the storm, and could have long-term effects if recreational or access facilities were damaged during the storm.

Wildfire

Increased wildfire risk is considered a secondary impact of climate change as increased temperature and shifts in precipitation patterns (prolonged drought) can increase the probability and intensity of occurrence. Figure 17, Recreational Resources and Access – Potential Wildfire, identifies potential risks to recreational resources and access due to wildfire. The only recreational facility within the high fire danger areas of the coastal zone is the Southern Pacific Railroad right-of-way, which is undeveloped. Wildfire effects on coastal recreation and access are likely to be primarily a temporary inconvenience due to high smoke levels.

2.2.4 Adaptive Capacity

Assessing the adaptive capacity evaluates the degree to which these facilities are able to withstand the conditions projected in the future as a result of climate change. Jurisdictions must evaluate their current ability to address the projected impacts, including current management plans for infrastructure, future plans, and funding allocations.

Recreational Resources

As described above, many of the recreational resources within Pacific Grove are located adjacent to the shoreline, and therefore susceptible to climate change effects, particularly sea level rise, shoreline erosion, coastal flooding, and tsunami. No plans are in effect to protect coastal recreational resources.

Shoreline Access

No plans are in place to address the effects of sea level rise on shoreline access. In general, although sea level rise and/or cliff retreat may make areas inaccessible, most informal coastal access would remain.

2.2.5 Risk and Onset

The IPCC considers sea level rise to be of high probability, therefore coastal communities should consider the potential impacts of sea level rise to be of higher priority for adaptive planning than other potential effects of climate change. The current rate of sea level rise over the last decade is about 0.12 inch per year, thus the current onset of sea level rise is relatively slow. The rate is expected to increase closer to the IPCC's 2100 climate change effects forecast year. Pacific Grove is fortunate in that the bluffs along its coastline are significantly higher than the projected rise in sea level; the greatest risk in Pacific Grove comes from the combined effects of sea level rise with coastal storm flooding and tsunami inundation. At a cliff retreat rate between two and four inches per year, the shoreline could potentially retreat about 14 to 28 feet by 2100. Those facilities nearest the shoreline, which would include hiking trails and viewpoints and could include parking areas, would need to be truncated, re-located, or abandoned.

The IPCC has not established probabilities for change in storm intensity risk. The IPCC has established changes in precipitation as medium probability and changes in temperature as high probability. Therefore, using the more conservative of the two, it is recommended that changes in storm intensity be considered to be of medium probability. Increases in storm intensity are of significant concern in Pacific Grove because, combined with sea level rise, intense storms pose one of the most significant climate change threats to Pacific Grove.

2.3 WATER MANAGEMENT

This section considers the potential effects of climate change on water supplies (surface water and groundwater sources for municipal water supplies) and flooding. The primary climate change impacts expected to affect water supplies are increased temperature, changes in precipitation, sea level rise, an increase in severe storm activity, and wildfire (as a secondary impact). Each of these potential exposures as they relate to water management is summarized below.

Please refer to section 1.2, Methodology of this report for a discussion the approach and methodology used in this assessment.

2.3.1 Exposure

Temperature

In many areas, climate change is likely to increase water demand while shrinking water supplies (EPA 2014). Warmer temperatures increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water. The projected annual average temperature in the Pacific Grove area is anticipated to increase as much as 5.3 degrees Fahrenheit by the year 2100 to 64.3 degrees Fahrenheit (Cal-Adapt 2014c). As this increase is not at a level that would significantly increase evaporation, increased average temperatures are not likely to significantly affect water supplies.

However, the projected number of extreme heat days for the city is anticipated to sharply increase from a historical average of four days per year to as many as 71 days per year by 2100 (Cal-Adapt 2014b). As temperatures rise, people and animals need more water to maintain their health and thrive. Therefore, water demand during extreme heat days may affect water demand.

Precipitation/ Intense Rainfall

It is expected that the Pacific Grove area could experience a potential reduction in precipitation of up to 10 percent by 2050 and 20 percent by 2100 (Cal-Adapt 2014a) which could affect water supply.

Reduced precipitation generally would reduce the potential for long term flooding, however, expected changes in precipitation patterns include a continued risk of intense rainfall events and associated flash flooding, with the occasional greater-than-historical flooding events.

Sea Level Rise

Salt water intrusion occurs in coastal freshwater aquifers when the different densities of both the saltwater and freshwater allow the ocean water to intrude into the freshwater aquifer. Rising sea level and the occurrence of drought can increase the salinity of both surface water and ground water through salt water intrusion (EPA 2014), reducing the quality of water supply.

Potential sea level rise will also likely increase the inland extent of coastal flooding from storm surges and highest tides. These effects can not only reduce the quality of water but can damage the infrastructure that used to transport and deliver water (EPA 2014).

Severe Storms and Ocean Acidification

Potential severe storms will bring heavy rainfall that could potentially benefit surface water and groundwater supplies. However, this storm activity could also increase the frequency and/or inland extent of coastal flooding and runoff, particularly for storms that coincide with high tides, which could affect water quality.

Ocean acidification is not expected to affect water supplies.

Wildfire (secondary impact)

Increased wildfire risk is considered a secondary impact of climate change as increased temperature and shifts in precipitation patterns (prolonged drought) can increase the probability and intensity of occurrence

Wildfire could potentially affect water quality and run-off rates of surface waters. Wildfire could also potentially increase flooding associated with storm water run-off.

2.3.2 Sensitivity

Water Supply

Pacific Grove obtains its water supply through the California American Water Company (CalAm) from surface water in Carmel Valley and from groundwater resources in the Carmel Valley and Seaside Coastal Aquifers. Withdrawals from this system are governed by the Monterey Peninsula Water Management District (City of Pacific Grove 1994, Chapter 9, page 1). The water available to CalAm has been affected by Regional Water Quality Control Board and Superior Court decisions. CalAm has been ordered to reduce withdrawals from the Carmel River, by 2016, to its legal entitlement of 3,376 acre-feet per year. The Seaside Basin has been adjudicated with CalAm limited to 1,474 acre-feet per year. These water source restrictions will leave CalAm about 9,000 acre-feet short of historic demands (State of California 2012).

The well nearest Monterey Bay is the Playa Well, located about one-half mile inland on Playa Avenue east of Fremont Boulevard (Groundwater Basin Watermaster 2006). This section addresses the water supply itself. Water related infrastructure is discussed in Section 2.5 Coastal Development and Infrastructure.

Flooding

Pacific Grove's topography generally slopes northward and westward from the highest points along the boundary with Monterey. The only flood zones identified by the Federal Emergency Management Agency are offshore, along the Monterey Bay and Pacific Ocean shorelines (FEMA 2009). Run-off concentrates in several small creek drainages, but there are no rivers within Pacific Grove. Under very heavy rainfall, conditions the small drainages could overflow causing local flooding. Additionally, the city has a system of underground storm water conveyance pipes that discharge to 34 stormwater outfalls in Pacific Grove, 24 of which drain into the Area of Special Biological Significance (ASBS) designated by the State Water Resources Control Board (California State University Monterey Bay 2011). Outfalls and other stormwater structures are identified on Figure 23 presented in Section 2.5, Coastal Development of this report. Coastal flooding and localized flooding near drainages are the most likely types of flooding in Pacific Grove.

2.3.3 Potential Impacts

Temperature

Increased temperature would have a minor direct effect on water supplies, primarily accelerating evaporation from the surface. This might slightly reduce percolation to groundwater or flows within the Carmel River, but without data to the contrary, this is not expected to significantly affect water supplies. The greater effect of temperature increases would be on demand for water resources, with human consumption and landscape consumption likely to rise, perhaps to a measureable degree.

Increased temperatures are not expected to result in flooding impacts or ocean acidification.

Precipitation

Reduced precipitation would reduce surface flows within the Carmel River watershed, and would reduce re-charge rates within both the Carmel River and Seaside Basin areas.

Reduced precipitation in the Carmel River watershed would lower water levels in the Carmel River, but as long as there is enough water to support the CalAm withdrawals, its water supply would not be restricted below the legal entitlement.

Reduced recharge over time would reduce storage within the Seaside Basin, and make seawater intrusion more likely or more severe. Adjudication of the Seaside Basin was intended to bring the withdrawals and recharge of the basin into balance, but a reduction in average annual precipitation would adversely affect that balance. CalAm has an adjudicated entitlement from the basin, so unless further adjudication were to occur, reductions in withdrawals is not likely. The most likely adverse effect of reduced precipitation would be sea water intrusion as groundwater levels recede. Seawater intrusion would compromise the quality of water from the wells within intruded areas.

Increased temperatures are not expected to result in flooding impacts or ocean acidification.

Sea Level Rise

Sea level rise is not expected to directly affect water supplies. However, sea level rise could have an effect on seawater intrusion. Under balanced natural conditions, there is a point near the coastline where underwater salt-influenced water interfaces with fresh water in on-shore groundwater aquifers. The outflowing pressure of the fresh water keeps the seawater from moving very far inland. However, when groundwater aquifer levels are depressed (typically from over-pumping) then the seaward fresh water pressure is reduced, and saltwater flows onshore into the groundwater basin. With sea level rise, the interface between salt and fresh water will move inland, thus pushing salt water into the fresh groundwater aquifers.

Sea level rise could result in additional flooding near the shoreline, especially during storm surges. With a higher sea level, storm surges would need to overcome a smaller elevation differential at the shoreline, so flood waters could extend farther inland and flooding could occur more frequently. A second concern with sea level rise is the potential for high sea levels to inhibit discharge at storm water system outlets. If storm water outlets are not sufficiently elevated above the adjusted mean high tide line, interference may occur.

Severe Storms and Ocean Acidification

Severe storms and ocean acidification are not likely to have significant adverse effects on water supply.

Severe storms are a major cause of coastline flooding, and these would reach farther inland and be more destructive in conjunction with sea level rise.

Wildfire (secondary impact)

Wildfire could have indirect effects on surface water sources. Bare ground resulting from a wildfire in the Carmel River watershed would result in additional siltation of the river due to the

increased exposure of the upland soils, and would also reduce the time it takes for rainfall to reach the Carmel River since less rainfall and run-off would be intercepted and detained by vegetation. Under this scenario, there would be lower quality water in the river (i.e. a heavier sediment load) and storm water run-off rates would change so that more water would flow into the river during and shortly after the storm and less would flow into the river after the storm had passed.

Wildfire effects on flooding are most likely associated with de-vegetation of upland slopes and the potential for storms to saturate bare soils and cause erosion or mudslides.

2.3.4 Adaptive Capacity

Flooding

No known efforts have been made to adapt the storm water drainage system in response to climate change exposures.

Options for underwater storm drainage discharge: check valves/flap gates at outfalls; pumping; force mains (San Francisco Bay Conservation and Development Commission and National Oceanic and Atmospheric Administration Coastal Services Center 2012).

Water Supply

Water supply has been a concern on the Monterey Peninsula for at least 25 years and alternative water supplies have been under consideration for the Monterey Peninsula for as just long. The Monterey Peninsula Water Management District imposed a moratorium on projects that would increase water use January 1990. The moratorium was relaxed in August 1992 and eliminated in 1993 when the Paralta well was approved. In 1990, a desalination project was first proposed but failed when placed on the ballot. A reclaimed water project to irrigate golf courses in Del Monte Forest was completed in 1994, but plans to extend lines to transport irrigation water to Pacific Grove's golf course and cemetery have not yet been realized. New water connections are currently under an allocation system. The City of Pacific Grove has a residential water waiting list with about 10 residences on the list, however, there are no credits in the residential category of the city's water allocation. The Monterey Peninsula Water Management District's November 2014 allocation report shows that Pacific Grove has no credits in the Paralta allocation, 0.312 credits in the Pre-Paralta allocation, and 0.228 credits in the Public allocation; for a total of 0.540 credits citywide.

An ongoing effort to replace Carmel River and Seaside Groundwater Basin sources includes three approaches: desalination, aquifer recharge, and aquifer storage. There are currently three major desalination projects in the planning stages, any of which could supply water to Pacific

Grove if built. CalAm is sponsoring a project located in Marina that would take in seawater through slant wells. The Deep Water proposal would use an existing outfall pipe to uptake seawater offshore from Moss Landing. The Peoples project would utilize seawater intake that has historically been used at the Kaiser Refractory plant in Moss Landing. With any of these projects, water would be piped south to Monterey Peninsula cities. Potential effects of seawater rise on desalination infrastructure are being considered in the designs. Although the target date for these projects is the end of 2016, given the complexities of the approval process and the significant construction required for implementation, delivery of desalinated water is likely to commence later than that date. The Monterey Peninsula Water Management District is developing a groundwater replenishment project that would recharge the Seaside groundwater basin with high quality purified water, which it hopes to have operational by the end of 2016. A similar project already implemented injects water to the Seaside Groundwater Basin for storage.

The City of Pacific Grove has proposed to replace irrigation demand at the golf course (100 to 125 acre-feet per year) with non-potable water as part of the overall water replacement project. The City of Pacific Grove endorsed the CalAm desalination plant in 2010. On April 18, 2012, the Pacific Grove City Council voted to become a water agency for the Monterey Peninsula, effectively allowing the city to sponsor the Peoples desalination project, but that arrangement was later terminated by the developer of the desalination project (Jim Johnson 2014).

At a statewide level, water conservation efforts are being promoted. The Green Building Standards Code includes provisions for new plumbing fixtures that should reduce water consumption in new construction in California by about 20 percent. As an emergency measure during the current drought, significant water use reductions are requested by the state, and penalties have been imposed for non-compliance with conservation measures.

2.3.5 Risk and Onset

Water Supply

Significant water supply issues already exist within the Monterey Peninsula area. Effects on water supply from Climate Change appear inevitable and would worsen an existing situation. Effects are likely to be gradually more noticeable and important over time, although completion of the water source replacement project would largely address concerns during a period of time following completion.

Flooding

The climate change effects on flooding would likely be less far-reaching than the effects on water supply.

2.4 BIODIVERSITY AND HABITAT

In this section, consideration is given to coastal species and their habitats: sand dunes, forested areas, wetlands and estuaries/sloughs, littoral zone habitats, nearshore marine ecosystems, and other coastal habitats (as appropriate). It should be noted that the analysis of possible effects on all special-status species with potential to occur in the project areas, along with updated habitat mapping data, is beyond the scope of this report.

Please refer to section 1.2, Methodology of this report for a discussion the approach and methodology used in this assessment.

2.4.1 Exposure

The climate change impacts most likely to affect Pacific Grove's coastal biodiversity and habitat are alterations in temperature, precipitation, and sea level resulting in changes such as altered seasons, flooding/erosion, heat waves, and drought.

Temperature

Increased coastal temperatures over time may result in changes such as altered seasons and heat waves which can affect biodiversity and habitat, especially habitat distributions, plant blooming periods, and animal breeding patterns.

Precipitation/Intense Rainfall

Decreased overall precipitation amounts may lead to increased likelihood of drought conditions. A reduction in precipitation in combination with an increase in average coastal temperatures may worsen incidence of drought, resulting in decreased water supplies which can affect biodiversity and habitat. Expected changes in precipitation patterns include risk of intense rainfall events and associated flooding, which can cause physical damage to habitat.

Sea Level Rise

Sea level rise may result in impacts to biodiversity and habitat through increased coastal inundation/flooding and erosion. It would also directly reduce the size of certain habitats in the project areas, particularly low-lying beaches and nearshore rock formations, used especially by marine mammals and birds.

Wildfire (secondary effect)

Increased risk of wildfire, a secondary climate change effect due to lowered precipitation/ increased drought conditions and warmer overall temperatures, also has the potential to alter project area ecosystems and the species dependent upon them. Within the Pacific Grove coastal zone, risk of wildfire decreases as distance from the more forested central area of the city increases.

Severe Storms and Ocean Acidification

Increased severe storm activity and ocean acidification cannot be estimated with tools available for this assessment, including Cal-Adapt, but it is acknowledged that these direct impacts of climate change may affect biodiversity and habitat. Severe storm activity can directly endanger animals and plants living on or adjacent to the shoreline and their habitat.

Ocean acidification is expected to impact ocean species to varying degrees. Photosynthetic algae and seagrasses may benefit from higher carbon dioxide conditions in the ocean, as they require carbon dioxide to live in the ocean just as plants do on land. On the other hand, studies have shown that a more acidic environment has a dramatic effect on some calcifying species including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton. If shelled organisms are at risk, the entire food web may also be at risk (NOAA 2014).

2.4.2 Sensitivity

Many project area species and habitats may be sensitive to projected climate change impacts, especially marine mammals and birds that require low-lying coastal areas for resting/foraging/ breeding habitat, along with plant species and less mobile animal species that are unable to move to avoid unsuitable habitat conditions.

The assessment of this biodiversity and habitat sensitivity included a reconnaissance field survey conducted by EMC Planning Group on September 17, 2014. Database occurrence records and maps for special-status species in the general project vicinity were also reviewed. A search of the California Department of Fish and Wildlife (CDFW 2014) *California Natural Diversity Database* was conducted for the Monterey, Marina, Seaside, Soberanes Points, and Mount Carmel United States Geologic Survey (USGS) quadrangles. Records of occurrence for special-status plants were reviewed for those same USGS quadrangles in the California Native Plant Society (CNPS 2014) *Inventory of Rare and Endangered Plants*. A U.S. Fish and Wildlife Service (USFWS 2014) threatened and endangered species list was also generated for Monterey County.

In addition, the analysis included review of the *Natural Resource Areas and Associated Natural Resources in Pacific Grove* (City of Pacific Grove 2010) noting areas of significant natural resources, and the city's *Local Coastal Program Land Use Plan*, Figure 2 – Land Habitat Sensitivity Map (City of Pacific Grove 1989).

Land uses adjacent to coastal sand dunes and forested habitats were assessed, and there is little undeveloped land in and adjacent to the project areas available to possibly allow for habitats to migrate inland as climate change impacts intensify over time. Habitat connectivity is limited to undeveloped project areas along the coastline and adjacent sand dunes/forested areas. Existing undeveloped habitats in the project areas should be protected to allow wildlife movement.

It is noted that many of the ecosystems that support biodiversity also support recreation for residents and visitors alike. Impacts on these ecosystems will also harm their recreational value. Recreational Resources are assessed in Section 2.2 of this report.

Figure 18, Habitat Sensitivity Map, provides an illustration of the sensitive habitats within the city's coastal zone and nearshore ASBS. It is noted that the sensitive habitats identified on Figure 18 are based on a 1989 Land Habitat Sensitivity Map as an update to this mapping was not within the scope of this report.

Critical Habitats

A nearshore ASBS is located in project areas I through IV-A. Also, area VI contains USFWS-designated critical habitat for the federally listed Threatened Monterey spineflower (*Chorizanthe pungens* var. *pungens*). Though no future development is anticipated in these areas, the specific conditions required for such critical habitats to continue to support the current level of biodiversity in the face of future climate change impacts are not quantified.

Special-Status Species

Regarding special-status plants, Monterey pine (*Pinus radiata*) and Monterey cypress (*Hesperocyparis macrocarpa*), both CNPS Rare Plant Rank 1B species, were observed in many locations throughout the project areas. Sand dune scrub habitats also provide suitable habitat for notable listed plant species, including: federally and state-listed Endangered Menzies' wallflower (*Erysimum menziesii*), federally and state-listed Endangered Tidestrom's lupine (*Lupinus tidestromii*), federally and state-listed Endangered beach layia (*Layia carnosa*), and federally listed Endangered and state-listed Threatened Monterey gilia (*Gilia tenuiflora* ssp. *arenaria*). Special-status wildlife species with high potential to occur in the project areas include state Fully Protected white-tailed kite (*Elanus leucurus*) and state Species of Special Concern western pond turtle (*Emys marmorata*).

Habitats for these species (and for additional special-status species with potential to occur in the project areas due to the presence of suitable habitat) are likely to be adversely impacted by the climate change impacts discussed above, or future development projects.

2.4.3 Potential Impacts

The degree to which anticipated levels of climate change threaten the areas of biological resource sensitivity identified earlier in this section is discussed below.

Temperature

As discussed in Section 1.0 of this assessment, due to climate change, the annual average temperature in Pacific Grove is expected to increase by as much as 5.3 degrees Fahrenheit by the year 2100. The city is anticipated to experience a sharp increase in extreme heat days (from four to as many as 71 days per year) and heat waves (from zero to six per year) by the year 2100.

Plant and animal species have a preferred temperature range and ecological setting. Climate change results in altered seasonal temperature and precipitation patterns. In combination, this can alter the suitability of habitats for various native species.

Potential impacts to biodiversity and habitat due to increased temperature may include:

- Habitat Suitability: As temperature increases, it may alter the quality of coastal habitats for indigenous plant and animal species. This could particularly reduce the quantity and distribution of special-status species that already have restricted population areas.

- Species Range: Based on current population size and distribution, some species may comfortably persist with higher temperature. This assessment of impact seeks to identify those species that will struggle with anticipated higher regional temperatures.

  For example, species already surviving at the upper end of their preferred temperature range are likely to experience more frequent and prolonged thermal stress (California Emergency Management Agency and California Natural Resources Agency 2012a). These changes not only alter the physical comfort of species, but also may alter the entire habitat type. This is particularly true for confined habitats such as lakes, wetlands, or vernal pools, where the combination of reduced precipitation and increased temperature reduces not only the extent but potentially the existence of these habitats and all species that rely on them, due to the species' inability to slowly shift in location.

Species that experience stress due to climate change may be able to migrate (shift their ranges) to more suitable conditions. However, migration implies a level of habitat accessibility and species mobility that may not be present. Few species, particularly those endemic to California that are adapted to a specific microclimate, are able to adapt to changes without shifting location. If migration is not possible, species risk extirpation (California Emergency Management Agency and California Natural Resources Agency 2012a). The pressures that may lead a species to seek possible relocation affect all habitat types, including aquatic, marine, and terrestrial.

- Ecosystem Relationships: Climate change can alter the seasonal patterns in an ecosystem such as the timing of flowering, which can shift out of step with pollinators. Some of these impacts can have consequences for the survival of species (California Emergency Management Agency and California Natural Resources Agency 2012a).

  Species that experience stress due to changes in ecosystem condition, such as temperature increase, do not all have the same capacity to migrate. As a result, newly established ranges are unlikely to have the same complement of ecosystem members (plants and animals). These new combinations of adaptable species, that may not all be native, must establish interactions that are difficult to predict. According to the California Natural Resources Agency (CNRA), climate change may further affect species due to changes in ecosystem interactions, but the extent and consequences of these changes are not definitively known (CNRA 2009).

- Invasive Species: The same changes that threaten endemic species described above also influence the ranges and distribution of invasive species. Highly adaptable non-native species that are better equipped for altered habitat conditions are likely to outcompete native species in the face of climate change impacts (CDFG 2007). Invasive species, a particularly threatening class of non-native species, can tolerate a wide range of environmental conditions and reproduce much more quickly and to a greater spatial extent than native species, particularly following a disturbance such as wildfire, landslide, or flood. The threat of invasive species is not confined to any one habitat type (CNRA 2009).

  While the short-term biodiversity (number of native and non-native species in a particular area) may increase during changing climatic conditions, invasive plant and animal species cause an intense competition for resources, physical damage to invaded habitat, displacement of special-status native species, and other impacts that may lead to a long-term loss of native species diversity. Invasive species can predate native species, introduce or transmit disease, or dramatically alter environmental conditions (CDFG 2007). Invasive species threaten not only natural ecosystems but also many ecosystem services, such as available water supply and even navigable waterways (CNRA 2009).

Precipitation/Intense Rainfall

Decreased rainfall may result in altered water levels in aquatic settings. Aquatic and riparian ecosystems will be detrimentally affected by these changes. This will limit the available habitat for species dependent on these unique ecosystems. Increased temperature not only changes evaporation rates but also alters water chemistry and vegetative characteristics in aquatic ecosystems, exacerbating the changes already occurring due to altered water availability.

Increased drought conditions are also likely to adversely impact the amount of plant reproduction possible, and over time will likely lower the population quantity and distribution of less adaptable plant species, and may allow more adaptable (likely non-native) pioneer species to take over various habitat areas.

Sea Level Rise

Sea level rise will result in increased flooding and erosion. According to projections of inundation at high tide, up to six feet of inundation would affect low-lying beaches and off-shore rock formations in all project areas, and the coastal portion of Majella Slough in Area VI. This would also impact biologically important tide pool habitat. In addition, this sea level rise would contribute to increased flooding zones; predictions for increased coastal flooding by 2100 would notably cause increased impacts to existing habitats at Majella Slough and Crespi Pond, along with areas reaching further inland across sand dune scrub natural and restored habitats. Figure 19, Sensitive Habitat – Potential Sea Level Rise, identifies the potential extent of flooding on sensitive habitat areas due to potential sea level rise combined with a 100-year flood event.

The modeled 2100 erosion hazard zone would not impact the western portion of the project areas, but would impact the northern portion of the project areas, notably with increased beach and coastal bluff erosion hazards. Figure 20, Sensitive Habitat – Potential Coastal Erosion, identifies the potential extent of erosion given a 55-inch sea level rise by 2100 as related to sensitive habitat areas.

The modeled tsunami danger zone would impact all project areas, with increased risk to beach, coastal bluff, and sand dune scrub habitats. Figure 21, Sensitive Habitat – Potential Tsunami, identifies potential risks to sensitive habitat due to tsunami.

In particular, the project areas contain nearshore haul-out rocks for harbor seals (*Phoca vitulina*) to rest on during the daytime so they can hunt food at night, along with pupping beaches used during spring by female harbor seals to give birth and provide early care for their pups. Though harbor seal is not listed as special-status, the Marine Mammal Protection Act of 1972 prohibits the killing of any marine mammals. These harbor seal pupping beaches and haul-out rocks are important biological habitats that would be reduced or possibly eliminated in the project areas by sea level rise.

Potential biodiversity and habitat impacts due to sea level rise may include:

- Coastal Habitats: As sea level rise advances, it will force a slow migration or succession of coastal habitats. Of particular concern will be habitat areas that are small and/or isolated. These factors will exacerbate impacts since they will restrict the ability of species to migrate or adapt to changing conditions. In addition, particular attention will need to be given to impacts on critical habitat and federally or state-listed species.

- Species Range: Based on current population size and distribution, some species may comfortably persist in the face of climate change-induced sea level rise. Adaptable species that experience stress due to climate change may be able to tolerate slow changes, and less adaptable species may migrate (slowly shift their ranges) to more suitable conditions. However, as mentioned above for temperature increases, migration due to sea level rise implies a level of habitat accessibility and species mobility that may not be present in many situations for the project areas. Few species, particularly those endemic to coastal central California that are adapted to a specific microclimate, are able to adapt to changes without shifting location. If migration is not possible, species risk local extirpation (California Emergency Management Agency and California Natural Resources Agency 2012a). The pressures that may lead a species to seek possible relocation affect all habitat types, including aquatic, marine, and terrestrial.

Wildfire

Areas V and VI contain moderate to very high wildfire hazard classes, and future wildfires may therefore impact some sand dune scrub habitat, but mostly Monterey pine forest habitat. It should be mentioned that ornamental landscaping in the project areas that contain gum (*Eucalyptus* sp.) trees are particularly flammable and capable of helping spread wildfire. Figure 22, Sensitive Habitat – Potential Wildfire, identifies habitat areas at risk for wildfire.

Non-native (particularly invasive) species are typically adapted to spread quickly and take advantage of habitats impacted by wildfire. Increased spread of non-native species in the project areas would adversely impact the local ranges and distribution of native species.

Combination of Impacts

Heat, drought, flood, and fire are all projected to increase in frequency and severity in the project area natural habitats due to climate change. Each of these impacts is addressed in other sections with respect to their impact on human systems. The focus in this section is on the impact on natural systems.

Ecosystems typically have a recurring disturbance regime that, over the long term, supports biodiversity. By changing the natural character of these regimes, climate change may detrimentally affect these ecosystems. Results can range from unusually large physical alteration from erosion, to pest outbreaks, to ecosystem shifts (CNRA 2009). Each of these changes stresses or eliminates native species.

2.4.4 Adaptive Capacity

A majority of Pacific Grove is located within an ASBS Watershed zone. As identified in the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan Final Draft* (September 2014), the city has recently received grant money to fund infrastructure improvements and Low Impact Development Techniques throughout the city and the city is in the process of implementing this. Incorporating watershed measures will not only protect the marine sanctuary, but it will also encourage the alleviation of flood hazards, sea level rise potentials, and storm water runoff issues. (Monterey County Hazard Mitigation Planning Team 2014, Appendix A., Table P-10).

Adaptive capacity for habitats and species is a product of two factors. First, some species and habitats have a greater ability to adapt to change than others. Second, to some degree, local management practices can support or detract from the capacity of local ecosystems to support a high level of native biodiversity. Although the evaluation of specific habitats and individual species are beyond the scope of this assessment, the *California Adaptation Planning Guide: APG: Defining Local and Regional Impact* (2012a) provides key questions that communities should consider as they move forward with developing adaptation strategies:

<u>Questions Regarding Characteristics of an Ecosystem</u>

- What is the current condition of existing ecosystems and habitats? Note: The city's current Habitat Sensitivity Map is based on 1989 LUP data.
- Is the landscape permeable, allowing ease of movement across and between habitat patches and types?
- What is the level of redundancy in the ecosystem, particularly for special-status species?
- Does the conservation/open space element in the general plan protect contiguous tracks of habitat?
- What natural protections currently exist for local ecosystems?
- Are there management plans, programs or policies in place to protect open space and associated ecosystems in the community? Do these plans explicitly protect sensitive species and habitats?

- Has the community established a monitoring program to track changes in species population and ecosystem health?
- Is there a land conservancy or similar organization that works to protect vulnerable habitat?

Questions Regarding Characteristics of Species

- What species currently utilize or may utilize the coastal zone?
- Is the species able to modify behavior or physiology with shifting conditions?
- Is the species able to move over large distances (e.g., through seed dispersal mechanisms)?
- Does the species have robust genetic diversity (related to population size)?

2.4.5 Risk and Onset

The IPCC considers sea level rise to be of high probability (California Emergency Management Agency and California Natural Resources Agency 2012a), therefore the potential impacts to coastal habitats and species range due to higher sea levels identified in this section should be a priority for adaptive planning. Sea level rise itself is a relatively slow process which allows for some species and habitat adaption. The greatest risk in Pacific Grove comes from the combined effects of sea level rise with coastal storm flooding and tsunami inundation.

Many of the factors that influence the anticipated changed seasonal pattern are labeled by the IPCC (California Emergency Management Agency and California Natural Resources Agency 2012a) as moderately certain. In the project areas, increased wildfire, sea level rise, drought, and temperature also are viewed as moderately certain. The overall impact of climate change on biodiversity and habitat expected to occur over time is not due to any single factor, but rather the collective outcome of several interrelated impacts. For example, the combined change in the seasonal distribution of precipitation and temperature will affect biodiversity to a greater extent than either of these separate impacts.

The fact that climate change impacts cannot be precisely projected on small spatial scales does not imply that change is not occurring. It simply places a burden on a community to track the behavior and health of local ecosystems and facilitate the protection of special-status species and habitats to the extent feasible.

2.5 COASTAL DEVELOPMENT AND INFRASTRUCTURE

This section consists of the issues associated with potential climate change impacts on coastal development and infrastructure. Potential impacts addressed in this analysis include increases in temperature, shifts in precipitation levels, higher sea level, severe storms, and secondarily, wildfire.

Coastal development considered in this assessment includes residences, commercial uses, community services (schools, libraries), and emergency services (hospitals, schools, emergency facilities). Infrastructure considered includes roads, water, wastewater, storm water drainage, electricity, communication systems, and natural gas, located partially or entirely within the coastal zone, at increased risk due to the impacts of climate change.

Please refer to section 1.2, Methodology of this report for a discussion the approach and methodology used in this assessment.

2.5.1 Exposure

Climate change will affect coastal development and infrastructure along the California coast. The largest projected damages will come from sea level rise threatening large portions of California's coastal transportation, housing, and energy-related infrastructure. The most significant climate impacts to California's infrastructure are predicted to be from higher temperatures and extreme weather events across the state, reduced and shifting precipitation patterns in Northern California, and sea level rise (California Natural Resources Agency 2009).

Direct climate change effects that the coastal zone will experience that would potentially affect development and infrastructure include: increased temperatures and extreme heat events, changes in precipitation patterns and rain events, sea level rise, coastal erosion, and flooding. Secondary effects associated with some of these changes include an increased risk of wildfire.

Temperature

Anticipated temperature increases are expected to increase energy demands in summer and decrease them in winter. Temperature increases and prolonged extremes may also directly affect building structures as well as infrastructure through premature wear and aging. It is expected that extreme hot days (including prolonged periods of very hot days), are likely to become more frequent, increasing maintenance costs due to premature failure of street pavement. (California Natural Resources Agency 2009).

The temperatures anticipated are regularly experienced by structures in inland areas with much higher temperatures. However, it is possible that building features, especially attic ventilation, which may have been viewed as less critical when many of the structures in Pacific Grove were built, could be inadequate to handle a higher temperature range. The most likely effect of higher temperatures with inadequate attic ventilation would be premature aging of roofing materials, resulting in a shorter replacement cycle. Older buildings with poor insulation will experience higher discomfort levels during periods of elevated temperatures, or may require retrofitting with air conditioners and resulting increased electrical demands.

Temperature would not affect underground utilities. Above-ground utilities, especially electrical distribution lines, could be susceptible to overheating under extreme conditions if not designed for those conditions, but this would not occur with the projected temperature range (an increase of approximately 5.3 degrees Fahrenheit for an average annual temperature of 62.0 degrees Fahrenheit).

Precipitation / Intense Rainfall

Changes in precipitation patterns can be expected to affect various types of infrastructure. For example, sewers and wastewater treatment facilities could see growing strains as climate change proceeds. Overall, Pacific Grove should expect drier winters, however, expected changes in precipitation patterns could include a continued risk of short and intense rainfall events and associated flooding, with the occasional greater-than-historical flooding events. Such extreme rainfall events and flooding can cause overloading of wastewater systems, as well as physical damage to culverts, canals, and water treatment facilities (California Natural Resources Agency 2009).

Sea Level Rise

The potential for sea level rise is present along the entire coast of Monterey County. Accelerating sea level rise is likely to cause some of the greatest impacts on California's infrastructure. The economic cost associated with the required alteration, fortification, or relocation of existing infrastructure is likely to be substantial. Certain types of infrastructure may also be at risk from indirect impacts of sea level rise and coastal inundation, such as the potential for sea water backflow to impair coastal water sanitation drainage systems during flood events, or collapse due to increased erosion.

Coastal flooding in Monterey County is generally associated with Pacific Ocean storms in the months of November through February that work in conjunction with high tides and strong winds to cause significant coastal flooding. Coastal communities experiencing increases in mean sea level are at greater risk to the effects of coastal flood hazards as natural, protective buffers such as the coastal bluffs are lost and property and infrastructure become more exposed to the

frequency and severity of coastal flood and storm surge inundation. Such communities may also be at greater risk to increased coastal erosion and the intrusion of saltwater into groundwater aquifers which can lead to contamination of sources of freshwater for drinking or agricultural use, and other consequences including the loss of critically important habitat.

Pacific Grove's shoreline is mostly dominated by exposed granitic rock that forms a relatively stable and durable barrier to protect shoreline development from the constant barrage of ocean waves. Although wave activity can become intense during winter storms, the Pacific Grove shore has historically not retreated significantly (PG 1994, Ch. 10, p.6).

Severe Storms

Increase in the occurrence and intensity of severe storm events (e.g. hurricane, tornado, storm surge, etc.) is a direct impact of climate change that has the potential to expose Pacific Grove's development and infrastructure to severe damage. As forecasts for this phenomenon is not yet available, a prediction of the extent of vulnerability is beyond the scope of this assessment.

Wildfire (secondary effect)

Increased wildfire risk is a secondary effect of climate change largely related to higher temperatures, reduced precipitation or drought, and changes in weather patterns. The three main factors contributing to wildland fire behavior are topography, fuel, and weather. Higher temperatures combined with reduced precipitation can be expected to increase wildfire threat through increased fuel loads and ignition risks. In Pacific Grove, areas with the highest risk of wildfire are located in the inland central portion of the city where neighborhoods are more forested and contain a higher density of mature trees. In the study area, risk of wildfire decreases as distance from the more forested central area of the city increases.

2.5.2 Sensitivity

This section discusses existing and proposed development, critical facilities, and infrastructure most likely to be affected by climate-related effects.

Coastal Development

As shown in Figure 23, Development and Infrastructure, there are residential areas, commercial and visitor-serving facilities, and emergency services/responder facilities in the study area. Homes and facilities closest to the Pacific Ocean are more susceptible to direct effects associated with sea level rise, flooding, and coastal erosion while homes and facilities located in the more forested areas of the city are likely more susceptible to wildfire, including homes nearer more treed areas of the golf course.

Residences

Residential density in the study area is highest in Areas I-III, associated with the Pacific Grove Retreat, Beach Tract, and Monarch Pines Mobile Home Park. Development in these neighborhoods is denser than in the other planning areas due to small lots sizes, typical of the Retreat's "tent" lots. In addition, the lots in the Asilomar Dunes neighborhood have a minimum lot size of a half-acre in the LUP, which inherently prevents a higher residential density.

Commercial and Visitor-Serving Facilities

The Sunset Commercial District is located along Sunset Drive, south of the Asilomar Conference Grounds. The area consist of one lot north of Sunset Drive developed with an existing lumber yard, Hayward Lumber; and three lots south of Sunset Drive developed with a storage facility, PG Self Storage on the western lot, and the Russell Service Center on the two eastern lots.

Visitor-serving facilities include both commercial and accommodations uses as identified in Table 5, Inventory of Existing Visitor-Serving Commercial in the Coastal Zone, and Table 6, Inventory of Existing Visitor-Serving Accommodations in the coastal zone, below.

Critical Facilities, Emergency Services, and Infrastructure

Table 7, Inventory of Critical Facilities and Infrastructure in the Coastal Zone, summarizes the existing critical facilities and infrastructure located in the study area (based on a review of data used to prepare the *Monterey County Multi-Jurisdictional Hazard Mitigation Plan Final Draft* (September 2014)).

Educational Facilities

All Pacific Grove Union School District schools and the District office are located outside the coastal zone. Educational facilities within the coastal zone are Stanford University's Hopkins Marine Laboratory and the Monterey Bay Aquarium. These facilities are abutting and located in Area I, with the Aquarium property being bisected by the eastern city limits and the City of Monterey's city limits.

Marine, Environmental, and Community

Three facilities within this category are located within the coastal zone: NOAA Southwest Fisheries Science Center; Pacific Grove Carnegie Public Library; and the Sally Griffin Senior Center/Meals-on-Wheels program.

Sewer System

The main sewer trunk line enters the coastal zone at Arena Avenue, from where it follows Asilomar Avenue northward, then Ocean View Boulevard eastward to Monterey. The entire

distance along Ocean View Boulevard is force main, and there are six pump stations located along the main between Arena Avenue and the eastern city limits. Most of the Ocean View Avenue force main, and five of the six pump stations between Arena Avenue and the eastern city limit, are within 150 feet of the shoreline (see Figure 23, Development and Infrastructure). The remaining two pump stations are located in Planning Area VI, and neither of these is located within 150 feet of the shoreline.

The Pacific Grove ASBS watershed drains into approximately 3.2 miles of coastline, to which most of the eastern portion of City of Pacific Grove drains. Since 2003, the city has implemented two phases of connections between the storm drain and the sanitary sewer to divert dry weather runoff in the ASBS watershed, from immediately west of Lovers Point along Ocean view Boulevard to First Street.

In 2012, the third phase of the diversion system and a set of integrated wastewater system improvements were approved and constructed. The site is located within the Ocean View Boulevard corridor between First Street and Eardley Avenue. The dry weather diversion and sewer force main facilities are now located primarily within the Ocean View Boulevard right-of-way, but cross the Monterey Peninsula Recreation Trail in one location (underground), near the intersection of Ocean View Boulevard and Eardley Avenue. The pump station facility is located in this corridor, within the landscaped median between Ocean View Boulevard and the Recreation Trail (City of Pacific Grove 2012).

Many single-family residences in the Asilomar Dunes neighborhood are still on septic systems and are not connected to the city's sewer system. Connecting to the sewer main is typically triggered with redevelopment as a condition of the building permit per Pacific Grove Municipal Code (PGMC) section 9.20.050, Sewer connection – Required – Septic tank.

Storm Drain System

The city has five major storm drain lines, all of which collect storm water run-off at higher elevations and dispose of it offshore. Two lines drain westward into the Pacific Ocean and three drain northward into Monterey Bay. Numerous other outfalls serve local drainage areas. The most significant concern of the storm drain lines is functionality of the outfalls. Storm water outfalls can function above or below the water line, but those discharging below the water line must be designed accordingly. An underwater storm water discharge pipe will be filled with sea water to the tide elevation, and thus capacity for storm water within the pipe will be reduced. Underwater pipes can also collect sand from the ocean, also reducing capacity. An outfall sitting at the tide line would be best designed with a check valve to keep ocean water from entering. In some cases, pumping storm water out of the collection pipe might be desirable to overcome the counter-pressure of sea water and prevent storm water backing up where it reaches the tide level.

Refer also to the discussion above under Sewer System regarding connections between the storm drain and the sanitary sewer systems associated with the city's dry weather diversion projects.

Water Distribution System

The coastal zone is served by the five million gallon storage tank at Forest Lake in Del Monte Forest, which is at a high elevation, and the distribution system downslopes from that site. Consequently, most of the larger water pipes are located upland of the coastal zone. Pacific Grove's primary water distribution system consists mostly of a system of looped 4-, 6-, 8- and 12-inch mains with adequate fire flows and pressures (City of Pacific Grove 1994, page 2). Only one pipe 6 inches or larger in diameter is located within 150 feet of the shoreline, and that for only about 1,000 feet.

Electricity/ Communication Systems

PG&E has utility poles throughout the coastal zone in Pacific Grove located in existing roadway rights-of-way. For all new construction in the city, except for the construction of single-family dwellings in an R-1 zone, all utilities must be placed underground on the building site according to PGMC section 18.21.010, Underground utilities. Equipment appurtenant to underground facilities such as surface-mounted transformers, pedestal-mounted terminal boxes, meter cabinets, and concealed ducts are exempted from being underground.

There are also regulations regarding cable communication systems in PGMC section 21.12, Cable Communication Franchise Procedures, which applies to both overhead and underground facilities. These are outlined in PGMC section 21.12.140(c), General Construction and Operational Practice.

Natural Gas

PG&E does not have any natural gas transmission lines within Pacific Grove (PG&E 2014). The only natural gas lines in Pacific Grove are distribution lines and local lines.

Transportation

The only significant transportation infrastructure within the city's coastal zone is ground-related: streets, trials, and sidewalks. No air or marine transportation facilities exist within the city. None of the ground infrastructure within the coastal zone is of region-wide importance, but does serve the residents and visitors in the city, and serves a critical role in ingress, egress, and emergency response. Ocean View Boulevard and Sunset Drive are the main collectors within the coastal zone, with arterials traveling landward or parallel to the shoreline outside the coastal zone.

2.5.3 Potential Impacts

Temperature

Increased temperatures, within the range predicted for Pacific Grove (an increase of approximately 5.3 degrees Fahrenheit for an average annual temperature of 62.0 degrees Fahrenheit), would not have any direct significant impacts on residential and commercial development or institutions located within the coastal zone. The temperatures anticipated are regularly experienced by structures in inland areas with much higher temperatures. However, it is possible that building features, especially attic ventilation, which may have been viewed as less critical when many of the structures in Pacific Grove were built, could be inadequate to handle a higher temperature range. The most likely effect of higher temperatures with inadequate attic ventilation would be premature aging of roofing materials, resulting in a shorter replacement cycle. Older buildings with poor insulation will experience higher discomfort levels during periods of elevated temperatures, or may require retrofitting with air conditioners and resulting increased electrical demands.

Temperature would not affect underground utilities. Above-ground utilities, especially electrical distribution lines, could be susceptible to overheating under extreme conditions if not designed for those conditions, but this would not occur with the projected temperature range.

Temperature extremes can have a considerable impact on transportation facilities, especially environmental conditions that range outside of the conditions for which the system was designed. Temperature extremes – like heat wave events – can cause buckling of roadways and premature deterioration or failure of transportation infrastructure, leading to transportation-related safety issues and higher costs related to infrastructure maintenance and repair (California Natural Resources Agency 2009). In addition to hindering general travel and the public's ability to reach needed services, damage to transportation infrastructure may obstruct emergency responder access. While there are no major regional transportation routes through the study area, damage to roadways that creates unsafe travel conditions could result in increased accidents, or in extreme scenarios, hazardous materials spillage. However, the predicted temperature ranges for Pacific Grove are within ranges that are acceptable for normal pavement aging, so significant deterioration of asphalt roadways is not likely.

Precipitation/Intense Rainfall

Increased precipitation would not have significant direct effects on coastal residential or commercial development or institutions. Structures housing these uses are presumably equipped to handle rainfall, and increasing the amount or intensity of precipitation should not result in significant adverse effects on these structures. Minor adverse effects could occur if intense rainfall results in flooding adjacent to these structures, which could result in water infiltration or water damage to foundations, basements, or crawl spaces.

Storm water infrastructure could be affected through higher loading due to larger peaks in the runoff. Storm water drainage systems are sized to accommodate the majority of intense rainfalls, but for economic reasons, are not sized to accommodate the largest rainfalls. Temporary flooding during these largest rainfall events is considered acceptable. With increased precipitation and more frequent intense rainstorms, the frequency at which the storm drainage system is unable to handle run-off would increase, and the severity of flooding could also increase.

Widespread power outages are a concern for the city following major winter storms, mostly caused by downed trees, typically associated with strong winter storms (Monterey County Hazard Mitigation Planning Team 2014).

Water, wastewater, and natural gas infrastructure would not be significantly affected by increased precipitation.

Transportation would be affected primarily through the increased potential for flooding and potential for landslides or related roadway damage. Flooding on roadways would be related to the inability of the storm drainage system (discussed above) to carry off rainwater. Although located outside of Pacific Grove, one especially critical transportation link that could be prone to flooding is the Del Monte Boulevard tunnel in Monterey, which provides one of two major access routes to Pacific Grove. Landslides, mud flows, or debris flows associated with prolonged heavy rainfall could temporarily block roads, disrupting travel and emergency response services. Landslides can also damage roadway surfaces and underlying soils, which can result in long-term lane closures. Roadways in and outside of the coastal zone could be disrupted by landslides, and could potentially result in significant blockages.

Sea Level Rise

Sea level rise will result in increased flooding and erosion, both of which may affect Pacific Grove's coastal development and infrastructure. However, less than one percent of the City of Pacific Grove's population (approximately 155 people) resides in this hazard zone (U.S. Census Bureau 2014). No buildings, critical facilities, or critical infrastructure as identified in the city's hazard mitigation plan are located in this hazard area (Monterey County Hazard Mitigation Planning Team 2014).

The greatest increase in coastal flooding is expected to occur in Areas IV-A and IV-B, with notable increases at Lovers Point (in Area III) and the southern portion of Area IV. The main land use affected in Area IV-A would be residential while the affected land uses in Area IV-B include mainly residential and the golf course. In the Lovers Point area, land uses affected would be mostly Lovers Point Park and nearby commercial businesses. In the eastern portion of the study area in Area VI, development density is low and coastal flooding would have minimal effect on development.

Figure 24, Development and Infrastructure – Potential Sea Level Rise, identifies the potential extent of flooding due to sea level rise combined with a 100-year flood event. No structures are located within areas that would experience inundation from sea level rise alone. Two factors account for this: first, the base elevation of developed areas in Pacific Grove is sufficiently high, due to the bluffs along the shoreline; secondly, relatively few structures are located immediately adjacent to the shoreline. However, when the effects of sea level rise and coastal flooding from storms are combined, about 50 houses seaward of Surf Avenue, about ten houses upward of Surf Avenue, and about 15 houses seaward of Shell Avenue, all in Area IV-A, would be subject to flooding.

One of the two houses located west of Sunset Drive (between Lighthouse Avenue and Jewell Avenue) appears to be subject to inundation. All of the facilities at Lovers Point Park, including the commercial uses, would potentially be subject to inundation with the combined effects of sea level rise and coastal flooding.

The Hopkins Marine Station is outside of the area that would be directly affected by sea level rise. However, the Hopkins Marine Station is located within an area that is already prone to coastal flooding, and the level of coastal flooding would intensify in conjunction with sea level rise. Therefore, the Hopkins Marine Station could experience more intensive temporary flooding under future conditions.

Figure 10-2 of the 1994 General Plan Health and Safety Element shows evacuation routes, with the main collectors being State Route 68 traveling south to Highway 1 and Central Avenue traveling west and connecting to the City of Monterey. Smaller arterials connect to City of Monterey streets crossing over David Avenue at the Pacific Grove/Monterey city limits. Additionally, there are two routes into Pebble Beach: 17 Mile Drive and Forest Lodge Road. With the exception of a short section of Ocean View Boulevard adjacent to the Hopkins Marine Station, the designated evacuation routes are outside the coastal zone. The section of Ocean View Boulevard that is designated as an evacuation route is subject to coastal flooding under future sea level rise conditions.

Flooding associated with sea level rise could affect storm water systems designed for current mean sea level outfall levels. As shown in Figure 23, Development and Infrastructure, presented earlier there are numerous storm water outfalls located within the study area, five of which serve large drainage areas. Sea level rise, or a combination of sea level rise and coastal storm flooding, could place outfalls at or below the surf level, potentially interfering with discharges and backing up storm water at inlets, causing flooding. Although the wastewater system does not intermix with storm water flows, there is critical wastewater infrastructure that could be affected by coastal flooding. Seven of the wastewater pump stations within the coastal zone could be inundated by coastal flooding (Pump numbers 11, 12, 13, 14, 15, 15.5, and 16). The remaining two pumps stations are located outside of flooding areas associated with sea level rise. If flooding causes the pumps to fail, the wastewater system would backup behind the pump station,

with potentially serious health consequences, e.g., possible illicit discharges caused by overflows. In an extreme situation, storm surges or tsunami could damage a pump station and result in spillage of wastewater. Water and natural gas infrastructure would not be significantly affected by either sea level rise or the combined effects of sea level rise and coastal flooding.

Ocean View Boulevard and Sunset Drive are considered at long-term risk to wave attack, coastal flooding, erosion, and scouring (particularly on the north end of peninsula). Under existing conditions, much of Ocean View Boulevard/Sunset Drive between Esplanade Street and Asilomar Avenue is subject to coastal flooding, and the area of flooding and intensity of flooding would increase with sea level rise.

Pacific Grove is susceptible to both dune and cliff erosion. While the average dune erosion rate is approximately 2.6 feet per year, the rocky cliffs only erode at 2-4 inches annually (Monterey County Hazard Mitigation Planning Team 2014). Figure 25, Development and Infrastructure – Potential Erosion, shows the areas within the study area that are expected to be susceptible to increased coastal erosion associated with climate change. The greatest increase in coastal erosion is expected to occur along the coastline within Areas I through IV-B. By far the main land use affected by coastal erosion in these areas will be residential. Other land uses expected to be affected include public parks and trails (including Lovers Point), Hopkins Marine Station, Pacific Grove Golf Course, and commercial businesses along Ocean View Boulevard.

In addition, the Monterey Interceptor pipeline, which transports all of the untreated sewage from the city to the Monterey Regional Water Pollution Control Agency (MRWPCA) Regional Treatment Plant in Marina, is a critical facility deemed at risk to the long-term effects of coastal erosion and sea level rise (Monterey County Hazard Mitigation Planning Team 2014). As discussed in the introduction to this assessment, the extent and intensity of tsunami events is anticipated to increase with climate change. Figure 26, Development and Infrastructure – Potential Tsunami, identifies risks due to tsunami and provides a discussion of impacts to the community.

Wildfire (secondary effect)

Rising temperatures and reduced precipitation increase the likelihood of wildfire which may pose a significant threat to development and infrastructure. Using the California Fire and Resource Assessment Program model, nearly 97 percent of the city's population is located in a moderate wildland fire hazard area (Monterey County Hazard Mitigation Planning Team 2014). Figure 27, Development and Infrastructure – Potential Wildfire, shows the current wildfire risk to development and infrastructure within the city's coastal zone. The majority of land uses within the wildfire zones indicated on Figure 27 are residential. Also located within these zones are Asilomar State Beach and Conference Grounds and the Sunset/Crocker Commercial District businesses.

City planning staff had indicated that the wildland fire hazard area for their jurisdiction is more expansive than previously mapped through the Fire Resource and Assessment Program. There are a lot of dead or dying trees in the heavily forested Pacific Grove Retreat which leads to higher risks, especially when combined with the fact that most surrounding residential construction is wood frame with Class C roofs (more combustible/flammable) (Monterey County Hazard Mitigation Planning Team 2014, Appendix P, P13). In addition, wildfire risk could be expected to increase over time as temperatures continue to rise and precipitation patterns result in longer periods of decreased rainfall and/or drought.

Coastal development within the coastal zone is at risk of wildfire to the extent that wildfire from wooded upland areas could move into the developed coastal areas. The portion of the coastal zone most prone to wildfire is the Asilomar Dunes area (Area IV), which is more heavily vegetated, but which also has a less-dense development pattern. None of the institutional uses within the coastal zone is at high risk from wildfires.

Wildfire would not have significant direct effects on underground utilities. However, in the aftermath of a wildfire, storm drainage infrastructure can be clogged with debris. Mud and sediment can flow into storm drains from ground left un-vegetated by fire if precautions are not taken in advance of the rainy season. The public water supply is deemed a critical local issue for the city (and entire peninsula), particularly with regard to the supply available during future major fires. The city has seen hydrant pressure drops during past fire events (Monterey County Hazard Mitigation Planning Team 2014). Wildfires can damage above-ground electrical infrastructure, for example, wooden telephone poles, which also carry communications lines.

The threat from flames near roadways, the smoke from the fire, and the need to move emergency responders and protect public safety can all affect the transportation system by closing roads. Very hot fires can damage road pavement. Wildfire can also increase the potential for and/or severity of landslides during subsequent winter storms (refer to discussion of Precipitation/Intense Rainstorms, above). Most of the designated evacuation routes are outside the coastal zone, but many are located in uplands areas that have a higher susceptibility to wildfire. The State Route 68 evacuation route is especially susceptible to disruption in the event of a wildfire owing to the dense vegetation that it passes.

2.5.4 Adaptive Capacity

Assessing the adaptive capacity evaluates the degree to which these systems are able to withstand the conditions projected in the future as a result of climate change. Jurisdictions must evaluate their current ability to address the projected impacts, including current management plans for infrastructure systems, future plans, and funding allocations.

Coastal Development

Most coastal development is out of reach of significant climate change effects. There are no developed properties that would be permanently inundated by sea level rise, although some structures could be inundated through a combination of sea level rise and either a severe storm or tsunami.

Residences

To a large degree, the city's current planning and zoning mitigates flooding of homes, by preserving large open areas adjacent to the shoreline in most parts of the city. However, up to 75 houses in Area IV-A could be inundated by the combined effects of sea level rise and either coastal storm flooding or a tsunami. No precautions or design features are known to have been implemented at any of these houses. The city does not have any regulations in place to ensure that modification to existing buildings or construction of new buildings in this area would include designs to withstand coastal flooding or tsunami. Although coastal flooding or tsunami inundation would be an occasional and temporary effect, the result would be none-the-less devastating for those properties. In addition, there are a multitude of homes in Areas I and II on the city's Historical Resources Inventory, which would restrict the potential for alterations that could result in improved flooding resistance.

Houses located in wooded areas are susceptible to wildfire. Significantly remodeled or newly constructed structures within the State Responsibility Area for fire response are subject to wildfire protective measures required by the Urban Wildland Intermix Code. However, only a very small portion of Pacific Grove along its boundary with the unincorporated Pebble Beach area is within the State Responsibility Area and subject to these design requirements.

Commercial and Visitor Serving Facilities

Several commercial buildings could also be temporarily affected by a combination of sea level rise and coastal flooding or tsunami. The city does not have any plans to construct flood barriers or to finance private property improvements for coastal flooding protection.

Critical Facilities, Infrastructure, and Emergency Services

Facility redundancy (where if one segment of a system is out of use, another segment can serve as a substitute) is one of the best approaches to safeguarding against network type systems failure during a climate induced emergency, such as coastal flooding or wildfire. However, redundancy is not always an economically viable choice.

Educational Facilities

Most educational facilities are out of reach of significant climate change effects, with a significant exception being the Hopkins Marine Station, which could be inundated by waves in combination with sea level rise. The Hopkins Marine Station requires a shoreline location in order to carry out most of its mission. Among other activities, the Hopkins Marine Station monitors a variety of ocean conditions, including indicators that could assist in understanding ocean changes related to climate change.

Marine, Environmental, and Community

Marine, environmental, and community facilities in Pacific Grove are out-of-reach of direct climate change effects.

Sewer System

The city has significant wastewater infrastructure potentially at risk under combined sea level rise and coastal storm flooding, but duplication of this infrastructure would be infeasible and relocation to higher elevation locations would be difficult to accomplish. Phased and prioritized relocation of sewer lines would be more feasible to accomplish and could potentially be coordinated with long-term system maintenance or capital investment. A plan that took into account age and condition of the infrastructure, capacity and functionality of the infrastructure, and susceptibility to damage, would need to be developed in order to establish priorities for system relocation. Measures to safeguard against inundation damage to critical pump station facilities might be necessary as a short-term approach.

Storm Drain System

The storm water drainage system is potentially susceptible to back-up and upstream flooding if the outfalls are submerged. Specific elevation surveys would need to be conducted for storm water outfalls to determine the extent to which these outfalls could be submerged and adversely affected by rising sea level and coastal flooding events under elevated sea level conditions.

Water Distribution System

The water distribution system is mostly outside the coastal zone and out-of-reach of direct climate change effects.

Electricity/ Communication Systems

Widespread power outages are a concern for the city following major winter storms, mostly caused by downed trees (Monterey County Hazard Mitigation Planning Team 2014). Protection of power lines is the responsibility of Pacific Gas and Electric Company, which owns the facilities.

Natural Gas

Major components of the natural gas distribution system are located outside the coastal zone and out-of-reach of direct climate change effects.

Transportation

Because Pacific Grove is situated at the end of a peninsula, regional ingress and egress are limited to the south and east. There are three general ingress/egress routes: Monterey city roads (although this access is limited to a great extent by the lack of roads through the Presidio and past downtown Monterey); over State Route 68; and Pebble Beach roads. The city's priorities are for roadway improvements and protection of vital transportation infrastructure from future coastal events. The city is concerned with limited ingress/egress to the community following major disaster events, and continues to review and update designated evacuation routes through its emergency operations plan. A related concern is the narrow design of many city streets, which will make mobility and evacuation difficult during major events (Monterey County Hazard Mitigation Planning Team 2014). This is true especially in the city's older neighborhoods located in the Pacific Grove Retreat in Planning Areas I and II, some of which actually are classified as an alley in the zoning code due to their narrow widths. PGMC 23.08 defines an alley as a public right-of-way for vehicular and pedestrian traffic which is 16 feet or less in width. Oftentimes these alleys and narrow streets have on-street parking in both directions, making it possible for only one vehicle to pass at a time. In addition, residents have difficulty accessing driveways, both pulling in and attempting to pull out due to the tight parking conditions on the street.

With the exception of a short section of Ocean View Boulevard adjacent to the Hopkins Marine Station, the designated evacuation routes are outside the coastal zone. The section of Ocean View Boulevard that is designated as an evacuation route is subject to coastal flooding under future sea level rise conditions, and could not be counted on for use during a coastal flooding or tsunami event. Alternative routes are available upland of Ocean View Boulevard, including eight streets that are also designated as evacuation routes. The upland evacuation routes, and especially the State Route 68 evacuation route, are susceptible to disruption the event of a wildfire.

The city has redundancy in at least portions of its transportation system, especially in Area II where a grid of streets could be utilized for traffic flow during emergencies.

2.5.5 Risk and Onset

The IPCC considers sea level rise to be of high probability, therefore coastal communities should consider the potential impacts of sea level rise to be of higher priority for adaptive planning than other potential effects of climate change. The current rate of sea level rise over the last decade is

about 0.12 inch per year; thus the current onset of sea level rise is relatively slow. The rate is expected to increase closer to the IPCC's 2100 climate change effects forecast year. Pacific Grove is fortunate in that the bluffs along its coastline are significantly higher than the projected rise in sea level; the greatest risk in Pacific Grove comes from the combined effects of sea level rise with coastal storm flooding and tsunami inundation.

The IPCC considers temperature increase to be of high probability; therefore, communities should consider the potential impacts of temperature rise to be of high priority for adaptive planning. Cal-Adapt shows expected temperature until 2090. These projections can be used to determine onset and rate of change over time. It is assumed that temperature rises would occur at rates similar to sea level rise. In Pacific Grove, because the climate is cool to begin with, even fairly large rises in temperature would not result in extreme high temperatures.

The IPCC has not established probabilities for change in storm intensity risk. The IPCC has established changes in precipitation as medium probability and changes in temperature as high probability. Therefore, using the more conservative of the two, it is recommended that changes in storm intensity be considered to be of medium probability. Increases in storm intensity are of significant concern in Pacific Grove because, combined with sea level rise, intense storms pose one of the most significant climate change threats to Pacific Grove. (California Emergency Management Agency and California Natural Resources Agency 2012a, page 76).

Table 1 Historic Tsunamis in Monterey Bay

Date	Source of Tsunami	Location Wave Recorded	Wave Height
June 15, 1896	Japan	Santa Cruz	1.5 meters
April 1, 1946	Alaska	Santa Cruz	1.5 meters
May 22, 1960	Chile	Monterey	1.1 meters
March 28, 1964	Alaska	Moss Landing	1.4 meters
		Monterey	1.4 meters
		Capitola	1.4 meters
		Santa Cruz	1.5 meters
October 18, 1989	Northern California	Moss Landing	1.0 meters
March 11, 2011	Japan	Monterey	0.7 meters

Source: California Department of Conservation 2013; California Coastal Commission 2011.

Table 2 Recreational Resources

Area/Facility	Type	Visitor-Serving Commercial Uses
Berwick Park	Park	Rented out for special events
Greenwood Park	Park	None
Andy Jacobsen Park	Park	None
Jewell Park (Gazebo/Little House)	Park	Rented out for special events, gazebo for weddings, little house has kitchen facility
Caledonia Park	Park	Rented out for special events, tot lot play area, swings, baseball field, basketball court, open space free play area, picnic tables, bathrooms, Americans with Disabilities Act (ADA) compliant
Chautauqua Hall	Building	Rented out for special events
Shoreline Park	Park	None
Chase Park	Park	None
Sally Griffin Senior Center	Building	Rented out for special events
Lovers Point Park	Park	Rented out for special events, picnic tables, barbeque pits, large lawn, vista points, bathrooms, bus/oversize parking, beach volleyball, Beach House Restaurant
Lovers Point Beach	Beach	Point Pinos Grill, kayak and surrey rentals
Stillwell Children's Pool	Pool	Gated pool, outdoor shower
Point Pinos Lighthouse	Building	Rented out for special events-coming soon, tours provided, gift shop, bathrooms
Pacific Grove Golf Course	Golf Course	18-hole golf course, partially in the coastal zone, bathrooms located south of Crespi Pond
Perkins Park	Park	None
Marine Gardens Park	Park	None
Asilomar State Beach	Beach	None

Source: City of Pacific Grove 1994, 2014d.

Table 3 Shoreline Access Facilities

Area/Facility	Off Street Parking	Viewing	Trails	Beach	Tide Pools/ Rocks	V-C
Monterey Peninsula Recreation Trail		✓	🚲🚶♿			
Berwick Park		✓	🚶		✓	
Shoreline Park		✓	🚶		✓	
Lovers Point Park	✓	✓	🚶♿	✓♿	✓	✓
Perkins Park	✓	✓	🚶		✓	
Marine Gardens Park	✓	✓	🚶	✓	✓	
Point Pinos Reservation	✓	✓	🚶		✓	
Asilomar State Beach	✓	✓	🚶♿	✓♿[1]	✓	

Source: City of Pacific Grove 1994, 2014d.

Notes: [1]Asilomar State Beach handicapped trail access provided at Jewell Avenue and opposite Conference Grounds.

✓ = available; ♿ = handicapped access available; 🚶 = hiking trail; 🚲 = bicycle trail

Table 4 Park, Recreational, and Access Facilities at Risk from Coastal Flooding

Area/Facility	Non-commercial Uses	Visitor-Serving Commercial Uses
Berwick Park	Hiking trails, tide pool/rocks access	Rented out for special events
Shoreline Park	Hiking trails, tide pool/rocks access	None
Lovers Point Park	Off-street parking, hiking trails, beach/ tide pool/rocks access	Rented out for special events, picnic tables, barbeque pits, large lawn, vista points, bathrooms, bus/oversize parking, beach volleyball, Beach House Restaurant
Lovers Point Beach	Beach, handicapped access	Point Pinos Grill, kayak and surrey rentals
Stillwell Children's Pool	None	Gated pool, outdoor shower
Pacific Grove Golf Course (partially affected)	None	18-hole golf course, partially in the coastal zone, bathrooms located south of Crespi Pond
Perkins Park	Off-street parking, hiking trails, beach/ tide pool/rocks access	None
Marine Gardens Park	Off-street parking, hiking trails, beach/ tide pool/rocks access	None
Asilomar State Beach	Off-street parking, hiking trails, beach/ tide pool/rocks access, handicapped access	None

Source: City of Pacific Grove 1994, 2014d.

Table 5 Inventory of Existing Visitor-Serving Commercial Facilities in the Coastal Zone

Area/Facility	Address	Area	Visitor-Serving Commercial Uses
American Tin Cannery businesses	125 Ocean View Blvd.	I	Mix of retail and restaurants
Nob Hill	900 Lighthouse Avenue, Monterey	I	Grocery store
Central-Eardley Commercial District businesses	Central Avenue, from Eardley Avenue to Dewey Street	I	Mix of retail, restaurants, professional
Vacant	631 Ocean View Boulevard	III	Historically used as restaurant, onsite parking
Fishwife Restaurant	1996 Sunset Drive	IV	Restaurant
Berwick Park	Ocean View Boulevard between 9th Street and Carmel Avenue	I	Rented out for special events
Jewell Park (Gazebo/Little House)	Central Avenue between Grand and Forest Avenues	II	Rented out for special events, gazebo for weddings, little house has kitchen facility
Caledonia Park	Caledonia Avenue between Central and Jewell Avenues	II	Rented out for special events, tot lot play area, swings, baseball field, basketball court, open space free play area, picnic tables, bathrooms, ADA compliant
Sally Griffin Senior Center	700 Jewell Avenue	III	Rented out for special events
Lovers Point Park (Beach, Stillwell Children's Pool/Grill/Beach House Restaurant)	620 Ocean View Boulevard	III	Rented out for special events, picnic tables, barbeque pits, large lawn, vista points, bathrooms, bus/oversize parking, beach volleyball, Beach House Restaurant, Grill, kayak and surrey rentals, gated children's pool, outdoor shower

Area/Facility	Address	Area	Visitor-Serving Commercial Uses
Point Pinos Lighthouse	80 Lighthouse Avenue	IV-B	Rented out for special events-coming soon, tours provided, gift shop, bathrooms
Pacific Grove Golf Course	77 Asilomar Avenue	IV-B	18-hole golf course, partially in the coastal zone, bathrooms located south of Crespi Pond

Source: EMC Planning Group 2014, Google 2014.

Table 6 Inventory of Existing Visitor-Serving Accommodations in the Coastal Zone

Accommodation	Address	Area
Martine Inn	225 Ocean View Boulevard	II
Green Gables Inn	301 Ocean View Boulevard	II
Seven Gables Inn	555 Ocean View Boulevard	II
Lover's Point Inn	625 Ocean View Boulevard	III
Borg's Ocean Front Motel	635 Ocean View Boulevard	III
Centrella Inn	612 Central Avenue	III
Bide-A-Wee Inn & Cottages	221 Asilomar Avenue	VI
Asilomar Conference Grounds	800 Asilomar Avenue	VI
Beachcomber Inn	1996 Sunset Drive	VI

Source: EMC Planning Group 2014, Google 2014.

Table 7 Inventory of Critical Facilities and Infrastructure in the Coastal Zone

Category	Facility	Address/Location
Government	None in the coastal zone	
Emergency Response	None in the coastal zone[1]	
Care	None in the coastal zone	
Educational	Stanford University Hopkins Marine Station	120 Ocean View Boulevard
Marine, Environmental, and Community	NOAA Southwest Fisheries Science Center	1352 Lighthouse Avenue
	Pacific Grove Public Library	550 Central Ave

Category	Facility	Address/Location
	Sally Griffin Senior Center/Meals-on-Wheels	700 Jewell Avenue
Utilities and Communication Systems	Point Pinos Lighthouse	90 Asilomar Avenue
	Former Point Pinos Wastewater Treatment Plant	West of Crespi Pond, landward of Ocean View Boulevard
	Water systems	Major infrastructure outside coastal zone
	Sewer and storm water systems	Throughout coastal zone
	Sewer system lift stations	Eight lift stations located in the coastal zone. See Figure 23 for exact locations.
	Thirty-four outfalls	Refer to Figure 23 for locations
Transportation and Roadways	Ocean View Boulevard and Sunset Drive are main collectors, with arterials traveling landward	Throughout coastal zone
	Union Pacific Railroad Right-of-Way Trail	Begins at terminus of Monterey Peninsula Recreation Trail, travels west and turns south-south-east after Monarch lane, ends at Sunset Drive just east of Asilomar Avenue intersection
	Monterey Peninsula Recreation Trail	Travels along coastline from Planning Area I-III
	Lovers Point Parking Lot 1	Ocean View Boulevard/17th St intersection
	Lovers Point Parking Lot 2	631 Ocean View Boulevard

Source: Monterey County Hazard Mitigation Planning Team 2014; Google Earth 2014; City of Pacific Grove 1994, 2014e.

Note: [1] The Emergency Operations Center is based out the Police Department, not located in the coastal zone, but responds to emergencies citywide.

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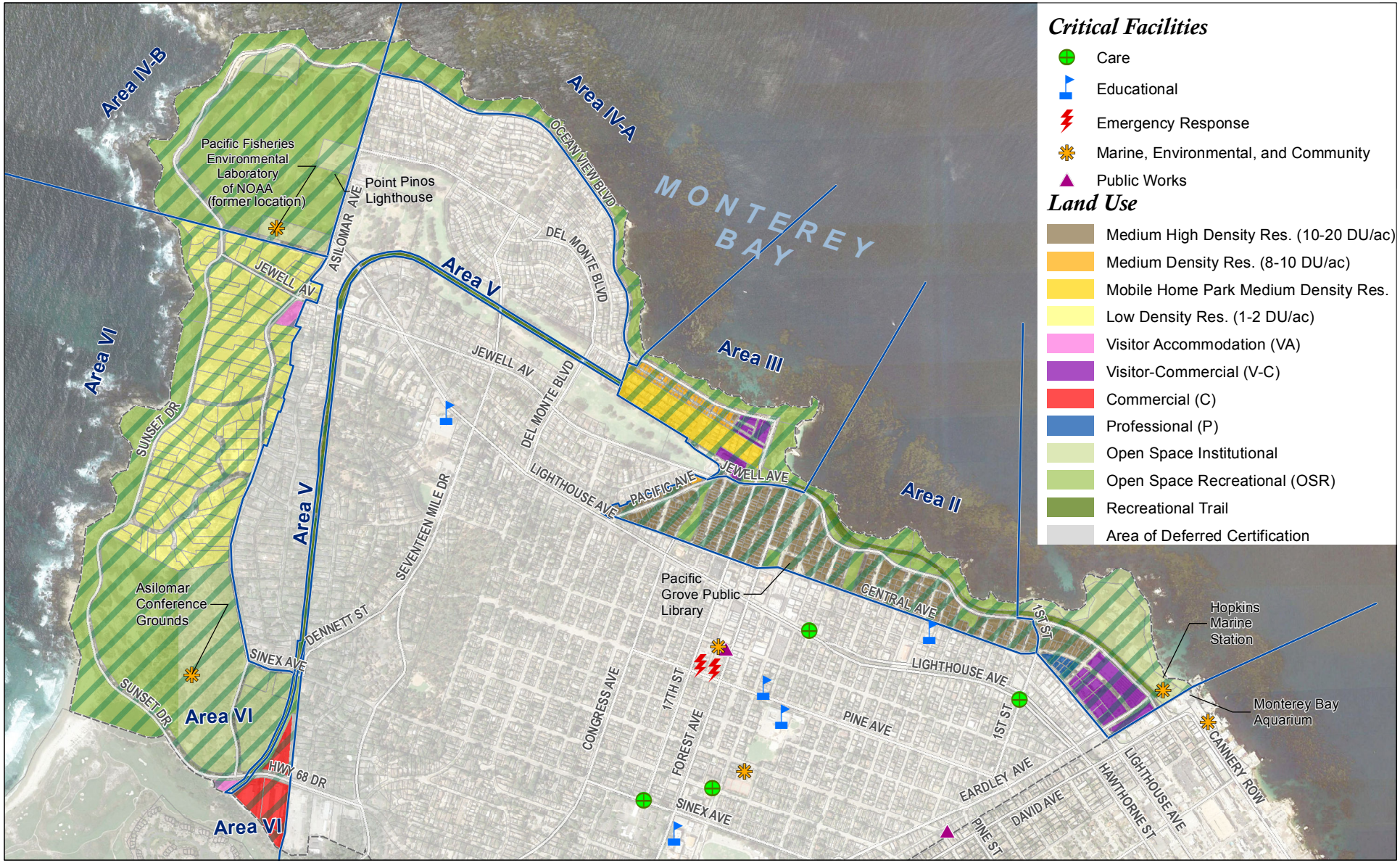

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: City of Pacific Grove 2014, Google Earth 2013

Figure 8

Health and Safety

Pacific Grove Vulnerability Assessment

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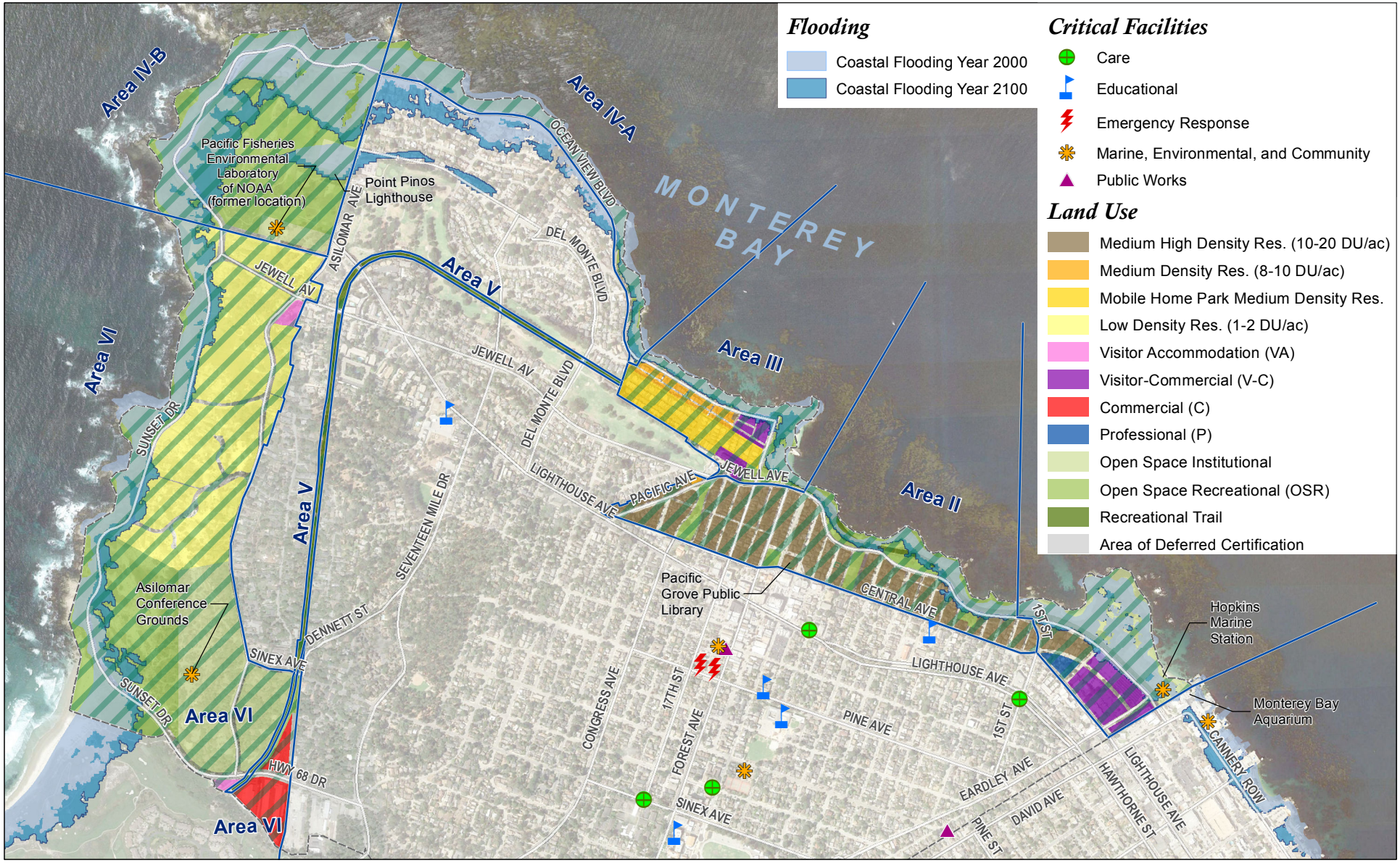

Source: Pacific Institute 2014, City of Pacific Grove 2014, Google Earth 2013

Figure 9

Health and Safety - Potential Sea Level Rise

Pacific Grove Vulnerability Assessment

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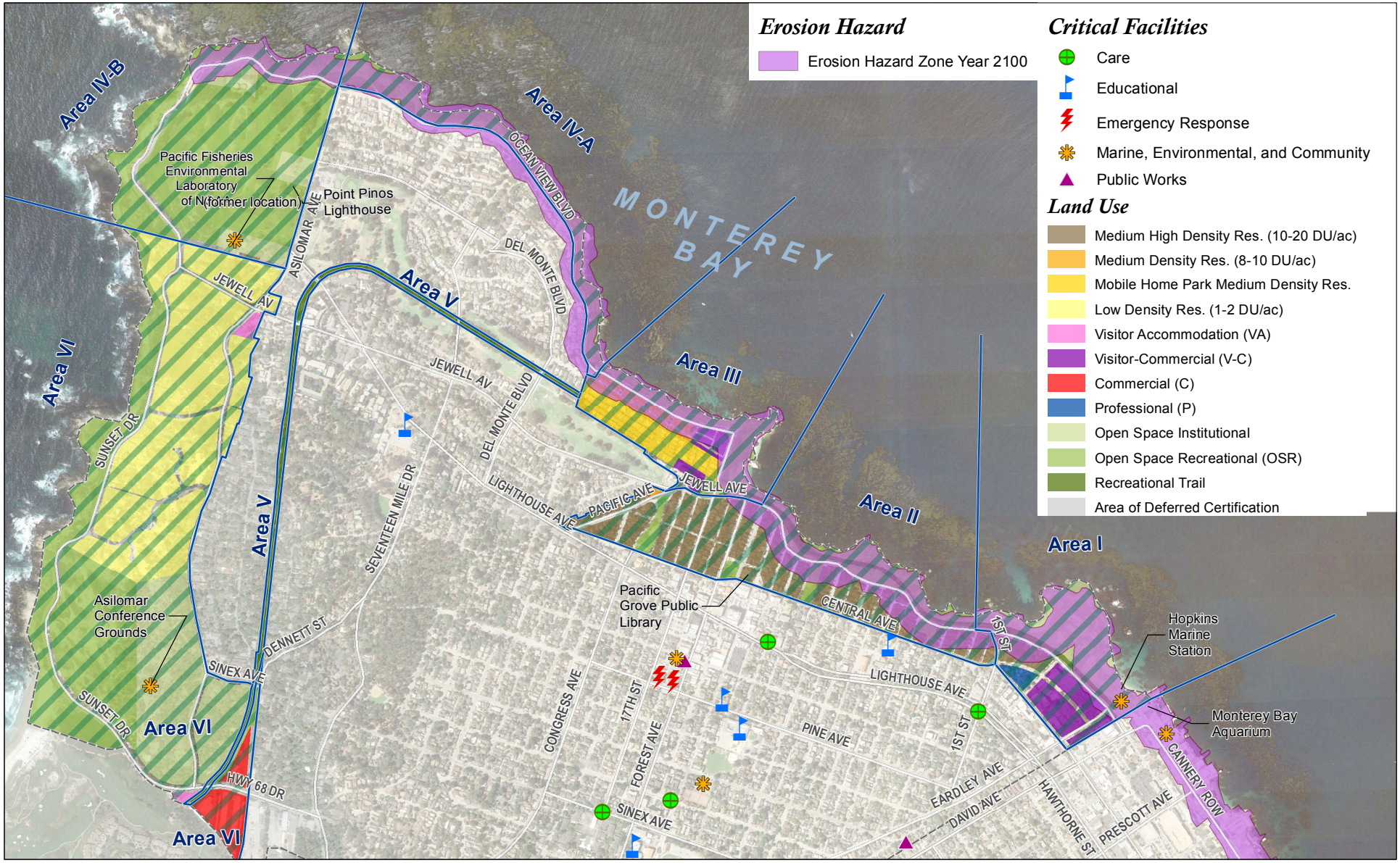

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: Pacific Institute 2014, City of Pacific Grove 2014, Google Earth 2013

Figure 10

Health and Safety - Potential Coastal Erosion

Pacific Grove Vulnerability Assessment

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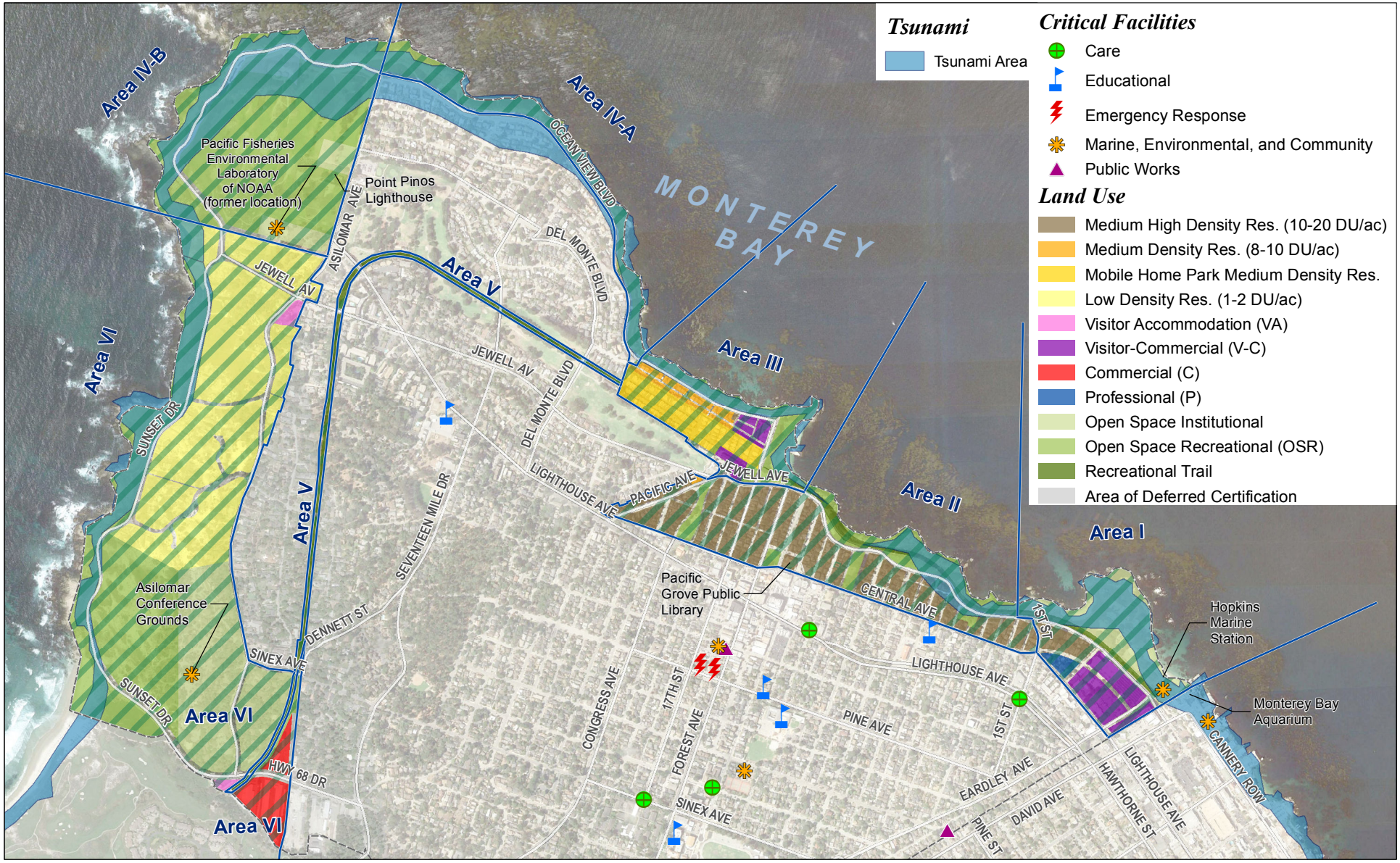

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove 2014, Google Earth 2013

Figure 11

Health and Safety - Potential Tsunami

Pacific Grove Vulnerability Assessment

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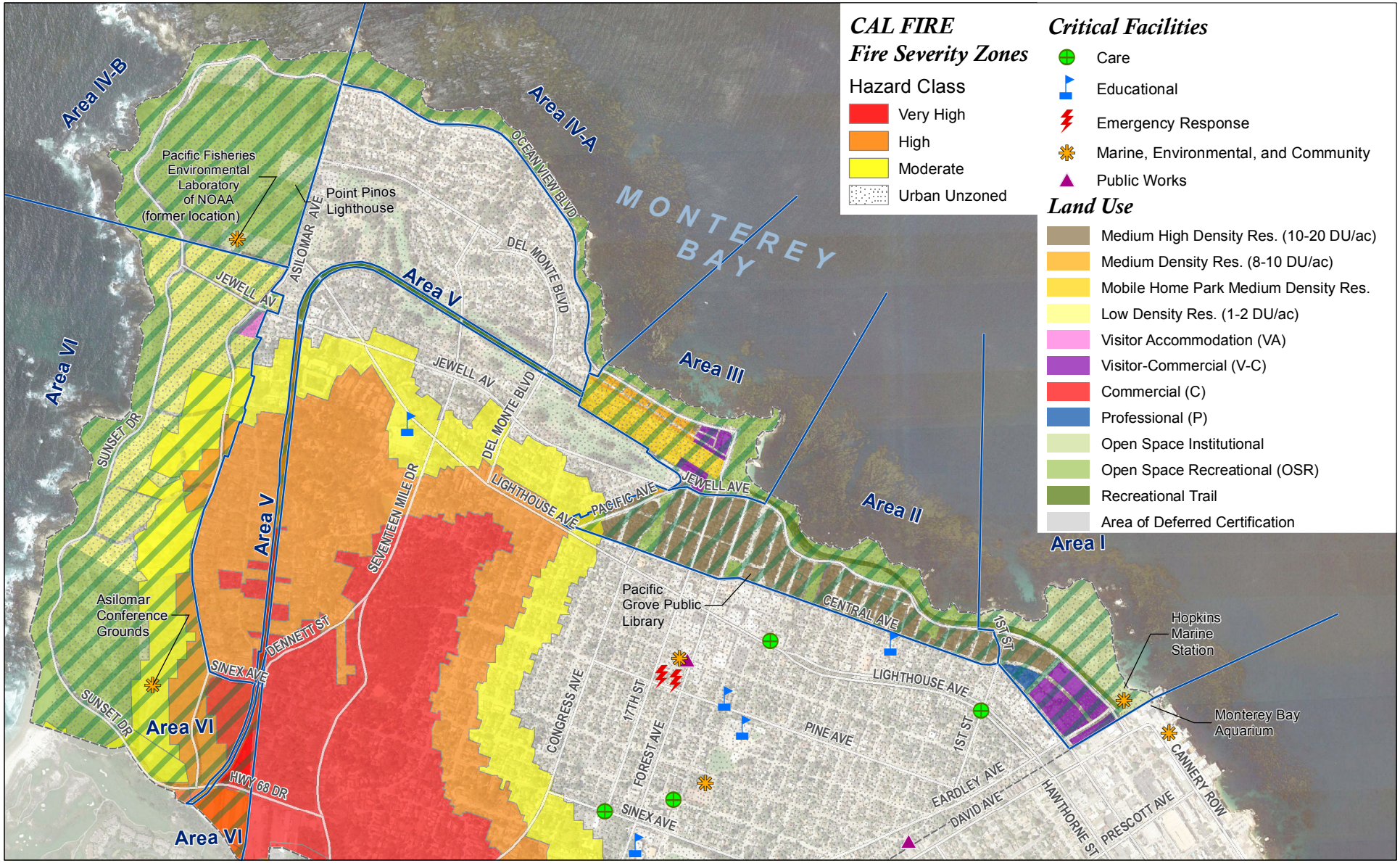

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Legend
- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: CAL FIRE 2007, City of Pacific Grove 2014, Google Earth 2013

Figure 12

Health and Safety - Potential Wildfire

Pacific Grove Vulnerability Assessment

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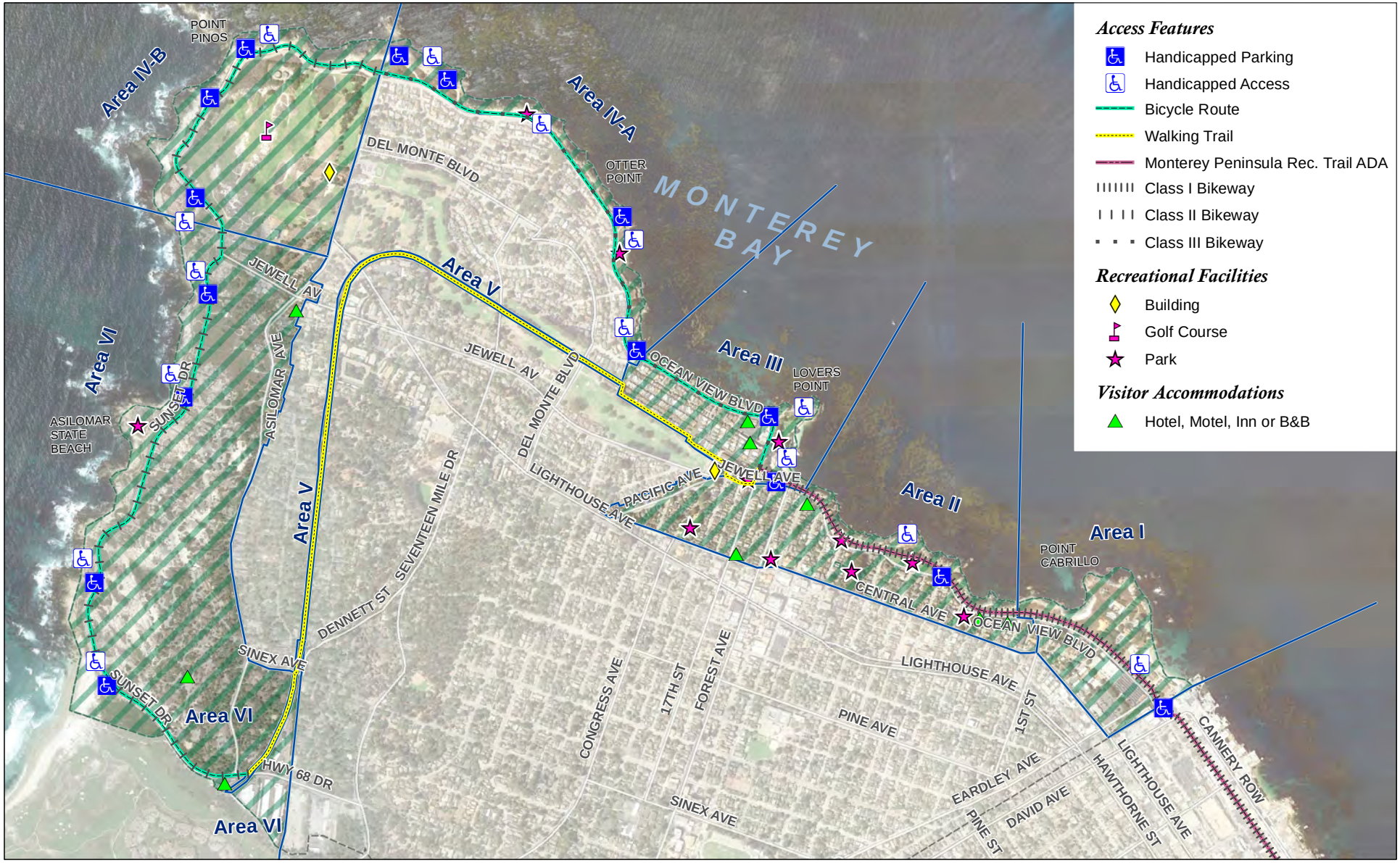

Source: City of Pacific Grove 1989 and 1998, Google Earth 2013

Figure 13

Recreational Resources and Access

Pacific Grove Vulnerability Assessment

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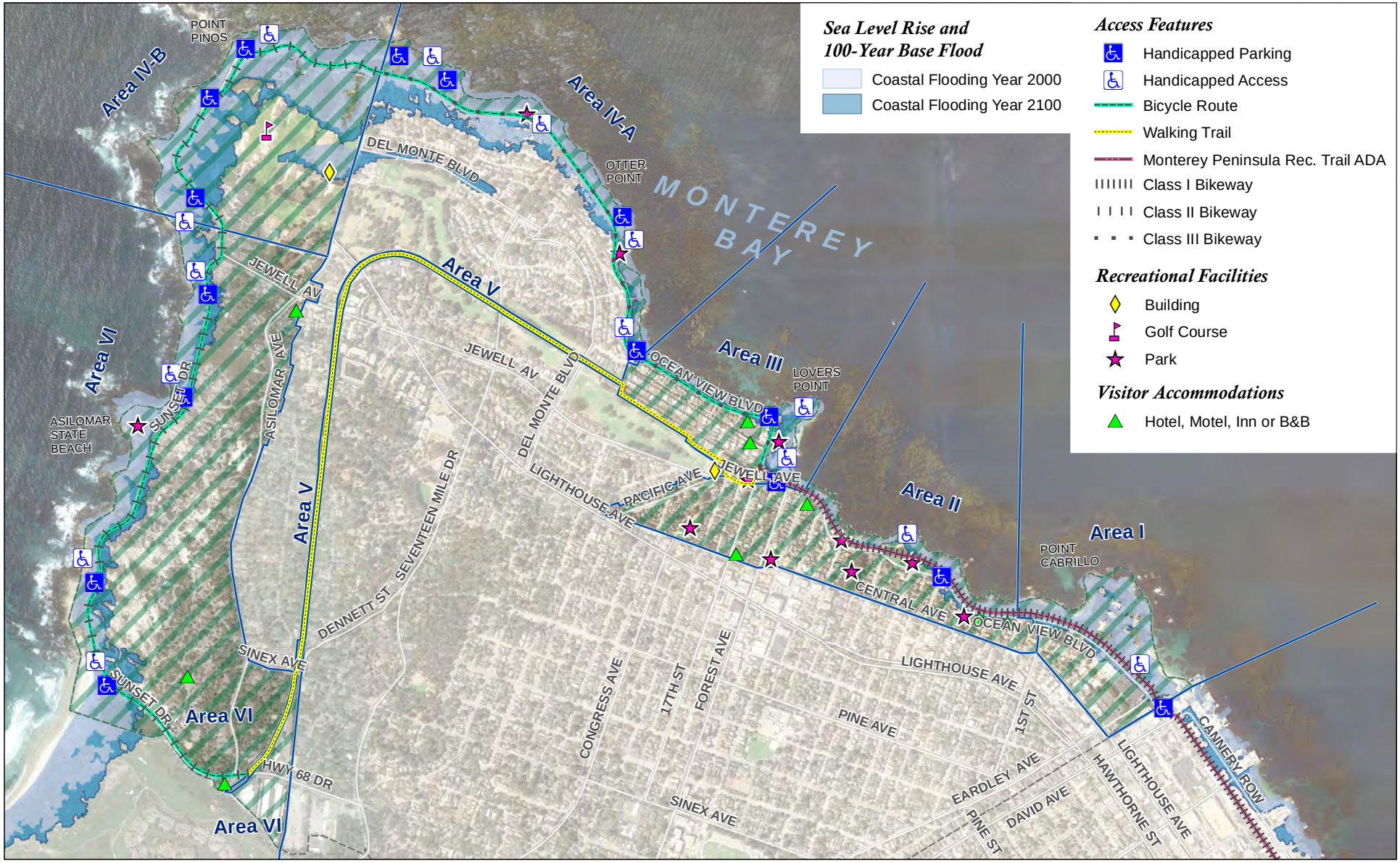

Source: City of Pacific Grove 1989 and 1998, Pacific Institute 2014, Google Earth 2013

Figure 14

Recreational Resources and Access - Potential Sea Level Rise

Pacific Grove Vulnerability Assessment

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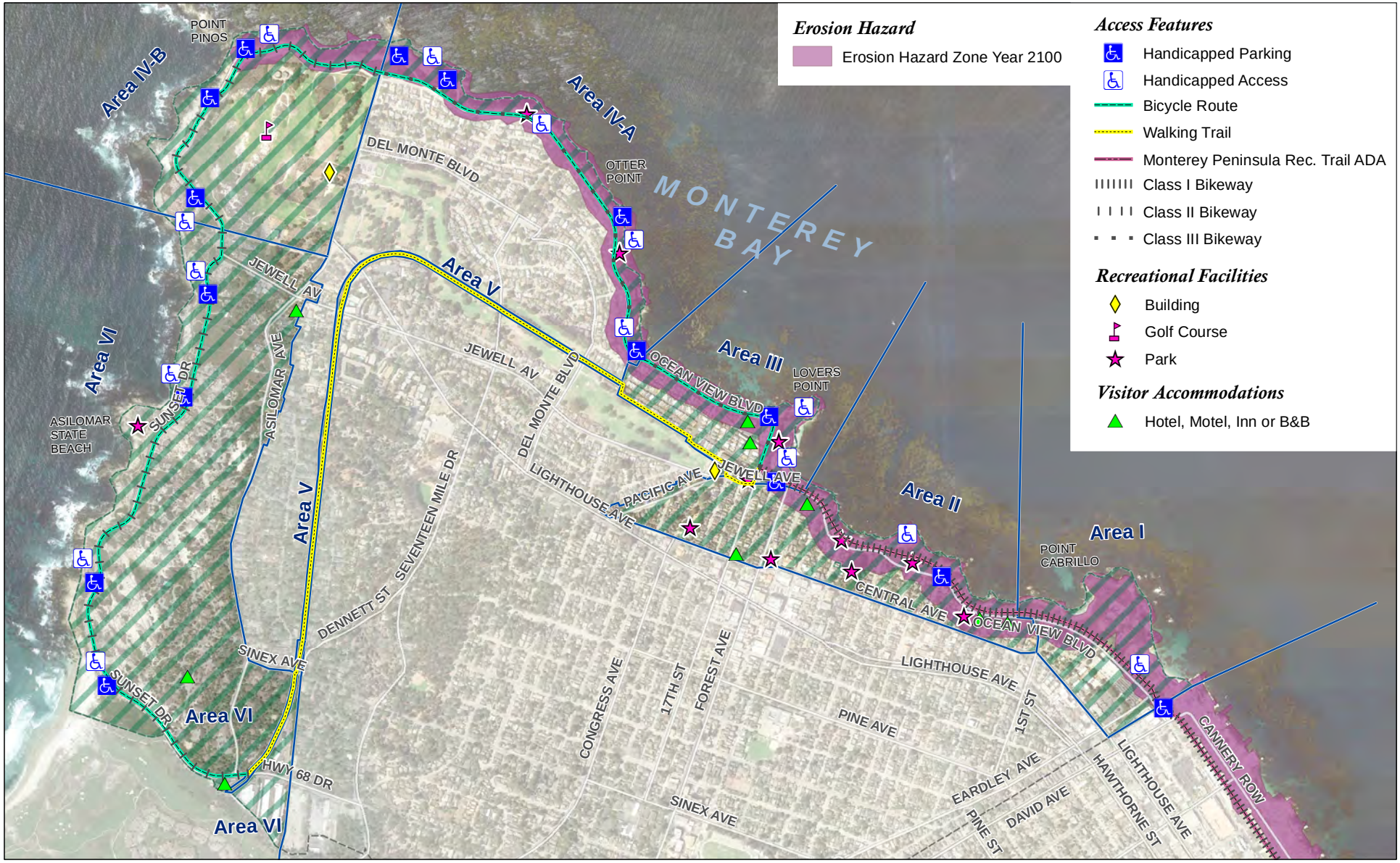

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: City of Pacific Grove 1989 and 1998, Pacific Institute 2014, Google Earth 2013

Figure 15

Recreational Resources and Access - Potential Coastal Erosion

Pacific Grove Vulnerability Assessment

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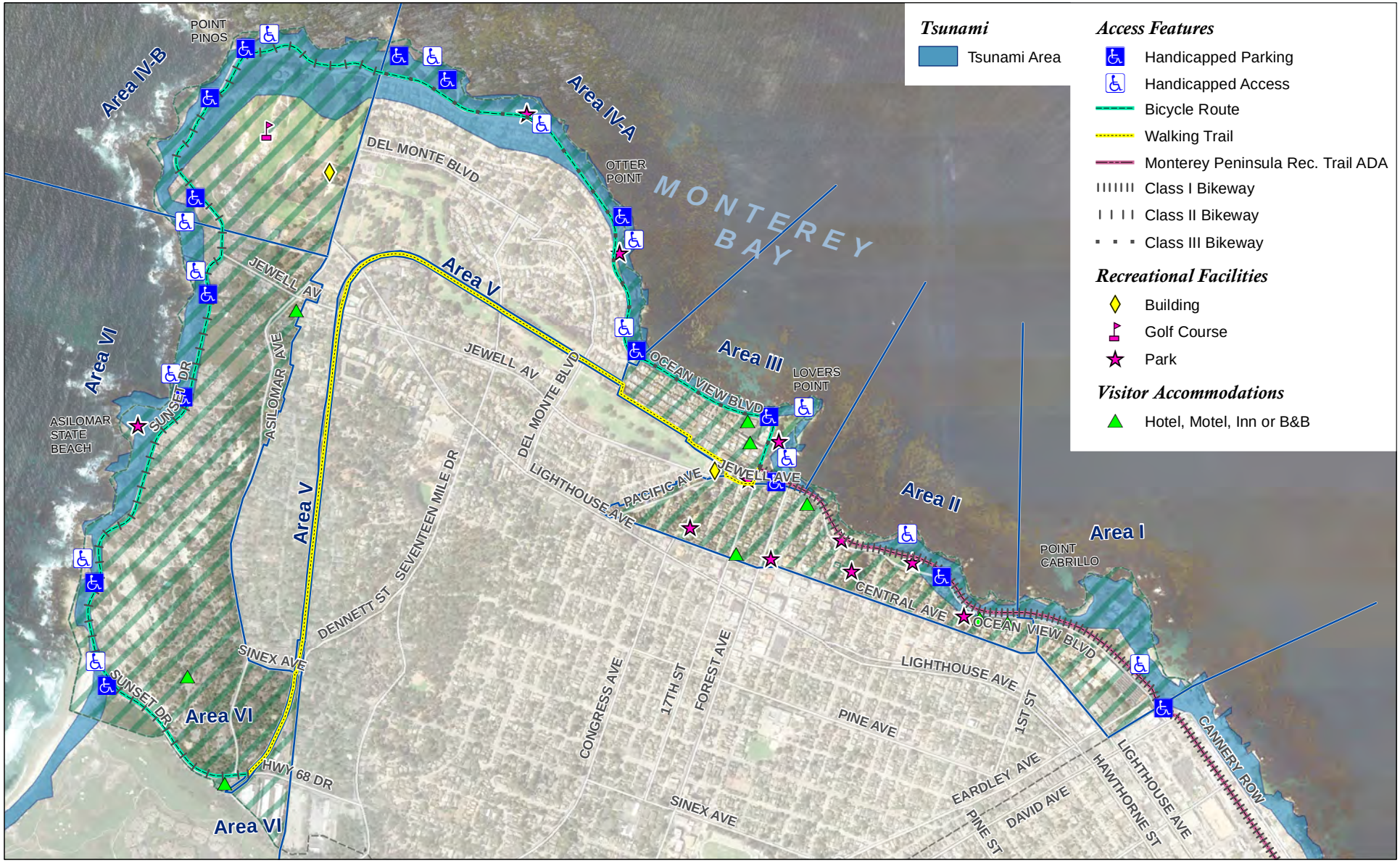

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove 1989 and 1998, Google Earth 2013

Figure 16

Recreational Resources and Access - Potential Tsunami

Pacific Grove Vulnerability Assessment

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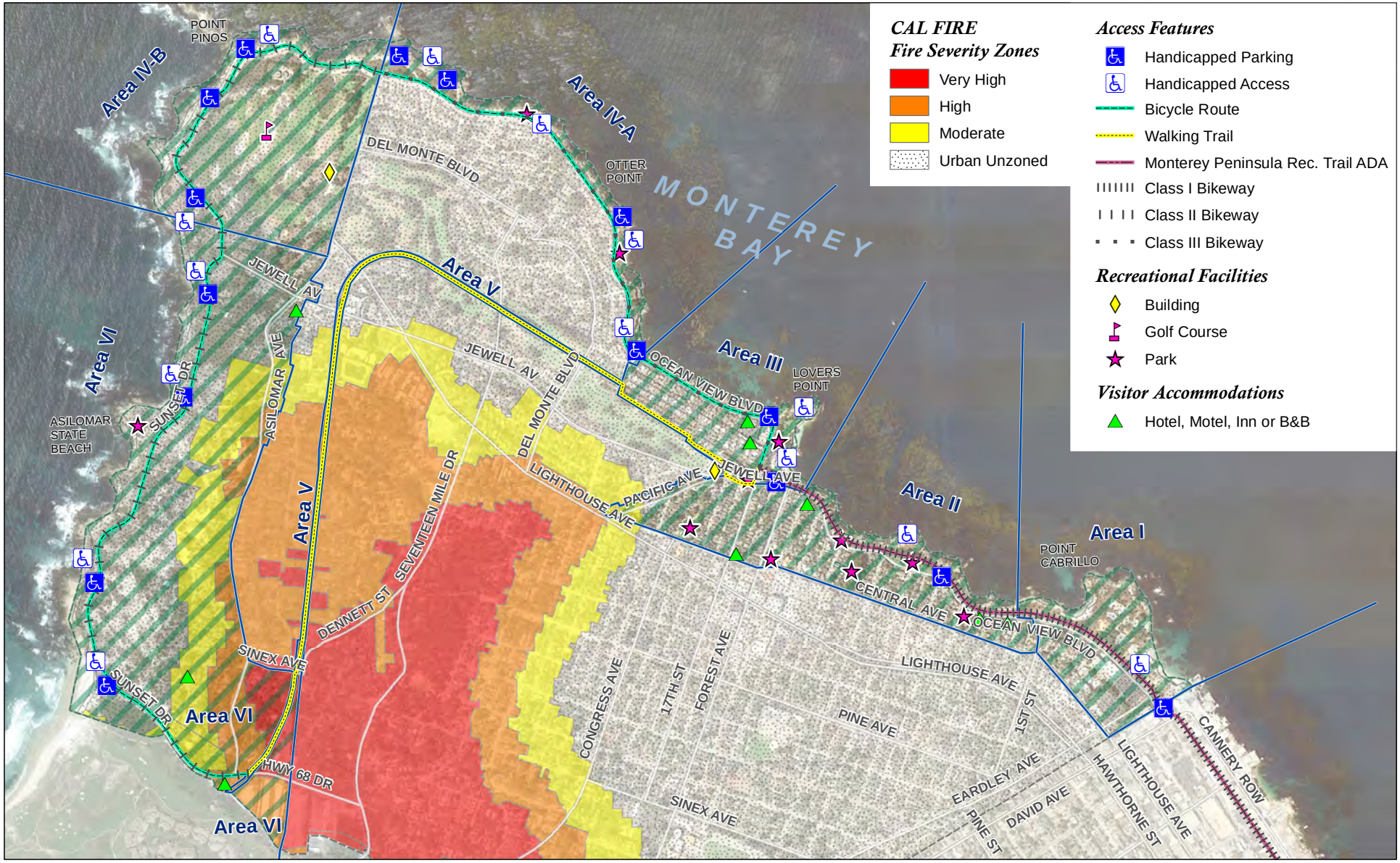

Source: CAL FIRE 2007, City of Pacific Grove 1989 and 1998, Google Earth 2013

Figure 17

Recreational Resources and Access - Potential Wildfire

Pacific Grove Vulnerability Assessment

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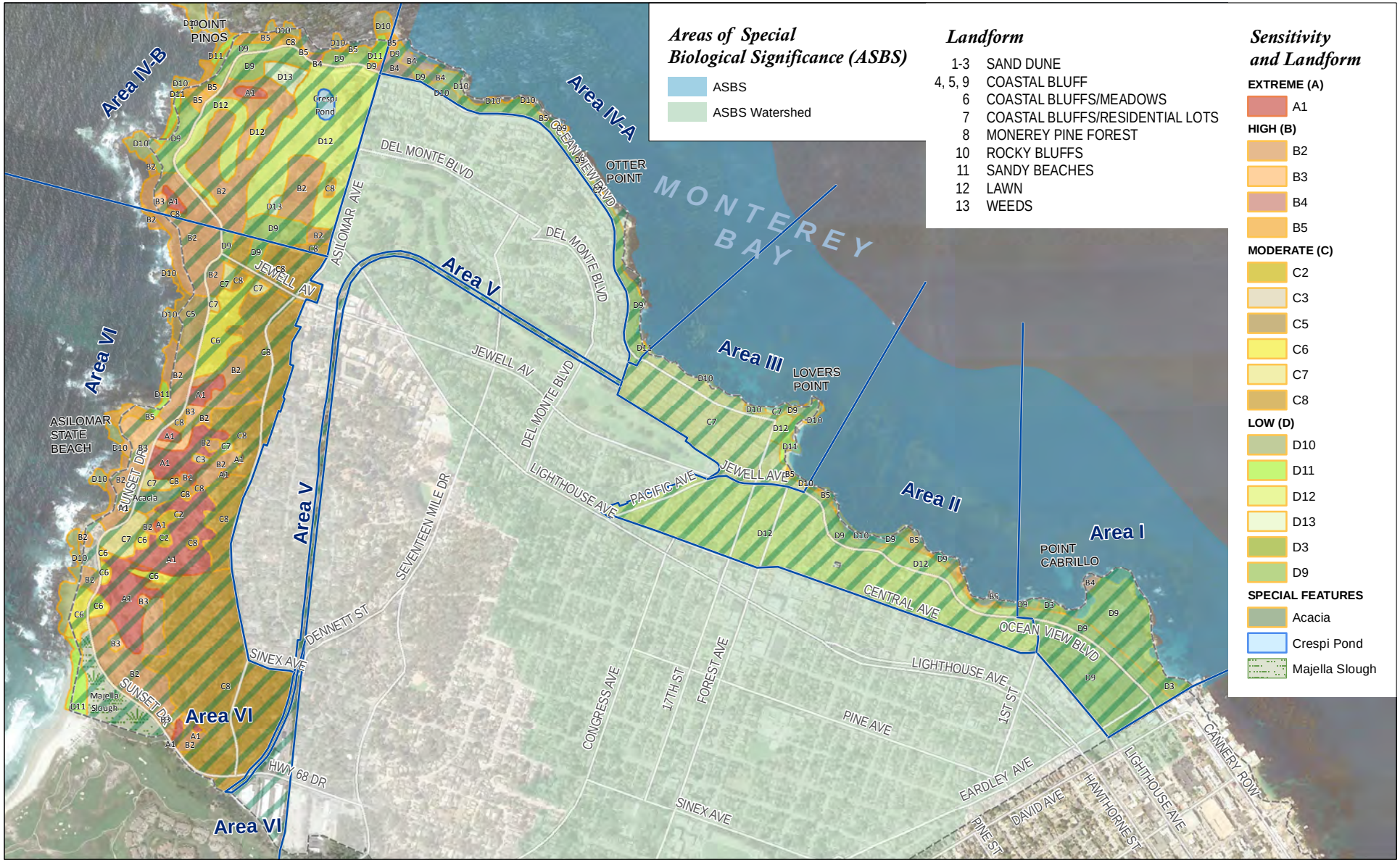

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: City of Pacific Grove, Google Earth 2013

Figure 18

Habitat Sensitivity Map

Pacific Grove Vulnerability Assessment

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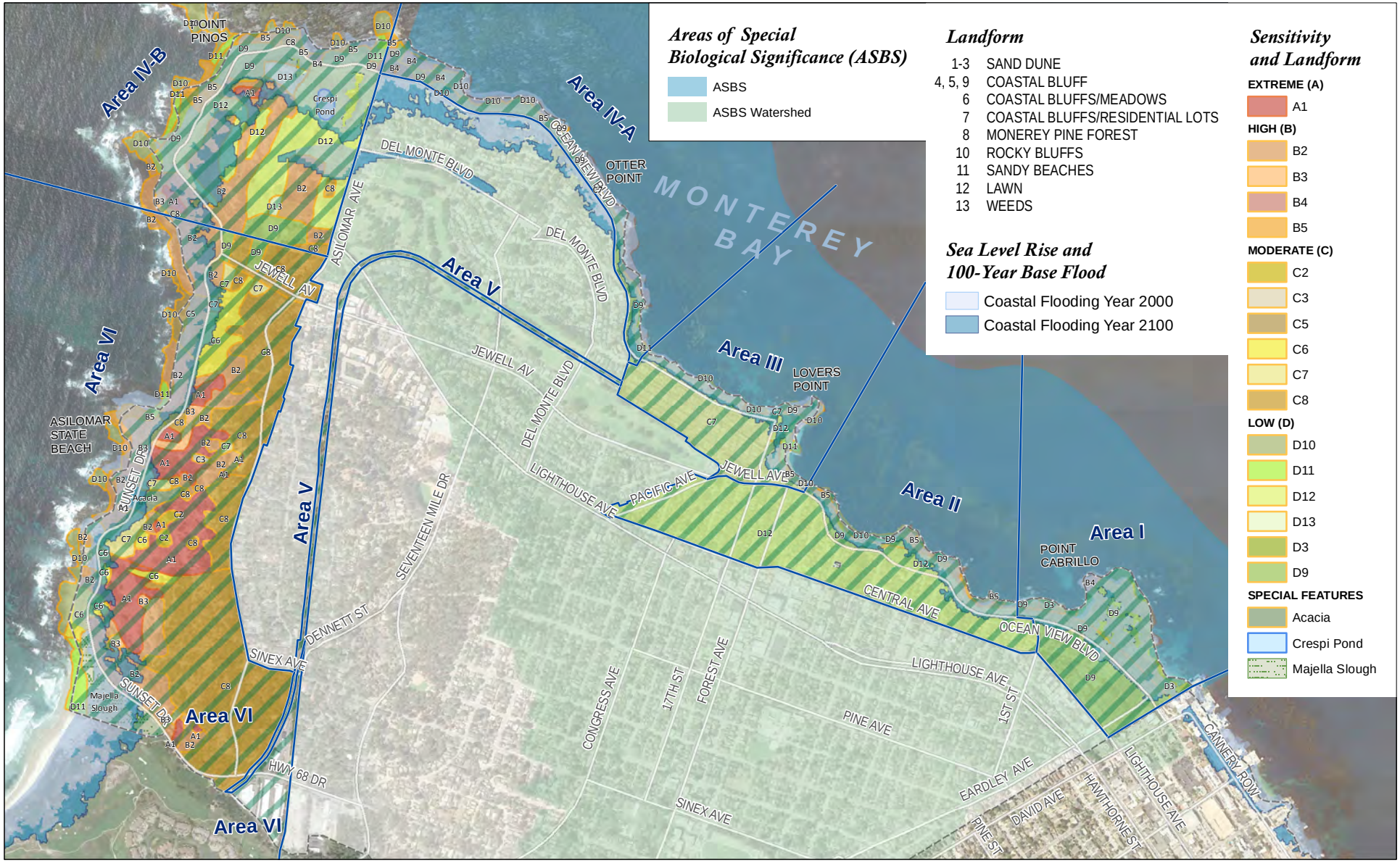

Source: City of Pacific Grove, Pacific Institute 2014, Google Earth 2013

Figure 19

Sensitive Habitat - Potential Sea Level Rise

Pacific Grove Vulnerability Assessment

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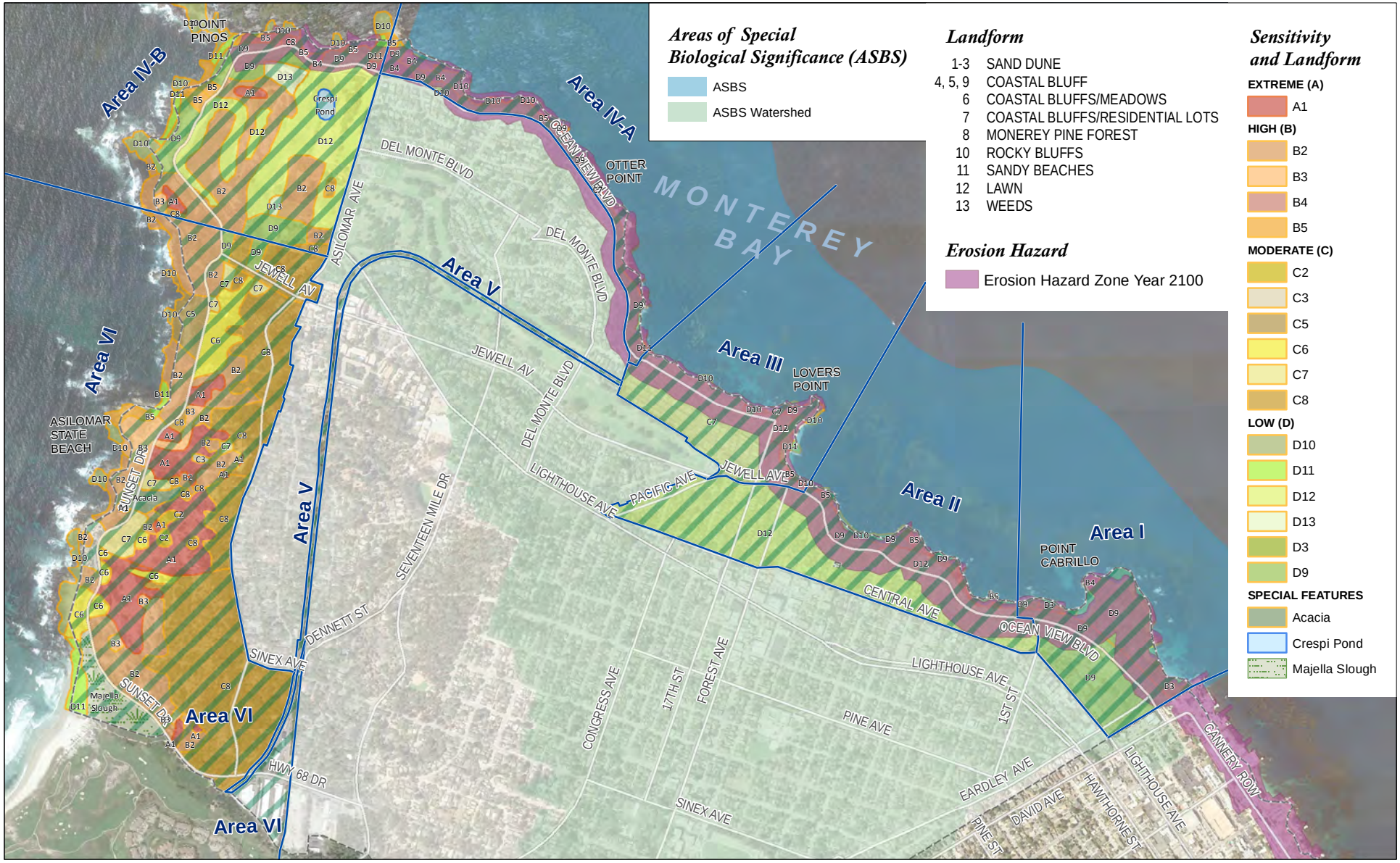

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

City of Pacific Grove, Pacific Institute 2014, Google Earth 2013

Figure 20

Sensitive Habitat - Potential Coastal Erosion

Pacific Grove Vulnerability Assessment

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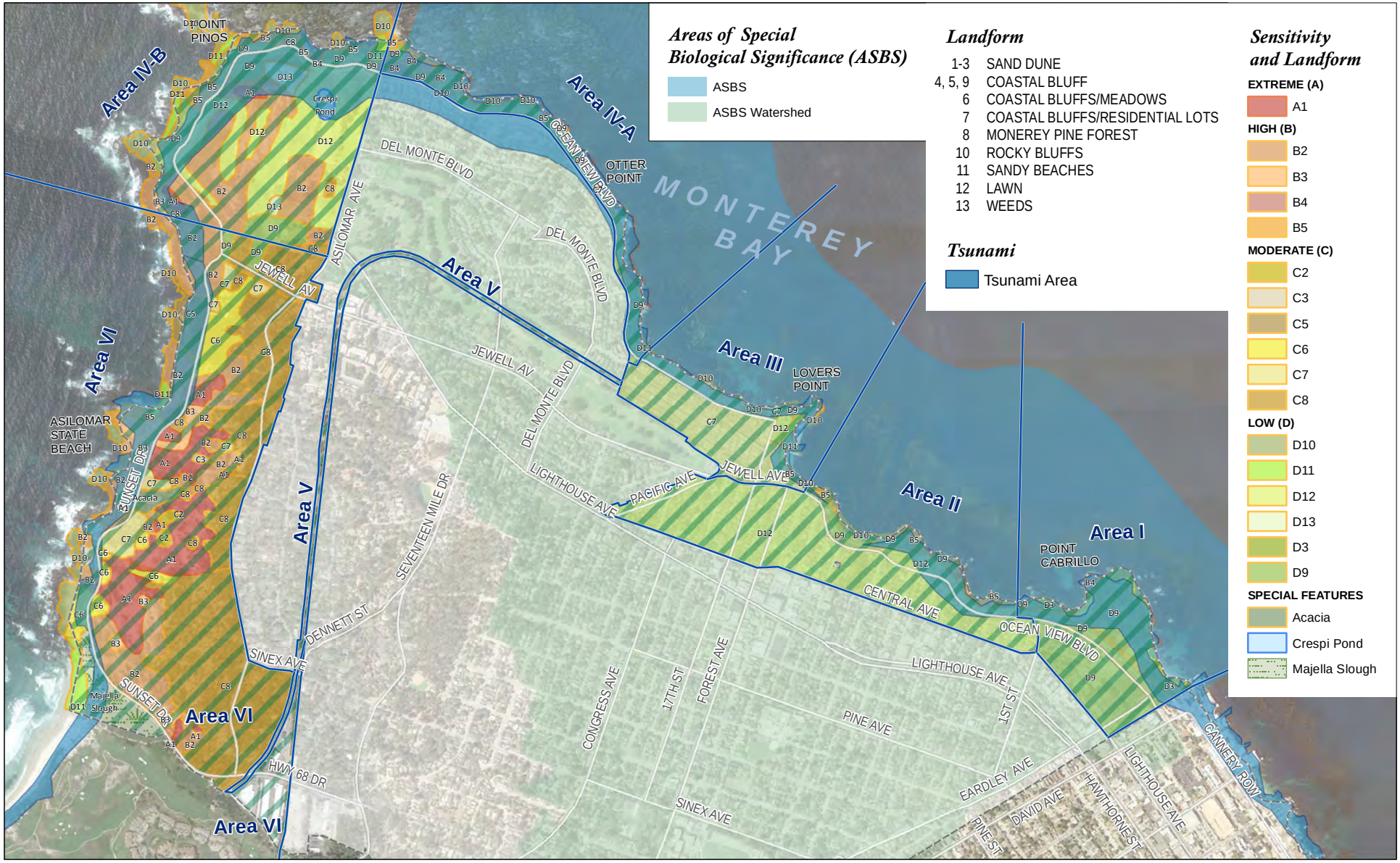

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Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove, Google Earth 2013, Google Earth 2013

Figure 21

Sensitive Habitat - Potential Tsunami

Pacific Grove Vulnerability Assessment

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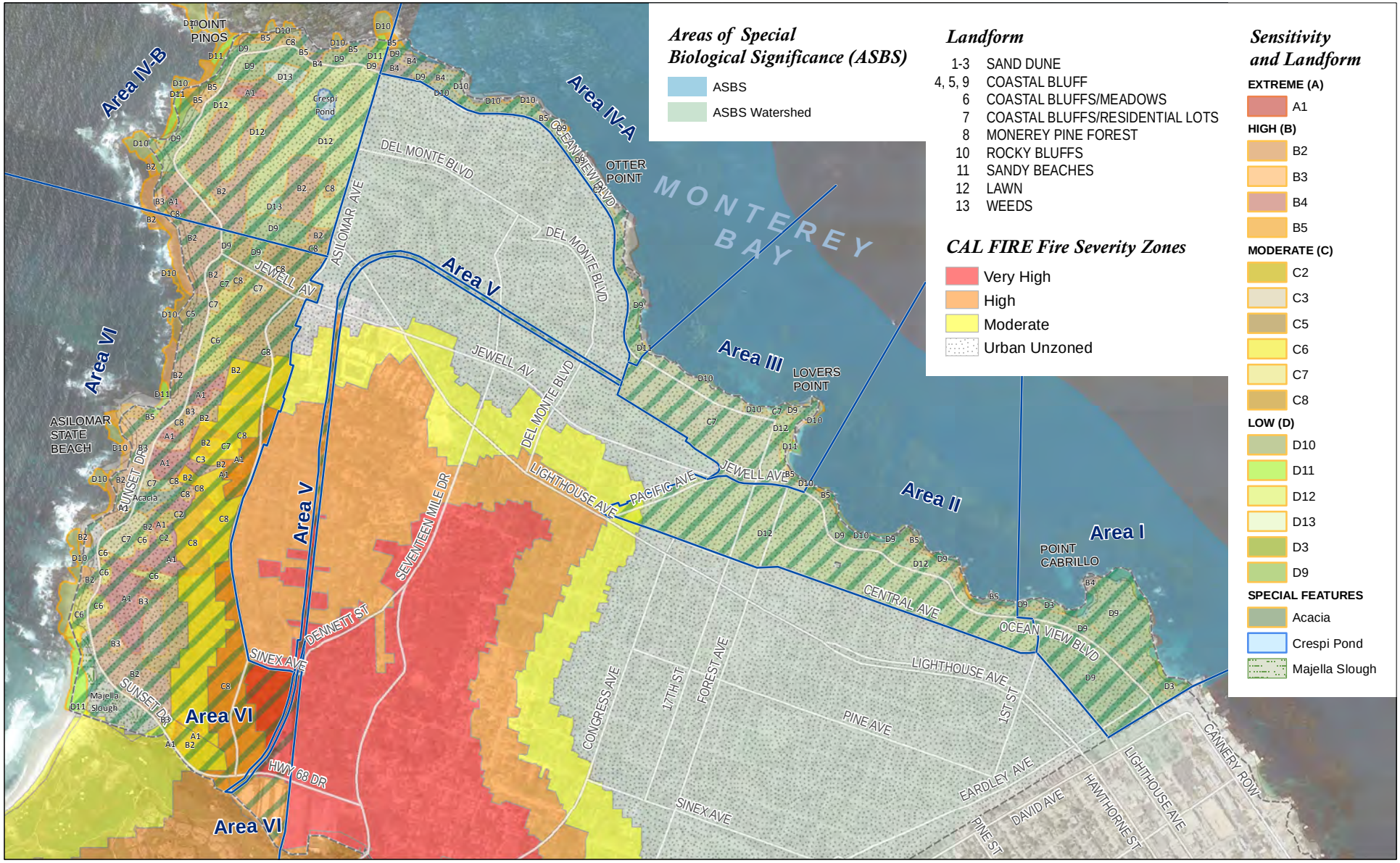

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: CAL FIRE 2007, City of Pacific Grove, Google Earth 2013

Figure 22

Sensitive Habitat - Potential Wildfire

Pacific Grove Vulnerability Assessment

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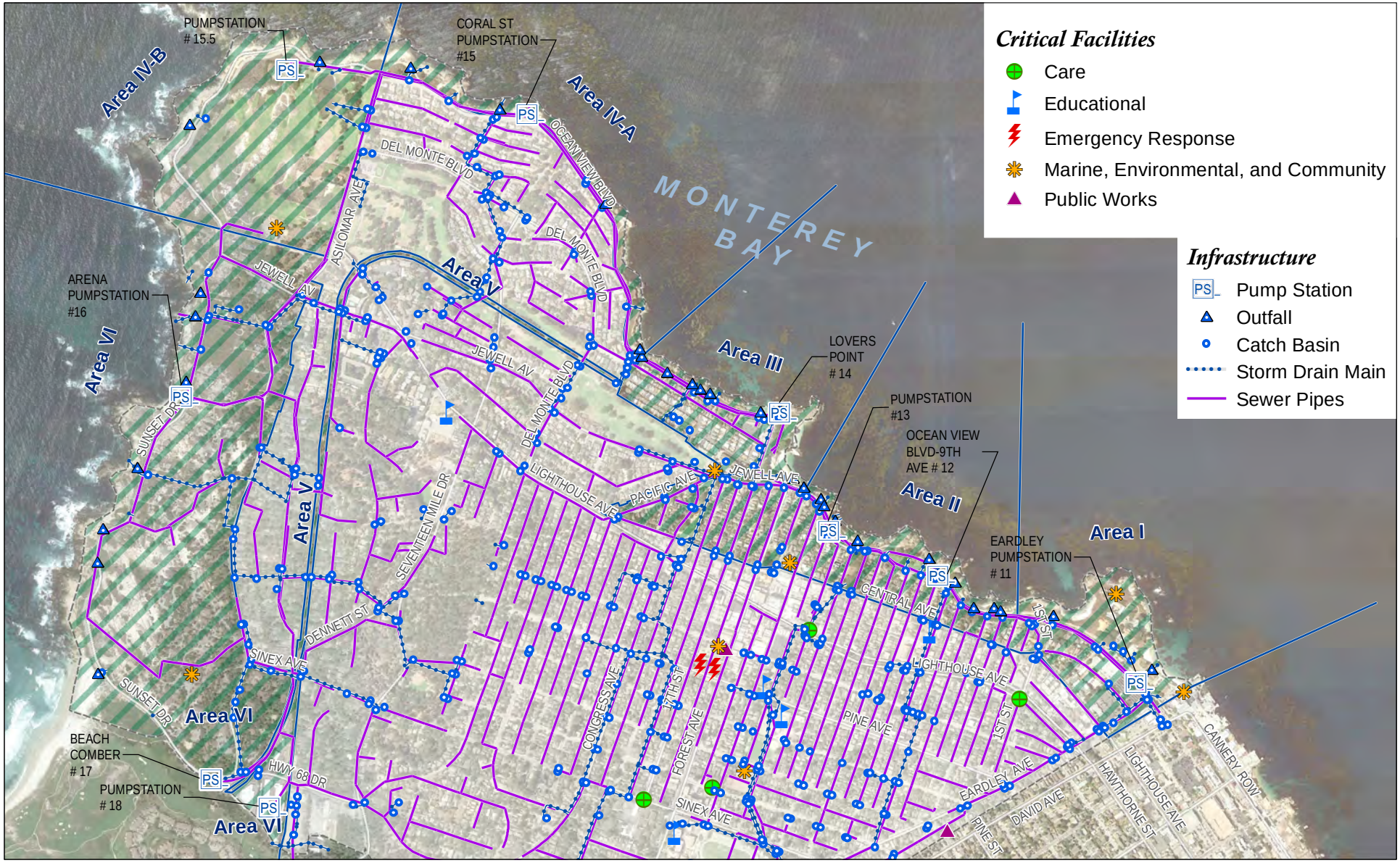

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: NOAA 2014, City of Pacific Grove, Google Earth 2013

Figure 23

Development and Infrastructure

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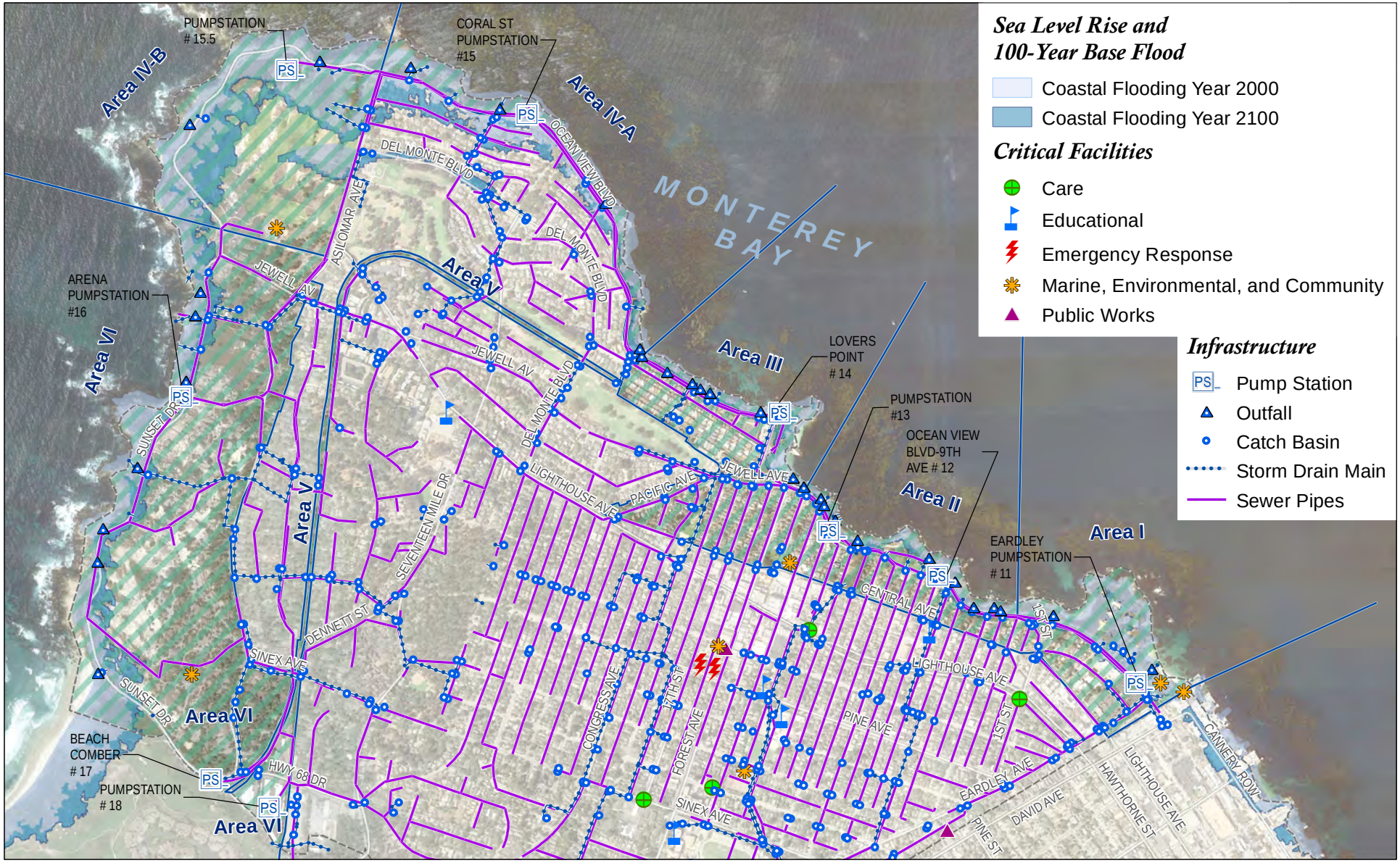

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: Pacific Institute 2014, City of Pacific Grove, Google Earth 2013

Figure 24

Development and Infrastructure - Potential Sea Level Rise

Pacific Grove Vulnerability Assessment

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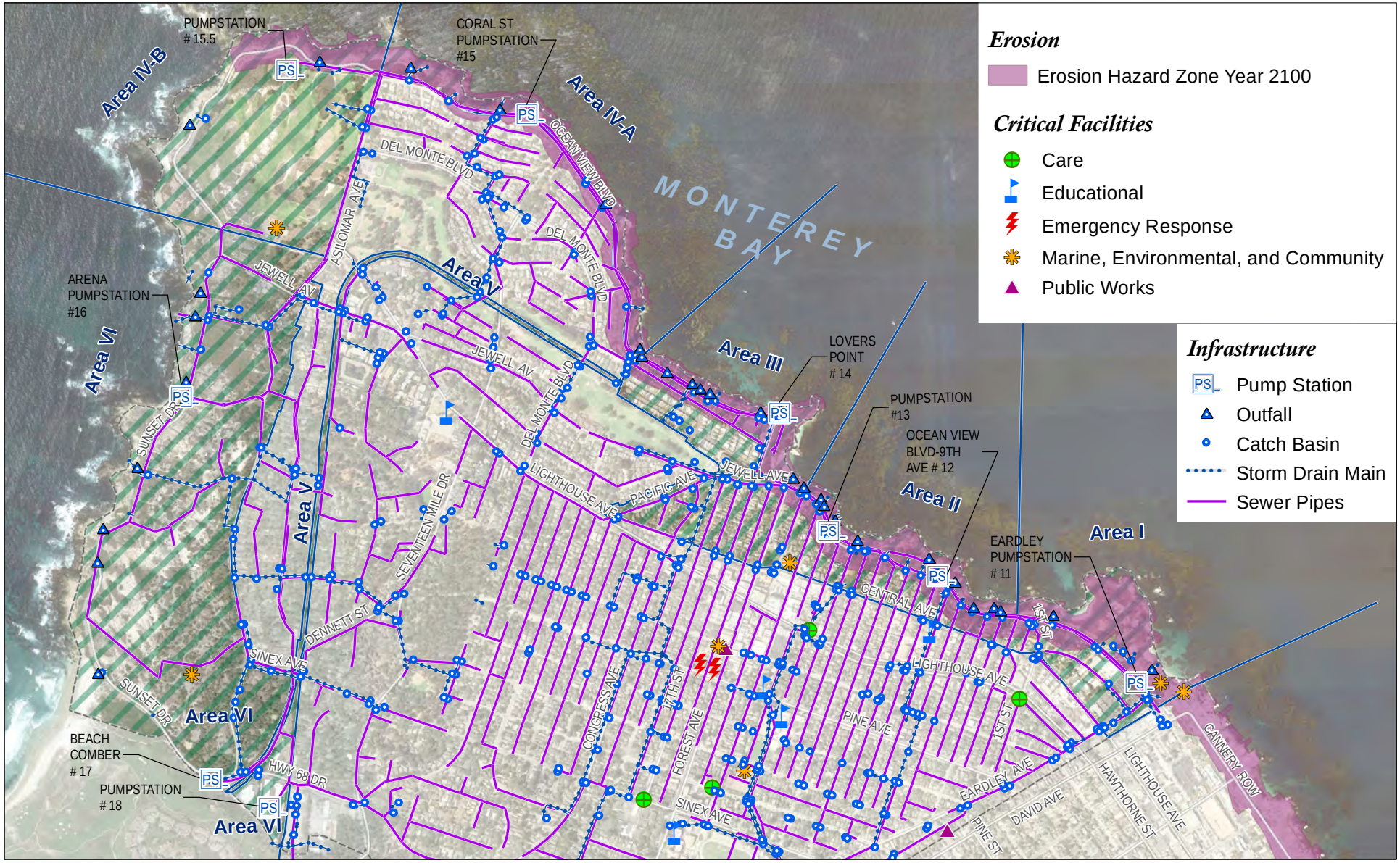

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: Pacific Institute 2014, City of Pacific Grove, Google Earth 2013

Figure 25

Development and Infrastructure - Potential Erosion

Pacific Grove Vulnerability Assessment

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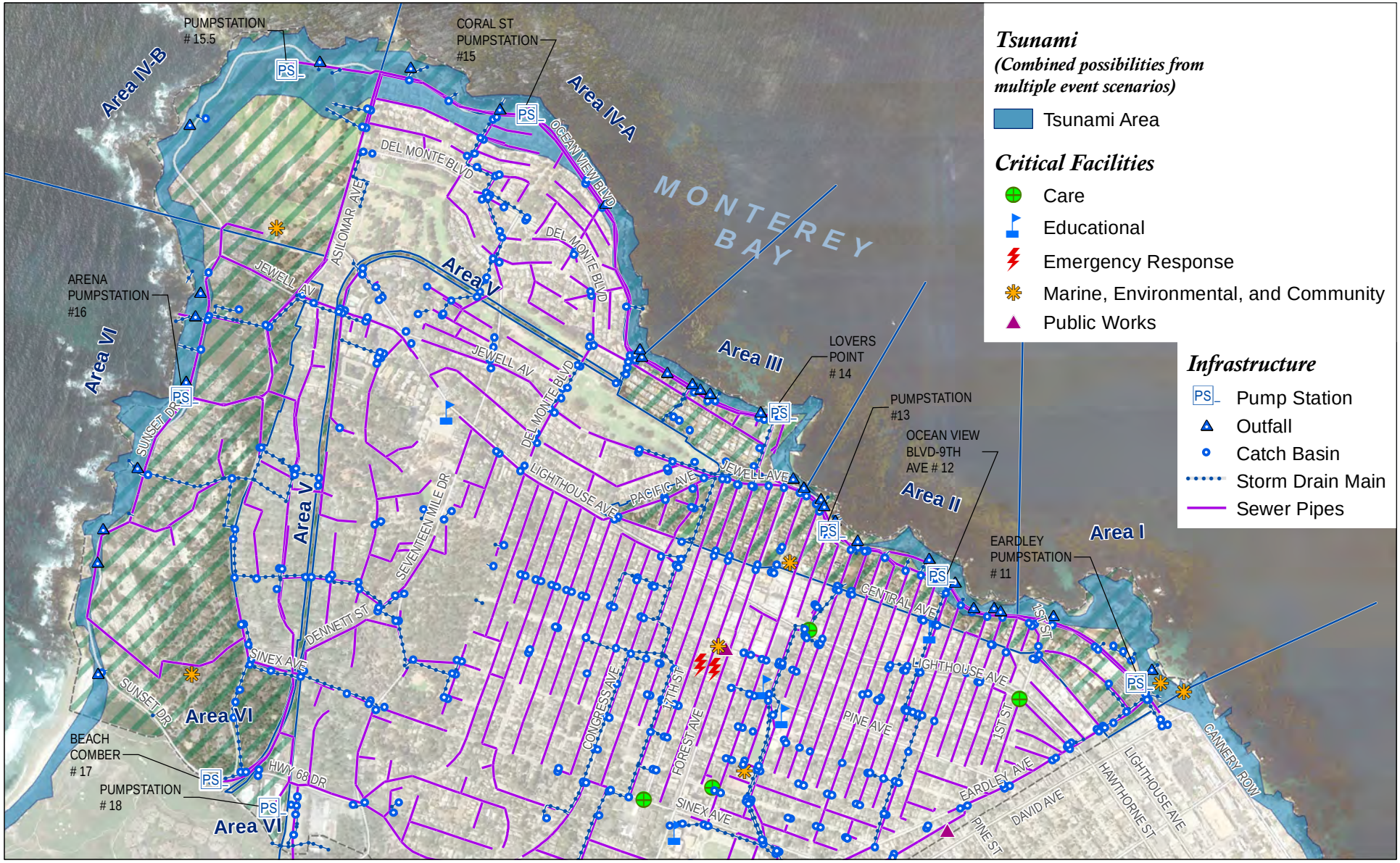

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove, Google Earth 2013

Figure 26

Development and Infrastructure - Potential Tsunami

Pacific Grove Vulnerability Assessment

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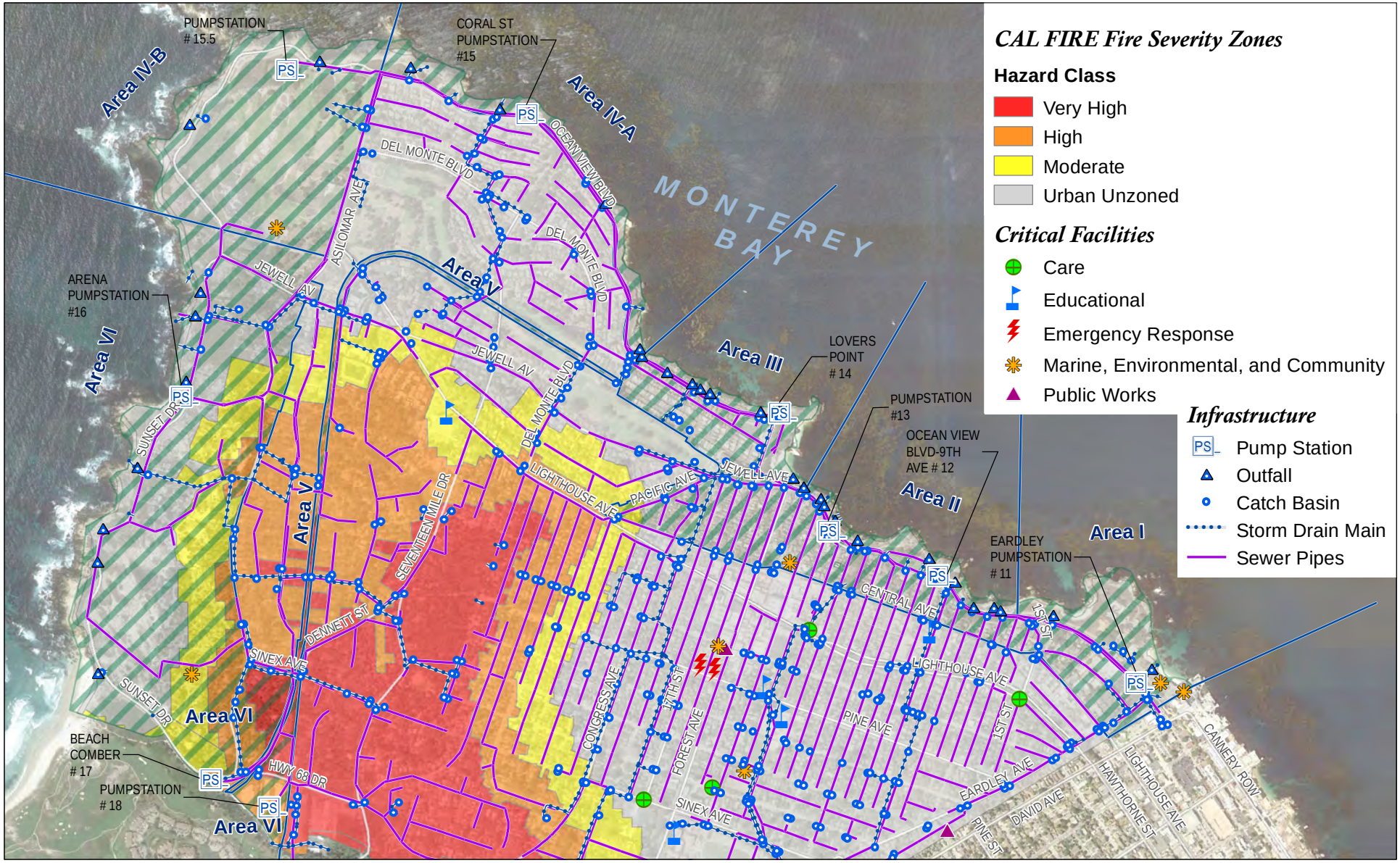

0 1800 feet

Legend

- Planning Area Boundaries
- City of Pacific Grove
- Major Roads
- Coastal Zone

Source: California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS), City of Pacific Grove, Google Earth 2013

Figure 27

Development and Infrastructure - Potential Wildfire

Pacific Grove Vulnerability Assessment

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3.0
FREQUENTLY USED ACRONYMS

3.1 ACRONYMS

ADA	Americans with Disabilities Act
APG	California Adaptation Planning Guide
ASBS	Areas of Special Biological Significance
CalAm	California American Water Company
CDFW	California Department of Fish and Wildlife
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
CSUMB	California State University Monterey Bay
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
LCP	Local Coastal Program
LUP	Land Use Plan
IP	Implementation Program
IPCC	Intergovernmental Panel on Climate Change

MRWPCA	Monterey Regional Water Pollution Control Agency
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PG&E	Pacific Gas and Electric
PGMC	Pacific Grove Municipal Code
PRC	California Public Resources Code
USGS	United States Geologic Survey
USFWS	United States Fish and Wildlife Service

4.0
RESOURCES AND REFERENCES

4.1 RESOURCES

Climate Change/Sea Level Rise

- AECOM:

  http://www.aecom.com/
  Mike J. Robinson, CFM
  Senior Planner, Water
  D 919.760.4019 C 919.622.0174
  mike.robinson@aecom.com

- Cal-Adapt: http://cal-adapt.org/

- California Coastal Commission, Global Warming and Climate Change web resources: http://www.coastal.ca.gov/climate/climatechange.html

- Pacific Institute Sea Level Rise Maps (2009): http://www2.pacinst.org/reports/sea_level_rise/maps/

Planning

- Coastal Commission, Central Coast District Office:
  http://www.coastal.ca.gov
  725 Front Street, Suite 300
  Santa Cruz, CA 95060-4508
  Phone (831) 427-4863
  FAX (831) 427-4877

- Coastal Act of 1976: http://www.coastal.ca.gov/coastact.pdf
- San Francisco Bay Conservation and Development Commission (BCDC). Climate Change web resources. http://www.bcdc.ca.gov/planning/climate_change/climate_changes.html

4.2 REFERENCES

State of California

- 2014. *California Coastal Act of 1976.* http://www.coastal.ca.gov/coastact.pdf
- 2012. Public Utilities Commission. Monterey Peninsula Water Supply Project (Application A.12-04-019). Filed April 2012. Accessed October 2014, http://www.cpuc.ca.gov/Environment/info/esa/mpwsp/index.html

Cal-Adapt

- 2014a. Precipitation: Decadal Averages Map. Search Pacific Grove. (webpage). Accessed October 2014, http://cal-adapt.org/precip/decadal/#
- 2014b. Temperature: Extreme Heat Tool. Number of Extreme Heat Days by Year.Search Pacific Grove (webpage). Accessed October 2014, http://cal-adapt.org/temperature/heat/
- 2014c. Temperature: Extreme Heat Tool. Number of Extreme Heat Waves Per Year Search Pacific Grove. (website). Accessed October 2014, http://cal-adapt.org/temperature/heat/#
- 2014d. Local Climate Snapshots. Temperature. Search Pacific Grove. (webpage). Accessed September 2014, http://cal-adapt.org/tools/factsheet/

California Coastal Commission

- 2014. Global Warming and Climate Change. (webpage). Accessed September 2014, http://www.coastal.ca.gov/climate/climatechange.html
- 2013. *Draft Sea-Level Rise Policy Guidance Public Review Draft*. October 14, 2014
- 2011. *The Tohoku Tsunami of March 11, 2011: A Preliminary Report on Effects to the California Coast and Planning Implications.* April 18, 2011. Accessed November 18, 2014, http://www.coastal.ca.gov/energy/tsunami/ccc_tohoku_tsunami_report.pdf

California Department of Conservation

- 2013. California Department of Conservation. December 11, 2013 Accessed November 18, 2013, http://www.consrv.ca.gov/cgs/geologic_hazards/tsunami/pages/about_tsunamis.aspx#historic tsunamis in California

California Department of Fish and Wildlife (CDFW)

- 2014. *California Natural Diversity Database (CNDDB).* Records of Occurrence for Monterey, Marina, Seaside, Soberanes Points, and Mount Carmel USGS quadrangles. Sacramento, California. 2014. Accessed October 2014, http://www.dfg.ca.gov/biogeodata/cnddb/mapsanddata.asp

California Emergency Management Agency and California Natural Resources Agency

- 2012a. *California Adaptation Planning Guide: APG: Defining Local and Regional Impact*
- 2012b. *California Adaptation Planning Guide. Planning for Adaptive Communities*

California Native Plant Society (CNPS)

- 2014. *Inventory of Rare and Endangered Plants. Records of Occurrence for Monterey, Marina, Seaside, Soberanes Points, and Mount Carmel USGS quadrangles. Sacramento, California, 2014* Accessed October 2014, http://www.cnps.org/inventory

California Natural Resources Agency (CNRA)

- 2009. *2009 California Climate Adaptation Strategy*. Accessed September 2014, http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf

California State University Monterey Bay (CSUMB)

- 2011. CSUMB Class ENVS 660: Pugh K, Arenas R, Cubanski P, Lanctot M, Purdy A, Bassett R, Smith J, Hession S, Stoner K, Ashbach R, Alberola G, Jacuzzi N, Watson F. 2011. Stormwater outfall watershed delineation, land cover characteristics, and recommended priorities for monitoring and mitigation in the City of Pacific Grove, California. The Watershed Institute, California State Monterey Bay, Publication No. WI-2011-02, 74 pages

City of Pacific Grove

- 2014a. Pacific Grove Municipal Code. Current through Ordinance 14-005, March 19, 2014. http://www.codepublishing.com/CA/pacificgrove
- 2014b. *Sewer Collection System Master Plan.* Prepared by Wallace Group http://www.ci.pg.ca.us/modules/showdocument.aspx?documentid=11926
- 2014c. *Sewer Collection System Master Plan Mitigated Negative Declaration.* Prepared by EMC Planning Group, Inc. http://www.ci.pg.ca.us/modules/showdocument.aspx?documentid=11205
- 2014d. Parks and Recreation Department Webpage. Accessed October 30, 2014: http://www.ci.pg.ca.us/index.aspx?page=140
- 2010. *Natural Resource Areas and Associated Natural Resources in Pacific Grove.* 2010 Accessed October 2014, http://www.ci.pg.ca.us/modules/showdocument.aspx?documentid=802
- 1994. *City of Pacific Grove General Plan.* http://www.ci.pg.ca.us/index.aspx?page=96
- 1989. *Local Coastal Program Land Use Plan.* Accessed September 2014, http://www.ci.pg.ca.us/modules/showdocument.aspx?documentid=3498

City of Seaside Groundwater Basin Watermaster

- 2006. Seaside Groundwater Basin Watermaster. Seaside Basin Monitoring and Management Program. May 17, 2006. Accessed October 2014, http://www.mpwmd.dst.ca.us/mbay_irwm/IRWM_library/Seaside%20Basin/SGB%20Program%20final%205-24-06%20PDF.pdf

Climate - Adapt

- 2014. *Vulnerabilities and Risk.* (webpage). December 18, 2014. Accessed December, 2014, http://climate-adapt.eea.europa.eu/vulnerabilities-and-risks

Environmental Protection Agency (EPA)

- 2014. *Climate Impacts. Water Resources*. (webpage) Accessed December, 2014, http://www.epa.gov/climatechange/impacts-adaptation/water.html

Federal Emergency Management Agency (FEMA)

- 2009. Flood Insurance Rate Map, Monterey County, California. Panels 165, 170, 305, and 306. April 2, 2009

Healthline

- 2014. *Hot & Cold: Extreme Temperature Safety.* (webpage). November 6, 2014. Accessed November 2014, http://www.healthline.com/health/extreme-temperature-safety

Intergovernmental Panel on Climate Change (IPCC)

- 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* March 31,2014. Accessed December 2014, https://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf

- 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* 2007. Accessed September 2014, http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

Jim Johnson

- 2014. Jim Johnson. "Agha's People's Desal Project, Moss Landing Harbor District ink pact." *Monterey County Herald*. September 25, 2014. Accessed November 17, 2014, http://www.montereyherald.com/20140925/aghas-peoples-desal-project-moss-landing-harbor-district-ink-pact

Monterey County Hazard Mitigation Planning Team with Professional Planning Assistance from AECOM

- 2014. *Monterey County Multi-Jurisdictional Hazard Mitigation Plan – Final Draft.* September 2014. Accessed September - November 2014, http://www.co.monterey.ca.us/oes/documents/Main_Plan_Body.pdf

Monterey Peninsula Water Management District

- 2014. November 2014 Monthly Allocation Report. http://www.mpwmd.dst.ca.us/asd/board/boardpacket/2014/PDF/20141215/1215agenda.pdf

National Aeronautics and Space Administration (NASA)

- 2014. Global Climate Change: Vital Signs of the Planet. Causes. (webpage). Accessed September 2014, http://climate.nasa.gov/causes/

National Research Council

- 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Accessed September - November 2014, http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=13389 or http://www.nap.edu/openbook.php?record_id=13389&page=R14

National Oceanic and Atmospheric Administration (NOAA)

- 2014. What is Ocean Acidification (web page). June 2014. Accessed October 2014, http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F
- 2013. Ocean Acidification – Educational Resources for the High School Classroom (web page). Accessed on-line at: http://coralreef.noaa.gov/education/oa/interactive-multimedia.html. October 30, 2014

Pacific Gas and Electric (PG&E)

- 2014. Gas Transmission Pipeline System Map. Accessed October 2014, http://www.pge.com/en/safety/systemworks/gas/transmissionpipelines/index.page

Pacific Institute

- 2009. *The Impacts of Sea-Level Rise on the California Coast.* Authors: Matthew Heberger, Heather Cooley, Pablo Herrera, Peter Gleick, Eli Moore. May 2009. Accessed October 2014, http://pacinst.org/wp-content/uploads/sites/21/2014/04/sea-level-rise.pdf

Rincon

- 2014. *Monterey-Pacific Grove ASBS Stormwater Management Project Final Environmental Impact Report*

San Francisco Bay Conservation and Development Commission and National Oceanic and Atmospheric Administration Coastal Services Center

- 2012. San Francisco Bay Conservation and Development Commission and National Oceanic and Atmospheric Administration Coastal Services Center. *ART (Adapting to Rising Tides) Vulnerability and Risk Assessment Report*. September 2012

United States Fish and Wildlife Service (USFWS)

- 2014. U.S. Fish and Wildlife Service (USFWS). Endangered Species Program. Species list for Monterey County. Washington, D.C. 2014. Accessed October 7, 2014, http://www.fws.gov/endangered

United States Environmental Protection Agency (EPA)

- 2014. Climate Change: Basic Information. (web page). September 2014. Accessed September 15, 2014, http://www.epa.gov/climatechange/basics/

University of Hawai'i at Manoa

- 2008. *Sea Level Rise Hawaii: Hawaii's Changing Climate*. Accessed October 2014, http://www.soest.hawaii.edu/coasts/sealevel/index.html

U.S. Census Bureau

- 2014. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013. Released May 2014. Accessed September 2014, http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

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