COUNTY OF SAN MATEO

SEA LEVEL RISE VULNERABILITY ASSESSMENT

SEA CHANGE
SAN MATEO COUNTY

OFFICE OF SUSTAINABILITY
COUNTY OF SAN MATEO

COUNTY OF SAN MATEO

SEA LEVEL RISE VULNERABILITY ASSESSMENT

FINAL REPORT

PUBLISHED MARCH 2018

This report was completed with funding from the California State Coastal Conservancy.

ACKNOWLEDGEMENTS

San Mateo County Board of Supervisors

District 1 – Dave Pine
District 2 – Carole Groom
District 3 – Don Horsley
District 4 – Warren Slocum
District 5 – David Canepa

Project Funders

California State Coastal Conservancy

Authors

County of San Mateo

Hilary Papendick, Climate Change & Adaptation Program Manager
Jasneet Sharma, Climate Resiliency Specialist
Carolyn Raider, Resource Conservation Specialist
Avana Andrade, Resource Conservation Specialist
Emi Hashizume, Resource Conservation Specialist
Montserrat Plascencia, Sustainability Fellow
Sally Prowitt (former Climate Resiliency Specialist)
Timothy Carter (former Sustainability Fellow)

California State Coastal Conservancy

Kelly Malinowski, Project Manager, San Francisco Bay Area

Arcadis

Jessica Ludy
Alex Trahan
Heather Sprague

Project Manager

Hilary Papendick, Climate Change & Adaptation Program Manager

Consultants

Arcadis

Served as a technical lead on the project, completed asset inventories and asset maps, and developed the assessment methodology, asset characterization report, the Asset Vulnerability Profiles, the sea level rise and groundwater report, recommendations for reducing risk, and the administrative draft report.

AECOM

Completed the Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore report, collected GIS data, and developed the asset exposure maps and the OCOF and ART memo.

Circlepoint

Provided design services to create custom graphics and lay out the assessment.

Project Advisors

County of San Mateo

Supervisor Dave Pine
Supervisor Don Horsley
Peggy Jensen
Jim Eggemeyer
Danielle Lee
Michael Barber
Deborah Hirst
Jim Porter
Sandy Wong
Matt Fabry
Brian Perkins
Erika Powell
Joe LaClair
Kim Springer
Reid Bogert

California State Coastal Conservancy

Kelly Malinowski
Matt Gerhart
Amy Hutzel

Stakeholder List

Association of Bay Area Governments (ABAG)
Alain Pinel Realtors
Bay Area Rapid Transit (BART)
Bay Area Regional Collaborative (BARC)
Bay Localize
Bay Planning Coalition
Bayshore Sanitary District
California Coastal Commission
California Department of Fish and Wildlife
California Department of Transportation (Caltrans) District 4
California State Coastal Conservancy
California State Lands Commission
California State Office of Assemblyman Rich Gordon
California State Office of Assemblyman Kevin Mullin
California State Office of Congresswoman Jackie Speier
California State Office of Senator Jerry Hill

Caltrain
Cargill, Inc.
City of Belmont
City of Brisbane
City of Burlingame
City of Daly City
City of East Palo Alto
City of Foster City
City of Half Moon Bay
City of Menlo Park
City of Millbrae
City of Mountain View
City of Pacifica
City of Redwood City
City of San Bruno
City of San Carlos
City of San Mateo
City of South San Francisco
City of South San Francisco/San Bruno Water Quality Control Plant
City/County Association of Governments of San Mateo County (C/CAG)
Committee for Green Foothills
Coravai, LLC.
County of Marin
East Palo Alto Sanitary District
Environmental Risk & Financial Solutions (ER&FS)
Facebook
Federal Emergency Management Agency (FEMA) Region IX
Foster City Chamber of Commerce
Genentech, Inc.
Gilead Sciences, Inc.
Google
Granada Community Services District (GCSD)
Greater Farallones National Marine Sanctuary (GFNMS)
Kaiser Permanente
League of Women Voters
Life Moves Maple Street Shelter
Metropolitan Transportation Commission (MTC)
Midcoast Community Council
Midpeninsula Regional Open Space District
Mid-Peninsula Water District
Montara Water & Sanitary District
National Oceanic and Atmospheric Administration (NOAA)
North Coast County Water District (NCCWD)
Oracle
Pacific Gas and Electric Company (PG&E)
Pacifica Care Center, Inc.
Point Blue
Port of Redwood City
San Carlos Airport
San Francisco Bay Conservation and Development Commission (BCDC)
San Francisco Estuary Institute (SFEI)
San Francisco International Airport (SFO)
San Francisco Public Golf Alliance
San Francisco Public Utilities Commission (SFPUC)
San Francisquito Creek Joint Powers Authority (SFCJPA)
San Mateo - Foster City School District
San Mateo County Department of Public Works
San Mateo County Economic Development Association (SAMCEDA)
San Mateo County Harbor District
San Mateo County Office of Education
San Mateo County Office of Emergency Services (OES)
San Mateo County Office of Supervisor Horsley
San Mateo County Office of Supervisor Pine
San Mateo County Office of Sustainability
San Mateo County Office of the County Counsel
San Mateo County Parks Department
San Mateo County Resource Conservation District (RCD)
San Mateo County Transit (SamTrans)
San Mateo County Transportation Authority (SMCTA)
San Mateo County Union Community Alliance
Santa Clara County Office of Sustainability
Sewer Authority Mid-Coastside
Shore Up Marin
Sierra Club, Loma Prieta Chapter
Silicon Valley Clean Water (SVCW)
Silicon Valley Community Foundation
Silicon Valley Joint Venture
South Bay Salt Pond Restoration Project
San Francisco Bay Area Planning and Urban Research Association (SPUR)
Sustainable San Mateo County
Sustainable Silicon Valley
Town of Atherton
Town of Colma
Town of Hillsborough
Town of Portola Valley
Town of Woodside
United States Army Corps of Engineers (USACE)
United States Fish & Wildlife Service (FWS)
United States Geological Survey (USGS)
West Bay Sanitary District
Westborough Water District
Youth United for Community Action (YUCA)

Plus members of the Sea Level Rise Community Task Force, and over 100 community members

TABLE OF CONTENTS

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Climate change impacts are already being felt across the globe, and the case for planned approaches to climate change adaptation is clear. Sea level rise is one of the primary and most devastating impacts from climate change, and it is of critical importance in the San Francisco Bay Area, particularly for San Mateo County (County), which is bounded by the Pacific Ocean to the west and the San Francisco Bay to the east.

The County is highly vulnerable to the effects of rising sea levels. If left unmanaged, future flooding and coastal erosion could pose considerable risks to life, safety, critical infrastructure, the County's natural and recreational assets, and the economy. The assessed value of parcels in the project area exposed to near-term (present-day) flooding exceeds $1 billion, and the assessed value of parcels exposed to erosion and flooding in the long term (50–100 years) totals roughly $39.1 billion.[1] More than 30,000 residential parcels and 3,000 commercial parcels may also be vulnerable in the long term. Furthermore, flooding, erosion, and sea level rise not only directly threaten people and property in the sea level rise hazard areas, but they also affect all communities in the County, even those on high ground. Such indirect effects are present because assets and infrastructure in the sea level rise areas provide critical services and functions to communities outside these areas. The County is already exposed to present-day flooding when large rain events coincide with high tides on the San Francisco Bay, making it imperative to create action steps to reduce risk.

Vulnerable assets are located along both the Pacific Coast and the San Francisco Bay; they include critical infrastructure (police stations, hospitals, wastewater treatment plants, and schools); essential regional transportation networks and infrastructure (Bay Area Rapid Transit [BART], Caltrain, Highway 101, State Route 1); and important regional natural and recreational assets (Pacifica State Beach, the California Coastal Trail, and the Ravenswood Pond Complex).

"The County is already exposed to present-day flooding when large rain events coincide with high tides on the San Francisco Bay, making it imperative to create action steps to reduce risk."

Vulnerability Assessment Goals

This Vulnerability Assessment report serves as the first step of the Sea Change SMC Initiative, which has the purpose of increasing the resilience of the County's economy, environment, and communities through collaborative planning and projects. This Assessment contributes to increasing the resilience in the County through achieving the following goals:

Map Assets and Future Risk Scenarios
Create inventory of people, places, and critical infrastructure to assess risks

Assess Vulnerability
Identify impacts of flooding, sea level rise and erosion on people, structures and community functions

Provide Actionable Results
Develop solutions and reduce impacts in vulnerable communities

Build Awareness
Share information with a wide variety of audiences

Facilitate Collaboration
Build a Countywide network to support joint actions and solutions

[1]These numbers are based on the assessed value of property affected by the 6.6 feet of sea level rise scenario as of January 1, 2015 lien date.

This report provides an overview of what is at risk from current and future flooding and erosion in the County. Using three different sea level rise scenarios and one erosion scenario, this report answers the following questions:

1. Where does sea level rise pose concerns? What areas are expected to be affected first?
2. What are some of the consequences of sea level rise to different sectors?
3. How might sea level rise affect human health and communities that have characteristics making them more vulnerable to flooding?
4. What types of actions are available to prepare the County for sea level rise?
5. What are recommended next steps to prepare the County for sea level rise?

The results of the report are intended to help County and city officials, advocacy groups, community members, and other stakeholders make informed decisions on how to move forward with the adaptation planning process.

Methodology and Approach

This Assessment takes a risk-based approach, using best available existing data, to understand and communicate about the County's vulnerability to sea level rise. It lays the groundwork for preparation of a transparent decision-making process for near- and long-term steps.

The approach supports a sea level rise preparedness strategy that

- **Identifies** risks to life and safety
- **Recognizes** the natural and beneficial functions of the County's natural areas
- **Considers** impacts and benefits to community populations, especially those with increased vulnerability

The methodology employed uses existing data on projections of sea level rise hazards to understand the geographic extent to which the County could be exposed to inundation and erosion. Three sea level rise scenarios and one scenario for coastal erosion data were selected for the evaluation:

BASELINE SCENARIO	1% annual chance flood (present-day extreme flood also known as 100 year flood)
MID-LEVEL SCENARIO	1% annual chance flood + 3.3 feet of sea level rise
HIGH-END SCENARIO	1% annual chance flood + 6.6 feet of sea level rise
COASTAL EROSION	The projected extent of coastal erosion expected with 4.6 feet of sea level rise

The project used sea level rise inundation data from the United States Geological Survey (USGS) and from Point Blue's Our Coast, Our Future tool, which provided the best available sea level rise data for the County at the time of the report. The scenarios indicate the projected extent of flooding should the project area experience a 1% chance annual storm plus sea level rise. The baseline scenario shows the possible extent of flooding with a 1% annual chance storm. The mid-level scenario shows the possible extent of flooding during a 1% chance annual storm plus 3.3 feet of sea level rise. The high-end scenario shows the possible extent of flooding during a 1% chance annual storm plus 6.6 feet of sea level rise. However, each parcel shown to be affected within a given scenario may not necessarily be inundated. The scenarios only show what kind of flooding is possible. In the event of a storm, inundation may take place in a variable and unpredictable manner.

The erosion data are from the Pacific Institute Study developed by Philip Williams and Associates, Ltd. in 2009. The erosion scenario illustrates potential future erosion with 4.5 feet of sea level rise and assumes no shoreline protective devices. Sea level rise inundation and erosion data are the best modeling data for the County and were combined with data on the location and types of built and natural assets as well as demographic data in the County to provide an inventory and spatial representation of populations and assets in harm's way.

A critical part of developing this Sea Level Rise Vulnerability Assessment was categorizing and classifying the built and natural assets that will be exposed to present and future inundation, using the San Francisco Bay Conservation and Development Commission method of categorization and the American Society of Civil Engineers method of classification. Asset categories and classes provide a framework through which to evaluate potential impacts. This Assessment provides finer detail on the vulnerabilities and risks of sea level rise to the County and its assets through Asset Vulnerability Profiles of 29 assets and one community.

Certain limitations exist in this Assessment because it had to rely on readily available data and modeling tools. The project area was limited because of the availability of inundation modeling data for Half Moon Bay and areas north of it; the inundation modeling data do not include the area south of Half Moon Bay, though the County intends to initiate a similar vulnerability assessment as data becomes available from USGS and Point Blue for this area in 2018. Funding and time limited the number of assets that received an Asset Vulnerability Profile, which provides a detailed analysis of an asset's vulnerability. As such, only a small subset of the County's built and natural assets were evaluated. This Assessment is a planning level document and is not intended for design purposes.

Vulnerability Analysis

Rising sea levels on the Bay and the Coast will affect a wide array of built and natural assets that every resident in the County relies on or uses on a daily basis. The impacts are potentially severe and far-reaching because the systemic nature of many assets and critical services mean that flooding or a loss of function at one site can trigger a cascade of effects throughout the County. This report identifies what is vulnerable to sea level rise among built and natural assets, explores public health and risks from cascading impacts, and discusses what these factors mean for policy and planning purposes.

The report findings highlight that many of the assets have cross-cutting vulnerabilities (i.e., multiple and indirect sources of vulnerability) and may have more than one point of exposure to sea level rise. The table below identifies the following asset categories as being at risk from sea level rise in the County.

WHAT'S AT RISK?	WHAT'S VULNERABLE UNDER MID-LEVEL SCENARIO?	POTENTIAL IMPACTS AND CONSEQUENCES
Natural Assets: including but not limited to beaches, wetlands, lakes, and streams	• 7,090 acres of exposed wetlands[2] • 3 miles of exposed beaches • 11 acres of vulnerable kelp forests	• Permanent or temporary flooding or erosion of habitat areas, potentially leading to biodiversity loss, loss of natural flood protection, and loss of natural recreational areas • Overflow and flooding from local creeks and waterways (San Pedro Creek, San Francisquito Creek, San Mateo, Creek, San Bruno Creek, Bayfront Canal, Atherton Channel, Belmont Creek)
Key Built Assets: including but not limited to residential properties, schools, hospitals and other health care facilities, police stations, airports, energy infrastructure, wastewater treatment systems, ground transportation, flood protection infrastructure	• 22,063 acres of land • 30,604 residential parcels • 2,235 commercial parcels • 34 schools • 22 outpatient health care facilities; 1 emergency room • 3 police stations; 8 fire stations • 2 airports • 12 electric substations • 5 wastewater treatment plants • ~21.5 miles of levees	• Inundation of homes and businesses • Inundation of power supply and cessation of power to homes, hospitals, and businesses • Damage to or loss of emergency care facilities, human service providers, and homeless shelters • Inundation of access roads for emergency vehicles and supplies • Disruption of regional transportation network • Overtopping of shoreline levees
Public Health Assets: impacts from sea level rise may both impair critical health care facilities and cause unhealthy environmental conditions. Due to social vulnerability factors, some residents face disproportionate impacts from sea level rise, particularly when impacts to larger infrastructure systems (e.g., transport) are taken into account.	• Health-related infrastructure: e.g., emergency facilities, inpatient and outpatient facilities • Inundation of the built environment can lead to injury, illness, disease, and death	• Disruption to health-related infrastructure could drastically reduce the availability of medical services in the event of a flood, and may place many residents already within a facility, or those seeking medical attention, in danger • If water reaches infrastructure and interior spaces not designed to withstand inundation, conditions become unsuitable for human health (e.g., mold). Infectious diseases are also more likely to spread in these conditions • Disproportionate impact to populations with existing social vulnerability characteristics such as the young and elderly, people of color, or those with limited English proficiency, or those with poor or unstable housing conditions

[2]Numbers may overestimate wetland vulnerability. Wetlands may be able to persist with some amount of sea level rise if there is room for the habitat to migrate inland (landward), or if wetlands can accumulate enough sediment to migrate upward.

Public Health

Sea level rise will also have consequences for public health because health facilities will be affected and access to emergency medical services could be impaired. Flood events can lead to physical injury, illness, or disease (e.g., vector-borne diseases such as West Nile virus), and they can also cause income loss and disruption of employment. Many of these impacts will disproportionately affect socially vulnerable populations, such as the homeless; people who are income, food, or housing insecure; the elderly and the very young; and individuals with pre-existing health conditions. For more information on this topic, see Chapter 3C, Community Health and Vulnerability.

Governance and Vulnerability

Managing for the impacts of sea level rise is extremely challenging for several reasons. Multiple governing agencies, nonprofit organizations, and research institutions are involved, forming a complex picture. Challenges posed by sea level rise do not fit neatly into agency or organizational mandates, often making governance and decision-making processes opaque or convoluted. Furthermore, when assessing vulnerability and planning for adaptation at the individual asset level, the asset owner may not actually have decision-making power over the other infrastructure that they rely upon. Many assets and stakeholders may have shared jurisdictions involved, and decision-making can entail competing priorities or mandates. To meet this challenge, governance structures will need to be re-evaluated. They will need to build strong relationships and create robust systems for communication. Governance structures will also need to encourage coordinated systems for stakeholder engagement, and consistent monitoring and evaluation processes. For more information on this topic, see Chapter 3A, Setting and Context.

Cascading Impacts

Cascading impacts, or a series of impacts triggered by the primary loss of an asset, can occur when any part of a networked asset or its system or function is affected, or when assets or functions are connected physically or functionally in some way (Florida Division of Emergency Management 2015). Cascading impacts, which are most typically associated with networked infrastructure, cause the geographic impact of a flood to reach farther than the geographic extent of the flood. In the County, some of the cascading impacts caused by flooding or inundation in one or more locations can include disruptions to critical services such as transportation networks, water delivery and treatment processes, or energy infrastructure. For more information on this topic, please see Chapter 3A, Setting and Context.

Adaptation Planning

Adaptation planning for sea level rise is critical because it minimizes many of the potential negative impacts highlighted in this report through reducing risk and increasing resiliency throughout the County. Sea level rise will affect numerous aspects of life in the County over differing time scales, which makes planning difficult and will require extensive Countywide coordination and collaboration. Direct physical manifestations, including harm to natural and built assets, adverse impacts on wildlife, and groundwater depletion, could occur; indirect impacts, such as a decrease in public safety, community equity, and economic vitality, may also take place. This section of the report functions as a guide for decision makers, whether they are state, city, or county employees, asset owners, or other stakeholders, who wish to be engaged in the process.

Adaptation Planning Considerations

Some important considerations for adaptation planning include ensuring that adaptation approaches meet the specific needs of particular locations or sectors, and that planning is coordinated and information is shared across different scales (i.e., community, city, county, or region). Additional recommendations are that any plans ultimately adopted and implemented are flexible and have adaptive capacity so they can be modified to accommodate future sea level rise. It is preferable to design multifunctional strategies, which can play multiple roles in the community.

Policy Responses in the County of San Mateo

Numerous opportunities exist for incorporating adaptation planning and sea level rise initiatives into local planning processes. For example, cities and the County can introduce sea level rise into planning and policy updates in the following ways:

- **Administrative policy, procedures, and initiatives**
- **General Plan**
- **Local Hazard Mitigation Plan**
- **Climate Action Plan**
- **Zoning Code and other land development codes, ordinances, and resolutions**
- **Local Coastal Program**
- **Capital Improvement Plan/Program**
- **Climate Change Adaptation Plan**
- **Integrated Regional Water Management groups**

Strategies for Adaptation

This section of the Assessment presents a variety of strategies for sea level rise adaptation that could be deployed in the County. While further research is necessary to determine where each approach would be most appropriate in particular locations, the strategies generally fall under three broad categories of measures: protect, accommodate, and retreat. Combinations of actions from among these categories can also be implemented to increase the overall resilience and adaptive capacity of each asset or location.

Adaptation is critical, as demonstrated by both the concentration of high-risk assets along certain areas of the shoreline and the cross-jurisdictional and multi-vulnerability issues raised by assets (Highway 101 and State Route 1), and will require a coordinated approach that involves multiple stakeholders. In some cases, relatively small investments can improve the reliability or adaptive capacity of individual critical assets and their functions; however, in many cases, adaptation will require a broader and more regional strategy. Such assets will require coordination of many stakeholders and their input to ensure that adaptation in one area does not increase flood or erosion risk in another area.

Adaptation will require the use of a wide range of tools, including

- Protection measures that reduce exposure such as
  - Levees, seawalls, and horizontal levees
  - Wetlands restoration
- Accommodation or retreat measures that reduce *sensitivity*, improve *adaptive capacity*, and reduce the consequences, such as
  - Land use planning policies or regulations and building codes
  - Asset elevation, flood proofing, or relocation
  - Flood insurance
  - Enhanced crisis management efforts

Adaptation provides an important opportunity to integrate nature-based strategies and to leverage the opportunities presented by the recently passed Measure AA (a parcel tax that funds wetland restoration) toward achieving regional ecological goals. Nature-based strategies not only seek to preserve and protect the region's natural assets, but also have some ability to reduce the risks of sea level rise hazards. For example, enhancing wetlands in front of an urban shoreline can reduce wave action on the waterfront; wetlands in riverine or tidal floodplains can act as sponges and can slow the onset of flooding or temporarily retain the water. The Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) lays out regional ecological objectives along the Bayshore that can be integrated with any regional flood risk management or sea level rise adaptation strategy. More on this strategy is provided in Chapter 4, Adaptation Planning.

Building a more resilient San Mateo County requires decisions that are based on the level of exposure and consequences that individual asset managers, communities, and the County are willing to tolerate. Adaptation measures can then be developed to reduce risks and can be evaluated for

- How effectively measures reduce risk
- How cost-effective specific risk reduction measures are
- What benefits and trade-offs exist for the economy, environment, equity, and society

Getting Ahead of Sea Level Rise

Given the severity of the risks from sea level rise in the County, actions to prepare for risks and reduce them are needed at multiple scales. No single step or individual player can resolve the issue of flooding and erosion due to sea level rise. A combination of shoreline protection strategies, individual property and facility modifications, land use policies, and emergency flood preparedness actions will be needed to reduce impacts over the near and long term. Chapter 5 is based on needs and recommended actions shared by the Sea Level Rise Vulnerability Assessment stakeholder group participants.

Through the Sea Change SMC Initiative, the County is committed to helping to facilitate Countywide coordination on sea level rise policies, building standards, and the development of a Countywide sea level rise strategy. This Sea Level Rise Vulnerability Assessment recommends the following actions, which are described in detail in Chapter 5.

Countywide Actions

- Continue to convene a steering committee and working group
- Develop a Countywide Adaptation Framework and Strategy
- Develop a Policy Toolkit
- Conduct public education
- Engage in regional coordination efforts

City-/County-Specific Actions

- Complete South Coast Vulnerability Assessment
- Further evaluate key vulnerabilities and risks as needed
- Update Policy and Land Use Planning Documents
- Update Capital Improvement Plans
- Enhance Community Rating System Status

Site-Specific Actions

- Assist with development of site-specific plans for critical facilities
- Promote lessons learned from successful site-specific actions to increase resilience across jurisdictions

Research Needs

Sufficient information is available to begin to understand the County's vulnerabilities, more detailed data are needed in some areas to better inform project owners/sponsors and policy makers in their investment decision for sea level rise planning and the design and construction of risk-reduction measures. Additional research is needed to:

- **Better understand feasibility of adaptation options**
- **Further evaluate community vulnerability**
- **Refine habitat vulnerability**
- **Better understand subsidence and vertical land movement**
- **Estimate impacts from future erosion**
- **Evaluate the flooding impacts from both bay/ocean water and fluvial flows**

Please see Chapter 5, Getting Ahead of Sea Level Rise, for more information.

Conclusion

Sea level rise has the potential to affect every sector in the County: the economy, critical habitats and species, health care, wastewater treatment facilities, transportation, and stormwater, as well as neighborhoods, parks, and schools. Impacts need to be addressed through large-scale shoreline protection strategies in addition to site-specific adaptations and land use policies.

As a next step, this Assessment suggests that the County convene a sea level rise working group and steering committee to develop an action plan for the Sea Change SMC Initiative. While preparing for long-term sea level rise, it is also important to remember that the County is currently vulnerable to flooding and erosion, and it is necessary to prepare for near-term flooding and erosion emergencies in addition to combinations of multiple disasters, including earthquakes and floods. This preparation will help ensure the County's economy, habitats, transportation systems, wastewater treatment facilities, and ports are able to bounce back after disasters and are prepared to become resilient to sea level rise.

Bluffs above San Gregorio State Beach. Photo credit: San Mateo County Flickr.

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

Climate change planning and adaptation happen in phases, and this Sea Level Rise Vulnerability Assessment is part of the first phase of the County of San Mateo's (County's) Sea Level Rise Initiative (Initiative): Sea Change SMC. The goal of Sea Change SMC is to increase the resilience of the County's economy, environment, and communities through collaborative planning and projects.

This Vulnerability Assessment draws on the best available science and research methodologies to explore the ways in which the County, its communities, and its built and natural infrastructure are vulnerable to present and future hazards associated with sea level rise for the purpose of reducing long-term flood and erosion risk. In doing so, the report will increase understanding of the type and scale of potential impacts that could occur under different sea level rise scenarios.

This report also provides an overview of the risks associated with current and future flooding and erosion in the County. Using three different sea level rise scenarios and one erosion scenario, this report answers the following questions:

1. Where does sea level rise pose concerns? What areas are expected to be affected first?
2. What are some of the potential consequences of sea level rise for different sectors?
3. How might sea level rise affect human health and communities that are more vulnerable to flooding?
4. What types of actions are available to prepare the County and its cities for sea level rise?
5. What are recommended next steps to prepare the County and its cities for sea level rise?

The Assessment was guided by the following *principles*:

- Inclusive Process: Maximize participation from County cities and relevant agencies, businesses, organizations, and community groups.
- Best Available Science: Use best available science on sea level rise to inform the Assessment.
- Risk-Based Methodology: Analyze the threat posed by sea level rise according to two components of risk, the "magnitude of the consequences should an impact occur and the likelihood of an impact occurring" (San Francisco Bay Conservation and Development Commission [BCDC] 2012a). A risk-informed methodology enables the County to formulate an efficient, strategic, transparent, and rational approach to reducing risk that increases the community's "preparedness and resilience to sea level rise and storm events while protecting critical ecosystem and community services" (BCDC 2012a).

The Assessment had the following primary *goals*:

- Assess Vulnerability: Assess the overall vulnerability of the County to the impacts from sea level rise, including permanent inundation, temporary flooding, erosion, and saltwater intrusion.

Sea Change SMC Initiative

The Sea Change SMC initiative seeks to increase the County's resilience through the following activities:

- **Providing information** on the risks and vulnerabilities from sea level rise to cities, asset managers, and others
- **Collaborating with cities** to develop shared goals and a planning framework for addressing sea level rise in existing planning documents and processes
- **Providing templates and assistance** to cities, asset managers, businesses, and others in using the results of the vulnerability assessment and developing policy and planning language
- **Raising awareness** about sea level rise
- **Conducting research** to fill information gaps
- **Facilitating collaboration** across water efforts, such as helping to incorporate sea level rise into existing flood risk protection and stormwater efforts

- **Identify Consequences:** Identify potential consequences of hazards associated with sea level rise if no actions are taken.
- **Provide Actionable Results:** Provide useful information to lead to actionable outcomes. Lay the foundation for future, more detailed analyses to be conducted by the County or its cities.
- **Build Awareness:** Create an awareness of the need to prioritize nature-based solutions and to reduce impacts to socially vulnerable communities.
- **Use a Collaborative Process:** Build a collaborative network throughout the County on which to plan future efforts.

The Assessment seeks to *accomplish* the preceding goals through the following:

- **Exposure Maps and Inventory:** Produce maps and inventories of built and natural assets exposed as well as an assessment of communities in areas at risk from current and future inundation (for which data are available). Assets refer to useful or valuable things in the County, such as structures, buildings, infrastructure, or habitats.
- **Analysis of Short- and Long-Term Impacts:** Increase the understanding of the types of sea level rise and storm-related impacts that the County will experience and the potential long-term implications of inaction.
- **Case Studies of Vulnerable Assets:** Develop 30 Asset Vulnerability Profiles (AVPs) for a representative set of assets across geography and asset categories.
- **Menu of Adaptation Options:** Provide an overview of adaptation options and general considerations for adaptation planning.
- **Stakeholder Engagement:** Engage multiple stakeholders in a discussion of the complex and multifaceted challenges associated with sea level rise.
- **Roadmap for Future Efforts:** Develop a roadmap for taking actions to increase resiliency through suggested adaptation measures and improved flood and sea level rise mapping and data.

The scope of this report was limited to providing the background information for understanding sea level rise in the County and to laying a foundation for developing a Countywide adaptation strategy. Additional work and research will be needed to develop specific, granular adaptation options for each city and community. The next phase of adaptation developed by the County, cities, businesses, community groups and others can help create a template for action and coordinated efforts. In addition, further work will be needed to assess the vulnerability of the Coast south of Half Moon Bay, which was beyond the scope of this report, due to data for the South Coast being unavailable from United States Geological Survey (USGS).

1.2 Background on Sea Level Rise and Key Concepts

1.2.1 Adaptation to Climate Change

The impacts of climate change—melting ice caps, heat waves, changing precipitation patterns, and ocean acidification, to name just a few—are occurring now. The issue cannot be relegated to future decades and future generations; rather, all sectors of society must address it today through both collective and individual action. While greenhouse gas (GHG) mitigation measures are essential for curbing global emissions in the coming years, a certain amount of warming has already entered into the system, which no amount of GHG reductions can avert. The Third National Climate Assessment (NCA 2014), for example, projects that the average temperatures will rise 2–4°F across the United States during the next few decades.

The physical science basis for proactive responses to the threat of climate change is clear, and a strong economic argument for such responses also exists. The future costs of inaction are estimated to be 4–10 times higher than the current costs of investing in climate change adaptation and hazard mitigation measures (NCA 2014). In addition to initiatives to mitigate or reduce the effects of climate change, coordinated efforts will be needed to adapt to the effects of climate change both now and in the future. Climate change adaptation refers to the ways in which individuals, communities, and natural systems adjust to current or expected climate change and its impacts (IPCC 2014).

> "The impacts from climate change—including an increase in prolonged periods of excessively high temperatures, more heavy downpours, an increase in wildfires, more severe droughts, thawing permafrost, ocean acidification, and sea level rise—are already affecting communities, natural and cultural resources, ecosystems, economies, and public health across the United States" (White House Resilience Report 2016).

When reviewing the ways in which people and systems adapt to climate change, it is important to consider the different kinds of adaptation that occur. Adaptation can be reactive, when it happens in response to climate impacts, or anticipatory, when measures occur prior to climate impacts becoming obvious. An important distinction also exists between planned and autonomous adaptation: planned adaptation is a coordinated effort that arises from a deliberate decision-making process, while autonomous adaptation occurs as individuals and communities make localized adjustments according to their perceptions of climate risk

Resilience is "the capacity of social, economic, and environment systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation" (IPCC 2014).

Vulnerability is "a function of the magnitude of the impact, the sensitivity of the system to that impact, and the system's ability to adapt" (Pacific Institute 2012).

and impacts. This report focuses on anticipatory and planned adaptation actions that the County can undertake on the basis of rigorous community engagement and policy processes. Adaptation planning can help ensure that the strategies chosen will offer communities important co-benefits and no-regret solutions that improve both lives and natural systems.

Climate adaptation will also necessarily take place over various time scales, and actions need to be coordinated to meet both near- and long-term objectives. For example, while flooding from an extreme weather event requires swift decision-making, successful adaptation planning would ensure that decisions addressing immediate impacts would not reduce a community, city, or region's capacity to adapt to future impacts. This concept of adaptive capacity—the ability or potential of a system to adjust or respond successfully to climate variability and change (IPCC 2007)—is a key factor in adaptation planning, and it helps guide policy-makers and local governments when they are selecting among various adaptation measures. The kind of adaptation planning described in this report is not only intended to increase the County's adaptive capacity but also its resilience, which is a central concept in both the discussions and analyses in subsequent chapters. One additional component of resilience is vulnerability, which describes a community or system's propensity to be negatively affected by climate impacts; it includes factors such as sensitivity to harm and a lack of adaptive capacity. In an assessment of vulnerability in the County, each city, community, ecosystem, and building or structure will have a different profile, depending on socio-economic and governance considerations as well as geographic exposure to physical climate impacts. Climate change vulnerability and exposure co-determine a system's level of climate risk, while adaptive capacity and resilience will shape how that system can in turn respond when risk becomes reality.

1.2.2 Regulatory Context

The County's sea level rise work is situated within the broader scope of federal, state, and regional regulations and strategies. On a national level, sea level rise was addressed through President Obama's 2015 broadening of Executive Order 11988 (Floodplain Management), which enables creating a new flood standard that includes climate impacts when defining flood elevation and hazard areas for projects that build, retrofit, or significantly repair built structures with federal funding (Executive Order 11988 Amendment 2015).

On a state level, California has a long history of climate change and sea level rise policy, beginning in 2006, as described below:

- **California Assembly Bill 32 (AB 32), California Global Solutions Act, 2006.** Mandates GHG reductions to 1990 levels by the year 2020, which is a 15% reduction from business-as-usual scenarios.
- **Governor's Executive Order S-13-08, 2008.** Calls for using best available science to identify and prepare for sea level rise impacts through the coordination of the state Climate Adaptation Strategy.
- **State of California Sea-Level Rise Guidance Document, 2013. Draft update in 2017.** Provides information and recommendations to enhance consistency across agencies in their development of approaches to sea level rise.
- **California Climate Adaptation Strategy, 2009.** Provides a summary of impacts from climate change and recommends sectoral strategies for adaptation. Updated in 2013 to incorporate more recent climate science and risk management approaches (Safeguarding California Plan), with the Safeguarding California Implementation Action Plan released in 2014.
- **California Assembly Bill 2516 (AB 2516), 2014.** Stipulates that a Planning for Sea Level Rise Database be created to serve as a publicly accessible planning and informational tool to help local governments understand the issue and plan for next steps.
- **California Executive Order B-30-15, 2015.** Promotes an integrated approach to climate change and adaptation, requiring the incorporation of climate change impacts into both the state's Five-Year Infrastructure Plan and into state agencies' investment and planning procedures. Also calls for an update to the state adaptation strategy (Safeguarding California Plan).
- **California SB 379, 2015.** Mandates that local agencies move adaptation planning forward, in part through incorporating adaptation into their Local Hazard Mitigation Plans (LHMPs) or the next revision of that LHMP. Cities without an LHMP must analyze and update general plans (and safety elements in particular) to incorporate climate change adaptation and resilience priorities.
- **California SB 246, 2015.** Calls for the creation of an adaptation clearinghouse in order to coordinate regional and local efforts with state level climate adaptation measures. The clearinghouse will be "a centralized source of information that provides available climate data to guide decision makers at state, regional, and local levels when planning for and implementing climate adaptation projects to promote resiliency to climate change" (SB 246 2015, Section 71360).

- **California SB 32, 2016.** Updates GHG emissions goals and requires the state to reduce GHG emissions to 40% below 1990 levels by 2030.
- **California AB 197, 2016.** Increases legislative oversight of the California Air Resources Board through a number of different requirements, including establishing a Joint Legislative Committee on Climate Change Policies, and requires the Board to approve a statewide GHG limit equal to that of 1990 by 2020. It also requires the protection of the state's most disadvantaged communities when adopting rules and regulations regarding GHG reductions.
- **California AB 2800, 2016.** Requires state agencies to account for the current and future impacts of climate change when planning, designing, building, operating, maintaining, and investing in state infrastructure (from July 1, 2017, to July 1, 2020). It also requires agencies to establish a Climate-Safe Infrastructure Working Group to better integrate the best available climate change science into state infrastructure engineering, as prescribed.

1.2.3 Sea Level Rise Science

Sea level, which is the "height of the ocean surface at any given location" (IPCC 2013), is usually measured as an average over time at both a local and global scale. Alterations in sea level occur over large stretches of time and geography, making it a key indicator of global climate change because it allows observation and identification of long-term significant trends. Sea levels during the past three million years show that during certain periods, the world was much different than it is today—with temperatures 3.6°F higher and global average sea levels 16.4 feet above current levels (IPCC 2013). Since the late 19th century, measurements indicate that sea levels have been increasing and the rate of increase has been faster than during the previous 2,000 years. The Intergovernmental Panel on Climate Change (2013) reports the increase during the last century was 7 to 8 inches, which is "extremely likely" (i.e., greater than 95% probability) to have been predominantly caused by human activities. In addition, the historical rise in sea level over the last century has likely been underestimated (Hansen et al. 2015). **Research over the last 20-plus years has clarified several essential findings with respect to sea level rise (IPCC 2013):** *See box below.*

1.2.4 Sea Level Rise in California, the San Francisco Bay Area, and San Mateo County

While this report focuses on vulnerability and adaptation to sea level rise in the future, it is important to note that sea level rise is already happening. California has experienced around 7 inches of sea level rise from 1905 to 2005, and the rate of increase is projected to grow through the rest of this century (NCA 2014). Sea level rise is also projected to increase the height of coastal storm surges, while an increase in the number and intensity of extreme storms will lead to more frequent and severe flooding events over the next century. Coastal erosion, temporary flooding, and permanent inundation will put coastal communities, infrastructure, and wetlands at increasing risk. The National Research Council (NRC 2012) projects that areas south of Cape Mendocino in California will see an increase in sea level rise of 17 to 66 inches by 2100. The NRC report indicates that rates of sea level rise are likely to increase in this century compared to the last, and that California could experience up to 1 foot of sea level rise by 2030, 2 feet by 2050, and 5.5 feet by 2100 (NRC 2012). Table 1.1 provides a summary of sea level rise projections for California south of Cape Mendocino. The table provides a projection and a range in an attempt to incorporate various sources of uncertainty related to future GHG emissions and concentrations, global temperatures, and the response of the ocean to those global temperature distributions. The projections are derived for the A1B scenario, which assumes economic and population growth patterns similar to other emission scenarios but with a more balanced energy approach of both fossil-intensive and nonfossil sources. The value of the "ranges" is based on the lowest IPCC 4th Assessment Report future CO2 emissions scenario (B1) and the high end is based on the highest IPCC emissions scenario (A1FI). Since 2012, new sea level rise studies have provided updated projections. This recent work, developed in 2016 to support the 4th California Climate Assessment, incorporates new dynamics and modeling methods such as ice sheet modeling, and introduces possibly higher sea level rise estimates and more fine-tuned and regionally-scaled projections (Cayan 2016). The California State Natural

Coastal Storms: In California, coastal storms most often occur during the winter. The frequency of storms is not projected to increase in the 21st century, but the interaction effects between storms and sea level rise can increase tide levels and cause flooding, while also potentially increasing erosion. By the end of this century, sea level rise is projected to cause flooding (today caused by 1% change) on an annual basis (BCDC 2012a).

Findings

- Sea levels rose during the 20th century.
- The rate of change was faster than in the 19th century.
- Two main sources of sea level rise have been ocean thermal expansion and the loss of glaciers.
- The expected rate of sea level rise will be higher in the 21st century than in the 20th century.
- Sea level rise will be variable, not uniform.
- A certain amount of sea level rise is built into the system; that is, seas will continue to rise even with the reduction or elimination of GHG emissions.
- Both temperature and salinity can cause increases in the mean sea level in particular regions, but only temperature can be a significant source of increases to global mean sea level.
- Based on current levels of greenhouse gas emissions, a certain amount of sea level rise is guaranteed; that is seas will continue to rise even with the reduction or elimination of GHG emissions.

Table 1.1 Sea level rise projections for California south of Cape Mendocino (NRC 2012).

YEAR	PROJECTION	RANGES
2030	6 ± 2 inches	2 to 12 inches
2050	11 ± 4 inches	5 to 24 inches
2100	36 ± 10 inches	17 to 66 inches

Resources Agency is updating the State's sea level rise guidance based on these projections and, as of this writing, the State has released a draft of the State of California Sea Level Rise Guidance in November 2017. More information is available at http://www.opc.ca.gov/climate-change/updating-californias-sea-level-rise-guidance/. According to measurements taken at the San Francisco Tide Station at the Golden Gate, sea level has risen by 8 inches in the San Francisco Bay Area since 1897. According to the NCA (2014), the Bay Area is "particularly vulnerable to sea level rise and changes in salinity, temperature, and runoff," creating an intersection of impacts that will affect Coastside and Bayside communities alike.

However, the impacts from sea level rise cannot be fully understood through looking at sea level rise in isolation; a total water level approach is required, which incorporates multiple variables that contribute to coastal flooding and erosion. These variables occur at different time scales, and in the County, they include daily tides, king tides, storm surges, and El Niño, which can elevate water levels for several months. El Niño, in addition to bringing more rain and swell, also elevates water levels by 6–12 inches. In addition, an important component of total water levels in the County is subsidence, which is the gradual settling or sudden sinking of land due to activities that affect subsurface materials, such as groundwater depletion. The presence of subsidence can exacerbate the degree of relative sea level rise. Each of these factors has some impact alone, but in combination and in conjunction with sea level rise, the effects become more significant and are potentially compounded. In the near term, the effects of sea level rise will be felt primarily during storms, but in the future, even daily high tides could adversely affect shorelines and communities.

1.2.5 Impacts from Sea Level Rise

Sea level rise has a clear and direct impact on any Coastal or Bayside community, any people or businesses within inundation zones, and any ecosystem subject to erosion and flooding. Sea level rise causes direct physical damage to property and habitats, and it can have huge economic repercussions for both individuals and communities. Table 1.2 provides a summary of the primary direct impacts of sea level rise globally.

Table 1.2 Summary of sea level rise impacts.

Physical Effects Of Sea Level Rise: Adapted From The California Coastal Commission Sea Level Rise Policy Guidance (2015A).	
Flooding and Inundation	Low-lying coastal areas may experience more flooding (temporary) and inundation (permanent) and the inland extent of 1% change may increase. Higher water levels at the Coast may cause water to back up and increase upstream flooding. Climate change–associated shifts in precipitation patterns may decrease snow (and increase rain), which can cause flooding.
Wave Impacts	Wave impacts can cause erosion, damage, and destruction of built structures. The increase in the extent and elevation of flood waters from sea level rise will also increase wave impacts and move them farther inland. Rates of erosion of cliffs, beaches, and dunes will increase.
Erosion	Higher sea levels will mean that oceanfront bluffs will be increasingly pounded by waves, leading to greater erosion, which could in turn cause landslides and loss of structural and geological stability.
Changes in Sediment Supply and Movement	Sea level rise will change the availability of sediment, which is an important component of coastal ecosystems. Loss of sediment and erosion could lead to a need for beach re-nourishment.
Saltwater Intrusion	Sea level rise will cause saltwater to intrude into aquifers and groundwater resources. Local conditions determine how vulnerable these resources are, but those in coastal communities and those that serve as agricultural sources of water on the Coast will likely be at risk.

Sea level rise can also create many additional intangible losses as communities are threatened, important natural and public spaces are lost, and community members contend with the stress and uncertainty of current and future impacts.

When considering the ways in which sea level rise will play out on a local level, it is important to not only consider the impacts of sea level rise itself, but also the ways in which it might interact with other factors, such as storm events, or vulnerabilities (or combinations of vulnerabilities) that each location or asset might have. Exposure refers to the degree to which particular places and assets are affected by sea level rise and climate impacts, and the Adapting to Rising Tides Vulnerability and Risk Assessment (BCDC 2012a) identifies five of those primary impacts for the Bay Area:

- More frequent extreme high sea level events cause more frequent flooding in areas that are already flood-prone.
- With longer duration extreme high sea level events, flooding lasts longer.
- Higher high tides, shifts in tidal range, and increases in depth and duration of tidal inundation cause frequent or permanent inundation of areas that are not currently in the daily tidal range.
- Higher water level causes changes in wave activity leading to increased shoreline erosion and waves over-topping shoreline protection.
- Higher water level leads to elevated groundwater levels and salinity.

A final important concept in the consideration of climate and sea level rise impacts is the consequences (economic, environmental, governance, societal, and equity) for particular locations and assets (BCDC 2012a). Consequences incorporate numerous factors, including the scale of the impact and the scope of what and who are affected; the potential severity of the impact and the relevant adaptive capacity; and the costs of both frequent minor events as well as infrequent extreme events (BCDC 2012).

1.2.6 San Mateo County

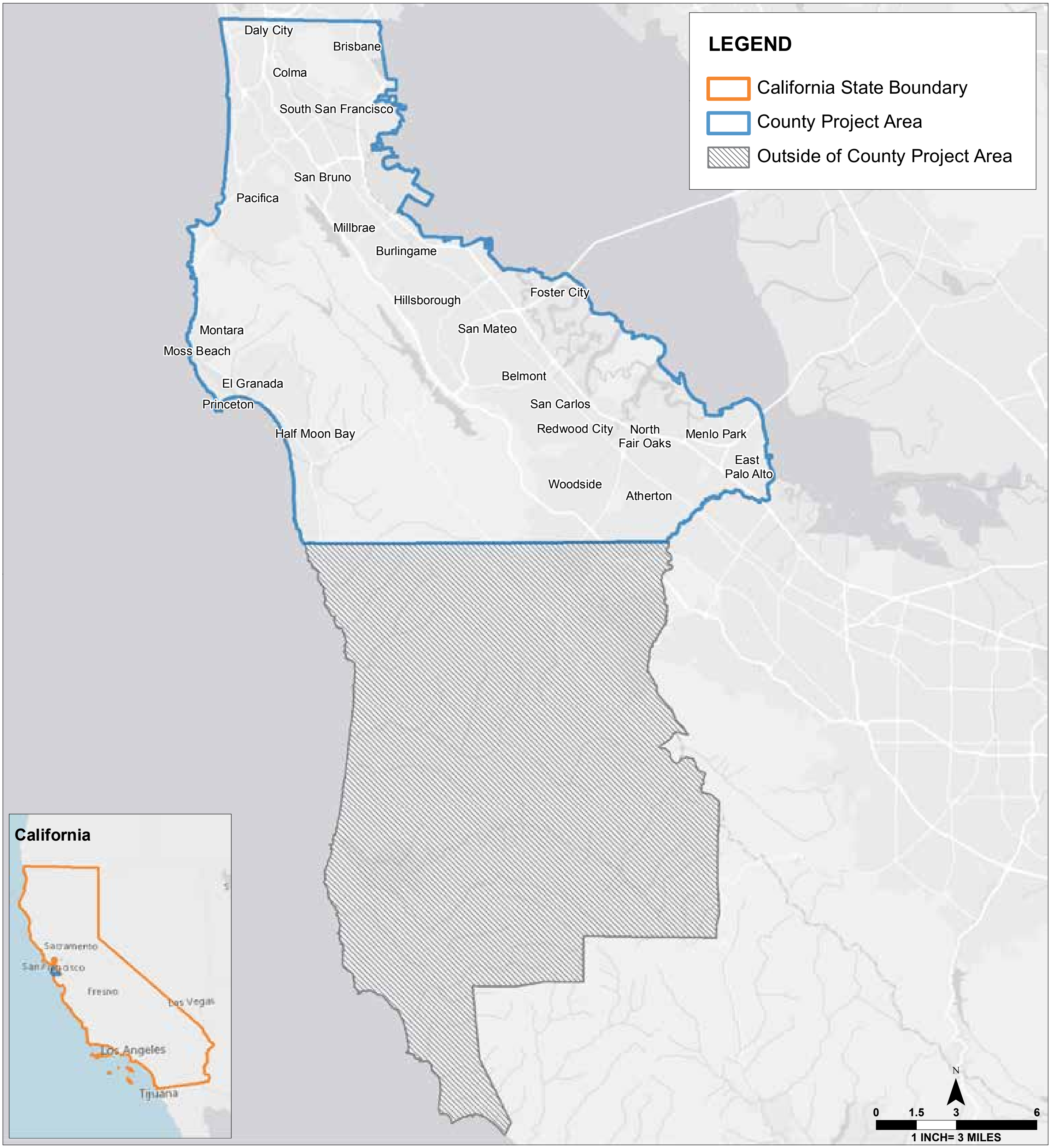
The San Francisco Bay Area is one of the top hotspots for sea level rise in the nation, and the economic value of property located in the County at risk from sea level rise exceeds that of any other county in the Bay Area (Pacific Institute 2012). When population projections are taken into account, the County is one of six counties in the nation (and the only one on the west coast) with over 100,000 people living in an area affected by 3 feet of sea level rise (Hauer et al. 2016). The County is divided into urban/suburban and rural regions with the eastern (Bayside) part of the County being urban/suburban and home to prominent companies, while the western (Coastside) side is rural and contains nearly all of the County's farmland. Table 1.3 provides a snapshot of key characteristics of the entire County (not just the study area), whereas Figure 1.1. shows a map of the entire County, including the study area and the area south of Half Moon Bay to the border with Santa Cruz County. The County will assess the area South of Half Moon Bay in a second phase.

Table 1.3 Characteristics of San Mateo County.

SAN MATEO COUNTY SNAPSHOT
Overview: 455 square miles of land with significant open space and unincorporated areas.
Population: 765,165 with population growth of nearly 50,000 over the last 5 years and 115,000 over the last 25 years.
20 Incorporated Cities and 23 School Districts.
20,653 businesses in technology, health care, finance, and others.
Workforce: 442,000, which has grown nearly 50,000 in the last 5 years and 72,000 in the last 25 years.
Over 78,000 acres of natural land, including 8,381 acres of wetlands and 12.9 miles of beaches.
Extensive recreational opportunities, including 20 County Parks encompassing over 17,000 acres and 190 miles of County and local trails.

UNIQUE QUALITIES
No dominant single city; population hubs are fairly dispersed.
Agriculture in the County contributes a total of $216 million to the local economy and provides 4,708 jobs to the economy.
San Francisco International Airport is the seventh busiest airport in the country, with over 50 million passengers annually.
Economic Diversity: the County has some of the wealthiest zip codes in the country, as well as some very poor areas.
Six Fortune 500 companies in the heart of Silicon Valley: Oracle, Visa, Facebook, Gilead Sciences, Franklin Resources, and Core-Mark.

Figure 1.1 Map of County of San Mateo



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

1.2.7 Social Vulnerability

Climate change impacts will not be distributed equally, whether among geographic locations or among populations. Some populations and communities will have more resources to adapt to climate change proactively and respond to climate change hazards, while others will be disproportionately affected by climate change, while also being less able to adapt to those impacts (EPA 2016). Social considerations like age, race, and income levels help determine an individual's capacity to "prepare, respond, and recover from a natural disaster or other potential climate impacts" (Cutter et al. 2012). The danger also exists that communities that are better prepared and have greater economic and political power will be prioritized over socially vulnerable populations when it comes to adaptation planning and financing. It is extremely important to take not just physical vulnerability into account when planning for sea level rise (and adaptation more generally) but also social vulnerability in order to ensure that equity is a central guiding principle.

Thirty-two percent of the population in the County is considered to live in vulnerable communities,[3] making it imperative that local sea level rise adaptation planning not only includes such communities, but also acknowledges and plans for the reality that many climate impacts will disproportionately affect vulnerable populations. For many lower-income communities, rates of home rentals are high, meaning that should flooding occur, people would likely face displacement and have less control over their own safety and ability to respond to it afterwards (e.g., repairs or rebuilding) (California Coastal Commission 2015a). Equally important is making social vulnerability central to adaptation planning and financing because adaptation will require huge amounts of investment; when deciding how to allocate this capital, it must be done with equity in mind rather than solely from economic considerations of perceived risk (Pacific Institute 2012). Table 1.4 summarizes key indicators of social vulnerability with respect to sea level rise and other environmental hazards, adapted from California Energy Commission (Cooley et al. 2012). See Chapter 3C for more information.

"While disasters do not discriminate, the existing societal and environmental conditions before, during, and after a disaster, produce differences in vulnerability among groups within the population affected" (Pacific Institute 2009).

Table 1.2 Summary of Indicators of Community Vulnerability (ABAG 2015).

CATEGORY	VULNERABILITY FACTORS
Socioeconomic	Low-income populations, people of color.
Age	Elderly people and children.
Housing/ transportation	People who rent their homes, people without a vehicle, people who spend a disproportionate amount of their income on housing and transportation.
Education/ language	Households where no one speaks English well or people without a high school diploma.
Other	People without health insurance or means of personal transport, people who have disabilities (mental or physical) or who have a disabled family member, or those who are institutionalized. (Note: The Assessment did not evaluate these factors)

[3]Percentage determined as part of this Assessment.

1.3 Background and Project History

Recent reports by the Pacific Institute in 2012 and the US Army Corps of Engineers (USACE) and the California Department of Water Resources (DWR) in 2013 have highlighted that the County is considered one of the most vulnerable counties in the state to the impacts of flooding. In response to these reports, efforts to address the challenge of sea level rise led to two conferences (one each in 2013 and 2014), spearheaded by County Supervisor Dave Pine, California Assemblyman Rich Gordon, and U.S. Congresswoman Jackie Speier. The dialogue started at these conferences made it clear that undertaking a coordinated effort and forming a central clearinghouse for sea level rise information in the County were imperative. Additionally the 2014-2015 San Mateo County Civil Grand Jury discussed ways for the County to formulate a plan for sea level rise, as well as alternative sources of funding for projects related to sea level rise. The Grand Jury strongly urged immediate action to undertake Countywide planning for sea level rise.

The challenges of climate change and rising tides are regional issues, and collaboration between all affected stakeholders is critical to finding effective solutions. This Assessment reflects the need for a more thorough understanding of these challenges in the County through a detailed analysis of Countywide sea level rise vulnerabilities, including the areas surrounding the San Francisco International Airport and the San Bruno and Colma creeks.

This Assessment is part of an ongoing effort led by the County, Sea Change SMC, to better understand and prepare for the potential impacts of sea level rise related to flooding and inundation, storm and tide surge, saltwater intrusion, and shoreline erosion. This report provides the groundwork for a Countywide vulnerability assessment.

The Sea Change SMC initiative includes a broad coalition of civic leaders, elected officials, municipal staff, and concerned citizens in the County. The Assessment is funded by a grant from the California State Coastal Conservancy (Conservancy), in-kind staff support from the Army Corps of Engineers Interagency Flood Risk Management Project, and funding from the County. The project is co-managed by the Conservancy and the County. Through a public bidding process in February 2014, the Conservancy and the County hired a team led by global engineering consultant ARCADIS U.S., Inc. (ARCADIS).

From the outset, a central principle of the Assessment was the importance of augmenting academic, archival, and field research with input from key stakeholders in the community. As such, the scope of work called for a robust engagement approach with stakeholder workshops, field visits, personal interviews, the integration of the project into a County website (www.seachangesmc.com), and ongoing communication with local stakeholders. Engagement efforts focus on collaboration with civic and elected leaders, municipal staff, representatives from agencies, special districts, environmental groups, and businesses from the 20 cities in the County, with an emphasis on individuals who have a working knowledge of public and environmental policy, physical assets and physical infrastructure.

The engagement effort is intended to (1) provide a platform for local stakeholders to contribute to the Sea Level Rise Vulnerability Assessment project; (2) gather their expertise, knowledge, and concerns about vulnerability; (3) provide for a greater appreciation of and connection to the project; and (4) ensure that stakeholders are in a better position to understand the motivations for the Assessment and to support its findings and recommendations. The three phases of Sea Change SMC are shown in Figure 1.2 below.

Despite a common perception that top-down climate policies are necessary for significant action, local and regional governments are actually in an ideal position to design and implement climate change adaptation measures because adaptation is necessarily a highly localized issue, requiring very specific knowledge about the physical and socio-political characteristics of each community, ecosystem, and asset in question. Even locations that appear to be similar or are in close proximity can face very different climate change impacts and thus require unique adaptation approaches at the subnational and local levels.

Figure 1.2 Phases of Sea Change SMC.

1.4 Organization of this Report

Chapter 1, Introduction provides the background and context for this Assessment.

Chapter 2, Methodology and Approach describes the process used to assess the County's vulnerability to sea level rise. More detail on the methodology can be found in Appendix A, Methodology Report. As will be explained, this methodology builds on the Bay Area's Adapting to Rising Tides approach and modifies it slightly to include a flood risk management component. This approach was used to facilitate a decision-making process that would lead to actionable outcomes and a clear understanding of risks. Particularly unique aspects of this method involve the risk-classified asset mapping and inventories, as well as the more detailed AVPs.

Chapter 3, Vulnerability Analysis presents the core findings of the County's vulnerability assessment and comprises four different, but related, subchapters. Chapter 3A, Setting and Context provides high-level insight into the potential types and the rough scale (geographic area and number of people affected) of the consequences from flooding, erosion, and sea level rise if no actions are taken to reduce vulnerability. Chapter 3B, Vulnerability Data Analysis and Discussion provides an in-depth analysis of Countywide natural and built asset vulnerability. Chapter 3C, Community and Health Vulnerability considers social vulnerabilities of the County's communities and public health impacts to them, including how certain characteristics of communities may make some populations less able to prepare for, respond to, or recover from impacts from sea level rise relative to others. Chapter 3D, City- and County-Specific Findings presents an inventory of assets affected under three different sea level rise scenarios in each city and unincorporated area of the County.

Chapter 4, Adaptation Planning provides an overview of adaptation planning, explains some of the necessary considerations for choosing adaptation options, and describes many of the adaptation options suitable for the County. The adaptation options include policy and planning recommendations, natural solutions and physical structures, and other methods for protecting assets from sea level rise.

Chapter 5, Getting Ahead of Sea Level Rise describes recommendations based on the results of this report for actions that the County, cities, asset managers, and other stakeholders can take over the near and long terms. The discussion includes recommendations for further study and additional considerations on how to move from a vulnerable San Mateo County to a resilient San Mateo County.

The following appendices are integral to this assessment and are included at the end of the report:

Appendix A - Methodology Report

Appendix B - Asset Exposure Maps

Appendix C - Asset Questionnaire Example – Wastewater Treatment Plant

Appendix D - Asset Vulnerability Profiles

Appendix E - Data Sources

Appendix F - Asset Categorization and Classification Report

Appendix G - Selection of Inundation Scenarios for San Mateo County Sea Level Rise Vulnerability Assessment Memo

Appendix H - Adapting to Rising Tides and Our Coast, Our Future – A Comparison of the Approaches

Appendix I - Groundwater Resources Evaluation

Appendix J - Pacific Gas & Electric – Sea Level Rise in San Mateo County

Appendix K - Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do: Application in San Mateo County

Appendix L - Stakeholder Group List

Appendix M - Summary of Local Sea Level Rise Planning Efforts

Appendix N - Additional Resources

Appendix O - Glossary

CHAPTER 2
METHODOLOGY AND APPROACH

METHODOLOGY AND APPROACH

This chapter summarizes the Assessment's methodology and approach to understanding and assessing the vulnerability of the County's communities to sea level rise (referred to as SLR in tables and figures), including the vulnerability of their built infrastructure, natural areas, and individual characteristics. The steps of the methodology and approach are outlined in Figure 2.1.

Assets refer to useful or valuable things in the County, such as structures, buildings, infrastructure, or habitats.

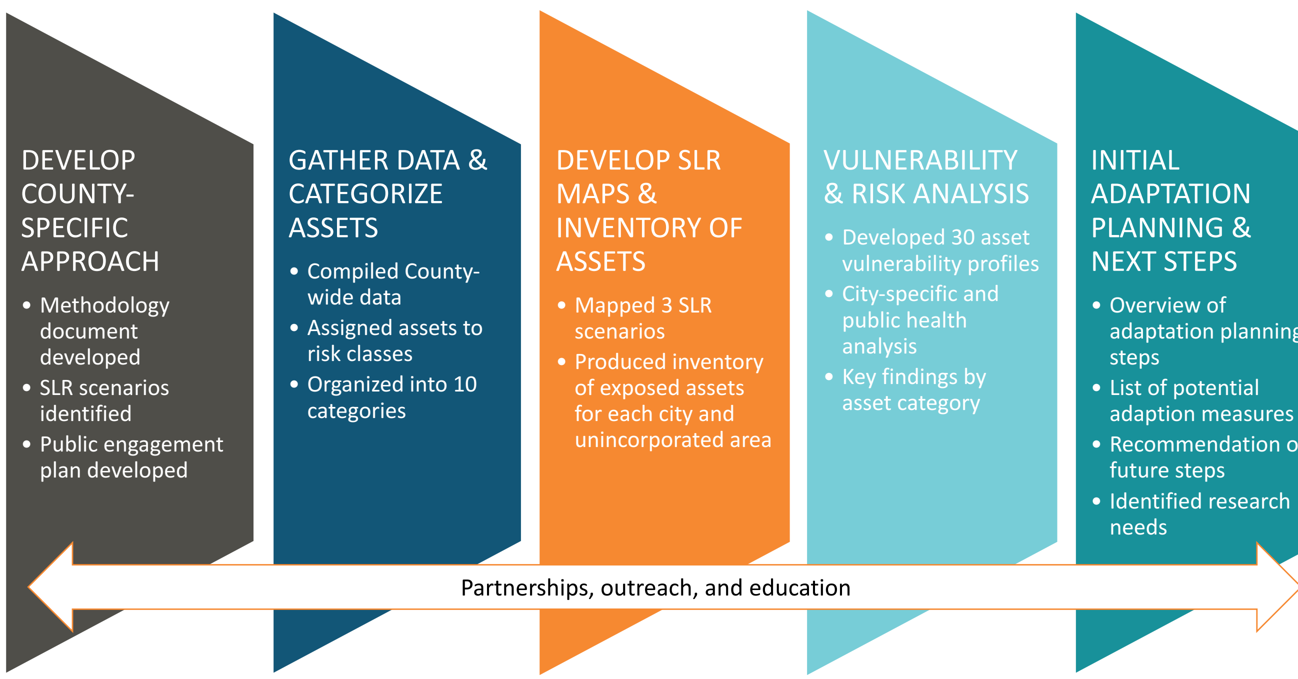


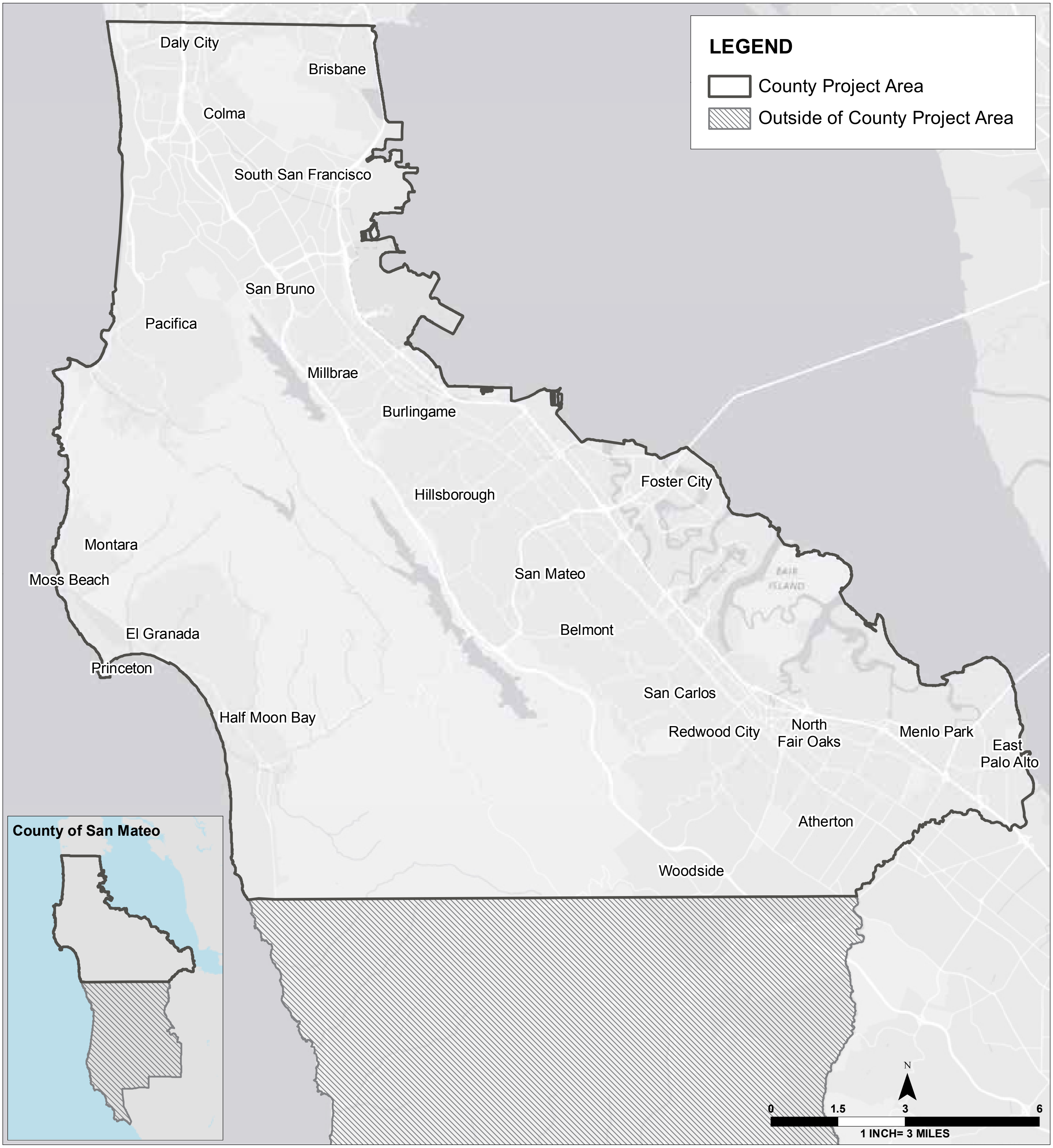
Figure 2.1 Methodology and Approach.

2.1 Development of Methodology and Approach

The methodology and approach of the Assessment were developed and adapted from best practices used in other sea level rise vulnerability assessments and flood risk management plans. They were also informed by regional sea level rise guidance documents, such as the California Coastal Commission's August 2015 Sea Level Rise Guidance, Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. The methodology incorporated strategies from the San Francisco Bay Conservation and Development Commission's Adapting to Rising Tides (ART) project (BCDC 2012a). However, the methodology deviated from ART strategies with the integration of a flood risk management component, developed by the American Society of Civil Engineers (ASCE). The integration led to categorizing assets by function or sector and assigning them a risk class (1, 2, 3, or 4). This Assessment assigned assets a risk class according to the severity or magnitude of the consequences should the asset experience flooding. Natural areas and community characteristics were incorporated into the Assessment, but they were not assigned a risk class. For more information and descriptions of the four risk ASCE classes used in this study, see Chapter 2, Methodology and Approach, Table 2.3.

To maintain an inclusive stakeholder process, a Technical Working Group, a Policy Advisory Committee, a Community Task Force, and input from the public guided the Assessment. This inclusive

Figure 2.2 San Mateo County Sea Level Rise Vulnerability Assessment Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community and collaborative process led to a deeper understanding of the vulnerabilities of assets and communities in the County and allowed the Assessment to be informed by the needs of the stakeholders.

More details on the methodology are available in Appendix A, Methodology Report.

2.2 Project Area

The Project Area includes the entire Bayshore and the Coastal areas north of Half Moon Bay. Figure 2.2 shows the geographic scope of the project in light green. Areas south of Half Moon Bay (the dark green hatched area on the map) were not included in this phase because of limitations in the available sea level rise inundation data. A future phase of the County's efforts will include a similar mapping and inventory assessment on the southern portion of the County below Half Moon Bay once modeling data are available for these areas.

2.3 Stakeholder Engagement

Throughout the course of the Assessment, local experts offered their input through public meetings, workshops, guided discussions, personal interviews, and site visits. Residents, asset managers, civic leaders, elected officials, and representatives from agencies and special interest groups also engaged in the research process, providing information and feedback. This information augmented scientific and archival information to provide a more comprehensive perspective on sea level rise vulnerability in the County. A full list of stakeholders can be found in Appendix L, Stakeholder Group List.

At the beginning of the project, the County invited representatives from cities, agencies and organizations to participate in one of two stakeholder-working groups, a Technical Advisory Committee and a Policy Advisory Committee. After the project started, the County developed a Community Task Force to allow for the coordination with community members, based on a recommendation from community representatives. The following section provides a description of the members of the three groups. The County held meetings with these groups throughout the project.

- **Technical Working Group (TWG)** Technical staff from each of the 20 cities in the County, including Public Works Directors, engineers, planning and emergency preparedness staff, special districts, local businesses, state and federal agencies, environmental groups, community organizations, and other entities with technical knowledge of critical facilities, community assets, and ecosystem and recreational assets.
- **Policy Advisory Committee (PAC)** City managers and elected officials from each of the 20 cities in the County, plus high-level staff from businesses, state and federal agencies, environmental groups, community organizations, and other entities with the ability to enact policy.
- **Community Task Force (CTF)** Members of community groups who applied to participate in the task force, are actively involved in the community, are able to assist with planning and conducting outreach efforts to raise public awareness on sea level rise.

Look Ahead—San Mateo hosted a temporary installation of virtual reality viewers at Coyote Point Recreation Area that display how the shoreline could change as sea levels rise. The project was produced by the nonprofit Climate Access in partnership with Owlized and the County of San Mateo with funding from the Federal Emergency Management Agency (FEMA) Region IX.

Throughout the development of the Assessment, the County worked to increase community awareness of sea level rise and the Sea Change SMC Initiative and to build support for future adaptation planning efforts. Specifically, the County held a public open house about the Assessment in January 2016, developed a social media presence, presented to a variety of organizations and community groups in the County, and implemented the Look Ahead—San Mateo project. The public outreach model in Figure 2.3 outlines the methods and opportunities that guided the County's public awareness efforts.

Figure 2.3 San Mateo County Sea Level Rise Vulnerability Assessment Public Outreach Model

INPUTS	ACTIVITIES	OUTPUTS	SHORT-TERM OUTCOMES	INTERMEDIATE OUTCOMES	LONG-TERM OUTCOMES
What resources are available to implement the program?	*What actions will be carried out to achieve outcomes? How will resources be used?*	*What are the tangible and direct results of our activities, to support the Assessment?*	*What changes do you expect to occur as a result of the program?*	*What changes do you expect to occur as a result of the program?*	*What changes do you expect to occur as a result of the program?*
Sea level rise models and data	Public workshops	Strategy documents	Target audiences are aware of SLR impacts to the County	Phase I and Phase II final products are robust, inclusive, and actionable	San Mateo County communities are more resilient as a result of adaptation planning
SLR impacts analyses	Surveys	Intuitive maps and information displays	Target audiences are aware of County's efforts to reduce adverse effects of SLR impacts	Information is used for planning and management decisions	
Project stakeholder group	Social media	Marketing materials	Target audiences provide input on Vulnerability Assessment		
County of San Mateo staff	Briefings and presentations	Public art			
Look Ahead-San Mateo project team	Media outreach	Survey findings and recommendation summaries.			
Support from County of San Mateo Board of Supervisors	Information design	Communications training module			
Funding	Pop-up community meetings	Localized Game of Floods activity			
Engaged members of the public	Experiential engagement				

2.4 Identification and Collection of Data

The Assessment relied on two broad categories of data: existing sea level rise modeling data and existing data on assets throughout the County. The first category comprises sea level rise modeling data (available for both the Coastline and the Bayshore) and coastal erosion data (available only on the Coastside of the County). The second category, asset data, is much broader and includes (but is not limited to) infrastructure, buildings, natural resources, cultural resources, recreational assets, and population census data. All asset data were uploaded into a geographic information system (GIS), which manages spatial and geographic data, to create visual maps of assets vulnerable to sea level rise.

This assessment uses the best available sea level rise and future erosion modeling data. Best available data refers to existing modeling systems that were evaluated in terms of their applicability to the County (available for both the Coast and the Bay), the process (good experimental design, clear documentation of methods and results, peer reviewed), technical information (SLR content, scenarios, terrain, model components, storm definitions), and the reputation of the research and science associated with the modeling.

Mean Higher High Water (MHHW) refers to the average of the two highest high tides per day over a 19-year period (the National Tidal Datum Epoch, which currently runs from 19832- 2001).

2.4.1 Sea Level Rise Modeling Data

At the time of this Assessment, the best available sea level rise modeling data were the U.S. Geologic Survey Our Coast, Our Future (OCOF) study and tool (Barnard et al. 2014, Ballard et al. 2016), which are available for the entire Bayshore and the Coastside north of Half Moon Bay. This Assessment used the OCOF sea level rise modeling data to evaluate which assets are at risk from sea level rise in the County. The report used the OCOF data layer to determine the geographical extent and depth of inundation along the Coast and Bayshore. The OCOF modeling provides 40 different scenarios, including nine sea level rise scenarios and three storm scenarios, and uses a baseline tide level of mean higher high water (MHHW). The nine sea level rise amounts are in 25-centimeter increments from 25 centimeters to 200 centimeters, with a high-end scenario of 500 centimeters. The storm scenarios include annual, 5% annual chance, and 1% annual chance storm options.

The Assessment also used sea level rise modeling data developed by AECOM using BCDC's Adapting to Rising Tides modeling method, available in the report Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore (Overtopping Analysis) (San Mateo County et al. 2016). The Overtopping Analysis became available for the Bay side of the County partway through the Assessment, and it identifies pathways of inundation or flooding from the Bay from 1- to 10-foot increments. The baseline tide level for the Overtopping Analysis maps is MHHW. The AVPs use these data and maps to evaluate when asset's could first become inundated from sea level rise, as described later in this Chapter. The hydraulic models used to support the Overtopping Analysis are different from those used to support the sea level rise hazard mapping (OCOF tool). Some of these key overarching technical differences include the following:

- The **purpose** of the mapping products (i.e., what considerations drove their development)
- The **scenarios** mapped
- The **terrain** used
- The **model components** and considerations
- The **storm definitions** (i.e., how the 1% annual chance storm is defined)
- **Inundation mapping** approach

An explanation of these differences and the reason for the use of the different approaches is explained in Appendix H, Adapting to Rising Tides and Our Coast, Our Future—A Comparison of the Approaches.

On the Coastside, erosion hazard zone dataset for the year 2100 from the Pacific Institute were used to estimate the potential future extent of erosion with sea level rise. This dataset is a merge of the Dune and Bluff hazard datasets created by Philip Williams and Associates, Ltd. 2009. This future erosion data were the best available data at the time of the Assessment and assumes 4.6 feet of sea level rise. Additionally, these erosion data assume the shoreline is eroding in its natural state, that is, without any shoreline protection infrastructure, such as sea walls, rock revetment, or groins. The modeling does not show shoreline protection over the next 50 to 100 years because the continuation of protection infrastructure is a shoreline management decision beyond the scope of the erosion modeling.

2.4.2 Asset Data

After selecting sea level rise scenarios, the County and ARCADIS collected data on a variety of assets located within the County. The County primarily managed data collection and compiled data related to transportation infrastructure, airports, stormwater infrastructure, levees and other shoreline infrastructure, wastewater treatment plants and pump stations, health care systems, hazardous materials, energy infrastructure, parks, and natural areas. The type of information collected included an assets location, elevation, owner or managing agency, construction date, and other general information about the asset.

Data needed to be in a GIS format in order to be incorporated into the Assessment. Data were obtained and compiled primarily by County of San Mateo staff, with some assistance from ARCADIS. County staff collected data via several avenues:

- Requests for data from members of the Technical Working Group. For example, County staff requested GIS data on stormwater infrastructure, parks, corporation yards, and other city-owned infrastructure from each of the cities in the County.

- Online sources
- Email requests to specific data sources
- Development of new data layers from Google map location data, and Excel spreadsheets with location data

This produced a list of over 400 datasets, of which the Assessment used a subset, excluding duplicates and selecting Countywide datasets where possible. If Countywide datasets were not available, the County merged individual city-specific datasets to make new Countywide datasets. If Countywide data sources were not available and not easily developed, data were omitted. A full list of the datasets used and their sources are provided in Appendix E, Data Sources. The County plans to make the majority of datasets available through the County's Open Data Portal upon the completion of the Assessment (excluding restricted access data).

2.5 Selection of Sea Level Rise Scenarios for Flooding and Coastal Erosion

The sea level rise scenarios selected for the Assessment provide an understanding of today's flood risk as well as realistic future scenarios that account for sea level rise hazards. The use of scenarios allows for a better understanding of the impact of inundation and erosion on local County communities under different circumstances. While higher sea level rise scenarios are less likely to occur or will likely happen over longer timeframes, considering the higher end scenarios provides valuable input for critical infrastructure with longer lifespans, zoning, and risk reduction decisions.

The Assessment used guidance provided by the California Coastal Commission's (CCC's) Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits (CCC 2015a). The Coastal Commission poses two key questions to help in establishing scenarios:

1. What is the minimum amount of sea level rise that causes inundation, flooding, or erosion concerns?
2. What are the impacts from the worst-case scenario of the highest possible sea level rise plus elevated water levels from high tide, El Niño, and a 1% annual chance flood?

The Assessment evaluates three scenarios of sea level rise and one future erosion scenario, as shown in Table 2.1. These scenarios included a "baseline," a reasonable "mid-level," and a reasonable "high-end" or "worst-case" sea level rise scenario. In addition, the Assessment includes one erosion scenario for the County's coastline. The three inundation scenarios were selected with input from the Stakeholder Group, guidance from the Coastal Commission (CCC 2015a), and best available science on sea level rise projections for the County. The best available science on sea level rise projections at the time of the Assessment was the National Research Council Report Sea Level Rise for the Coasts of California, Oregon, and Washington (NRC 2012). See Table 1.1 in Chapter 1 for a summary of the projections.

The baseline scenario shows present-day flood risk without sea level rise. This scenario is designed to show a similar water level as FEMA's flood insurance rate maps, which are based on the 1% chance annual flood event. The mid-level scenario uses 3.3 feet of sea level rise and is comparable to the National Research Council's "likely" 2100 sea level rise scenario (36 inches). Since the OCOF model is based on centimeters, the closest scenario to 3 feet is the 100-centimeter scenario, which equates to 3.3 feet. This scenario is also reflected in studies performed by the County of Marin and the City of San Francisco. The selection of the high-end scenario is in line with Coastal Commission's Guidance Document recommendation to use an extreme scenario that presents a potential worst-case sea level rise scenario. Our team chose to combine these water levels with a hypothetical 1% annual chance flood to show the combined risk of sea level rise and a potential storm.

Beyond the short-term episodes of significant inundation represented by the scenarios, daily water levels will also change with sea level rise. An analysis of scenarios without a storm was outside the scope of this report. However, there are methods to approximate a nonstorm scenario. The baseline scenario is roughly equivalent to 3.5 feet of sea level rise. This means that the baseline scenario illustrates generally an everyday water level with 3.5 feet of sea level rise, the mid-level scenario illustrates daily water levels with approximately 7 feet of sea level rise, and the high-end scenario approximates roughly 10 feet of sea level rise. For more

Table 2.1 Sea level rise and erosion scenarios used in the Assessment.

BASELINE SCENARIO	1% annual chance flood (present-day extreme flood)" to "1% annual chance flood (present-day extreme flood also known as 100 year flood)
MID-LEVEL SCENARIO	1% annual chance flood + 3.3 feet of sea level rise
HIGH-END SCENARIO	1% annual chance flood + 6.6 feet of sea level rise
COASTAL EROSION	The projected extent of coastal erosion expected with 4.6 feet of sea level rise

detailed mapping showing sea level rise inundation and storm equivalents, see the Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore report (County of San Mateo et al. 2016)."

All scenarios and inundation models include some level of uncertainty, meaning actual inundation depths will vary from what is projected on the inundation maps. As such, the maps are intended for planning purposes only; they would be inappropriate for design and construction. Details on sea level rise scenario selection are provided in Appendix G, Selection of Inundation Scenarios for San Mateo County Sea Level Rise Vulnerability Assessment Memo.

2.6 Categorization and Classification of Assets

A critical part of developing a comprehensive sea level rise vulnerability assessment is categorizing and classifying the built and natural assets that will be exposed to present and future inundation. Categorizing the built and natural assets helps organize the data and findings according to sector or asset function, and ensures consistency with regional practices. Asset categories and classes provide a framework through which to evaluate potential impacts.

2.6.1 Categorization

This Assessment employs the same asset categories as BCDC's ART Program, which was developed to guide vulnerability studies in the San Francisco Bay Area (BCDC 2012b). The ART Program specifically identifies and describes 12 categories into which all assets are organized for analysis. This Assessment and findings follow the same asset categorization process. Table 2.2 describes the 12 categories.

Table 2.2 BCDC asset categories and descriptions information adapted from BCDC Adapting to Rising Tides (BCDC 2012b).

BCDC CATEGORY	DESCRIPTION
Airports	Three commercial airports are located in the County: Half Moon Bay Airport, San Carlos Airport, and San Francisco International Airport.
Community Land Uses, Services, and Facilities	Community land use describes the services and facilities, such as job centers, residences, schools, and hospitals, that together make up the neighborhoods where people live and work.
Contaminated Lands	Types of contaminated lands include closed and active landfills, federal Superfund sites, state cleanup sites, leaking underground storage tanks, military cleanup sites, and California Department of Toxic Substances Control sites.
Energy Infrastructure and Pipelines	Energy infrastructure and pipelines include power plants, substations, and fuel transportation lines.
Ground Transportation	The region, state, and nation depend on the reliability of significant ground transportation assets. These assets link people with community facilities and services, jobs, family and friends, recreation, and other important destinations. They also link goods to markets.
Hazardous Materials	Facilities that generate and store hazardous materials include laboratories, manufacturing facilities, gas stations, and transportation maintenance facilities.
Natural Areas	Natural areas range from fully tidal marshes that are either exposed to the open Bay or are protected from wave and tidal energy by offshore mudflats, to muted tidal marshes and ponds that are protected from the Bay by berms and levees and have water levels controlled by tide gates and other structures.

Parks and Recreation Areas	Areas like parks, golf courses, and portions of the San Francisco Bay Trail and California Coastal Trail are included in park and recreation resources.
Seaports	Maritime facilities along the shoreline including the Port of Redwood City.
Structural Shorelines	Structural shorelines are identified as (1) engineered flood protection, e.g., levees/floodwalls designed to protect inland areas from inundation; (2) engineered shoreline protection, e.g., revetments or bulkheads that harden the edge to reduce erosion; and (3) nonengineered berms, e.g., mounds of Bay mud placed to separate managed baylands from the Bay, which can also provide “ad hoc” flood protection.
Stormwater Systems	Stormwater systems consist of drains that collect urban runoff and underground pipes that convey flows either by gravity or by pumping to a discharge location (outfall).
Wastewater Systems	Wastewater infrastructure and service areas, similar to stormwater have underground pipes that convey flows by either gravity or pumping to a wastewater treatment plant or discharge location.

Redwood City Port. Photo Credit: San Mateo County Flickr.

2.6.2 Classification

2.6.2.1 Built Infrastructure

This Assessment classifies built assets using guidance from the American Society of Civil Engineers Minimum Design Loads and Associated Criteria for Buildings and Other Structures 7-10 and Flood Resistant Design and Construction 24-14. These criteria aim to protect public health, safety, and welfare in the event of a hazard (ASCE 2013, 2015). The Asset Categorization and Classification Report (Appendix F) describes the criteria more fully. Built assets were assigned an ASCE Risk Class (1, 2, 3, or 4) based on function or occupancy type, ranging from Class 1 (no or low risk to public safety and society) to Class 4 (highest risk to public safety and society). This standard for building classification has also been adopted by the California Building Code. Thus, in this Assessment, built assets were assigned to one of 10 categories from the BCDC ART Program and one ASCE Risk Class. Some examples of asset types that fit into each class are provided below. Chapter 3D, City and County Specific Findings, provides a complete list of asset types and their assigned risk classes.

Table 2.3 ASCE Risk Classes, description, and examples.

RISK CLASS	DESCRIPTION OF BUILT ASSET TYPE	EXAMPLES
1	Buildings and other structures that represent a low risk to human health in the event of failure (flood).	• Trails and trailheads • Beach access points • Transit maintenance yards • Parking structures
2	All buildings and other structures except those listed in Classes 1, 3, and 4.	• Marinas • Job centers • Hotels, parks • Historic/cultural places
3	Buildings and other structures • The failure of which could pose a substantial risk to human health; • Not included in Class 4, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of a flood; • Not included in Class 4 (including, but not limited to facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing toxic or explosive substances whose quantity exceeds a threshold amount established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.	• Water sources • Gas wells • Natural gas pipelines and stations • Hotels • Railroads • Ports • Nonfederal roads/highways • Community centers • Jails and correctional facilities
4	Buildings and other structures • Designated as essential facilities • The failure of which could pose substantial hazard to the community; • Including but not limited to facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste, containing sufficient quantities of highly toxic substances whose quantity exceeds a threshold amount established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released • Required to maintain function of other class 4 structures.	• Hazardous/contaminated sites • Flood control infrastructure • Hospitals and health care facilities • Emergency shelters • Power generation stations

2.6.2.2 Natural Areas

To date, no guidance exists to assign natural areas to a risk class. The scientific community is not in agreement about which ecosystem types are more critical or valuable than others, and a risk classification for natural areas is consequently not available. However, not only do natural areas provide intrinsic value to the County and its residents, but natural areas are also recognized for the tangible, environmental, and structural services they offer. Examples of these services include increased biodiversity, flood and erosion control, water quality improvement, and carbon sequestration (BCDC 2012a). In this Assessment, natural area types will be listed with a descriptor based on the habitat types assessed in the Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean (Hutto et al. 2015), such as Beach, Wetlands, Rocky intertidal, or Species of concern. This approach allows for an inventory of natural areas in the County in order to support future flood risk analyses. This list of natural areas also provides a baseline against which future adaptation strategies can be compared in terms of how strategies may positively or negatively affect the County's natural areas.

2.6.2.3 Community Characteristics

Similar to natural assets, community characteristics are not classified according to risk in this Assessment. Community characteristics include data on the location and demographics of communities in order to identify how many people in which locations may be affected by present and future flooding and sea level rise hazards. The classification can also help identify what characteristics, if any, may cause some communities or individuals to be more or less able to prepare for, respond to, and recover from sea level rise hazard events. This information and an understanding of which populations may experience disproportionate impacts from flooding can help evaluate vulnerability and issues of equity. In this way, the County, cities, and agencies will be able to prioritize the protection of human health and safety.

2.7 Sea Level Rise Hazards Mapping and Asset Exposure

To determine the degree to which built and natural assets and communities may be exposed to coastal flooding and erosion, the asset data were overlaid with the sea level rise modeling data in GIS. This process produced exposure maps and an inventory of assets.

2.7.1 Asset Exposure Maps

Asset exposure mapping shows the general location and spatial concentration of important assets that could be exposed to present and future sea level rise hazards. This mapping works in conjunction with the asset exposure inventories for each city and town.

To generate maps of exposed assets, all asset information and sea level rise hazard data were mapped using GIS. The maps were first divided by project area, then categorized into a BCDC category, and finally classified into one of the four ASCE Risk Classes or into a natural area (habitat) as already described. Each asset was analyzed based on the four sea level rise hazard extents: the baseline, mid-level, high-end, and erosion scenarios. The analysis determined how many of each asset category and risk class was exposed in each scenario. County-scale built asset exposure and natural asset exposure maps are provided in Chapter 3. Individual maps divided by cities and towns are provided in Appendix B, Asset Exposure Maps.

Any datasets that contained asset information with more than one ASCE Risk Class were split into separate layers. If two or more datasets for a particular asset type were available (i.e., wetlands data from both San Francisco Estuary Institute and the California Department of Fish and Wildlife), the most recent dataset was chosen for the asset exposure analysis. Any remaining data that had duplicates were reduced in order to remove the overlapping data.

2.7.2 Asset Exposure Inventory Tables

The assets shown in the asset exposure maps were inventoried and compiled into inventory tables: one project area table and one table for each city and unincorporated area (Chapter 3D, City and County Specific Findings). The asset exposure inventory tables provide an accessible tool to County and city staff and other stakeholders for understanding what assets in their area will be exposed from multiple levels of sea level rise. Because the asset exposure inventory tables are organized by risk class and natural areas (identical to the organization of the maps), the tables enable a quick interpretation of the types of assets exposed with respect to their potential for economic, societal, or environmental disruption. The inventory tables also identify the number of people living in census blocks that may be exposed to sea level rise hazards, without taking into account population growth.

2.8 Methodologies Used for Equity and Groundwater Analyses

2.8.1 Sea Level Rise and Equity

Assessments of sea level rise risks and adaptation draw attention to issues of equity, both in terms of how some individuals or communities will bear a disproportionately greater the impact from sea level rise than others, and how some individuals and communities may receive more benefits from sea level rise adaptation than others may. This Assessment considered equity in sea level rise by evaluating the first of these two issues as follows.

The community vulnerability methodology developed by the Association of Bay Area Governments (ABAG) and BCDC for the resilience program Stronger Housing, Safer Communities (ABAG 2015) was utilized to discuss which characteristics of communities and individuals make them less able to prepare for, respond to, and recover from a disaster (relative to others). The ABAG and BCDC methodology expands upon a methodology developed by the Metropolitan Transportation Commission (MTC) to measure and score demographic indicators by census block group. ABAG and BCDC, in coordination with regional stakeholders, evaluated the MTC indicators and added additional indicators specific to disaster response. These indicators represent demographic data, collected from U.S. Census data. The methodology presumes that areas with a higher concentration of the 10 indicators have characteristics that could affect the ability to respond to or recover from a flood or other disaster. This Assessment identifies areas with increased community vulnerability as areas where three or more of the indicators are present. The demographic data were uploaded into GIS to create the community vulnerability map series discussed in Chapter 3. These 10 indicators, the census block measurements, and thresholds are described in Table 2.4.

Table 2.4 Community vulnerability indicators adapted from Housing and Community Risk Multiple Hazard Risk Assessment (ABAG 2015).

INDICATOR	MEASURE	PERCENTAGE
Age (Very Young)	% young children <5 years	Mean + 1 standard deviation
Age (Elderly)	% elderly, >75 years	>10%
Race/Ethnicity	% non-white	>70%
Education	% persons >18 years without a high school diploma	Mean + 1 standard deviation
Income	% households with income less than area median income	>30%
Language	% households where no one ≥15 years speaks English well	>20%
Home Ownership	% not owner-occupied housing	Mean + 1 standard deviation
Access to Vehicles	% households without a vehicle	>10%
Housing-Cost Burden	% household monthly housing >50% of gross monthly income	>15%
Transportation-Cost Burden	% household monthly transportation costs >5% of gross monthly income	>15%

To determine vulnerability, census block groups received a score of 1 point for each indicator that was greater than a certain percentage of the block group population. These percentages vary by indicator. For example, block groups with greater than 10% of individuals over 75 years would receive a score of 1. For indicators that were not identified by MTC (education, homeownership, and very young) did not have a pre-identified percentage, block groups received a score of 1 point for each indicator that was greater than the mean for the region, plus one standard deviation (consistent with the method used by the MTC process). This process identified block groups with higher than average concentrations of a particular indicator, which implied a greater level of vulnerability. The total possible score each block group could receive ranged from 0 to 10. This approach should only be used for planning purposes (ABAG 2015).

In addition, the Assessment includes a particularly close look at a vulnerable community to understand in more detail what makes it vulnerable and what special considerations should be integrated into adaptation solutions. The results of this effort are in the Community Vulnerability Profile written for East Palo Alto (Appendix D).

2.8.2 Sea Level Rise and Groundwater

The County and some of its jurisdictions are currently undergoing a detailed assessment of groundwater resources, which will include sea level rise impacts. In advance of the completion of those studies, this Assessment included a high-level analysis of the potential vulnerabilities of the County's groundwater resources and performed the following actions:

1. Identified the primary sources of municipal water supply of 15 water districts within the County with information obtained from the Bay Area Water Supply and Conservation Agency and from Annual Consumer Confidence Reports for each of the water districts.
2. Performed a qualitative evaluation of the potential vulnerability of groundwater extraction wells for cities and unincorporated areas where groundwater was reported to be a resource for municipal, industrial, and agricultural uses . These areas included San Bruno, South San Francisco, Daly City, East Palo Alto, Half Moon Bay, and less populated areas on the Pacific Ocean side of the County. It is not anticipated that groundwater extraction, groundwater level, or well screen information was located for all supply wells, so this qualitative assessment will need further future evaluation to more accurately estimate potential groundwater impacts.
3. Performed a limited search identifying contaminated land sites, such as hazardous waste sites and landfills, in the County that may be affected by sea level rise, with particular emphasis on sites in areas where groundwater is identified to be a source of municipal supply.
4. Summarized key findings of the groundwater analysis. A detailed evaluation and a brief technical memo are provided in Appendix I, Groundwater Resources Evaluation.

Although sufficient information was available to understand the County's groundwater-related vulnerabilities, more detailed information is needed in some areas to better understand the complexities and interrelated issues of sea level rise in decision-making, design, and construction of any risk reduction measures. The Assessment leveraged existing resources to supplement the areas with limited information for analysis.

2.9 Asset Vulnerability Profiles (AVPs)

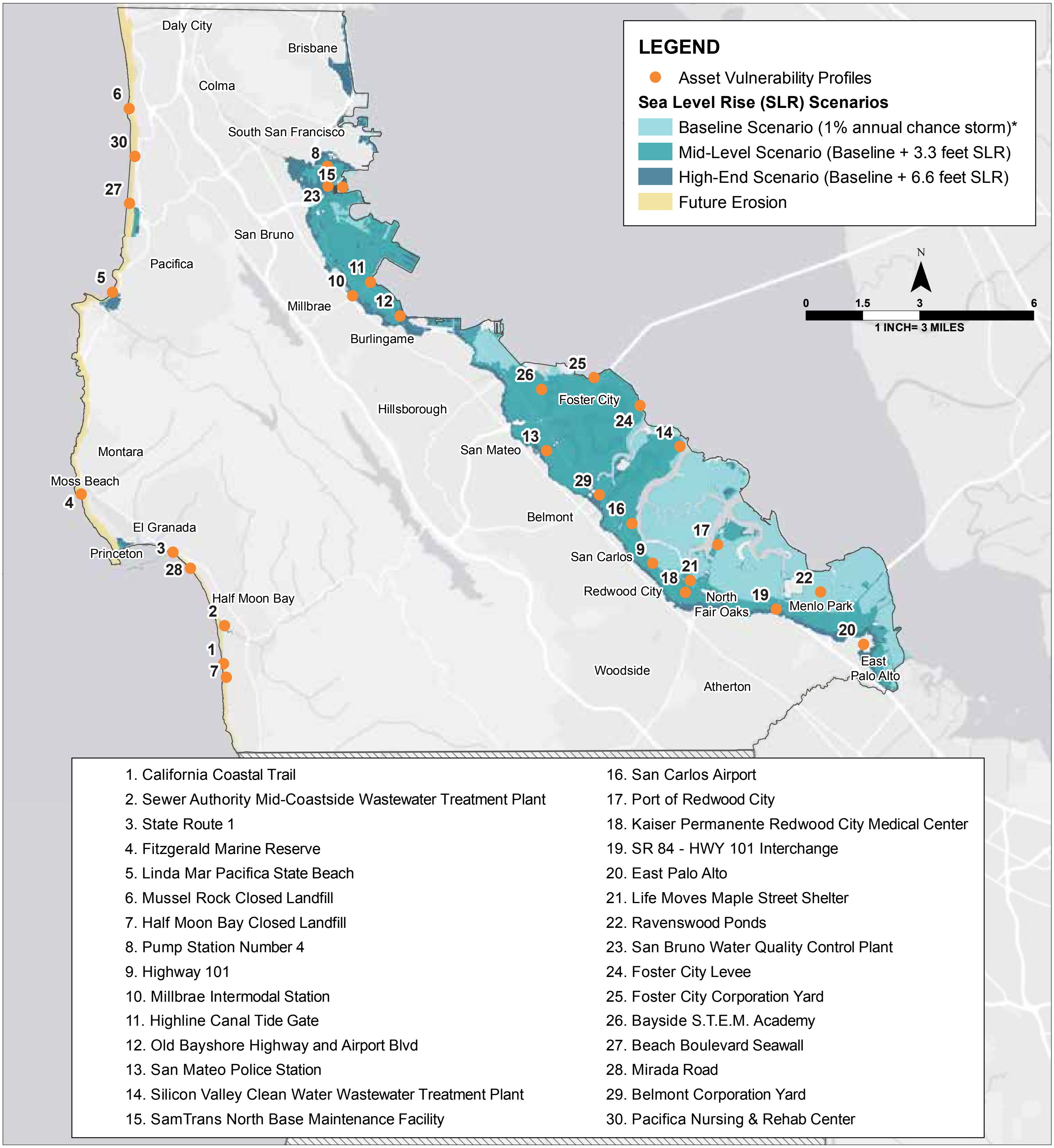
AVPs were developed for 29 assets and one community. The AVPs are a representative sample of the assets inventoried across asset categories and location. The AVPs provide more depth and detail to the asset exposure maps. For example, the maps show how many and which assets may be exposed, while the AVPs explain how each specific asset is vulnerable to a sea level rise hazard and provide insight into the potential consequences. Each profile provides an analysis of how, why, and the degree to which each asset is vulnerable to sea level rise. The profiles also include an analysis of the ability of the asset to cope with sea level rise and potential adaptation strategies to reduce impacts.

2.9.1 Asset Selection

With input from the Stakeholder Groups and the public, 29 assets and one community were selected for detailed profiling, shown in Figure 2.4. An initial list of possible assets to select for the profiles was compiled using the criteria described below, and based on suggestions submitted through a survey sent to cities and other key stakeholders. To help narrow the list further, input was then solicited through breakout sessions held for each of the Stakeholder Groups, as well as through an open survey housed on the project website. The feedback was then used to create a final selection list for the profiles. The criteria used to select assets for AVPs included the following:

- Geographic coverage of asset
- Representative across asset types, classes, and categories
- Representative across agencies and jurisdictions
- Size of the service area (some more local, some more broad)
- Availability of data
- Willingness of asset owner

Figure 2.4 Map of 30 Assets



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

2.9.2 Asset Survey, Interviews, and Site Visits

Through surveys, interviews, and site visits, detailed information was collected from asset managers to support the asset profiles. First, surveys were developed for each asset, informed by the survey questions used in the ART Program and augmented with questions and recommendations provided in Risk Analysis and Management for Critical Asset Protection Standard for Risk and Resilience Management of Water and Wastewater Systems, also known as the American Water Works Association J100 methodology (AWWA 2010). The survey questions were also based on real damages and losses experienced by similar asset types during flood events in other areas around the United States. For example, the wastewater treatment plant asset questionnaires were informed by the experiences of such plants affected during Hurricane Sandy. The survey included questions about the function of the asset, population served, elevation, and any historic issues.

After receipt of survey responses, asset managers were interviewed and site visits were made to each asset in order to obtain a more comprehensive understanding of the asset, view the vulnerabilities first-hand, and follow up on any questions raised in survey responses. The findings were then distilled and organized into 30 three- to five-page AVPs that describe the overall vulnerability of each asset or community. See Appendix C for an example of a survey.

2.9.3 Asset-Specific Vulnerability Assessments

Vulnerability, as addressed in these profiles, is composed of three major components: exposure, sensitivity, and adaptive capacity. After the information gathered from the surveys, interviews, and site visits was compiled, a series of analyses were performed to better understand the vulnerability of each asset. These analyses determined a Low, Moderate, or High level rating for exposure, sensitivity, and adaptive capacity, which together yielded an overall vulnerability rating for the asset.

First, ARCADIS used the Overtopping Analysis modeling data to identify low spots along the shoreline (Bayside only) that would likely be the first to overtop. This analysis used coastline elevation and types from the San Francisco Estuary Institute and the water levels that lead to shoreline overtopping and inundate the asset from the Overtopping Analysis. Maps of inundation for water levels 12 to 108 inches (at 12-inch intervals) above MHHW were used in order to roughly identify a potential flow path for flood water and to identify the first level of inundation that could cause significant impacts. Determination of the level of "significant impacts" was based on expert judgment using visual cues from the inundation map. For example, if the maps showed that the shoreline overtopped at 12 feet but major components of the asset were not affected until 36 inches of sea level rise, then 36 inches was determined to be the critical water level.

Next, the maximum and minimum potential inundation depths were determined for each asset. Extracting potential inundation depths required using information from the OCOF tool. Inundation depths in the OCOF data were first converted from metric to English units (feet), maintaining consistency with the Overtopping Analysis depths. Then asset footprint outlines were drawn via data collected in the inventory tables, parcel boundaries, or inspection of aerial/satellite imagery. With these outlines, the maximum and minimum potential inundation depths from each of the three inundation scenarios and the inundation level that caused the first significant impacts were found within each AVP footprint area (using zonal statistics tools in ArcGIS).

The overall vulnerability of the asset to near-term flooding and erosion and the future impacts of sea level rise was determined using the analyses described above, in combination with the information gained from the AVP surveys, interviews, and site visits. As described previously, the key drivers of vulnerability are based on three components: exposure, sensitivity, and adaptive capacity. An additional component was included to identify the

Fishing at Linda Mar Beach. Photo credit: Toby Roessingh.

level of consequences associated with loss of service for the asset, but it does not factor into the overall vulnerability. Each component (exposure, sensitivity, adaptive capacity, and consequences) received a determination of Low, Moderate, or High. The overall vulnerability was determined based on the combination of an asset's vulnerability components. In general, if all three components are low, then the final vulnerability will be low. If all three are high, then the final vulnerability is high. In between, are moderate cases based on the combination of components. If two components of an asset are high, then the final vulnerability is also high. If two components of an asset are low and one is moderate, then the final will be low. If two components are low and one is high, the final will be moderate. These vulnerability summaries in the profiles are not rankings or priorities. They were designed to lay the foundation for future analyses that can support hazard mitigation actions and could make asset managers more competitive in future funding requests.

In addition to describing vulnerabilities within each AVP is an explanation of the consequences of each scenario and a brief description of possible asset-specific adaptation (or risk reduction) strategy. The brief adaptation section in the AVPs does not reflect an exhaustive list of options or an evaluation of alternatives or consider issues such as feasibility, cost, or trade-offs. Further study is needed to identify options in detail and integrate measures into a comprehensive Countywide strategy. The AVPs and a detailed reader guide can be found in Appendix D.

These profiles had several iterations in which city and County staff, asset managers, and Assessment Stakeholder Groups vetted the information and analysis gleaned from the surveys, interviews, and site visits.

2.10 Adaptation Planning

This report uses national best practices, compiled from sources including BCDC and the California Natural Resources Agency, to provide an overview of the adaptation planning process and potential adaptation strategies. Adaptation planning is the process of creating a strategy in order to reduce a community's vulnerability to the negative impacts associated with sea level rise. Because of the complex nature of sea level rise, adaptation planning has no singular methodology (Mimura et al. 2014). As such, Chapter 4 was written as a guide to help communities develop adaptation strategies.

Ultimately, the County and city jurisdictions will need to more fully assess coastal and interior flood risks and develop a long-term risk reduction strategy that sets priorities for investment, identifies projects, evaluates trade-offs, and builds a financing program.

2.11 Limitations

Certain limitations and data constraints shaped the scope of the Assessment, as described below. Where possible, limitations and data constraints are noted in the relevant chapter.

2.11.1 Modeling Extent

This Assessment relied on existing sea level rise modeling tools. At the time of project initiation, the extent of the OCOF sea level rise tool included the entire Bayside of San Mateo County and the Coastside from the northern border to Half Moon Bay. As such, the geographic scope of this phase of the Assessment does not include areas south of Half Moon Bay to the southern extent of the County. Additional analysis will need to be completed for the remaining portion of the County. In addition, this Assessment does not include modeling for riverine flooding, which can exacerbate sea level rise hazards conditions.

The maps in the Assessment are intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. The maps are not detailed to the parcel scale and should not be used for navigation, permitting, regulatory, or other legal uses.

"Ultimately, the County and city jurisdictions will need to more fully assess coastal and interior flood risks and develop a long-term risk reduction strategy that sets priorities for investment, identifies projects, evaluates trade-offs, and builds a financing program."

Flooding due to sea level rise and storm surges is possible in areas outside of those predicted, and even the best predictions cannot guarantee the safety of an individual or structure. Nor do the maps model flooding from riverine, surface water flooding from rainfall-runoff events, or other sources. The contributors and sponsors of this product do not assume liability for any injury, death, property damage, or other effects of flooding.

All underlying data for the inundation layers are from the OCOF tool and the erosion layers are from the Pacific Institute. Although care was taken to capture relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures may not be fully represented. The OCOF tool is based on the United States Geological Survey (USGS) hydrodynamic model called CoSMoS (Coastal Storm Modeling System). The model incorporates wave projections, tides, and regional atmospheric forcing to generate sea and surge levels. CoSMoS uses Digital Elevation Models based on aerial Lidar flights carried out in summer 2010. Consequently, any post-2010 changes to the topography are not captured by the DEM. The model does not assume any changes in geomorphology or shoreline over time or assumes they do not erode over the time scale being simulated. As shoreline protection devices might degrade or erode over decades, the model holding them as constants results in an underestimation of vulnerability. In addition, the elevation data have a vertical accuracy of approximately 18 cm, so the model may over- or underestimate the height of sea walls or shoreline protection structures by 18 cm.

The Pacific Institute erosion scenarios look at the shoreline geology and assume how far it would erode over time, but they do not take any existing shoreline protection or seawalls into consideration. This means the erosion modeling may overestimate vulnerability since if shoreline protective devices are maintained in place, erosion rates will be significantly reduced.

2.11.2 Data Availability

This Assessment used readily available data to identify vulnerable areas, communities, and assets. This information was augmented by surveys, interviews, and site visits. Because of limitations in funding and time and the availability of data, not all relevant datasets could be integrated into the study.

2.11.3 Uncertainty

It is important to note that all data and modeling include uncertainty. The inundation and erosion extent and inundation depths are not intended to be used for design or construction purposes. Portions of sea level rise modeling in the County may not accurately reflect the shoreline elevation and could over- or underestimate the risk from sea level rise.

2.11.4 Scope

Funding and time limited the amount of assets that received an AVP, which provides a detailed analysis of an asset's vulnerability. As such, only a small subset of the County's thousands of built and natural assets were evaluated. Results from the AVPs are anticipated to be representative, but individual vulnerabilities and consequences may vary for the additional built and natural assets and for County communities.

Mariners Point. Photo Credit: San Mateo County Flickr.

CHAPTER 3A SETTING AND CONTEXT

CHAPTER 3A SETTING AND CONTEXT

3A.1 Introduction

In the coming decades, sea level rise has the potential to significantly alter everyday life in the Bay Area and in the County. Sea level rise affects natural assets, such as wetlands and streams, as well as critical pieces of built infrastructure, such as wastewater treatment facilities or roads and highways (discussed in depth in Chapter 3B, Vulnerability Data Analysis and Discussion). In developing approaches to adapting to sea level rise in the County, consideration of the interconnection between natural and built systems is essential. This chapter illustrates the extent to which these systems are interrelated and presents some of the key pieces of environmental and policy considerations that accompany sea level rise planning. Sea level rise is not only, or even primarily, a challenge related to infrastructure; rather, it holds the potential to disrupt countless systems and aspects of daily life, from public health to employment. With this in mind, solutions must also be systemic in nature, integrating both locally driven knowledge and a broader scientific and policy-driven approach to adaptation planning.

This chapter discusses the County's environmental context for the entire County and current and future patterns of Coast and Bayside inundation. It delves into how assets throughout the County may have cross-cutting and multiple sources of vulnerability that add additional complexity to planning for sea level rise impacts. The chapter presents a discussion of the vulnerabilities and challenges inherent in the present governance landscape, and it offers a description of how direct impacts from sea level rise such as inundated roadways can trigger a cascading series of systemwide impacts.

For key term definitions on Risk Class and vulnerability please see Table 2.3 (ASCE Risk Classes, Description, and Examples; Chapter 2) and the Glossary.

"Sea level rise is not only, or even primarily, a challenge related to infrastructure; rather, it holds the potential to disrupt countless systems and aspects of daily life, from public health to employment."

Mirimar Inn. Photo credit: Jack Sutton.

Pacific Beach Boulevard. Photo credit: Dave Rauenbuehler.

Erosion at Mirada Rd. Photo credit: Office of Sustainability.

3A.2 Environmental Context: San Mateo County's Vulnerable Shoreline

Bay Shore Key Attributes

- **53 miles** of Bay shoreline
- **11 miles** of levees and floodwalls
- **41 miles** of nonengineered berms and embankments
- **200 miles** of inner shoreline flood protection features[4]
- **7,100+ acres** of wetlands (i.e., Bair Island and the Ravenswood Pond Complex)

Coast Side Key Attributes

- **56 miles** of coastline
- **~60 acres** of wetlands (i.e., Pescadero Marsh)
- **300 miles** of rivers and streams
- **Diverse recreational assets** (parks and trails)

[4]Inner shoreline flood protection features refers to San Francisco Estuary Institute's (SFEI's) 2016 bay shore defenses categorization "not first line of shoreline defense," and are located landward of "first line of shoreline defense" features that are closer to the Bay.

Foster City. Photo credit: San Mateo County Flickr.

The County's shoreline consists of the eastern San Francisco Bay side (Bayshore) and the western side of the County along the Pacific Ocean (Coastside or coastline).

The Bayshore and Coastside are characterized by differing ranges of sea level rise impacts, and the specific characteristics of each impact pose different challenges to the County as it prepares for Countywide adaptation. Much of the County's 53 miles of Bay shoreline was once coastal floodplain and wetland, but over the course of the 20th century this land was diked and filled to support salt production and urban development. The Bayshore is low lying, and its densely developed lands are already subject to interior flooding caused by rain-driven events and high tides that cause Bay water to back up through outfalls into stormdrains, and then onto streets and other areas. The Coastside has both cliffs and beaches, is more sparsely populated, and is exposed to coastal surge and erosion.

The Bayshore's built environment is characterized by dense urban and suburban development, including houses, schools, highways, parks, wastewater treatments plants (WWTPs), airports, and other critical infrastructure that provides valuable services to the community. A portion of the Bayshore is protected by 11 miles of levees and floodwalls (mostly in Redwood City, Foster City, and the City of San Mateo), and the remainder of the shoreline has 41 miles of nonengineered berms, embankments, and other shoreline features,[5] with an additional 200 miles of inner shoreline flood protection features. The highest elevation along the Bayshore is in the unincorporated area of Skyline Ridge (roughly 2,000 feet above mean sea level), while the lowest areas (roughly 1 to 2 feet above mean sea level) are in Menlo Park, Redwood City, Foster City, and the City of San Mateo.

The Bayshore's natural environment has more than 7,100 acres of wetlands, mostly near Redwood City and Menlo Park. These wetlands support important ecological processes and provide habitat for a wide range of waterfowl and wildlife species, including threatened species. The wetlands provide an additional buffer between storm waves on San Francisco Bay and the urban waterfront along the County's shoreline and offer recreational opportunities for County residents. Preservation and restoration of these wetlands is a key objective in the region's restoration goals. The report Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) outlines the importance of restoring up to 100,000 acres of tidal wetlands in order to ensure a healthy Bay.

The County's coastline is roughly 60 miles long, with elevations ranging from sea level at Montara, Pacifica, and Half Moon Bay State Beaches, to 100-foot bluffs at Mori Point in Pacifica. The built environment along the coast is much less dense than along the Bayshore and is mostly housing and some commercial buildings. Major infrastructure on the coast includes State Route 1 and the Sewer Authority Mid-Coastside Wastewater Treatment Plant. Sea walls, riprap, and other hardened shoreline features protect some coastal communities from erosion and flooding, while other built assets remain subject to waves and tidal action.

The environment along the coast side is characterized by bluffs, beaches, and a range of natural communities including rocky intertidal areas, surfgrass, kelp forests, and roughly 64 acres of wetlands. The County's coast offers an abundance of regional recreational opportunities owing to the scenic vistas along State Route 1, public access to many unique parks and beaches, including the James V. Fitzgerald Marine Reserve and Pacifica State Beach, and the unifying asset that connects this region to the rest of the state, the California Coastal Trail. The project area contains over 300 miles of rivers and streams, nearly 300 parks, and about 480 miles of trails.

Groundwater in the County is a valuable resource and is present in alluvial groundwater basins. These basins include the more populated Westside and San Mateo Plain Basins on the Bayside of the County, and San Pedro Valley (Pacifica), Half Moon Bay Terrace, San Gregorio Valley, and Pescadero Valley on the less populated Coastside (see Figure 3B. 4 San Mateo County Groundwater Basins in Project Area.).

Other climate change impacts beyond sea level rise will also continue to influence the County's environmental context. Climatic warming, reductions in sediment availability, changes in freshwater flows, increased numbers of nonnative species, and increasing urbanization will all put additional stressors on the area's existing natural assets and will continue to bring change to the region without explicit intervention. These additional forces can increase the already fragmented quality of

[5]This includes SFEI's designation of berms, elevated transportation structure, and water control structures. See the asset inventory for a complete count.

Mirada Road. Photo credit: Maureen Grimm.

habitats or eliminate it altogether, or they may reduce environmental quality overall (Conservancy 2015).

Sea level rise poses different challenges to communities on the Bayshore and the Coastside; these risks are driven by the type of inundation or erosion to which each is exposed, as well as the range of potential impacts to natural and built assets.

3A.2.1 Coastal Inundation: Present Day and Projected Future

The County is presently subject to two major impacts from sea level rise: coastal flooding and coastal erosion. In addition, portions of the County already experience nuisance flooding due to insufficient interior drainage when high tides combine with rainstorms. The geographic extent of these hazards is discussed in this section, and the subsequent sections detail the implications of these hazards.

Areas surrounding creeks or channels on the Bayshore and the Coastside often experience interior flooding (ponding, pools, or street flooding) when high creek or channel flows from rainstorms combine with high tide levels in San Francisco Bay (the Bay) or Pacific Ocean. High water levels on the Bay or in the ocean prevent creeks and heavy rain that falls on the interior from discharging, which causes the creeks to overflow their channels or rainwater to back up in culverts. Some areas that experience regular flooding include but are not limited to (near Butano Creek), unincorporated portions of the County (near Denniston Creek), and the Bayshore communities that adjoin the Bayfront and Highline Canals, the Atherton Channel, and Belmont, San Mateo, Colma, and San Bruno Creeks. Sea level rise will increase water levels in the Bay and ocean, thereby also increasing how frequently high creek levels and high Bay level events coincide. In addition, as sea level rises, more of the County's low-lying areas will become below sea level, making interior drainage challenging in more locations because rain, creek, and coastal waters will not naturally drain to the bay. *Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore* (San Mateo County et al. 2016) provides more of an explanation on this issue. This situation will increase the County's dependency on stormwater systems to pump out floodwaters to reduce the extent and depth of any interior flooding.

Much of the Bayshore and the lower-lying areas along the Coastside are also vulnerable to present-day coastal flooding from extreme floods and the associated storm surge.[6] Sea level rise will increase both the frequency and extent of major floods because the base water level will be higher.

Though the Bayshore is mostly protected from erosion, the entire Coastside of the County is exposed to daily wave action and erosion. Some coastal cities have armored their shoreline with sea walls, riprap, or other constructed infrastructure to minimize the landward extent of erosion in these locations. Critical erosion hotspots within the project area and within the San Francisco Littoral Cell include the following (Environmental Science Associates et al. 2016):

- Middle Ocean Beach
- South Ocean Beach
- Middle Daly City (Thornton State Beach to the Landfill)
- Lower Daly City (contains the Landfill)
- Manor District (near the Daly City–Pacifica border)
- Beach Boulevard (from Paloma Drive to Clarendon Road)
- Sharp Park (Clarendon Road to Mori Point)
- Rockaway Cove
- Linda Mar (Rockaway headland to Point San Pedro)

[5]Increased water level due to changes in atmospheric pressure and the action of wind stress on the water surface.

Beach erosion concern areas within the project area and within the Santa Cruz Littoral Cell include the following (USACE 2015):

- Princeton-by-the-Sea – Pillar Point Harbor
- El Granada County Beach (Surfer's Beach)
- Half Moon Bay/Unincorporated County – Mirada Road
- Año Nuevo State Reserve

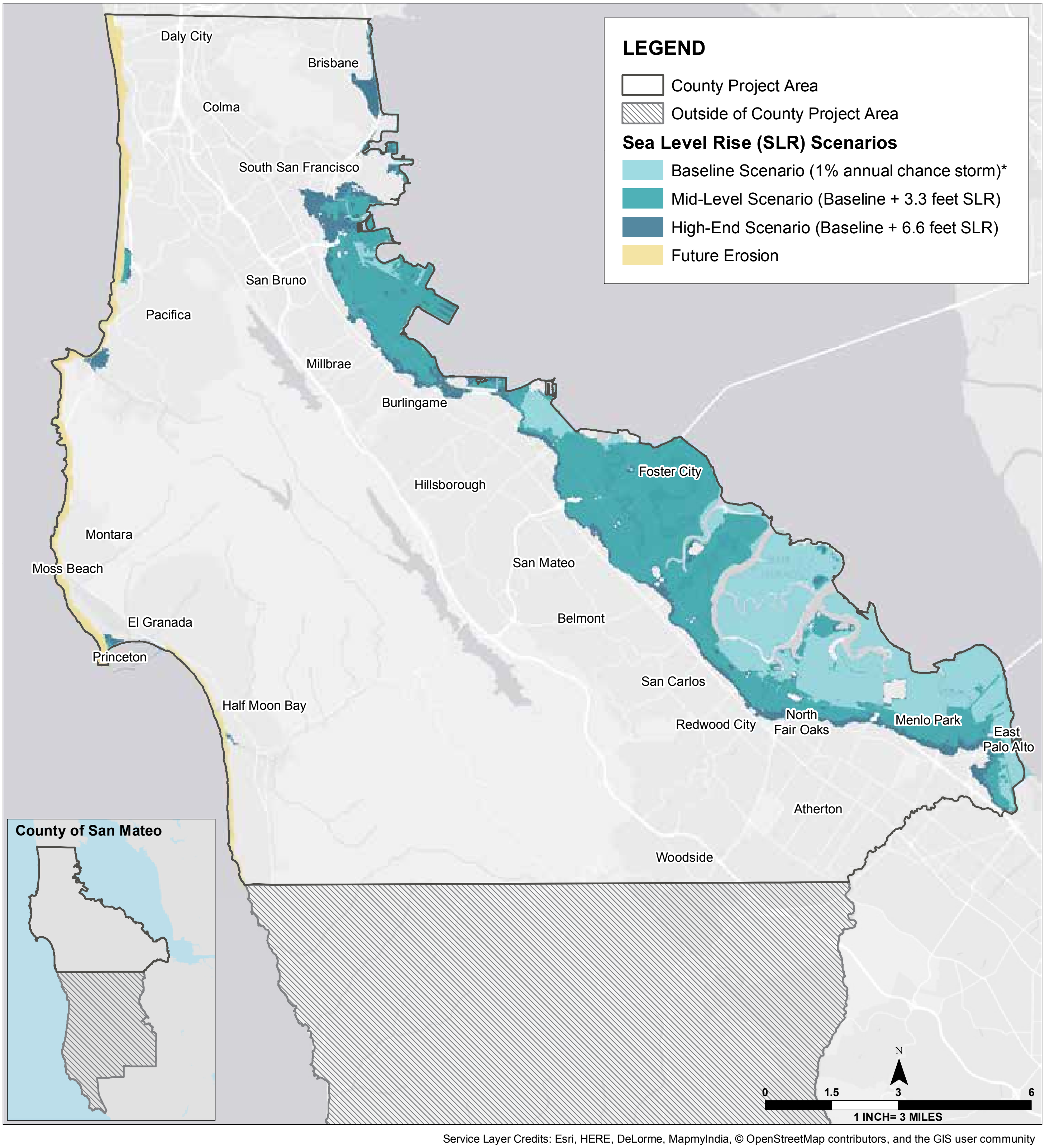
Sea level rise is expected to increase the severity and the eastern extent of erosion over time. Erosion presents a different type of hazard than flooding. For example, unlike flooding, erosion in the County is not experienced incrementally in the way that floodwaters can slowly rise onto a landscape, nor does erosion "recede" like floodwaters do after an event. In the case of erosion, some sections of coastline may be unaffected by waves for a long period of time, and then a single event or storm could dramatically erode a large portion of the coastline or beach.

For example, a study conducted by County of San Mateo Parks Department on the Pillar Point Trail, found that erosion has occurred in short periods of "catastrophic bluff collapse" during 1982–1983, 1998, 2010, and 2016, which were followed by long periods with very little erosion (County of San Mateo Parks Department 2016).
In Pacifica, the Esplanade area provides another example of episodic erosion. In the 1970s, the area in front of the Esplanade Apartments was approximately the size of a football field, with a sloping bluff (Fimrite 2016). In the 1982–1983, the homes first were threatened. In 2003–2004, 20 feet of bluff collapsed, and the rest of the bluff dropped off in 2009–2010, and in 2016 and 2017, the City of Pacifica had to remove several apartment buildings due to further bluff retreat. This aspect of erosion contributes to the uncertainty in projecting the frequency, timing, extent, and location of future erosion, necessitating further site-specific study prior to designing adaptation measures or permitting development in these areas.

Figure 3A.1 shows the landward extent of future inundation and erosion based on the sea level rise scenarios discussed in Chapter 2 that used existing best available data from USGS; Our Coast, Our Future; and Pacific Institute and Philip Williams and Associates, Ltd. Specifically, the map shows the projected extent of inundation under the baseline scenario (1% annual chance flood, shown in light green), the mid-level scenario (1% annual chance flood plus 3.3 feet, shown in teal), and the high-end scenario (1% annual chance flood plus 6.6 feet of sea level rise, shown in dark blue). All parcels of land shown to be affected within a given scenario may not necessarily be inundated. That is, inundation in the event of a storm may take place in a variable manner and not affect each parcel of land equally in the scenarios shown in Figure 3A.1. In addition, the map shows the eastern extent of erosion (light yellow) on the Coastside. The erosion extent shows the projected future amount of erosion with 4.6 feet of sea level rise. The modeling, developed by Philip Williams and Associates, Ltd. (2009) for the Pacific Institute, does not include existing shoreline defenses, such as seawalls. Flooding is the major risk on the Bayshore, and erosion is the predominant (but not only) hazard on the Coastside. Saltwater intrusion could be a concern on both the Bayshore and the Coastside, but it was not evaluated in detail in this Assessment.

Pacifica. Photo credit: Office of Sustainability.

Figure 3A.1 Sea Level Rise and Erosion Scenarios in Project Area



Data source: Our Coast, Our Future 2016; Point Blue Conservation Science 2016; USGS; Gulf of the Farallones National Marine Sanctuary; Coravai LCC; U.S. States Geological Survey; San Mateo County 2015.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

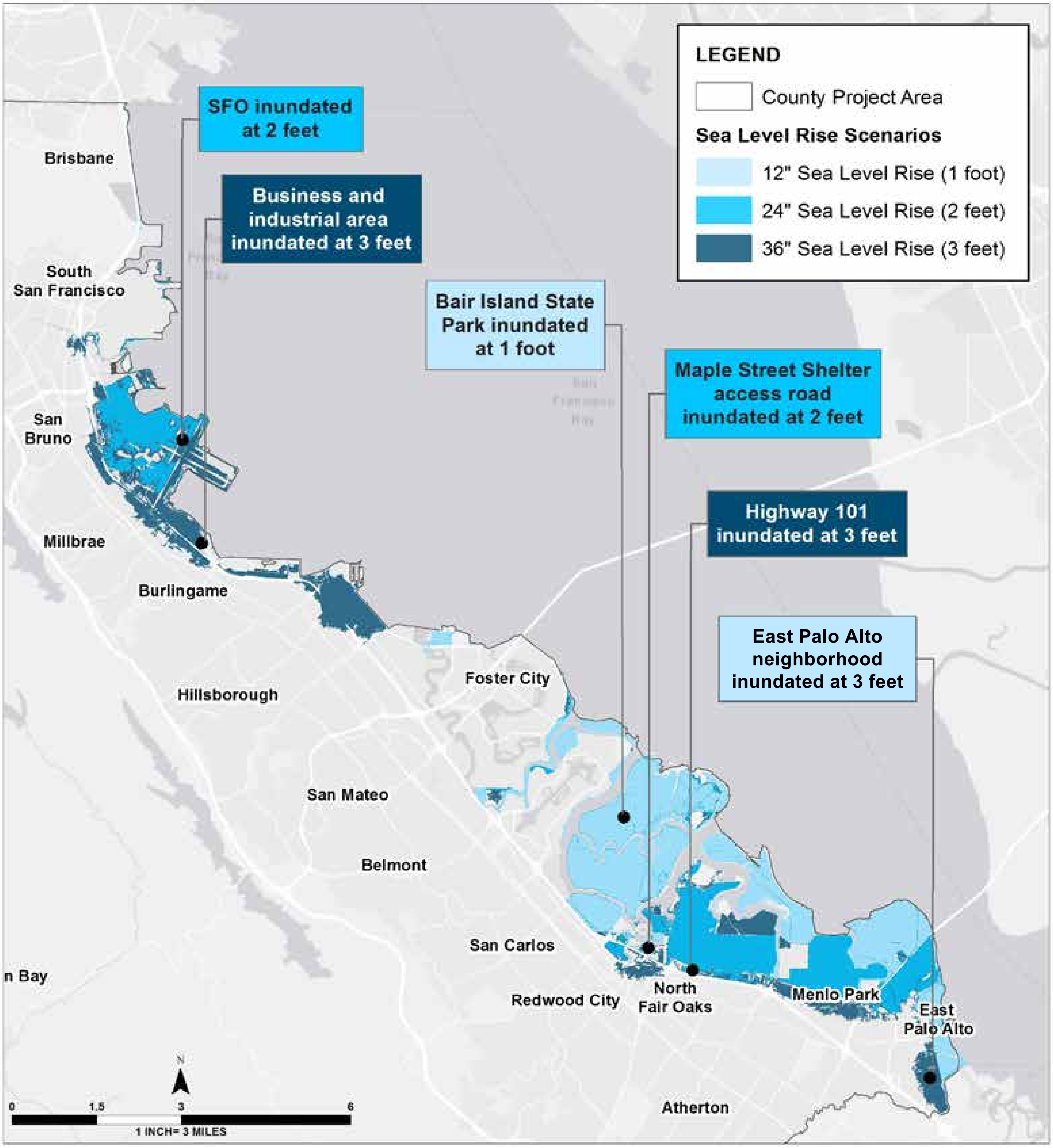
*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

The following text includes an overview of sea level rise inundation without a storm. In contrast to the scenarios used to develop the analysis in this report, the following map shows what daily tides could look like with 1, 2, and 3 feet of sea level rise. Figure 3A.2 provides a snapshot of some of the assets that would likely be affected by a 1- to 3-foot water level increase, and demonstrates impacts from near-term sea level rise. Natural assets, such as the Bair Island State Park in Redwood City may encounter flooding at 1 foot of sea level rise. Parts of East Palo Alto also may experience flooding with 1 foot of sea level rise. With 2 feet of sea level rise, SFO becomes inundated. Finally, 3 feet of sea level rise leads to broader impacts to transportation infrastructure, with both SFO and parts of Highway 101 being flooded in this scenario. A 1- to 3-foot water level increase could also occur due to storm surge or different combinations of sea level rise and storm surge as shown in the Table 3A.1. AECOM developed these equivalent water levels as part of the *Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore* report (San Mateo County et al. 2016).

Bair Island. Photo credit: Kingmond Young.

Figure 3A.2 Areas Inundated with 1 Foot to 3 Feet of Sea Level Rise



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: AECOM 2016. Overtopping and Inundation Maps developed using BCDC's Adapting to Rising Tides Methodology. For additional maps and more information, refer to the Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore report.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

Table 3A. 1 Total water level equivalents for 1, 2, and 3 feet of sea level rise.

SEA LEVEL RISE (SLR) AMOUNT	1 FOOT OF SLR	2 FEET OF SLR	3 FEET OF SLR
Equivalent storm surge	1-year storm surge (100% annual chance storm)	10-year storm surge (10% annual chance storm)	50-year storm surge (2% annual chance storm)
Equivalent SLR + storm surge		½ foot SLR + 2-year storm surge (50% annual chance storm)	½ foot + 25-year storm surge (4% annual chance storm)
		1 foot SLR + 1-year storm surge (100% annual chance storm)	1 foot SLR + 10-year storm surge (10% annual chance storm)
			1 ½ foot SLR + 2-year storm surge (50% annual chance storm)
			2 foot SLR + 1-year storm surge (100% annual chance storm)

3A.3 Cross-Cutting Vulnerability and Cascading Impacts

While some assets in the County have relatively more direct vulnerabilities and localized impacts than others if exposed to flooding or erosion, other assets have multiple or indirect vulnerabilities (cross-cutting). For these latter assets, flooding or erosion could set off a chain of events (cascading impacts) that would likely affect a large number of people or services. This issue has implications for both the impacts and for the complexity of adaptation (or hazard mitigation) and associated governance.

Built assets such as hospitals and airports (Risk Class 4) are likely to have vulnerabilities that stem from multiple exposed locations or complex governance systems (e.g., Pillar Point Harbor), and inundation will trigger a series of cascading impacts. Although the direct result of natural asset loss is not typically an immediate societal disruption, the loss of species, habitat types, and ecosystem processes over the long term is equally complex, affected by multiple issues (anthropogenic and natural), and could also trigger cascading impacts. Adaptation for natural assets also depends on complex management actions and a wide range of stakeholders.

Details on the cross-cutting vulnerabilities or cascading impacts associated with each asset type can be found in the AVPs. This section briefly highlights some of the major issues.

3A.3.1 Multiple Sources of Vulnerability

Many of the assets located in the County have multiple and indirect sources of vulnerability and may also have more than one point of exposure to sea level rise. Quantifying cross-cutting vulnerability and identifying how a fragmented governance landscape may amplify that vulnerability (see below) are both critical in developing a more complete picture of how impacts may cascade through infrastructural, environmental, and social systems (see 3A.3.3 Cascading Impacts).

Assets like Highway 101 are exposed in several locations, which will affect safety, travel, and businesses in multiple jurisdictions. Highway 101 from Whipple Avenue to Pulgas Creek is highly vulnerable to sea level rise because it runs along the edge of the San Francisco Bay, is exposed to creek backup, and is highly sensitive to flooding. Inundation and/or impairment would cause congestion, drastically reduced levels of service for those driving vehicles and public transit, and economic impacts that would be interregional in scale.

The intersection with State Route 84 is another highly vulnerable stretch of Highway 101 partly because it is already exposed to flooding from the Bayfront Canal and the Atherton Channel. The interchange currently operates at or above capacity during peak hours, and closure due to flooding would have far-reaching impacts to thousands of travelers from the North, South, and East Bay. Highway 101 would also cause additional cross-cutting vulnerability beyond the roadway, which would include flooding of nearby urban development and electrical infrastructure from highway spillover, water-quality impacts from oil and gas leaked onto the freeway, and an increase in accidents as flood waters start to affect the Highway.

Public transportation infrastructure, which includes miles of tracks, roads, bus routes, and any number of transit stations, is already or will be exposed in many locations. Impacts to this system will affect a substantial number of people, especially those without vehicle access, making the effect of service reduction far reaching. Transit service impairment would also have many direct and indirect economic effects. Mitigating these effects and adapting this system demands concerted and coordinated efforts across agencies because ownership and rights of way for each component of the public transportation infrastructure (rail, roads, stations, and maintenance facilities) vary.

Other assets with cross-cutting vulnerability are wastewater and stormwater systems. The integrity of these systems depends on each structural component, including the treatment plants, power feeds, and pump stations. This dependency means the vulnerabilities in these systems are located both on and off site. If any single pump station was exposed, it could affect the entire conveyance and collection system. A subsequent loss of service at a treatment plant likely affects all of its customers and poses additional environmental hazards in the case of untreated sewage spills, which could have an impact on surrounding natural assets and recreational assets. If severe enough, the loss of service could result in business interruption. The most vulnerable component of any wastewater facility is its power feed, meaning that mitigating or adapting a power feed to be floodproofed could ensure continuity of wastewater service, a relatively small action with a broad-reaching benefit. This scenario describes a cascading impact, which is discussed in greater detail below, and serves to demonstrate how these two concepts of cross-cutting or multiple sources of vulnerability are interlinked with the phenomenon of cascading impacts.

> "Many of the assets located in the County have multiple and indirect sources of vulnerability and may also have more than one point of exposure to sea level rise."

In sum, adapting these singular components or only one exposed location can still leave the asset (and its user base) vulnerable to impacts in the other vulnerable sections. Such infrastructure demands a holistic look at sources of vulnerability, concerted efforts, funding, and coordination among stakeholders and jurisdictions.

3A.3.2 Governance and Vulnerability

Many assets directly affect and involve a large number of entities, stakeholders, and processes or actions. As it relates to built infrastructure, one entity may rely heavily on a given shoreline asset that is completely controlled by a separate organization. For example, the Bayshore Expressway, Bayside STEM Academy, Millbrae Intermodal Station, and Silicon Valley Clean Water WWTP are all protected by a shoreline or levees that are managed by other government entities; therefore, these organizations have very little ability to independently reduce exposure. In some cases, an asset owner may take individual action to reduce vulnerability, such as floodproofing facilities or elevating critical components. Regardless, reducing exposure will require coordination between shoreline owners and managers and the assets, people, and property that our shoreline assets protect.

The entities listed below may be involved in planning for sea level rise adaptation measures and/or overseeing the implementation of adaptation measures in the future. Addressing sea level rise vulnerability in the County may involve more than 15 different governing agencies, depending on the location and extent of the project. The following analysis indicates the complex nature of the governance landscape as it intersects with sea level rise and what sort of additional vulnerabilities might be entailed.

- Bay Conservation and Development Commission (BCDC) is a California state planning and regulatory agency with regional authority over the San Francisco Bay, the Suisun Marsh, and the Bay's shoreline band, which extends to the mean high tide line in areas that do not contain tidal marsh and up to 5 feet above mean sea level in areas of tidal marsh.
- San Francisco Regional Water Quality Control Board protects surface and groundwater quality by setting standards, issuing permits (waste discharge requirements), determining compliance with requirements, and taking enforcement actions.
- California State Lands Commission protects the lands and resources through balanced management, marine protection, pollution prevention, and adaptation to climate change and ensures public access to these lands and waters for current and future generations.
- California Department of Fish and Wildlife manages and protects the state's fish, wildlife, plant, and native habitats. It is responsible for recreational, commercial, and educational uses of these resources.
- California State Parks Department manages state park lands on the County's coast, including a number of state beaches. It provides recreational opportunities for residents and protects biological and cultural resources.
- California Coastal Commission protects the California coast by regulating coastal development, utilizing sound science, generating public engagement, and coordinating between other State agencies.
- Environmental Protection Agency (EPA) is a federal agency tasked

with enforcing laws that protect human health and the environment. Regulations administered by the EPA govern natural resources (such as streams and wetlands), energy, transportation, agriculture, and industry.

- **California Environmental Protection Agency (CalEPA)** is a state agency that provides additional oversight and guidance in similar policy arenas as the federal EPA. CalEPA implements and enforces regulations relating to air, water, and soil quality; pesticide use; and waste recycling and reduction.
- **US Fish and Wildlife Service** manages and protects fish, wildlife, plants, and their habitats.
- **National Marine Fisheries Service** is responsible for stewarding national marine resources.
- **US Army Corps of Engineers (USACE)** is a public engineering, design, and construction management agency.
- **California State Coastal Conservancy** protects and improves natural lands and waterways, encourages public access to natural resources, and supports local economies along the California Coast and San Francisco Bay.
- **National Oceanic and Atmospheric Administration** oversees weather forecasting, storm warnings, climate monitoring, coastal restoration data collection, and policy implementation assistance. Its Office for Coastal Management facilitates state and federal partnerships to implement coastal management policy. In the Bay Area there are three Coastal Management Agencies, the San Francisco Bay Conservation and Development Commission (BCDC), the Coastal Commission, and the State Coastal Conservancy.
- **The City/County Association of Governments** coordinates city and County resource management, planning, and policy development.
- **The County of San Mateo** governs unincorporated portions of the County only and coordinates Countywide policy initiatives.
- **City government** exists for all cities (20) within the County. Each city has independent land use jurisdiction and maintains largely independent planning processes.

The long-term sustainability of most natural assets in the County depends on how well governance efforts are coordinated among these diverse entities. For example, beach loss at Surfer's Beach in Half Moon Bay is affected not only by the management of sediment in the littoral cell, but specifically by the jetty managed by the USACE just north of the beach. Pillar Point Harbor is similarly challenging due to the complexity of governance jurisdictions that intersect there, which include the Army Corps (breakwater), the National Oceanic and Atmospheric Administration (NOAA) Greater Farallones National Marine Sanctuary (coastal waters), the CA Coastal Commission (land use authority), the Harbor District (harbor), the State Lands Commission (authority over areas below the mean high tide line), and the City of Half Moon Bay and unincorporated San Mateo County (land use jurisdiction).

Because natural resource management and developmental activities are managed across a patchwork of multiple agencies, developing effective responses to sea level rise is especially challenging. Sea level rise governance involves confronting an environmental change that is rapid compared with historic rates of change, preparing for impacts that are historically unprecedented, and doing all of this work with little experience in testing the efficacy of specific adaptation actions. To date, the Bay Area's and the County of San Mateo's governing agencies have not had to perform such tasks, much less do them together. This fragmented governance landscape underscores the need for comprehensive regional planning within the County and beyond (BCDC 2011).

In sum, sea level rise governance involves a labyrinthine network of agencies, organizations, and ecosystems. Managing for the impacts of sea level rise is challenging primarily because:

1. Multiple governing agencies, nonprofit organizations, and research institutions form a complex picture, and may have competing priorities.
2. Individual asset owners may not have decision-making power over the infrastructure that they rely upon.
3. Many assets and stakeholders may have shared jurisdictions involved.
4. Challenges posed by sea level rise sometimes do not fit neatly into agency/organizational mandates.
5. Agencies and institutions balance competing demands on limited staff resources and time, and levels of understanding of sea level rise may differ among agency staff.

This context calls for strong relationships between governing agencies, robust communications networks, coordinated systems for stakeholder engagement, and consistent monitoring and evaluation processes. The challenges inherent in addressing sea level rise through public policy require redundancy so that critical aspects do not fall through the cracks and flexibility so managers can go beyond their traditional/historical mandate to address emerging issues.

3A.3.3 Cascading Impacts

Cascading impacts, commonly referred to as the "domino effect," can be defined as a series of secondary impacts that are triggered by the primary loss of an asset, a specific function, or a service. Cascading impacts can occur when any part of a networked asset or its system or function is affected, or when assets or functions are physically or functionally connected in some way (Florida Division of Emergency

Management 2015). For example, flood waters may contaminate a fuel oil tank; cascading impacts would occur when this fuel tank sends contaminated water into a power generator, thereby rendering the generator useless and causing emergency power to fail. Owing to these potential secondary and tertiary impacts, the entire County is likely to be affected by flooding and sea level rise over time, irrespective of whether individuals or communities are on high ground.

Cascading impacts, which are most typically associated with networked infrastructure, cause the impact of a flood to reach beyond the geographic extent of the flood. It is improbable, for example, that a person living in Atherton will be directly affected by storm surge on the Bayshore or along the open coast. However, that person can still be indirectly affected by storm surge because they depend upon the Silicon Valley Clean Water WWTP for wastewater treatment and probably rely on low-lying electrical infrastructure that could be subject to flooding. In addition, this person may use low-lying roadways (such as Highway 101), which could be inundated, causing major delays or shutting down access altogether. Transportation delays and access limitations would affect the ability to get to work, school, parks, and the grocery store and to receive medical care. A person may also have to postpone business and leisure travel if San Francisco International Airport is shut down or experiences major delays from flooding.

Businesses often provide networked services as well, and potential temporary and permanent flooding associated with sea level rise is likely to create cascading impacts for companies and consumers (business interruption). This study did not conduct an inventory and analysis of businesses in the County; however, when businesses and their services are affected, the entire supply chain may experience impacts. Those affected include customers, employees, suppliers, and distributors, and subsequent effects are apparent in productivity, product delivery, and revenue. Disruption may occur until the affected assets are repaired, replaced, and operable again. As one example, the major floods in Bangkok, Thailand in 2011, caused Western Digital factories (a major hardware supplier) to close. In addition, a very large amount of hardware was permanently damaged or lost, leading to a global shortage of some hardware products and a 10% increase in the price of external hard drives (Fuller 2011).

Vulnerability of networked assets or infrastructure is particularly high in terms of both the exposure and the consequences. The Adapting to Rising Tides framework highlights that networked infrastructure is particularly susceptible to failures (i.e., failures are more likely) because disruption in one component can affect the entire system. The loss of an entire asset's system, in turn, will result in wide-reaching and cascading impacts.

Linda Mar State Beach. Photo credit: Office of Sustainability.

3A.3.3.1 Networked infrastructure and potential cascading impacts in San Mateo County

Networked physical infrastructure in the County includes transportation assets, which enable access to goods, services, and evacuation, such as mass transit like BART and Caltrain; major roads (e.g., State Route 1 and Highway 101) and local roads; trails (e.g., the California Coastal Trail and the San Francisco Bay Trail); bus and bicycle routes; and airports. Other networked infrastructure includes utilities, such as power, water, wastewater, and telecommunications, and shoreline infrastructure, including both natural and structural shorelines that protect people, infrastructure, and property from flooding should also be considered. Critical networked services in the County include medical, police, fire, and schools. Any analysis of cascading impacts must convey how these networked services rely on networked infrastructure (e.g., emergency services rely on telecommunications, medical services rely on electricity within each hospital).

A prime example of this networked infrastructure would be the provision of Pacific Gas & Electric (PG&E) services. Almost all assets and utilities in the County, including commercial and residential properties and essential facilities, depend on external power from PG&E. The loss of a power plant or substation because of flooding could create power outages affecting each of these asset types across a large area. If backup power or the power feed of these assets was also flooded, many of them, such as wastewater and


Redwood Creek in Redwood City. Photo credit: Office of Sustainability.

transportation facilities, would experience additional consequences in the form of delays or outages. These outages and delays would in turn have further impacts, such as sewage (wastewater) backup or spills of untreated effluent that could cause public health and environmental hazards.

Fuel is often a key concern after a disaster, and critical fuel shortages are common in this context because of the very high demand from existing infrastructure and assets, including residential and commercial facilities. These shortages can be exacerbated when fuel provider facilities themselves are compromised or transportation pathways blocked, damaged, or submerged. This situation could lead to more severe cascading impacts across infrastructure systems.

Flooding of critical transportation routes such as Highway 101 or State Route 1 can cause significant traffic delays in the County and north and south of the County. In addition to disrupting daily life, flooded routes also affect evacuation and can delay the response time of any emergency services in incidents related to life safety. In a severe flood, BART, Caltrain, and bus service might be affected, reducing the availability of viable transportation alternatives. Where key routes are blocked, Kaiser Medical Facility could experience food and medical supply shortages or have trouble with the ingress and egress of patients. Any of the County's WWTPs could be adversely affected if flooded roadways inhibited the delivery of wastewater treatment chemicals.

Flooding at the County's essential facilities, including Emergency Operations Centers or police stations, could cause a disruption of service and a delay in emergency services response time across the entire County. Flooding at the San Mateo County Transit Authority (SamTrans) North Base Facility during a disaster could prevent the use of the fleet of disaster response busses. A loss of service at Kaiser Medical Facility or Pacifica Nursing and Rehab Center would likely increase the load on other medical centers and could result in increased stress or casualty among existing patients.

More discussion on cascading impacts associated with specific asset types are provided in the AVPs along with details on the reliance of specific assets types on networked infrastructure.

3A.3.4 Cross-Cutting Vulnerability and Cascading Impacts Conclusion

The County's vulnerability to sea level rise is multidimensional, and its systems of policy-making and governance add vulnerability or may impede and complicate future adaptation planning processes. Many assets and systems of assets are already subject to diverse risks in the current, or baseline, scenario, and they may be vulnerable to the effects of sea level rise in multiple ways in the near future.

This chapter is only a first step in mapping out the systemic nature of vulnerability in the County. Local administrators at the city and County level should, in collaboration with one another, continue to explore the interconnectivity in the systems that their residents rely on and how these systems are at risk over the next 30 years and in the next century. A failure to adequately respond to this network of vulnerability, as difficult as it may be to fully comprehend, will have profound consequences for everyone in the County and especially those in communities with limited economic resources.

> "In addition to disrupting daily life, flooded routes also affect evacuation and can delay the response time of any emergency services in incidents related to life safety."

CHAPTER 3B VULNERABILITY DATA ANALYSIS AND DISCUSSION

CHAPTER 3B VULNERABILITY DATA ANALYSIS AND DISCUSSION

3B.1 Introduction

San Mateo County is one of the most vulnerable counties in California to sea level rise. Rising sea level on the Bay and Coast sides would affect a wide array of built and natural assets that every resident in the County relies on or utilizes on a daily basis. The impacts are potentially significant and far-reaching.

This chapter provides an in-depth analysis of Countywide natural and built asset vulnerability under three different scenarios: baseline (current conditions plus 1% annual chance flood), mid-level (3.3 feet of sea level rise plus 1% annual chance flood), and high-end (6.6 feet of sea level rise plus 1% annual chance flood). The findings are organized by asset category so that a decision maker or resident may consider each in turn. Yet, as the findings suggest, these assets and infrastructural systems are interconnected and must be considered within the larger context with respect to sea level rise impacts rather than in isolation. While it may at first be necessary to consider each asset individually to perform in-depth analysis, as we do here, these assets are in no way isolated from each other in the functions they fulfill in the County or in their potential vulnerability to sea level rise. Chapter 3A demonstrates the interconnectedness of natural and built systems, and readers are encouraged to keep this in mind.

This subchapter is intended to provide a deeper understanding of what is at risk at a Countywide level by describing asset-specific vulnerability, while also situating that smaller picture of vulnerability within a systemwide frame of reference. Chapter 3B offers government officials and constituents a detailed impression of the types of impacts we could see in our County if we do not take action, while also underscoring the regional nature of the challenge. These data lay the groundwork for a pragmatic, science-based, and collaborative path forward.

Following Chapter 3B, Chapter 3C presents an analysis of community health and sea level rise interactions. Chapter 3D then provides a detailed inventory of County- and city-specific impacts under three sea level rise scenarios.

3B.2 Vulnerability and Exposure in San Mateo County

Understanding vulnerability is the first step in knowing what the County's current and future risks are and a key step in understanding how to best reduce those risks. The following discussion summarizes the major findings from the exposure analysis (maps and inventories) as well as the Asset Vulnerability Profiles (AVPs). It identifies which built and natural assets are or will be exposed to flooding and erosion (Appendix B, Asset Exposure Maps) and provides high-level insight into the sensitivity and adaptive capacity of assets and communities in the County.

> "Chapter 3A demonstrates the interconnectedness of natural and built systems, and readers are encouraged to keep this in mind."

This section provides an overview of the vulnerability of all exposed assets and more detail on individual asset types. The vulnerability discussion is separated by built and natural assets. Within the built assets discussion, the findings are presented according to American Society of Civil Engineers (ASCE) Risk Class and the Bay Conservation and Development Commission (BCDC) asset categories. Within the natural assets section, the findings are organized by natural asset class or habitat type.

Each section includes some discussion on the degree of asset exposure, sensitivity, and adaptive capacity, as well as the potential consequences from the temporary or permanent loss of an asset. A more detailed discussion on vulnerabilities and consequences of the various asset types can be found in Appendix D, Asset Vulnerability Profiles.

3B.2.1 Existing Land Use Patterns

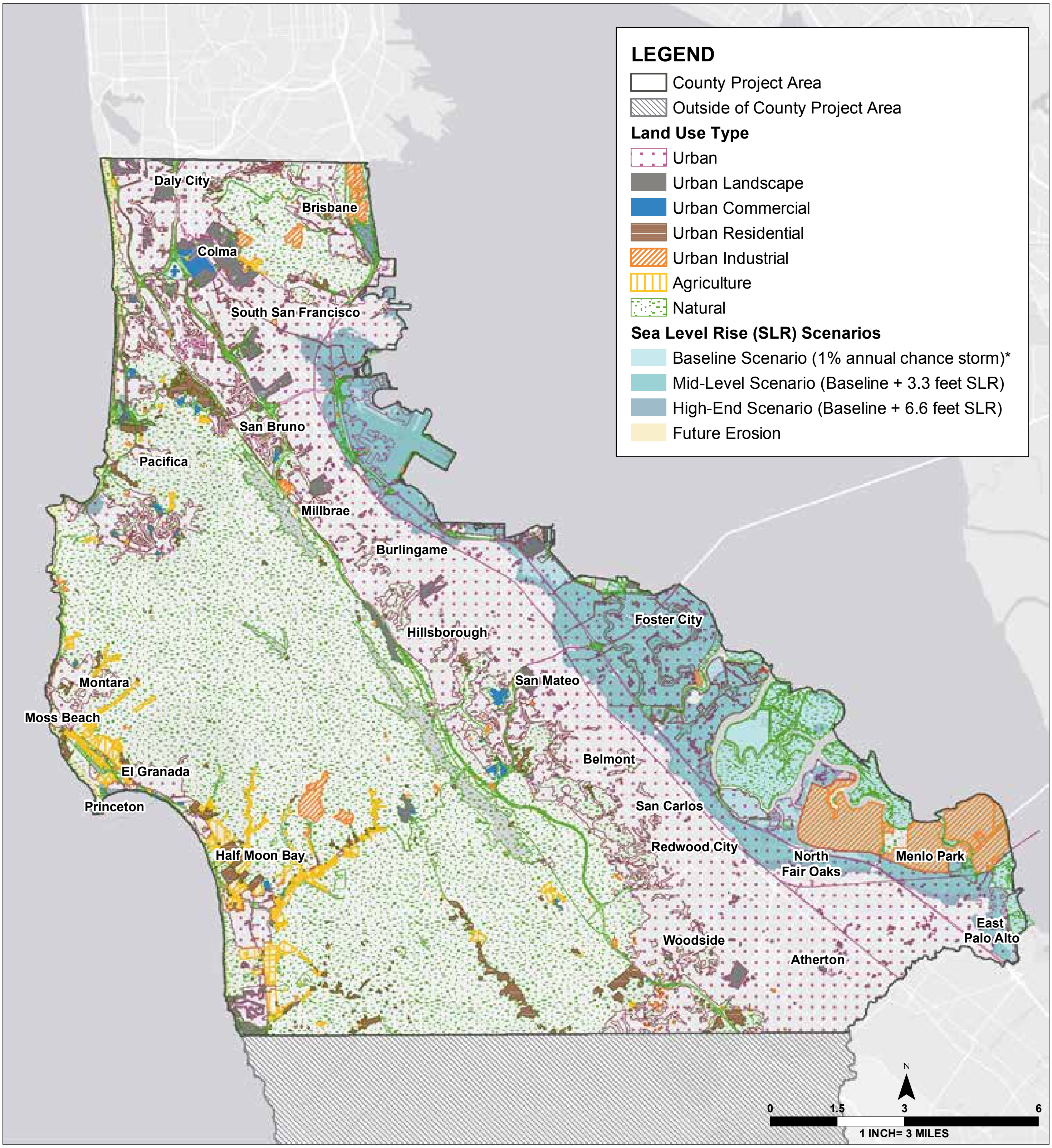
Table 3B. 2 Areas of land use types affected by sea level rise scenarios (in acres and relative to the project area).

SCENARIO	SCENARIO DESCRIPTION	INDUSTRIAL LAND (ACRES)	URBAN LAND (ACRES)	NATURAL LAND (ACRES)
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	2,900 (78%)	1,325 (2%)	4,803 (6%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	3,010 (81%)	12,627 (19%)	6,394 (8%)
HIGH-END	1% annual chance flood plus 6.6 feet	3,018 (81%)	15,181 (23%)	6,821 (9%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	3 (0%)	351 (1%)	1,317 (2%)

The County on the Bayside mostly consists of commercial and residential land uses, whereas the Coastside is dominated by agriculture, vacant land, and vegetation. All agricultural operations are located on the Coastside and on bluffs or hillsides above the projected areas of inundation. The spine of the County, formed by the Santa Cruz Mountains, creates a central region of natural vegetation from the north to the south. Figure 3B.1 shows these patterns of land uses within the project area.

Beach Blvd. Photo credit: Office of Sustainability.

Figure 3B.1 Land Use Type in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: California Department of Water Resources; Risk Characterization Study 2012.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

3B.2.2 Natural Asset Vulnerability Analysis

Many of the County's natural assets, including habitats, ecosystem services, and species, are already (or will be) exposed to sea level rise because they are aquatic systems or are located adjacent to the water (e.g., tidal marshes and sandy beaches). An inventory of the County's exposed natural assets is provided in Chapter 3D, City- and County-Specific Findings. This Assessment did not include an exhaustive inventory on the extent of all habitat in the project area. Based on existing data, the Assessment identified that vulnerable habitats include wetlands, beaches, rocky intertidal, and dunes. Coastal cliffs/bluff habitat could also be directly affected by flooding and erosion exacerbated by sea level rise. Figure 3B.2 shows the natural assets in the County (from the available data) that will be subject to sea level rise. Notably missing from the map, although vulnerable to coastal erosion and inundation, are rocky intertidal, dunes, and bluff habitats.

Natural assets are not categorized according to Risk Class because the gradual loss or impairment of these resources would not involve significant and immediate impacts to public health and safety. As this and other chapters demonstrate, losing or damaging natural assets over the long term could have significant and negative impacts to public safety. Protecting and enhancing these ecosystems is a critical component of maintaining and building resilience along the Coast and the Bay.

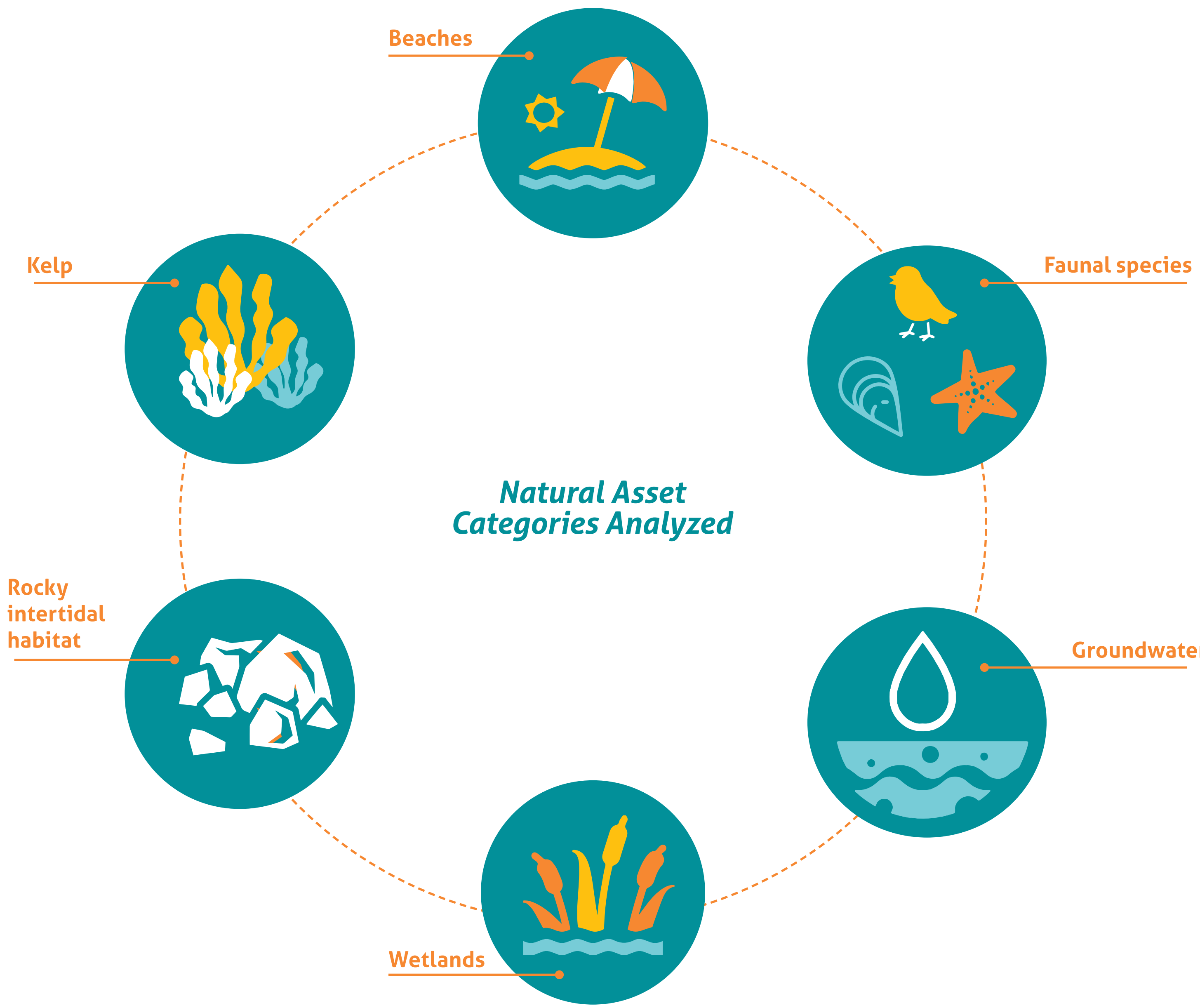
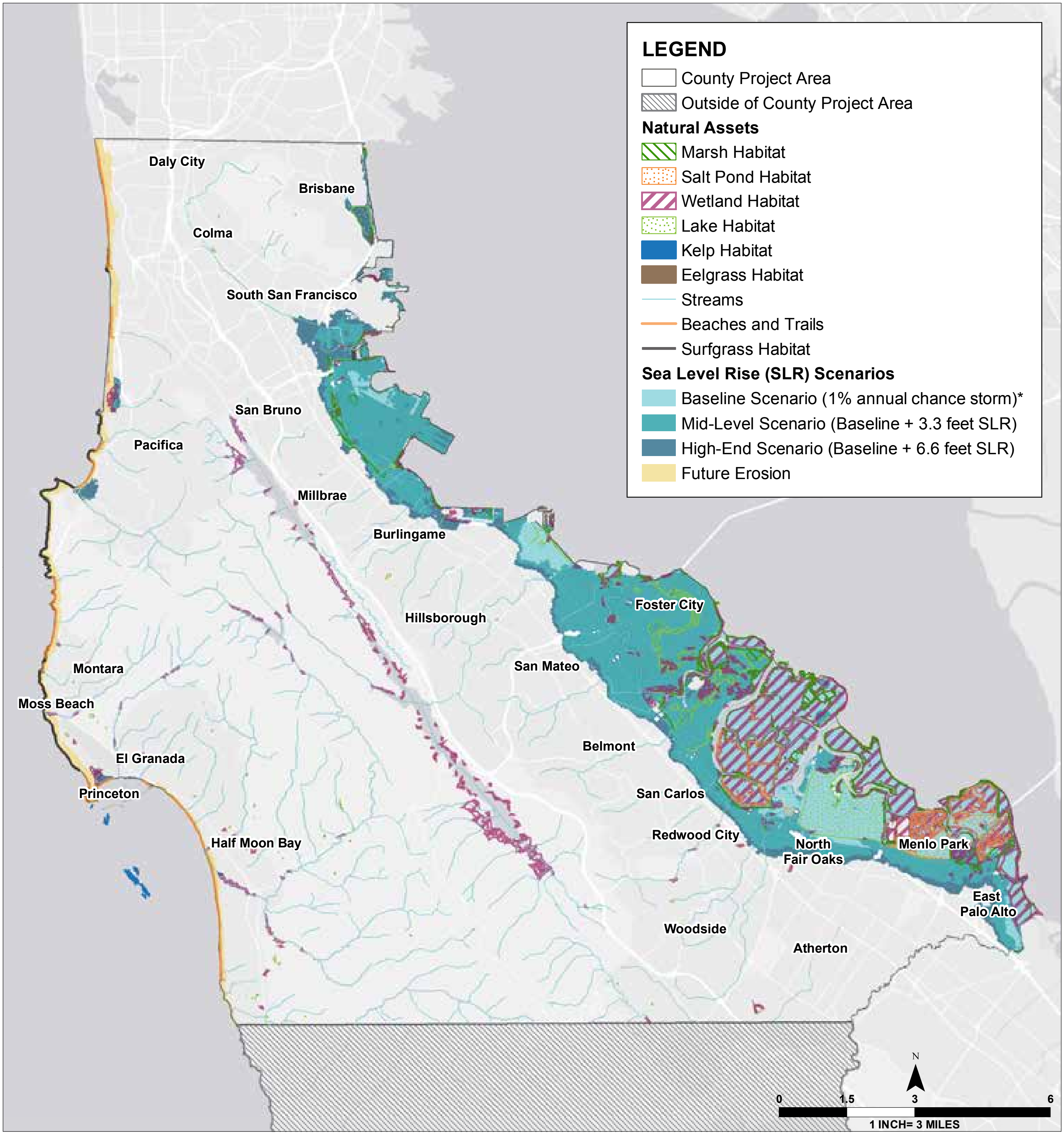


Figure 3B.2 Natural Assets Exposure in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: California Coastal Trail Association 2008; San Mateo County Parks Department 2015; California Department of Fish and Wildlife 2006; Marine Region GIS Unit 2005; County of San Mateo 2015; San Francisco Estuary Institute 2001; Marine Region GIS Unit 2009; Marine Region GIS Unit 2014.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

The sensitivity of natural assets and their long-term adaptive capacity to withstand sea level rise vary and will depend on a combination of both natural and anthropogenic factors. In some cases, the exposure or loss of a particular area or set of ecological processes may not necessarily be negative. For example, even if snowy plover habitat was lost near the Ravenswood Pond Complex (see Appendix D, Asset Vulnerability Profiles), the area provides valuable habitat for many other waterfowl. The following analysis explores the County's key natural assets, the extent to which these will be affected by sea level rise, and the capacity for each to adapt to changing conditions.

For detailed natural asset exposure maps that focus on specific coastal and Bayside zones, please see Appendix B.

3B.2.2.1 Key Findings: Natural Assets and Vulnerability

Table 3B. 3 Natural assets key findings.

NATURAL ASSET DESCRIPTION	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Vulnerable natural areas in the County include but are not limited to (mid-level scenario): • 7,090 acres of exposed wetlands • 13 miles of exposed beaches • 11 acres of vulnerable kelp forests	• Loss of habitat for endangered plant and animal species • Loss of biodiversity • Loss of natural flood protection • Loss of natural recreational areas	Some assets may be able to migrate landward, but this depends on sediment supply, available upland migration zones, and existing urban development.	Multiple management and permitting agencies, with potentially different goals and values, along with private owners, may present additional complexity in natural asset governance.

3B.2.2.2 Beaches

Approximately 13 linear miles of beaches in the County are exposed to sea level rise hazards. Some parts of the County's coastline are eroding faster than others. For example, Surfer's Beach has lost around 140 feet of beach since 1964 (see the corresponding AVP for Surfer's Beach, Appendix D). In addition to providing essential habitat for local fauna, beaches are an important recreational asset for all County residents. They also provide tourism-related economic benefits. Therefore, the loss of beach width would likely result in the loss of economic and tax revenue associated with beach visitation (King et al. 2011). Maintaining public and tourist access is an important part of the area's overall quality of life and reduction in the extent and quality of the County's beaches would not only affect local ecosystems but also have an impact on local recreation and economies as well.

The Climate Change Vulnerability Assessment for the North-Central California Coast (Hutto et al. 2015) identifies beaches as being overall moderately to highly vulnerable to climate change. Specifically, the report finds that exposure is very high, sensitivity is moderate to high, and adaptive capacity is moderate. If beach migration is limited, like at Pacifica State Beach where State Route 1 and urban development extend eastward, beaches and the species they support could be lost altogether (see the corresponding AVP for Pacifica State Beach, Appendix D). However, adaptation measures such as beach or dune nourishment and the protection of retreat areas would improve the adaptive capacity and slow the progression of beach loss (Hutto et al. 2015).

Protecting coastal assets from erosional impact of sea level rise may also lead to greater beach vulnerability. Coastal armoring, which may include temporary sandbags, seawalls, or offshore breakers, is often deployed to protect houses or other development. This strategy changes the pattern of sand movement along the shore and produces conditions that restrict the natural ability of the beach to move inland, thereby resulting in the eventual loss of the beach, especially as sea levels rise. When development, such as roadways, seawalls, or other structures, is removed, beaches are able to more naturally move inland and persist as sea levels rise. Figure 3B. 3 illustrates the dynamics of beach retreat with and without coastal armoring.

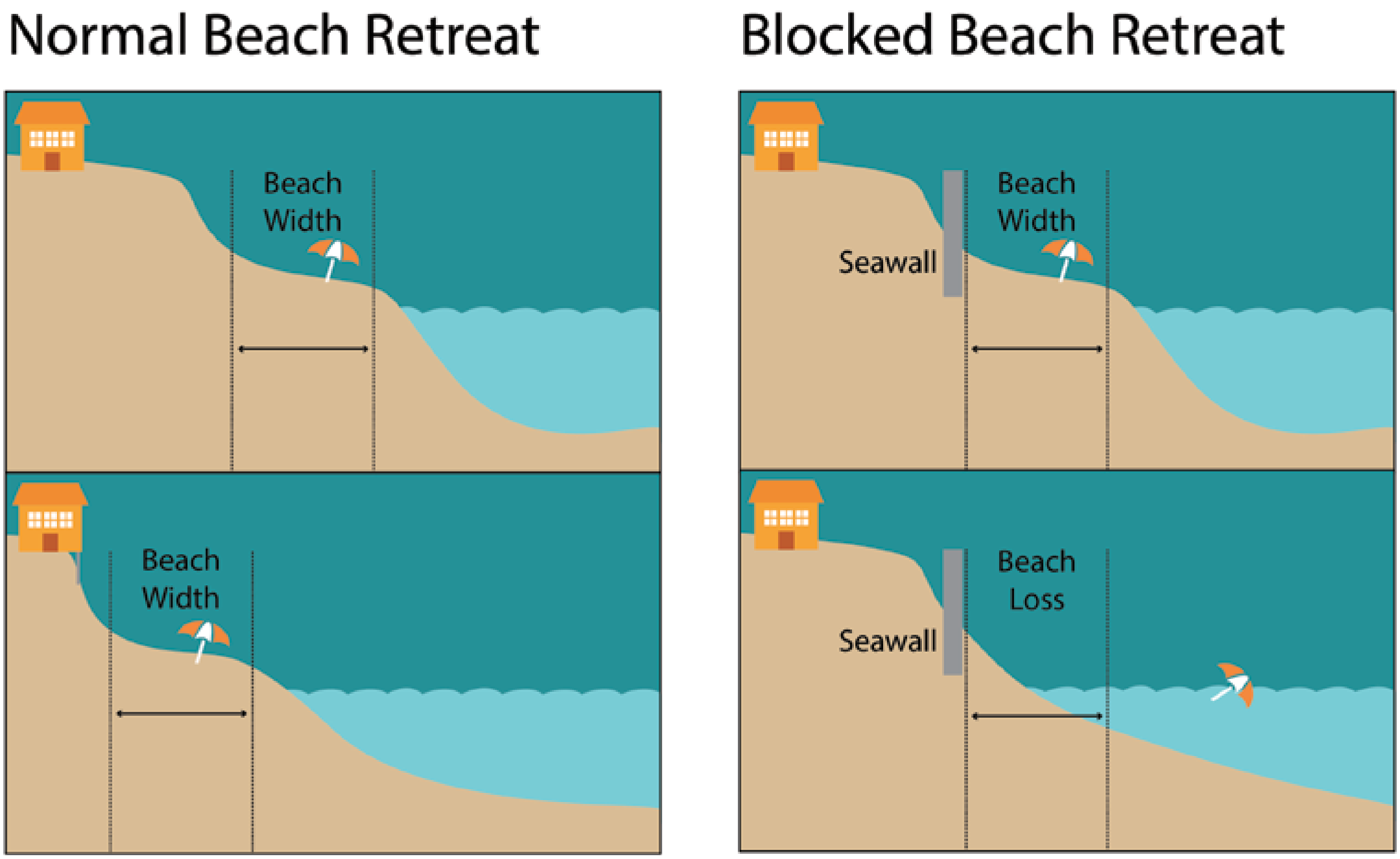


Figure 3B.3 Coastal Armoring and Beach Retreat

Seawalls can prevent a beach from naturally retreating, and lead to the loss of beaches due to "passive erosion" (California Coastal Commission, Senate Budget Subcommittee, 2014).

3B.2.2.3 Faunal Species

The County's natural environment supports a wide range of shorebirds, waterfowl, and other terrestrial and aquatic species, including ones listed as threatened or endangered. In particular, the threatened western snowy plover (referenced in both the Ravenswood Ponds and Pacifica State Beach AVPs, Appendix D) is vulnerable because it requires ground for nesting and its habitat is sensitive to temporary and permanent flooding. Dry ground is expected to decrease with sea level rise (assuming no management actions), and Western Snowy Plover habitat may therefore become limited. Adaptive capacity of the snowy plover (and other vulnerable species) will depend on the abundance of alternate habitat in the region. Detailed analyses and inventories were not performed on individual species; however, snowy plovers were identified as the most vulnerable species as a result of sea level rise in Hutto et al. (2015). When other climate stressors are considered, the vulnerable species ranking in Hutto et al. varies.

The following 12 species and groups of birds are of particular concern with respect to sea level rise alone (i.e., other climate factors are not considered). They are not listed in order of vulnerability. More information on these species is available in Hutto et al. (2015).[7]

- Ashy storm petrel
- Black oystercatcher
- Black rail
- California mussel
- Cassin's auklet
- Cavity nesting birds
- Mole crab
- Ochre sea star
- Red abalone
- Sea palm
- Surface nesting birds
- Western snowy plover

[5]This list is not exhaustive. Additional endangered species may also be negatively affected by sea level rise.

Impacts and consequences of damage to or loss of natural assets

The consequences of a loss of natural assets should be viewed in terms of the functions or services that the assets provide; for example, beaches and bluffs provide habitat, recreational opportunities, and access to trails, and possibly a small buffer between urban waterfronts and waves or storm surge. Similarly, wetlands provide habitat as well as water-quality benefits, recreation, and possibly a buffer between storm waves and urban waterfronts depending on the wetlands' location and size.

In the long term, a loss of natural assets would likely contribute to a regional loss of biodiversity. For particularly rare species or habitats, their loss in the County could threaten their sustainability as a whole. However, in other cases, the conversion of one habitat type to another may still enable valuable natural and beneficial functions. In addition to the loss of natural functions, the loss of coastal bluffs, beaches, wetlands, or rocky intertidal areas not only reduces recreation, but also the economic revenue normally generated by the visitors patronizing nearby businesses, hotels, and restaurants.

3B.2.2.4 Groundwater

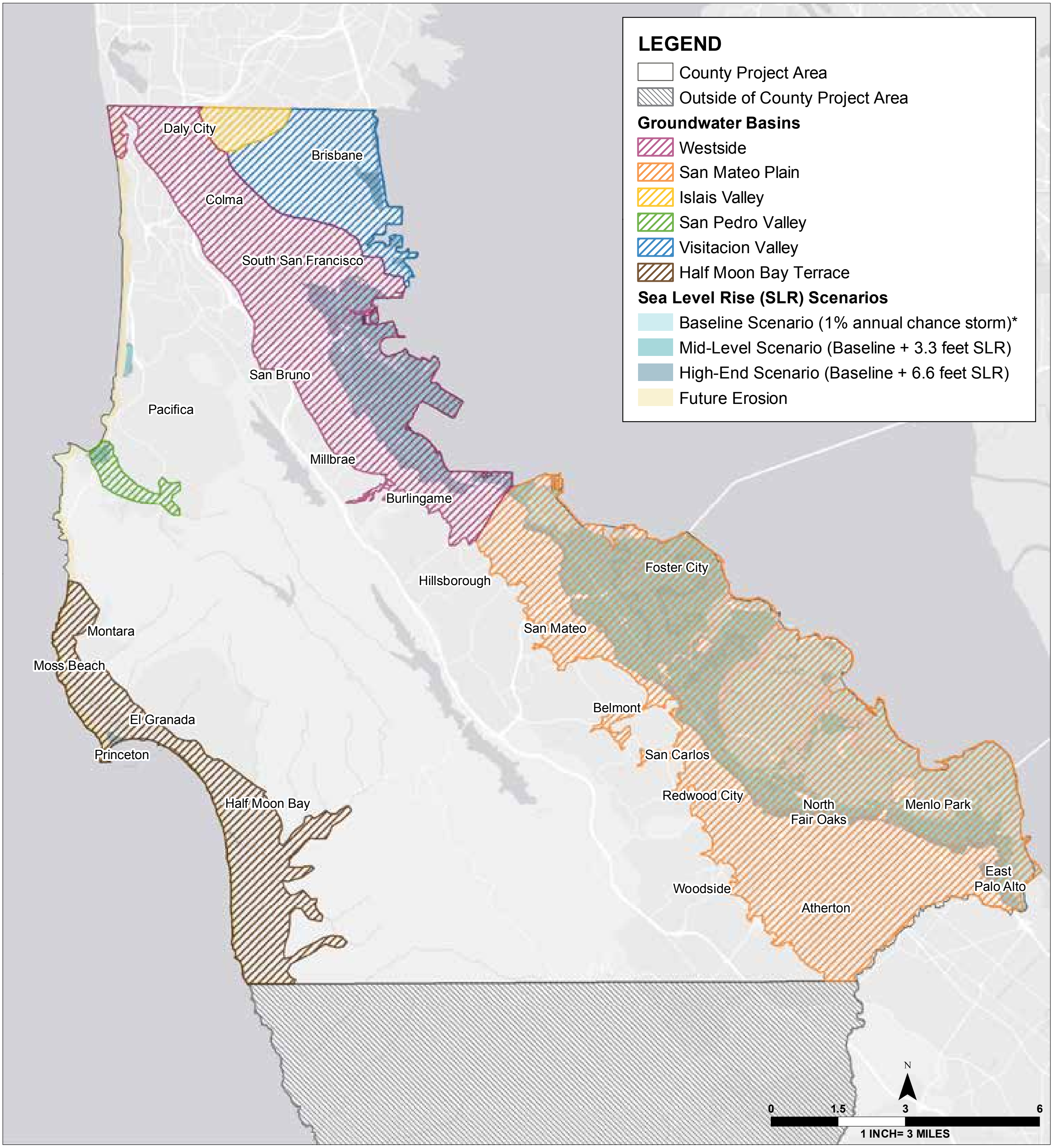
Sea level rise is anticipated to increase the groundwater table and could pose several potential vulnerabilities and impacts to groundwater resources in the County, particularly in areas where municipal water supplies depend on groundwater. A more detailed discussion on groundwater resources and sea level rise is provided Appendix I, Groundwater Resources Evaluation.

Findings generally suggest that sea level rise poses a limited risk to municipal supply wells because of (i) the great depths across which they are screened; (ii) the presence of shallow confining layers such as the Bay Mud above these deep supply wells; and (iii) the distances of supply wells from the San Francisco Bay on the eastern portion of the County. In addition, most of the population of the County receives potable water from the State Water Project (Hetch Hetchy), so groundwater is not a primary resource for the potable water supply. Figure 3B. 4, Figure 3B. 5, and Figure 3B. 6 illustrate where the County's groundwater basins are, how these function, and how they interact with an adjacent body of saltwater such as the Bay or Pacific Ocean.

A potential exception that warrants further review pertains to the municipal supply wells adjacent to the Pacific Ocean. These were reported to be screened at much shallower depths to contain much younger groundwater, indicating a higher potential for adverse impacts from sea level rise. In addition, some private domestic drinking water wells are reportedly in use in southern San Mateo County, and they may be screened in the shallow aquifer and vulnerable to sea level rise. Beneficial use of groundwater may also be affected by sea level rise, with many irrigation wells reported to be screened in the shallow aquifer, which is much more vulnerable to anthropogenic contaminants, flooding, and potential sea level rise. Another potential impact that warrants further review is the groundwater depths reported for environmental contamination sites (State Water Resources Control Board 2015); this impact is further described in Chapter 5. Figure 3B. 4 shows the County's groundwater basins in the project area.


Fitzgerald Marine Reserve.

Figure 3B.4 San Mateo County Groundwater Basins in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: California Department of Water Resources.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

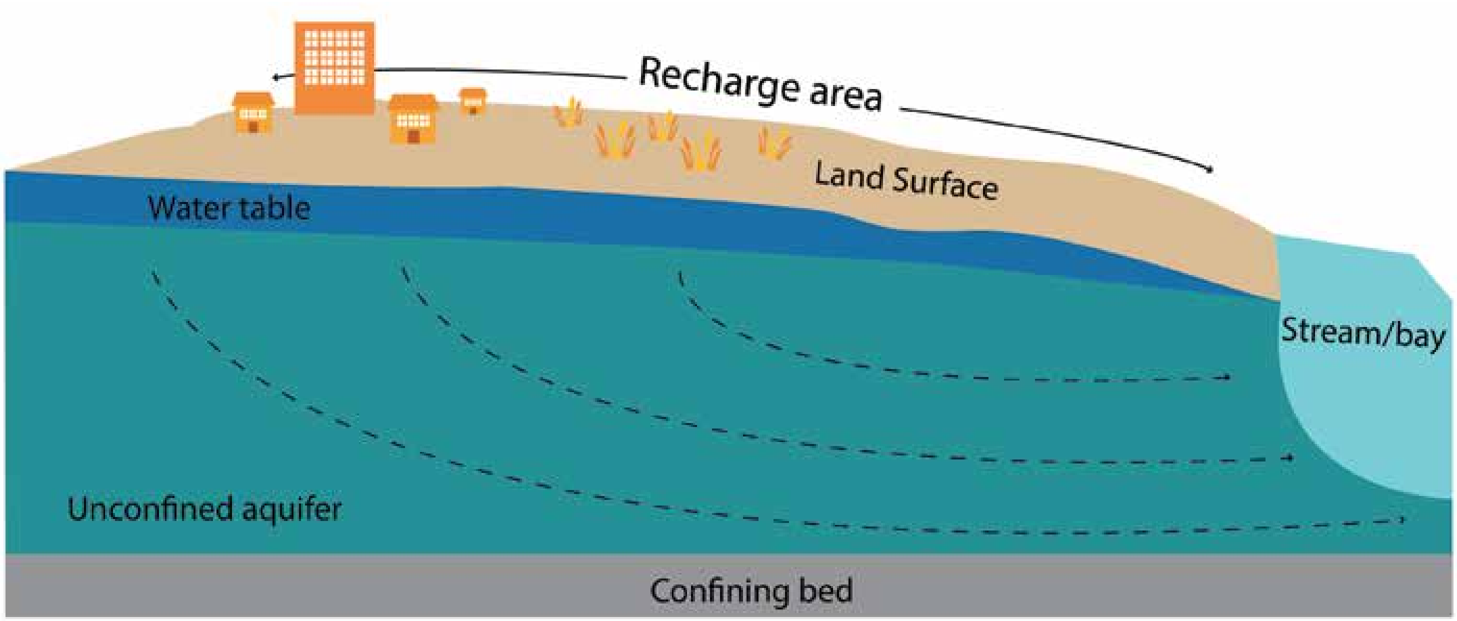


Figure 3B.5 Groundwater Basin (Winter et al. 1998)

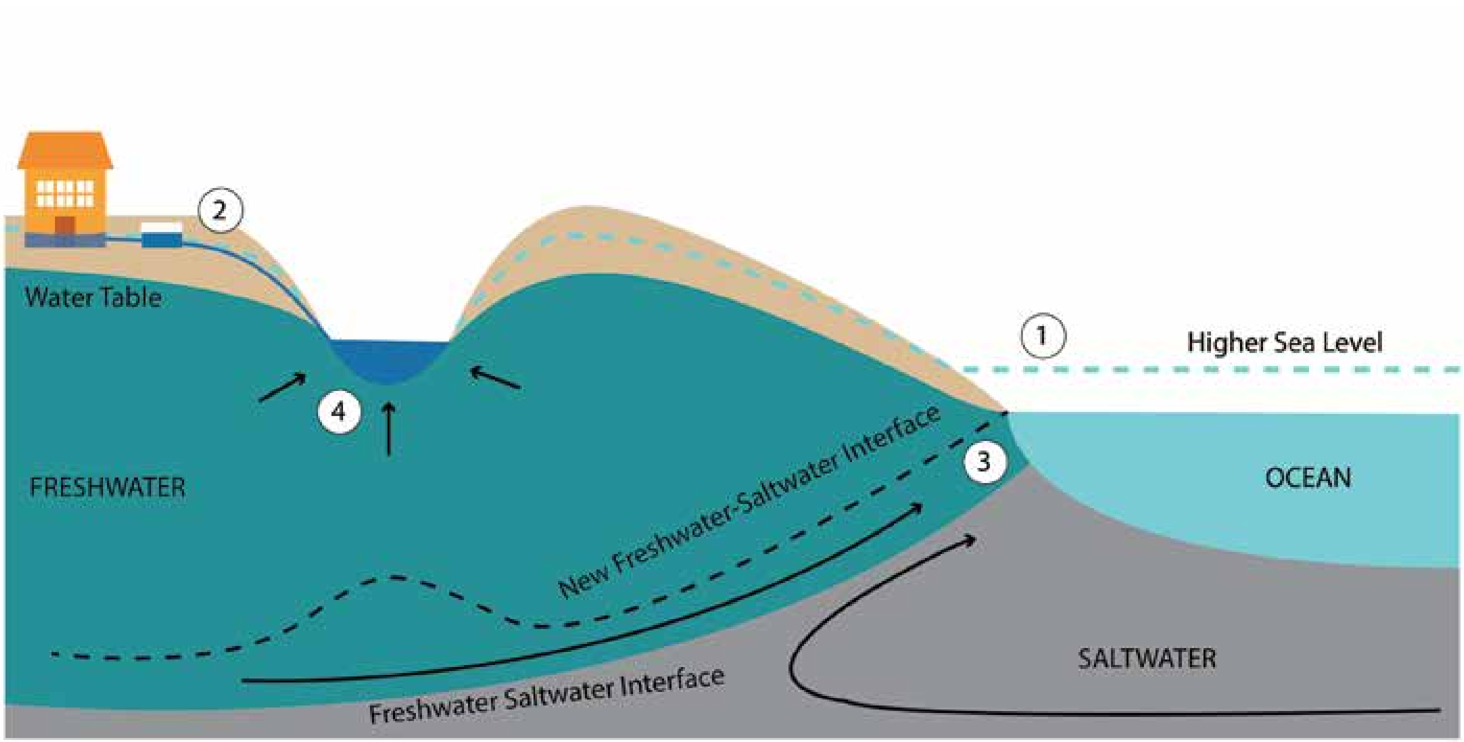


Figure 3B.6 Saltwater Intrusion

Sea level rise will affect groundwater flow in coastal aquifers (1). An increase in water table elevation (dashed blue line) may result in basement flooding and compromise septic systems (2). Sea level rise may also cause an upward and landward shift in the position of the freshwater-saltwater interface (3). Where streams are present, an increase in the water table elevation may also increase groundwater discharge to streams and result in local changes in the underlying freshwater–saltwater interface (4) (USGS 2014).

3B.2.2.5 Kelp

Eleven acres of kelp forests are present in the County and could be vulnerable to sea level rise. Kelp forests were not individually evaluated in this assessment, but details on their vulnerability to sea level rise and other climate stressors can be found in Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean (Hutto et al. 2015). Although not as critical a stressor as water chemistry properties, wave action, and increasing temperature, sea level rise may affect kelp forest communities through decreased light availability and forced shoreward migration (Graham et al. 2003, 2008). Sea level rise may also change the shape of the coastline and substrate composition (e.g., rocky versus sandy shores; Graham 2007), and thus affect the availability and living conditions of macroalgae and their associated species.

3B.2.2.6 Rocky Intertidal Habitat

Rocky intertidal habitat was identified by the Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean (Hutto et al. 2015) as moderately vulnerable to climate change compared with other habitat types in the region. Specifically, it has moderate to high exposure to climate impacts, moderate to high sensitivity, and also moderate to high adaptive capacity. As it relates to sea level rise hazards in particular, rocky intertidal habitat, like that at the Fitzgerald Marine Reserve (see Appendix D, Asset Vulnerability Profiles), is highly sensitive to wave action and coastal erosion and is moderately sensitive to sea level rise. The habitat is also affected by hard armoring of the coast line and roads that prevent inland migration of beaches. These sensitivities are compounded by other natural and human-related factors, including temperature, invasive species, pH, and pollution.

Because it is rare, maintaining extant rocky intertidal habitat in the County and the conditions that enable its survival is critical. The County has one of the most highly visited and rich examples of this ecosystem at the Fitzgerald Marine Reserve.

3B.2.2.7 Wetlands

Wetlands are an important natural asset in the County. They protect the shoreline from flooding and erosion from storms, and they are an important recreational and educational resource to the community (BCDC 2011). Wetlands contribute to a community's resilience to flooding by providing a storm surge buffer, erosion control, water-quality maintenance, and fish and wildlife habitat (EPA 2001, 2006). Plants in these environments grow quickly each year and store large amounts of carbon. The soils are mostly anaerobic and decompose very slowly, so once carbon is incorporated, it is not soon released (Conservancy 2015).

Wetlands are not very sensitive to temporary inundation, but they are more sensitive to permanent inundation from sea level rise, which could permanently convert them to tidal mudflat. However, wetlands may be able to build up sediment, or accrete at a pace equal to sea level rise (reflective of their adaptive capacity), which would prevent their permanent loss. This accretion would depend on an adequate supply of sediment, the extent to which the shoreline is developed, and how quickly the water level rises. These conditions are affected by human and natural processes upstream of San Francisco Bay and by coastal shoreline management practices on the Coastside. For example, coastline hardening or infrastructure (like a jetty) in one place can further exacerbate erosion elsewhere.

In total, over 7,000 acres of wetlands (more than 80% of all wetlands assessed in the project area) could be lost to temporary or permanent flooding or erosion.[8] This area includes the Pillar Point Marsh, Bair Island, and the Ravenswood Pond Complex. Refer to the AVP on the Ravenswood Pond Complex for more information (Appendix D, Asset Vulnerability Profiles).

3B.2.2.8 Natural Asset Conclusion

Addressing vulnerability across the County will require a meaningful examination of what "services" these natural assets currently provide and how these ecosystems may be a vital component of any adaptation planning in the future. As the above analysis indicates, viewing extant wetland systems as external or unrelated to the long-term resilience of the built environment may eliminate creative and balanced ways of preparing for sea level rise (this topic is discussed further in Chapter 4). As with built assets, considering natural assets in isolation does not facilitate a holistic or systemwide view of vulnerability, yet putting these pieces together is an immense challenge. Chapter 3A, Setting and Context addresses the challenge of bringing multiple sources of vulnerability into focus.

> "Wetlands contribute to a community's resilience to flooding by providing a storm surge buffer, erosion control, water-quality maintenance, and fish and wildlife habitat (EPA 2001, 2006)...In total, over 7,000 acres of wetlands (more than 80% of all wetlands assessed in the project area) could be lost to temporary or permanent flooding or erosion."

[8] This estimate includes the total area of wetlands that is within the hazard extent footprint. This estimate does not take into account sediment accretion.

3B.2.3 Built Assets in San Mateo County

Many of the County's built assets are concentrated near the Bay, but these structures will not necessarily be equally affected over time. Proximity to the water also does not correlate to vulnerability because structures and systems located uphill from the Bay will be affected by cross-cutting and cascading sea level rise impacts. This section focuses on the specific asset categories within the County that are vulnerable to impacts by sea level rise and elaborates on the broader potential consequences of flooding.

For detailed built asset exposure maps that focus on specific Coastside and Bayside zones, please see Appendix B.

Asset Categories

- **Airports**
- **Hazardous materials**
- **Energy infrastructure and pipelines**
- **Ground transportation**
- **Community land use, services, and facilities**
- **Wastewater systems**
- **Stormwater and interior drainage**
- **Homeless shelters**
- **Seaports**
- **Parks and recreation areas**

3B.2.3.1 Flood Protection Infrastructure

Flood protection infrastructure, such as levees or seawalls, is designed to withstand high water, making it less sensitive to those conditions relative to other assets. However, assets protected by this infrastructure are often are very sensitive to flooding. Much of the Bayshore is protected by 11 miles of levees and floodwalls (mostly in Redwood City, Foster City, and the City of San Mateo), and the remainder of the shoreline is characterized by 41 miles of nonengineered berms, embankments, and other shoreline features,[9] with an additional 200 miles of inner shoreline features.[10] This critical network currently plays a key role in reducing the frequency and exposure of flooding, which enables economic and community development in low-lying coastal cities like Foster City, the City of San Mateo, East Palo Alto, and portions of Pacifica.

AVPs on the Foster City Levee as well as the Beach Boulevard Seawall provide more information about these assets and their vulnerabilities (see Appendix D, Asset Vulnerability Profiles). Because levees and seawalls are inherently tied to the assets and people they protect, a discussion of levees and seawalls goes hand in hand with the services they provide (protecting people and assets). Levees and seawalls can be exposed to high water during storm events, whereas the assets and communities protected by those levees today may have a very low exposure to flooding (subject only to floods of greater magnitude and lower frequency than the 1% annual chance flood or baseline condition). If no action is taken, the exposure of levees and seawalls (as well as the assets and communities they protect) will increase in the future because high water levels, which are more frequently expected with sea level rise, could overtop a levee, seawall, or another shoreline protection feature.

Structural shorelines and other protection infrastructure have very little adaptive capacity to continue to perform primary functions once overtopped or breached. In some places, like Foster City, pumping stations or other infrastructure would work to reduce the extent of floodwaters in the case of overtopping. Levee and seawall managers can improve the adaptive capacity of the asset through frequent monitoring and maintenance. In addition, communities can increase their own adaptive capacity to a potential structural shoreline failure by enhancing emergency management activities.

Table 3B. 4 Flood protection infrastructure key findings.

BUILT ASSET DESCRIPTION: FLOOD PROTECTION INFRASTRUCTURE	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Flood protection infrastructure includes engineered structures such as levees and nonengineered structures such as berms that protect development from flooding. **Risk Class: 4** Vulnerable flood protection infrastructure (mid-level scenario): • 21 miles of levee and floodwalls • 190 miles of other built shorelines	• Failure of levees, floodwalls, and nonengineered structures could cause major, if not catastrophic, inland flooding in the case of a significant storm.	Once overtopped this infrastructure has very low adaptive capacity. Frequent maintenance and structural modification can increase the adaptive capacity.	Given the density of city governments within the County and the impacts built shoreline structures can have on adjoining municipalities, a high degree of coordination between cities and the County would enable more strategic and effective long-term decision-making regarding flood protection infrastructure. Cities are largely responsible for building, maintaining, and certifying levees and other built shoreline infrastructure, as well as authorizing zoning and land use decisions adjacent to flood protection infrastructure. Regional, state, and national agencies also play a large role in permitting and setting regulations that local entities must adhere to.

[9]This includes San Francisco Estuary Institutes' designation of berms, elevated transportation structure, and water control structures. See the asset inventory for a complete count.
[10]Outer shoreline differs from inner shoreline based on SFEI's categorization as a "first line of shoreline defense" in the SFEI bay shoreline study (2016).

Table 3B. 5 Flood protection infrastructure affected by sea level rise scenarios (in miles and relative to the project area).

SCENARIO	SCENARIO DESCRIPTION	LEVEES AND FLOODWALLS (MILES)	OTHER BUILT SHORELINES (MILES)
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	2.6 (10%)	59.1 (26%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	21.4 (82%)	188.9 (82%)
HIGH-END	1% annual chance flood plus 6.6 feet	24.5 (94%)	210.7 (91%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	1.4 (5%)	2.1 (1%)

Impacts and consequences of a loss of assets or service

If a levee or seawall was damaged by high water or erosion, it could be expensive to repair. In addition, a damaged levee or seawall no longer offers the same level of protection to property and people. Sandbags and other short-term fixes are available, but a greater risk of overtopping or breaching exists until the seawall or levee is fully repaired. Though some levees and seawalls have rigorous design standards, they do not eliminate flood risk, and even today a levee that meets Federal Emergency Management Agency (FEMA) and USACE standards could be overtopped by floodwaters that are higher than the levees and seawalls. Levees can also fail if the top surface wears down over time because of human use or vegetation, if an earthquake or land subsidence leads to settling of the levee, or if water seeps into the levee. All of these scenarios can lead to a decrease in levee stability and performance.

Figure 3B. 7 provides a graphic illustration of the results of the built asset exposure analysis. This map shows only the built assets that are currently or are expected to be exposed to flooding, erosion, and sea level rise; it does not show assets on significantly higher ground (such as in Atherton or Woodside) that are not expected to be directly exposed to sea level rise.

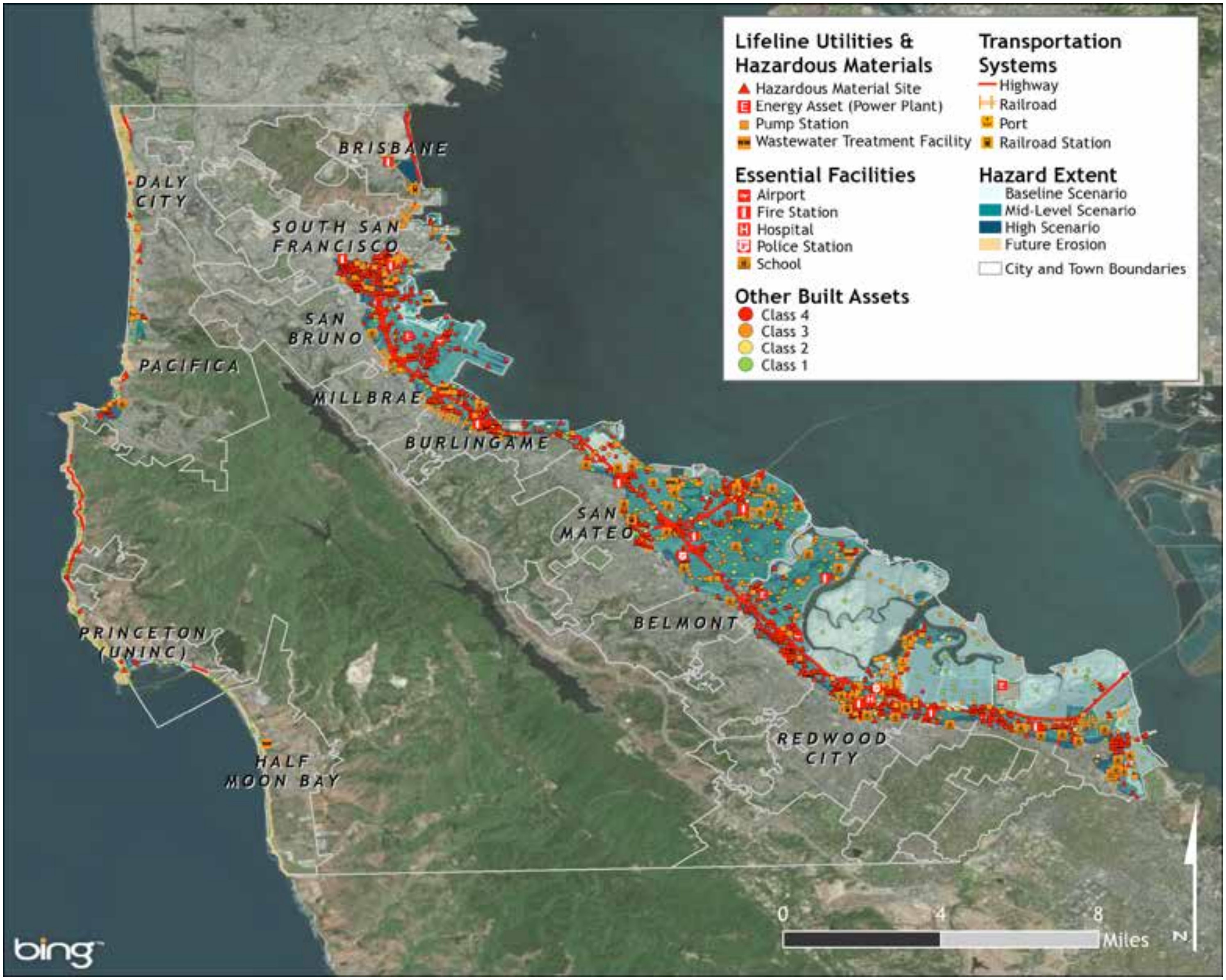
The asset exposure maps that follow are intended to represent the locations of the greatest potential for disruptions or risks to the community from flooding and erosion.[11] Clusters of red (Class 4) assets, for example, give a sense of where risks are spatially correlated; this type of information also provides insight into where risks could be collectively reduced or which assets may benefit from a potential future adaptation project.

Flooding in levee-protected areas is different than the type of flooding in nonprotected areas alongside waterbodies, and this difference will need to be considered in adaptation. Specifically, levee- or seawall-protected areas will experience no flooding until a levee or seawall is overtopped from a surge or fails, at which point flooding would involve sudden velocity, increasing infrastructural damage. The exact nature of flooding created by a levee breach depends on the elevation of flood water, elevation of the land, and the hydrologic conditions.

National Flood Insurance Program policies do not require property owners to purchase flood insurance or mitigate flood risk when properties are protected by an accredited levee. This can create a false sense of security among asset managers and residents who own or manage property located behind levees. As a result, it is common that infrastructure and assets in these areas are not covered by flood insurance, and most levee-protected assets are not designed to withstand even modest flooding events. Residents protected by accredited levees are commonly unaware of extant flooding risk and are unprepared (Ludy and Kondolf 2012), making them less able to safely withstand a flood.

[11] This is not a risk map, which would integrate the likelihood of exposure along with the current extent and potential consequence of exposure.

Figure 3B.7 Built Asset Exposure with Sea Level Rise Scenarios.



The following description of the legend explains Figure 3B. 7 and the maps in Appendix B.

- Critical Facilities (Essential Facilities, Transportation Systems, Lifeline Utility Systems, and Hazardous Materials) are identified with unique icons.
- All other assets are represented by small circles in the color corresponding to their ASCE Risk Class.
- Assets in red represent ASCE Class 4 assets (significant potential risk to health, safety, and societal disruption).
- ASCE Class 3 assets are orange.
- ASCE Class 2 assets are yellow.
- ASCE Class 1 assets are green.

Figure 3B. 7 indicates that most exposed infrastructure and assets are concentrated on the Bayshore rather than the Coastside of the County. In addition, the maps and inventories suggest that most, if not all, cities and towns have some critical infrastructure that either is currently exposed or is expected to be exposed to a sea level rise hazard. As one example, Highway 101 and State Route 1 run north to south and cross many jurisdictions on the Bayshore and Coastside, respectively. These two assets in particular give a proxy for the geographic scope of potential impacts of flooding or erosion, and they provide a sense of the scale of likely stakeholders involved in any decision-making. Many assets are located along the Highway 101 corridor. More detailed maps showing cities and towns are provided in Appendix B, Asset Exposure Maps. Chapter 3D City- and County-Specific Findings provides the total number of each asset type in the County.

Most built assets in the County are highly sensitive to flooding and are variably sensitive to erosion. In most cases, infrastructure and the County's building stock were built at ground level, not using materials or electrical systems designed to withstand flooding. As a result, the primary function of many built assets would likely be significantly disrupted in a flood. The sensitivity of built assets to erosion is on a spectrum, and it depends fully on the extent of erosion; some assets have erosion protection, but others do not.

Most built assets have little near-term adaptive capacity for the same reason that they are highly sensitive; they were not built to withstand flooding or erosion and therefore have few backup systems in place to function in the event of flooding or erosion. Adaptation will be necessary in order to avoid or reduce the impacts of sea level rise, which will occur more frequently in the future. Findings from this analysis suggest that those assets with greater near-term adaptive capacity are those that involve human services such as schools and health care facilities. Typically, these facilities require emergency plans for earthquakes or other hazards, and they are by default better prepared to survive or more quickly recover from a disruptive event.

3B.2.3.2 Airports

Table 3B.6 Airports key findings.

BUILT ASSET DESCRIPTION: AIRPORTS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Risk Class: 3 Vulnerable airports in the County (mid-level scenario): • San Francisco International Airport (SFO) • San Carlos Airport	• Overtopping of shoreline levees would lead to temporary or permanent inundation of airport runways and facilities. Impaired facilities would include runways, terminals, parking structures, roads, and railways. • Flooded pump stations or backed-up stormdrains on runways or parking garages could trigger a more widespread impairment of upstream stormwater systems, further exacerbating flood conditions elsewhere. • Loss of airport-wide operations and disruption to regional transportation system. • Costly damage to airplanes from exposure to saltwater.	Bay Area airports have limited redundancy. If SFO was flooded, San Carlos and Oakland Airports would likely be flooded as well. The Federal Aviation Administration regulations regarding shoreline height restrain options to limit flooding.	Multiple entities own and manage each airport property. Portions of shorelines, levees, or property within or around each airport may be owned by different agencies. This patchwork may make adaptive decision-making additionally complex.

Table 3B.7 Number and percentage of airports affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	NUMBER AND PERCENTAGE OF AIRPORTS AFFECTED
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	1 (0%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	2 (67%)
HIGH-END	1% annual chance flood plus 6.6 feet	2 (67%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)

There are three airports in the County: San Francisco International Airport (SFO), San Carlos Airport, and Half Moon Bay Airport. SFO is exposed to flooding in the baseline scenario, and the San Carlos Airport is exposed in the mid-level scenario. More specifically, SFO would be first inundated with a 24-inch increase in water level (the 1% annual change storm is equivalent to about 42 inches of total water level). The San Carlos Airport’s levee system protects the airport from the 1% flood. The Half Moon Bay Airport is not exposed in any of the sea level rise scenarios. The levees would be first overtopped with a 48-inch increase in water level.

Airports are highly sensitive to flooding because planes cannot take off or land on flooded runways. In general, airplanes become inoperable if the wheels and other components are exposed to saltwater. SFO depends on the San Carlos Airport to serve as a reliever airport, but both airports would need to find a new relief airport if both were flooded.

In the event of a significant flood, the San Carlos airport stormwater systems may cease to function; loss of electricity to the stormwater pump stations or backup of storm drains on runways or in parking garages during high tides would cause significant flooding and infrastructural damage. San Carlos Airport is particularly vulnerable because it is adjacent to San Francisco Bay, but Federal Aviation Administration (FAA) regulations prevent completing a seawall on all sections of the runway. Adaptation of the San Carlos facility will require considerable coordination between San Carlos and Redwood City jurisdictions.

Bay Area airports have limited redundancy: if SFO was flooded, San Carlos and Oakland airports would also likely be flooded. Near-term adaptive capacity of airports is moderate relative to other assets because a temporary barrier can be put in place on the runway in the event of high water. In addition, planes could take off and land at other regional airports if needed, although not without significant time disruption and economic cost to the airport and travelers. Stormwater pumps could reduce flooding and remove saltwater from the runway. The airports could also benefit from improvements to nearby wetland habitat, which could limit wave and surge height. Adaptive capacity overall is constrained because the FAA enforces shoreline height regulations for landing safety, which do not easily accommodate raising the height of levees. Options to restore marsh and provide natural flood reduction are limited because these efforts would increase the number of birds in the area, which can fly into propellers and cause safety issues.

In the long term, the SFO and San Carlos Airports will need considerable intervention to accommodate water level changes expected with sea level rise. Efforts are currently underway at SFO to assess and reduce its vulnerability to sea level rise (SFO 2015). Preliminary flood insurance rate map data suggest the entire airport property is in the 1% flood zone with flood elevations ranging from 10 feet to 14 feet North American Vertical Datum 88 along the shoreline.[12] SFO has undertaken a shoreline protection study aimed at removing the Special Flood Hazard Area designation for the airport property. The study will identify deficiencies in the current flood defense system, provide recommendations to correct deficiencies with preliminary cost estimates, and address sea level rise by providing solutions for the increase in water level. The results of this study will strengthen the baseline of information for advancing the County’s planning and adaptation efforts. SFO’s efforts are discussed in greater detail in Appendix M.

[11]NAVD88 is a measurement of height by vertical coordinates of points. It can be understood as the height above sea level where the NAVD88 datum is based on a “surface zero elevation to which heights of various points are referred in order that those heights be in a consistent system.” (National Geodetic Survey January 2017)

Impacts and consequences from damage to airport facilities or a disruption of service

Adverse impacts from saltwater flooding of airport facilities would be substantial and far-reaching, primarily because of the travel disruption and economic losses associated with the delays caused by closing the airport. At the San Carlos Airport, the loss of airport service could amount to Airport costs of approximately $5,000 per day. Many aircraft owners and businesses based in or dependent upon the San Carlos Airport would be highly affected by the closure. Inundation would also affect travelers' cars, rental cars, busses, and terminal infrastructure. The airport ground equipment is directly vulnerable to corrosion arising from saltwater exposure. In addition, damage to airport hangars, airfield lighting, or airplanes would be very costly to repair or would require complete replacement. The estimated cost of replacing the airport and the aviation museum is estimated at $75–100 million; if all airplanes needed replacement, costs could be increased by an additional $100 million.

Health and socio-economic impacts would also occur in communities using this asset. Airport employees could be without work, leading to additional economic impacts. More than 300 people at the airport, including staff, aircraft pilots and owners, and visitors to the aviation museum could be at risk of serious health impacts if the facility had to be evacuated because of flooding. Injuries could happen in this situation, especially if a levee breach occurred or if people were exposed to hazardous materials (e.g., leaded aviation fuel). The aviation museum's educational opportunities would be halted if damaged, thus affecting the community members, including nonnative English speakers who benefit from the multilingual program. The loss of a regional essential facility could have implications for any emergency services that depend on airports and airport functions. Lastly, water quality could be negatively affected as a result of runways flooding.

The County's airports are all Risk Class 4 assets because of the significant impact on the economy and society overall should a loss of function occur. A full count of Class 4 assets that are or will be exposed to a sea level rise hazard is provided in Chapter 3D, City- and County-Specific Findings. Refer to the San Carlos Airport AVP in Appendix D.

3B.2.3.3 Hazardous Material Sites

Table 3B.8 Hazardous material sites key findings.

BUILT ASSET DESCRIPTION: HAZARDOUS MATERIALS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Hazardous materials include contaminated lands, closed and open landfills, clean-up sites, superfund sites, and areas with stored fuel or chemicals. **Risk Class: 3,4** Vulnerable airports in the County (mid-level scenario): • 4 Superfund sites • 1 closed landfill • 135 hazardous material sites	• Release of hazardous contaminants from flooding, saltwater intrusion, or erosion • Potentially significant impacts to public health and environmental quality	The adaptive capacity of hazardous materials sites is limited. Options may include relocation or site redesign to protect containers or contaminated areas from inundation.	Each site is owned by a private or public entity. The release of materials largely depends on the proper storage technique of hazardous materials by the owners.

Table 3B.9 Number and percentage of hazardous material sites affected by sea level rise scenarios (relative to project area).

SCENARIO	SCENARIO DESCRIPTION	NUMBER AND PERCENTAGE OF HAZARDOUS MATERIAL SITES AFFECTED
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	8 (2%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	135 (35%)
HIGH-END	1% annual chance flood plus 6.6 feet	183 (47%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	1 (0%)

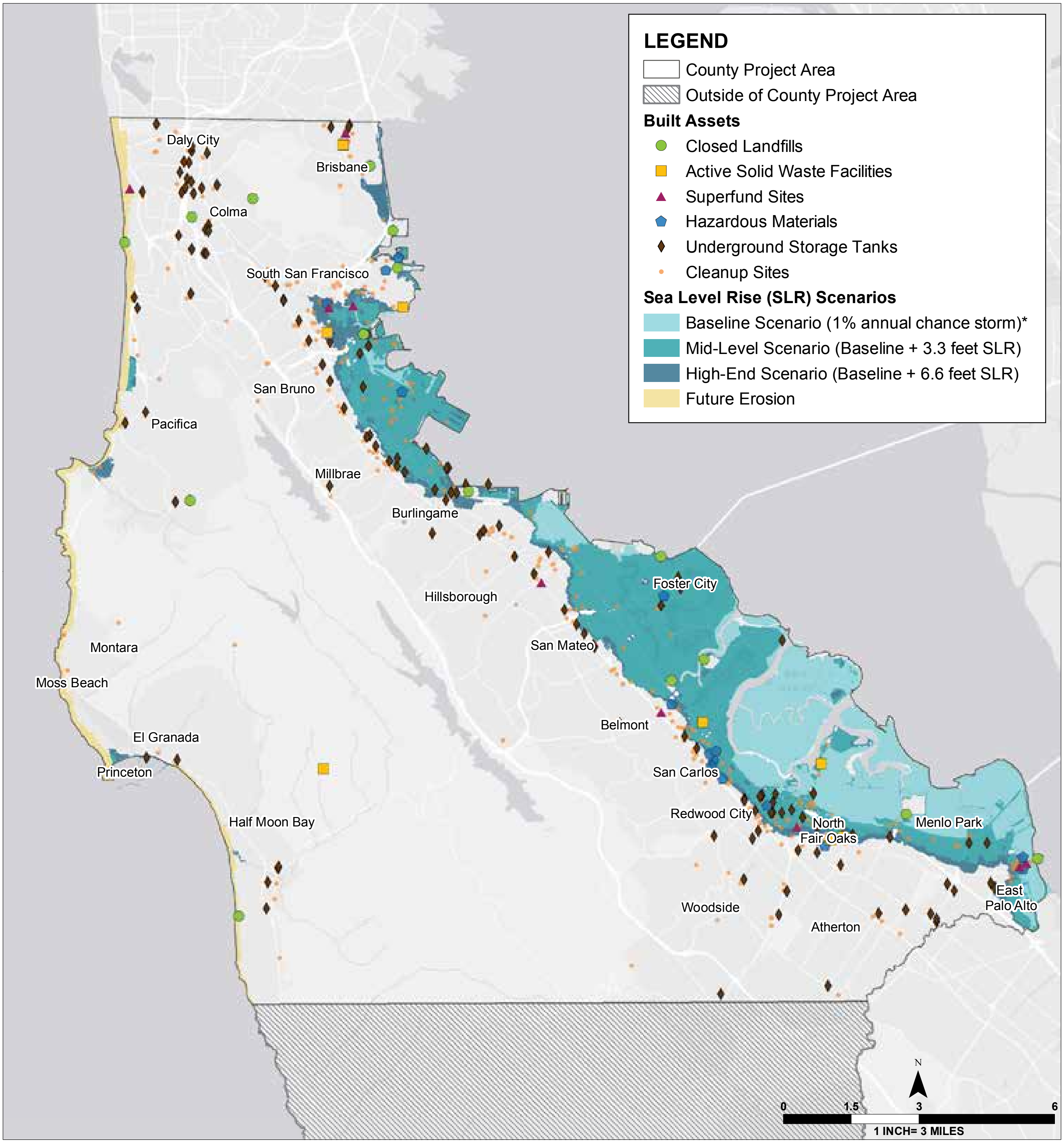
The County has 29 sites classified as hazardous materials or cleanup sites that are expected to be exposed to flooding in the near term and up to 665 sites that are expected to be exposed to flooding in the long term. The sites identified in the inventory only include open (nonremediated) sites, and not sites that have undergone remediation. They also include cleanup sites and areas with historical use of pollutants or industrial chemicals. This number is likely an underestimate because the data do not include locations of businesses where hazardous materials may be used or stored on site. As shown in Figure 3B. 8, hazardous materials sites are most highly concentrated on the Bayshore. Release of toxic substances may occur when floodwaters enter storage tanks and force existing contents out or if uncontained sites such as pits or piles come into contact with floodwater. Although not evaluated for this report, cleanup sites and other hazardous waste areas could also be sensitive to surface flooding or to an increase in the groundwater table because hazardous materials could be released and contaminants that would otherwise be contained could be mobilized. The adaptive capacity of hazardous sites in the near term is moderate because vulnerability can be reduced by continued monitoring and maintenance of any on-site flood and erosion protection infrastructure, as well as monitoring of groundwater for potential leachates. In the long term, adaptive capacity of hazardous sites to sea level rise is expected to be low because they would require considerable intervention, mitigation, or removal.

Impacts and consequences of a loss of assets or service

Direct or indirect contact with hazardous materials, trash, or pollutants poses a potential public health and safety concern (see Chapter 3C, Community and Health Vulnerability), as well as harm in the environment to natural communities, habitats, and species.

Hazardous materials sites are Risk Class 4 assets due to the significant impact on public health and safety and the environment should such a site be compromised. A full count of Class 4 assets that are or will be exposed to a sea level rise hazard is provided in Chapter 3D, City- and County-Specific Findings.

Figure 3B.8 Hazardous Material Sites in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: County of San Mateo 2015; David Ford Consulting Engineers Report 2013; California Department of Water Resources; Risk Characterization Study; California Water Board; United States Environmental Protection Agency.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

3B.2.3.4 Energy Infrastructure and Pipelines

Table 3B.10 Energy infrastructure key findings.

BUILT ASSET DESCRIPTION: ENERGY INFRASTRUCTURE AND PIPELINES	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
These assets include power plants, substations, and electrical and natural gas transmission lines **Risk Class: 3,4** Vulnerable assets include (mid-level scenario): • 2 power plants • 73 miles of transmission lines • 12 electric substations	• Corrosion of pipes from saltwater intrusion and erosion of pipelines • Inundation of pipelines and substations • Temporary or permanent loss of power • Threats to public life and safety resulting from direct contact with broken or exposed infrastructure (e.g., power lines), or other health concerns resulting from loss of power	Further study is needed to identify the adaptive capacity of energy infrastructure and pipelines in the County.	Many of the energy infrastructure and pipelines in the County are owned by private companies, like PG&E. State and federal agencies regulate aspects of the design, maintenance, and operation of the infrastructure.

Table 3B.11 Length (in miles and relative to project area) of energy infrastructure and pipelines affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	POWER PLANTS	ELECTRIC SUBSTATIONS	TRANSMISSION TOWERS	TRANSMISSION LINES (MILES)	NATURAL GAS PIPELINES (MILES)
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	0 (0%)	3 (7%)	46 (16%)	27.4 (13%)	1.4 (1%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	2 (65%)	12 (27%)	94 (32%)	72.7 (36%)	17.6 (12%)
HIGH-END	1% annual chance flood plus 6.6 feet	2 (65%)	19 (43%)	124 (43%)	84.5 (42%)	26.4 (18%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Power plants are not exposed in the near term, but four power plants could be exposed in the long term. Twenty-seven miles of transmission lines lie in the baseline hazard exposure area, and 85 miles lie in the long-term scenario area. An evaluation of the sensitivity and adaptive capacity of these assets and of energy systems was not part of this study. Figure 3B. 9 illustrates the geographic spread of energy infrastructure and pipelines in the project area. As part of a Natural Hazard Asset Performance assessment, PG&E has made initial statements on energy infrastructure risk exposure. The company found that two of its substations in the County are located within areas modeled for 2 feet of sea level rise and six are located in FEMA's 1% annual chance flood zones. In addition, about 3% of the company's gas transmission pipelines in the County are located within areas modeled for 2 feet of sea level rise and about 14% are located in FEMA's 1% annual chance flood zones. PG&E is working on a vulnerability assessment and adaptation plan for all of its assets. See Appendix J, PG&E and Sea Level Rise Vulnerability, for details on this effort.

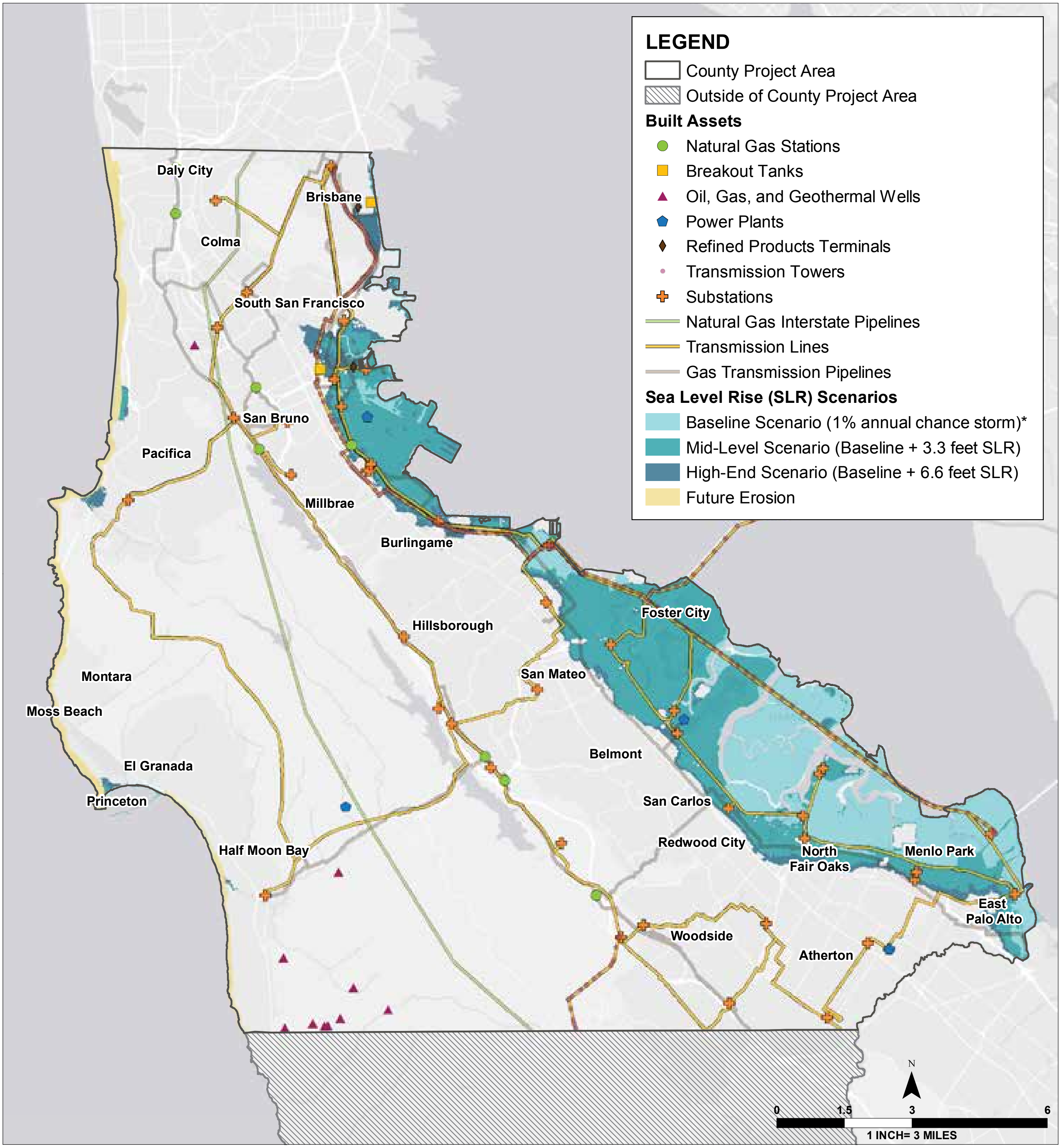
Compared with sea level rise, FEMA's flood zones put a larger number of PG&E's assets at risk given the streams and tributaries within a watershed that eventually flow into the Bay or ocean. Similar to earthquake zones, not all of the FEMA flood zones would be expected to be simultaneously affected by a flooding incident.

Impacts and consequences from a loss of assets or disruption of service

The energy network directly affects the day-to-day operations, lifelines, and economic activities in any community; therefore, any temporary or permanent loss of power could have substantial and cascading impacts on public health and safety and to societal and economic disruption.

Energy infrastructure and pipelines are Risk Class 4 assets because of the potentially devastating impacts to public health and safety that a loss of service would entail. These assets are critical pieces of infrastructure, and their impairment would cause significant community-wide problems. A full count of Class 4 assets that are or will be exposed to a sea level rise hazard is provided in Chapter 3D, City- and County-Specific Findings.

Figure 3B.9 Energy Infrastructure and Pipelines in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: National Pipeline Mapping System 2015; California Energy Commission 2015; California Energy Commission 2014;County of San Mateo 2015; Federal Communications Commission 2010; Wireless Telecommunications Bureau 2010

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

3B.2.3.5 Ground Transportation

Table 3B.12 Ground transportation key findings.

BUILT ASSET DESCRIPTION: GROUND TRANSPORTATION	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
This includes major roadways like Highway 101 and public transportation assets including BART and Caltrain. These assets connect people with community facilities and services, jobs, family and friends, recreation, and other important destinations, and they connect goods to markets. **Risk Class: 2, 3, 4** Vulnerable assets include (mid-level scenario): • 292 miles of local roads • 71 miles of highways including Highway 101 and State Routes 1, 84, 92, 114 • Millbrae Intermodal Station • Caltrain Stations: South San Francisco, San Bruno, Millbrae	• Erosion of roadways, resulting in significant and costly damages • Inundation of pick-up/drop-off stations • Permanent or temporary inundation of roadways and railways • Permanent or temporary loss of public transportation services • Disruption of local and regional commutes and travel • Threats to public life and safety resulting from attempting to navigate inundated roadways	For temporary flooding, Caltrans could deploy portable pumping systems to clear roadways. Roadways could be protected with berms, wetlands, and horizontal levees; elevated; or relocated inland.	Ground transportation is managed by multiple agencies including local, state, regional, and federal agencies, as well private entities (e.g., private commuter busses). These assets also tend to be linear, not easily relocated, and cross multiple city and county lines.

3B.2.3.5.1 Major Highways

Table 3B.13 Length (in miles and relative to project area) of highways affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	MILES AND PERCENTAGE OF HIGHWAYS AFFECTED
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	2 (1%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	70.6 (20%)
HIGH-END	1% annual chance flood plus 6.6 feet	94.4 (26%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	5.2 (0%)

Sea level rise will affect critical ground transportation infrastructure in the County. The major roadway network is highly exposed to the impacts of sea level rise on both the Bayshore and the Coastside. Roughly 2 miles of highways are subject to coastal flooding (not related to creek backup) in the near term, and around 100 miles will be exposed to erosion or coastal flooding in the long term. Highway 101 runs north–south through the County adjacent to San Francisco Bay, and multiple low spots along the shoreline provide pathways for flooding. Creek and culvert backup and overflow along the Bayshore already affects Highway 101 in multiple locations (see the corresponding AVPs in Appendix D). Along the coast, State Route 1 is vulnerable to erosion and wave run-up at several locations, and State Route 1 near Surfer's Beach has recently undergone erosion repairs (see the corresponding AVP in Appendix D).

Analysis suggests that all roadways are very sensitive to flooding, erosion, or wave run-up because exposure could force detours and road closure. Though not without impact or delay, alternate routes may be available for some roadways, and once water drains from the roads, roads are typically usable again without requiring significant repair. Although costly, sections of road can also be elevated or relocated. Consequently, relative to other assets, roadways have a moderate adaptive capacity. However, in most cases the road network is heavily used, and alternate routes are therefore becoming increasingly more difficult to accommodate. Figure 3B. 10 illustrates how the sea level rise scenarios may affect major highways and other ground transportation infrastructure.

Impacts and consequences from a loss of asset or service

Driving on flooded highways could cause injury or death. In addition, closure of Highway 101 or State Route 1 would likely cause widespread traffic delays, with impacts reaching north and south of the County. These delays could also result in economic impacts. Closure of State Route 1 in particular could isolate coastal communities because it is the main and in some cases the only thoroughfare on the coast.

Major highways are a Risk Class 4 asset because of the significant disruption in daily life and impact to public safety should a major route be impaired. A full count of Class 4 assets that are or will be exposed to a sea level rise hazard is provided in Chapter 3C.

3B.2.3.5.2 Local Roads and Public Transit Assets

Table 3B.14 Length (in miles and relative to project area) and number of local roads and public transit assets affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	RAIL (MILES)	LOCAL ROADS (MILES)	RAIL STATIONS
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	0.9 (1%)	23.9 (1%)	0 (0%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	9.6 (10%)	291.6 (15%)	2 (12%)
HIGH-END	1% annual chance flood plus 6.6 feet	24.7 (25%)	354.5 (18%)	3 (18%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)	19.3 (1%)	0 (0%)

In the San Mateo County project area, roughly 24 miles of local roadways are exposed in the near term (baseline scenario), and around 370 miles will be exposed in the long term. As with major highways, local roadways are sensitive to flooding and erosion; therefore, many roadways could be closed, requiring the use of alternate routes. See the AVP on Bayshore Boulevard for more details (Appendix D). Figure 3B. 10 indicates how the sea level rise scenarios might affect local roads and other ground transportation infrastructure.

Public transportation systems are vulnerable to sea level rise by means of the exposure, sensitivity, and adaptive capacity of transit stations, transit tracks, and transit maintenance facilities.[13] Not all public transportation facilities were evaluated in this Assessment, but the analysis of select facilities, including a BART and Caltrain station, and a San Mateo County Transit Authority (SamTrans) maintenance facility, provides insight into how public transportation is vulnerable and how sea level rise hazards could affect it. Several rail stations are likely to be exposed to sea level rise in the long term, including the Millbrae Intermodal BART and Caltrain Station (which was evaluated for an AVP, Appendix D); the Redwood City, Hayward Park, and South San Francisco Caltrain Stations; and the BART station at SFO. None of the stations are expected to be exposed in the near term (baseline scenario). Roughly 1 mile of rail/tracks in the County is exposed in the near term, and up to 25 miles of tracks could be exposed in the long term.

Transit tracks as well as power systems and pick-up/drop-off stations (including parking areas) are all sensitive to flooding, and they could lose function or access if inundated. Power systems affect train operation as well as ticket machines, turnstiles, and power at the stations.

SamTrans maintenance facilities are sensitive to flooding. Access to the site and to refueling and maintenance operations could be limited if they are inundated, and busses and maintenance equipment could be rendered inoperable. See the AVP on the SamTrans North Base Facility for more details (Appendix D).

Findings from the analysis suggest that public transportation generally has moderate near-term adaptive capacity compared with other infrastructure in the County. For example, if a single rail station or if rail tracks were out of service, Caltrans or BART could provide a bus "bridge service" to transport affected riders, and if the north base facility was closed for SamTrans bus maintenance, services could be temporarily moved to the SamTrans south base facility. In the long term, however, more train tracks, bus routes, and the SamTrans south base facility will be exposed as well, and a comprehensive adaptation strategy will be needed.

Impacts and consequences from a loss of asset or service

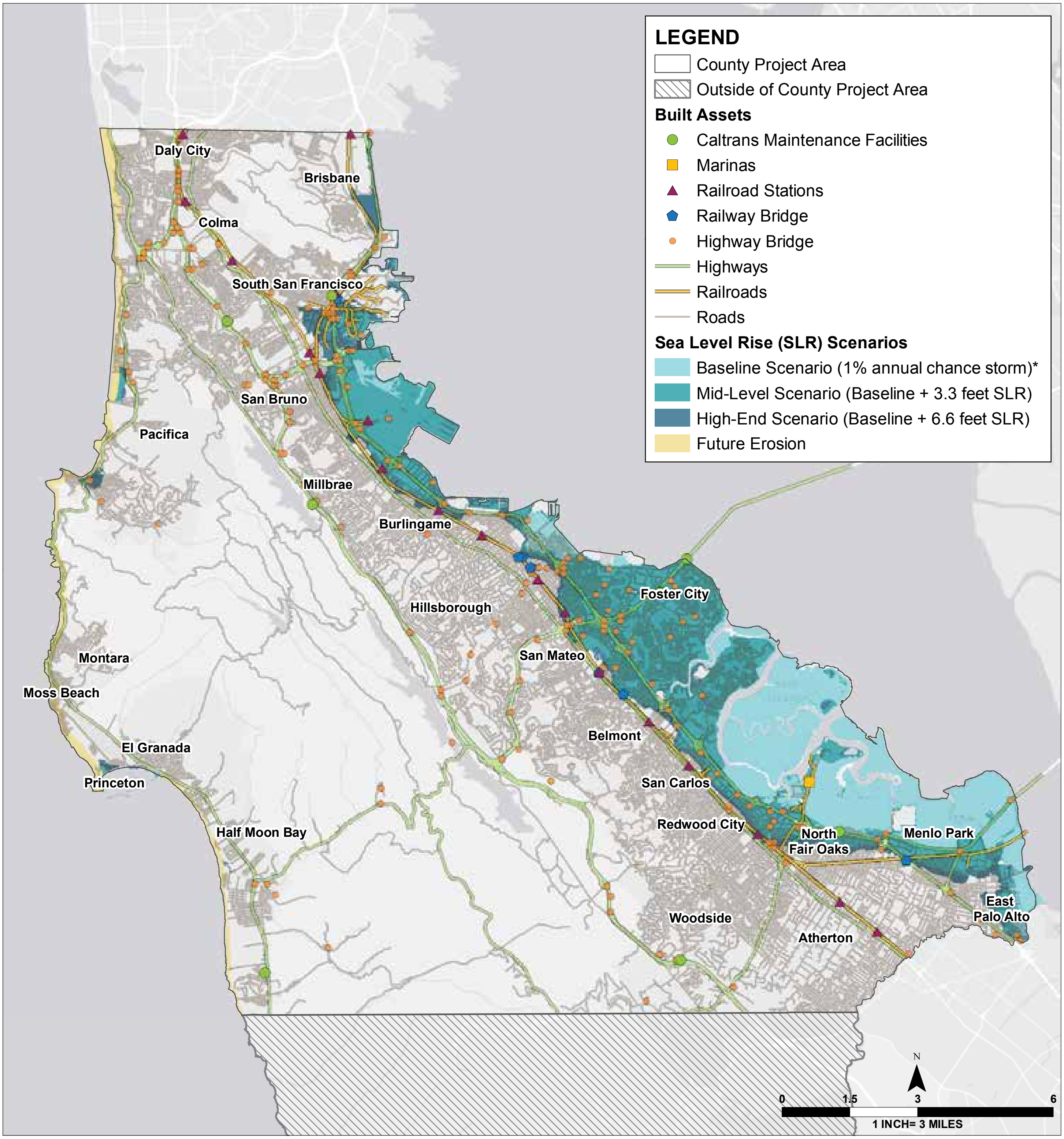
Damage to assets could require repair or replacement, and temporary or permanent loss of public transportation service would be substantial and far-reaching, regardless of the potential for bus bridge service to maintain continuity of service. Major delays are likely, and cancellation of service could occur, both affecting the way that people move about the County, including commuting to work. Some individuals might be able to use personal vehicles instead. However, a loss of public transit options would disproportionally affect many without access to a vehicle, potentially hindering their ability to get to work and other activities. In addition, a switch to personal vehicles could lead to gridlock on already congested freeways. See Section 3C.4.7 Limited Access to Vehicles in Chapter 3C, Community Health and Vulnerability on Communities for more discussion on this topic.

While Class 4 transportation infrastructure includes major highways, Class 3 transportation infrastructure includes local roads and public transit assets. These latter assets are generally not "lifeline" facilities. However, impairment of such assets may still lead to considerable disruption of public health and safety.

"[A] loss of public transit options would disproportionally affect many without access to a vehicle, potentially hindering their ability to get to work and other activities."

[13]Public transportation could also be vulnerable if particular routes are exposed to flooding or erosion, but bus routes were not evaluated. The evaluation of Highways 101 and State Route 1 should serve as a proxy for how routes could be affected.

Figure 3B.10 Local Roads and Public Transit Assets in Project Area



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data source: California Department of Transportation; David Ford Consulting Engineers 2013; California Department of Water Resources; Risk Characterization Study; United States Census Bureau 2015; San Mateo County Transit District 2015; California Department of Fish and Wildlife; Marine Region GIS Unit 2012.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

3B.2.3.6 Community Land Use, Services, and Facilities

Table 3B.15 Community land use, services, and facilities key findings.

BUILT ASSET DESCRIPTION: COMMUNITY AND COMMERCIAL LAND USE, SERVICES, FACILITIES, AND COMMERCIAL	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
This land use includes hospitals, police, corporation yards, and other critical facilities; schools; and residential properties, marinas, and remaining health care facilities. **Risk Class: 2, 3, 4** Vulnerable assets within category (mid-level scenario): • 23 health care facilities, including one hospital with an emergency room • 3 police stations • 8 fire stations • 34 schools • 30,604 residential parcels • 2,235 commercial parcels	• Inundation of commercial and residential building stock • Damage to or loss of emergency care facilities • Flooding at medical facilities, residences, schools, and businesses • Loss of police and fire services • Significant disruption of economic activity	Some health care facilities are required to have measures in place to permit functioning for 72 hours in the event of a flood.	Ownership and management over assets within this category is extremely diverse. Coordinating action and decision-making among these entities will be especially important given residents' reliance on these facilities.

3B.2.3.6.1 Hospitals, Police, and Other Critical Facilities

Table 3B.16 Number and percentage of emergency health care facilities and police stations affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	EMERGENCY HEALTH CARE FACILITIES	EMERGENCY SHELTER SITES	POLICE STATIONS
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	0 (0%)	2 (1%)	0 (0%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	1 (13%)	26 (12%)	3 (18%)
HIGH-END	1% annual chance flood plus 6.6 feet	1 (13%)	36 (17%)	3 (18%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)	0 (0%)	0 (0%)

In San Mateo County, no hospitals with an emergency department are exposed in the baseline scenario, and only one hospital with an emergency department will be exposed to sea level rise in the long term (Kaiser Medical Facility in Redwood City). Given its design, the Kaiser Medical Facility emergency care in the County is moderately vulnerable. The facility is moderately sensitive to flooding and has a higher adaptive capacity than most critical facilities in part because its design incorporated resiliency lessons learned from Hurricane Sandy (see the corresponding AVP for Kaiser Medical Facility, Appendix D). The most vulnerable component of the facility is the entrance/exit ramp, which is low-lying and could impede ambulance arrival. For more discussion on other health care facilities, public health, and sea level rise, see Chapter 3C, Community and Health Vulnerability.

Consequences of a loss of emergency care and other medical facilities

Damage to or loss of emergency care facilities could require repair or replacement of a facility itself, but more importantly, a reduction in the availability of these essential services to the community could occur. Furthermore, flooding at medical facilities could result in direct injury or death or could create additional stresses when already vulnerable patients are forced to evacuate. A loss of a medical facility could also increase the load on other facilities if patients need to be redistributed.

Police and fire stations are considered essential facilities and are key to supporting community needs both in day-to-day and emergency situations. To date, no police or fire stations in the County have been exposed to flooding, and exposure does not occur in the baseline scenario. However, three police and 11 fire stations will be exposed in the long term, and the San Mateo Police Station (see the corresponding AVP, Appendix D) does experience some minor seepage in its underground facilities, although the source of the seepage is not clear. To date, this seepage has not affected operations or caused damage, but national security concerns require that sensitive equipment be stored in basements, and the San Mateo Police Station fleet of vehicles below ground makes the asset vulnerable to any severe seepage or to surface water flooding that enters low-lying facilities. Most police stations and operations are sensitive to flooding because it could affect building occupancy and the ability of personnel to respond to calls. Power systems are sensitive to flooding and could significantly affect police operations.

Fire stations were not evaluated in detail for this analysis. Corporation yards (corps yard) are present in many cities and play a critical role in maintaining city functions; however, this study did not include an exhaustive inventory of corp yards in the County.

In Foster City, for example, the corp yard houses a pump system used to reduce interior flooding, as well as water supply tanks and communications towers that play key roles during emergencies (see the corresponding AVP, Appendix D). Meanwhile, the corp yard in Belmont provides important maintenance for all city vehicles, among other critical functions.

The vulnerabilities of corp yards vary based on the location (and exposure) as well as the primary activities that normally occur on site. If the sites themselves were to flood, inundation could affect the power feed or damage assets and infrastructure on site. In the case of Foster City, however, the lagoon pump system could continue to function because it is powered by diesel. If access to the corp yard was inhibited because of flooding or erosion, services could be reduced considerably because important vehicles (and staff) could not enter.

Consequences of damage to assets or from a loss of service

Damage to essential facilities could require repair or replacement. More importantly, a loss of police and fire services or other emergency operations and essential services could have cascading impacts on the community. If facilities are flooded, response to the greater community would be impaired, with especially severe impacts on more vulnerable or disadvantaged populations who likely have fewer resources (financial, vehicle, social) to cope with emergency situations.

Community land use, services, and facilities are Risk Class 4 assets because of the highly significant impact a loss or impairment of these assets would have to public health and safety. Many assets within this category are critical for protecting public health and responding to small- or large-scale crises. A full count of Class 4 assets that are or will be exposed to a sea level rise hazard is provided in Chapter 3C.

3B.2.3.6.2 Schools

Table 3B.17 Number and percentage of schools affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	SCHOOLS
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	2 (1%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	34 (13%)
HIGH-END	1% annual chance flood plus 6.6 feet	45 (18%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)

Two schools in the County are exposed to near-term flooding, and roughly 45 schools are vulnerable in the long term. Schools are extremely sensitive to flooding because floodwaters entering a building could directly affect teaching as well as the safety of students and staff. Floodwater exposure would likely force closure of a school until water drained from the site and the building could be made safe for occupancy. Near-term adaptive capacity of individual schools and the school system (provided that other schools are not affected by the same flood event) as a whole is moderate relative to other built infrastructure because students could be temporarily or permanently redistributed to other schools in the district or use temporary trailers to continue their education. In the immediate case of a flood hazard, schools are prepared with extra supplies of food and water. More details are provided in the AVP for the Bayside STEM Academy (Appendix D).

Consequences of damage to or loss of a school

Direct exposure to floodwaters could damage the building, requiring repair or replacement. Of greater concern, however, is the potential for injury or death for the students, teachers, and other staff. The loss of the use of a single school would be disruptive to students, staff, and families when students are forced to attend alternate schools. If a school is a designated emergency shelter, a loss of school service could also reduce the number of shelters available for emergencies.

Schools are Class 3 because they are not "lifeline" facilities, but the loss of these facilities would involve considerable disruption to society overall and to public health.

3B.2.3.6.3 Residential Properties, Marinas, and Outpatient Health Care Facilities

Table 3B.18 Number and percentage of outpatient health care facilities and other services affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	OUTPATIENT HEALTH CARE FACILITIES	HUMAN SERVICES AGENCY PARTNER FACILITIES	SENIOR CENTERS
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	0 (0%)	0 (0%)	0 (0%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	22 (41%)	1 (3%)	3 (13%)
HIGH-END	1% annual chance flood plus 6.6 feet	26 (48%)	4 (11%)	4 (17%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)	0 (0%)	0 (0%)

Approximately 2,250 residential parcels could be exposed in the near term, and nearly 36,000 residential parcels could be exposed in the long term. Long-term exposure also includes six mobile home parks and the occupants. Detailed analyses were not performed on individual residences, although most housing stock (buildings and structures) is likely sensitive to flooding and erosion. This sensitivity is because most housing in the County, and particularly mobile home parks, was not designed to be resilient to flooding. The County's housing stock should be evaluated for vulnerability to flooding.

The County has 13 marinas and because of their locations, all would be exposed to the impacts of near- and long-term flooding on both the Bayshore and Coastside. Marinas were not evaluated for this study, but they are likely less sensitive relative to other built assets because docks and boats are designed with water in mind. Wave and surge exposure, but not water level increase alone, could cause damage. Marinas likely have a higher adaptive capacity relative to other assets because docks and piers could potentially be elevated or modified in place to accommodate higher water levels.

Lastly, there are 25 Class 2 healthcare facilities in the County that will be exposed in the long term (none are exposed presently). These facilities were not evaluated in this Assessment, but a discussion on public health and sea level rise is offered in Chapter 3C, Community and Health Vulnerability.

Impacts and consequences of a loss of asset or service

Neither residential parcels or marinas were directly evaluated for their vulnerability and potential consequences of flooding, erosion, and sea level rise, but both could experience direct damages requiring repair or replacement, and both could pose health and safety concerns. In particular, exposure of residential buildings could require long-term use of shelters or other temporary housing, if not permanent relocation altogether.

These facilities are Risk Class 2 assets because failure or loss would not lead directly to widespread social disruption, nor would it entail a significant risk to public health.

3B.2.3.7 Wastewater Systems

Table 3B.19 Wastewater systems key findings.

BUILT ASSET DESCRIPTION: WASTEWATER SYSTEMS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Wastewater infrastructure includes treatment plants (WWTP), wet weather facilities, effluent pump stations, overflow structures and ponds, dechlorination and discharge facilities, and ancillary facilities such as sludge drying beds and out of service oxidation ponds (BCDC 2017). **Risk Class: 3** Vulnerable WWTPs (mid-level scenario): • 5 wastewater treatment plants	• Inundation of external power feeds, which are low lying, would cause a WWTP to cease functioning. • Inundation of pump stations may cause significant flooding in a WWTP. • Saltwater intrusion of WWTP treatment process would disrupt the biological treatment process and could significantly impede or completely shut down the treatment process. • Flooding or secondary impacts of flooding could cause an overflow of untreated waste both at the WWTP and off site. This overflow would have significant impacts to environmental and public health.	Adaptive capacity in the near and long term for WWTPs and pump stations is low because there are typically no alternates to treat the wastewater that will continue to come from the service area irrespective of whether a WWTP and/or pump station has lost service.	Multiple entities manage different components of the wastewater system (e.g., flow conveyance and treatment/discharge).

Table 3B.20 Number and percentage of wastewater treatment plants affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	WASTEWATER TREATMENT PLANTS	WASTEWATER PUMP STATIONS
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	0 (0%)	7 (7%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	5 (63%)	55 (54%)
HIGH-END	1% annual chance flood plus 6.6 feet	7 (77%)	64 (63%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)	4 (4%)

Wastewater infrastructure includes treatment plants (WWTPs), effluent pump stations, overflow structures, dechlorination and discharge facilities, and ancillary facilities such as sludge drying beds and out-of-service oxidation ponds.

The inundation mapping analysis suggests that none of the County’s WWTPs are directly exposed to coastal flooding in the baseline scenario, but seven out of the nine WWTPs could be directly exposed to flooding from much lower probability storms or in the long-term scenario. In addition, many wastewater pump stations (WWPSs) are low lying; seven are exposed to coastal flooding in the baseline scenario and 64 could be exposed over the long term. The AVPs (Appendix D) analyze three exposed WWTPs and one vulnerable WWPSs in San Mateo County: South San Francisco-San Bruno Water Quality Control Plant, Silicon Valley Clean Water WWTP, the Sewer Authority Mid Coastside WWTP, and Pump Station Number 4 in South San Francisco.

The WWTPs have similar vulnerabilities. Specifically, wastewater treatment systems, including pump stations, are highly sensitive to flooding because they depend upon an external power feed, which is very sensitive to flooding. While WWTPs and pump stations have backup power generation, utilizing it relies on keeping the power distribution system (switchgear) dry. It is common, however, to co-locate power distribution with the power feed. Consequently, if one is flooded, the other is likely flooded as well. A power loss could create a total loss of service at a WWTPs or WWPSs until power could be restored. In general, WWTPs and WWPSs are also sensitive to saltwater intrusion, which affects the biological treatment processes; saltwater could enter a WWTP by direct coastal flood exposure or by means of a WWPS.

Adaptive capacity in the near and long term for WWTPs and WWPSs is low because typically no alternate WWTPs or WWPSs are available to treat the influent (wastewater) that will continue to come from the service area irrespective of whether a WWTP and WWPS has lost service. A review of the three WWTPs found that there are generally no on-site emergency measures that enable the plants and pumps to function in the event of a power failure, and no floodproof backup or redundant power systems. In many cases, however, staff are on site at all times, which improves the ability to respond in an emergency. Actions to improve adaptive capacity significantly, such as mitigating or floodproofing the electrical system, would require adaptation.

Impacts and consequences from a loss of asset or service

Damage to or the loss of wastewater treatment services from a health and safety perspective could be significant. A loss of function occurs on a spectrum. At the high end, a loss could create overflow both at the plants and off site, potentially leading to sewage backup in manholes. Any wastewater overflows could create a serious public health hazard and environmental damage, similar to what occurred during Hurricane Sandy in October 2012 when the Bay Park Sewage Treatment Plant was flooded and spilled untreated sewage into the surrounding waterways.

Wastewater treatment services are Risk Class 3 assets because they are not necessarily lifeline facilities, but facility loss or damage would cause considerable disruption to public health and safety and the environment.

3B.2.3.8 Stormwater and Interior Drainage

Table 3B.21 Stormwater and interior drainage key findings.

BUILT ASSET DESCRIPTION: STORMWATER SYSTEMS AND INTERIOR DRAINAGE	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
The stormwater management system includes storm drains and pipes that connect to flood control infrastructure such as creeks, channels, culverts, pump stations, and outfalls along the Bay. Drains collect urban runoff, and underground pipes convey flows either by gravity or by pumping to a discharge location (outfall). **Risk Class: NA** Vulnerable stormwater assets (mid-level scenario): • All tide gates (This Assessment did not include a comprehensive inventory of tide gates in the County because data were unavailable at the time.) • 51 stormwater pump stations • 112 miles of storm drains	• Rainstorms and high tides could coincide and prevent creeks or channel flows from discharging into San Francisco Bay or the Pacific Ocean. This could result in creek and channel overflow and significant local flooding. • Inundation of pump stations could impair local flood mitigation capacity and cause more extreme flood conditions in adjoining properties and neighborhoods. • Overflow of interior drainage infrastructure from insufficient capacity can inundate nearby areas. • Flood conditions may damage culverts, pump stations, canals, and other stormwater infrastructure, resulting in costly repairs.	Stormwater infrastructure can be modified to enhance drainage capability. Green infrastructure or nature-based solutions can increase the ability of stormwater infrastructure by reducing or delaying discharge downstream, while also providing other water-quality and habitat benefits.	Cities are responsible for zoning and other land use decisions that can affect the amount of stormwater runoff. Therefore, a high degree of coordination between the County and the cities is necessary to manage stormwater in an integrated, proactive way.

Table 3B.22 Number and percentage of stormwater and interior drainage infrastructure affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	STORM DRAINS (MILES) (GREATER THAN 2 FEET IN DIAMETER)	STORMWATER PUMP STATIONS (NUMBER)	OUTFALLS (NUMBER)
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	14.8 (3%)	12 (15%)	32 (9%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	111.5 (22%)	51 (63%)	182 (49%)
HIGH-END	1% annual chance flood plus 6.6 feet	136.1 (27%)	63 (78%)	209 (57%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	4.1 (1%)	3 (4%)	7 (2%)

Stormwater systems, including culverts, canals, and pumps, aim to reduce the extent and depth of interior or stormwater flooding. Exposure of stormwater infrastructure is substantial; 13 of 84 stormwater pump stations are exposed to flooding in the baseline scenario, and up to 68 could be exposed in the long term. Similar to wastewater pumps, power systems for stormwater pumps are highly sensitive to flooding, and coastal flooding could therefore render stormwater pumps inoperable, potentially exacerbating the depth and extent of any coastal or interior rain-driven flooding. Furthermore, some of the existing stormwater infrastructure has insufficient pumping capacity to meet current demands (such as the O'Connor Pumping station in East Palo Alto) or insufficient drainage capacity (such as the Bayfront Canal), or it is in need of upgrade (such as the Highline Canal Tide gate—see the corresponding AVP, Appendix D). In some cases, culverts designed to drain water from the interior of the County out to San Francisco Bay are buried in sediment, and therefore the water backs up on land. The adaptive capacity of existing stormwater infrastructure is low, though it can be modified to enhance drainage capacity. Green infrastructure, or nature-based solutions, have been shown to increase the ability of infrastructure by reducing or delaying the discharge of water downstream, while also providing additional water-quality and habitat benefits.

Impacts and consequences of a loss of assets or service

If a pump station or other component of a stormwater management system ceased to function during a flood event, flooding would likely occur in adjoining properties and neighborhoods. Damage to culverts, pump stations, canals, and other stormwater infrastructure could result in costly repairs or replacement being needed. The more significant impact comes from the loss of service of these infrastructure. Specifically, a loss of function of stormwater infrastructure means that any coastal flooding or high coastal water that coincides with high rainfall or creek levels will be exacerbated because stormwater infrastructure will not be able to reduce the depth and extent of interior flooding or ponding. This situation could in turn increase the frequency and severity with which people, property, and other infrastructure are flooded, leading to damage and potential injury or other health and safety concerns.

Stormwater and interior drainage infrastructure are Risk Class 3 assets because they are not necessarily lifeline facilities for members of the public, but their loss or damage would cause considerable disruption to public health and safety and the environment.

3B.2.3.9 Seaports

Table 3B.23 Seaports key findings.

BUILT ASSET DESCRIPTION: SEAPORTS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Seaports are locations along the Coast or Bay that facilitate the transfer of people and goods to or from ships and land. Maritime facilities at seaports include wharves, roads, rail infrastructure, and buildings for tenants and administration. **Risk Class: 3** Vulnerable seaports (mid-level scenario): • Port of Redwood City (Port)	• Inundation of Port access roads and railways would make it impossible for trucks and trains to access the Port leading to a loss of operations. Closure of the Port, which would disrupt the delivery of goods and services, could have broader regional economic impacts. • Without the use of the Port for shipping goods, local roads and interstate systems could see an increase in traffic. • Hazardous contaminants present at the Port could be released into the Bay, which could be harmful to the life and safety of plants, animals, and residents of the area.	There is limited redundancy in Bay Area ports, and if the Port of Redwood City was flooded, cargo loads could increase in surroundings ports, including the Port of Oakland.	The Port owns 120 acres, 40 of which are leased to tenants. The Port officially manages this property, though it shares some property management decisions with tenants, leading to some complex and negotiated management decisions.

Table 3B.24 Number and percentage of seaports affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	NUMBER AND PERCENTAGE OF SEAPORTS AFFECTED
BASELINE	1% annual chance flood (also known as the “100-year flood”) at mean higher high water	1 (100%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	1 (100%)
HIGH-END	1% annual chance flood plus 6.6 feet	1 (100%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	0 (0%)

The Port of Redwood City (the Port) is the County’s only port, and it was found to be moderately vulnerable to the impacts of sea level rise. Relative to other built infrastructure, primary port operations are less sensitive to flooding and have a greater near- and long-term adaptive capacity than other assets. Ships can still reach the wharf and could delay unloading and loading until a storm passes; similarly, wharves and other port infrastructure are built on the waterfront and are regularly exposed to marine environments, so they would be less likely to suffer severe damage in the near term. If needed, though not without economic implications, port operations could be moved to one of the other public ports on San Francisco Bay. Despite other nearby ports, redundancy is still limited overall. In the long term, because port infrastructure is already waterfront infrastructure and is built for frequent changes in water elevation as well as minor storms, adapting to sea level rise may be less complex relative to other assets. More detail on the Port is provided in Appendix D, Asset Vulnerability Profiles.

Impacts and consequences from damage to or a loss of asset or service

Impacts of flooding or a loss of service at the Port could be severe because of the potential release of any hazardous materials stored on port property, or from the economic disruption that comes when trains or trucks transporting goods are unable to reach the Port because of short- or long-term closures of the facility and Seaport Boulevard. This circumstance would disrupt the delivery of goods and services regionally, which would affect business activity and could put employees out of work.

Seaports are Risk Class 3 assets because they are not necessarily lifeline facilities, but their loss or damage would cause considerable economic disruption.

3B.2.3.10 Homeless Shelters

Table 3B.25 Homeless shelters key findings.

BUILT ASSET DESCRIPTION: HOMELESS SHELTERS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
There are over 1,200 single homeless adults in the County (San Mateo County Human Services Agency 2015), and each of the exposed homeless shelters face unique challenges related to sea level rise. This study did not include a comprehensive inventory of vulnerable homeless shelters in the County. **Risk Class: N/A** Vulnerable homeless shelters (mid-level scenario): • At least two homeless shelters, including LifeMoves Maple Street Shelter and the Samaritan House in South San Francisco	• Inundation of the LifeMoves Maple Street Shelter would incur significant costs to repair or replace the facility. Replacement of the shelter could cost over $5 million. • Disruption of homeless shelter services could negatively affect a shelter's residents, who are already a vulnerable population.	The adaptive capacity of homeless shelters and homeless people is low both in the near and long terms. If a single homeless shelter was closed, it would be difficult to find near-term housing options for those residents because most shelters are at capacity. In the long term, the housing crisis in the County and the San Francisco Bay Area makes finding additional buildings for shelters particularly difficult.	In the case of the LifeMoves Maple Street Shelter, different agencies or organizations own the property, manage it, and have jurisdiction over the area where it is located. Other shelters may have similar arrangements.

Over 1,200 single homeless adults are in the County (San Mateo County Human Services Agency 2015), and any of the exposed homeless shelters face particular and unique challenges related to sea level rise. This study did not include a comprehensive evaluation of homeless shelter vulnerability. The County has 12 shelters at present, and a detailed discussion on one vulnerable shelter can be found in Appendix D (see AVP on the LifeMoves Maple Street Shelter). The nature of the vulnerability of homeless shelters is tied closely to the particular vulnerabilities of the clients and the regional affordable housing crisis. If a facility was flooded, clients would likely need to evacuate until floodwaters receded and the facility was safe again for occupancy.

The adaptive capacity of homeless shelters and homeless people is low both in the near and long term. For example, if a single homeless shelter was closed, it would be difficult to find near-term housing options for the residents because most shelters are at capacity. In the long term, the housing crisis in the County and the San Francisco Bay Area makes finding additional buildings for shelters particularly difficult. Furthermore, an individual homeless person likely has few if any alternatives for affordable housing. Adaptation will need to consider either location or building design that would ensure clients could remain safely in the building with minimal disruption.

Impacts and consequences from damage or loss of service

In addition to costs associated with repairing or replacing a shelter, any disruption to a homeless shelter would add stress and complication to the daily lives of an already vulnerable group of people and could pose an immediate health and safety hazard that could result in injury or death.

Homeless shelters are Risk Class 3 assets because they are not necessarily critical pieces of infrastructure for society to function, but their loss or damage would cause a considerable disruption to public health and safety.

3B.2.3.11 Parks and Recreation Areas

Table 3B.26 Parks and recreation areas key findings.

BUILT ASSET DESCRIPTION: PARKS AND RECREATION AREAS	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	ADAPTIVE CAPACITY	GOVERNANCE ATTRIBUTES
Parks and recreation areas include city- and County-owned parks, trails, and other open space preserves. These areas provide free or low-cost recreational opportunities for County residents and visitors. **Risk Class: 1** Vulnerable parks and recreation areas (mid-level scenario): • 79 parks Countywide • Portions of the San Francisco Bay Trail • Portions of the California Coastal Trail	• Loss of trails due to erosion might lead to reduced recreational opportunities for lower-income residents, reduced tourism, and overcrowding in parks not affected by sea level rise. • Temporary and permanent inundation of trails and park space could lead to inundation through overflow of shoreline levees, creeks, or backup of drainage systems.	If space exists, trails can be easily moved inland over time as bluffs or cliffs erode.	Parks and recreation areas may be governed and operated by different agencies, nonprofit organizations, private entities, or land trusts. Some trails and parks on the shoreline may be under the jurisdiction of BCDC or the Coastal Commission.

Table 3B.27 Number of recreational assets affected by sea level rise scenarios.

SCENARIO	SCENARIO DESCRIPTION	PARKS	TRAILS (MILES)	FISHING PIERS
BASELINE	1% annual chance flood (also known as the "100-year flood") at mean higher high water	18 (6%)	12.8 (5%)	5 (45%)
MID-LEVEL	1% annual chance flood plus 3.3 feet	79 (27%)	55.2 (19%)	7 (64%)
HIGH-END	1% annual chance flood plus 6.6 feet	97 (33%)	69.2 (24%)	8 (73%)
EROSION	The projected extent of coastal erosion expected, assuming a sea level increase of approximately 4.6 feet (1.4 meters)	28 (9%)	22 (8%)	1 (9%)

The exposure analysis suggests that roughly 13 miles of trails and 18 parks are exposed in the near term (baseline scenario) and about 90 miles of trails and over 100 parks could be exposed in the future. The near-term sensitivity of trails and parks is likely moderate, and it depends on the degree of exposure to erosion or flooding. For example, minor erosion may only cause settling or a crack in the trail; however, a severely eroded bluff could cause the trail section to collapse, prohibiting use. A flooded trail or park would also likely require temporary closure; however, in both cases, trail users could potentially take an alternate route or visit a different park. Once water drained from the trail or park, it could likely reopen rather quickly. The adaptive capacity of trails and parks in the long term is high relative to other built assets because relocating a trail inland of an erosion and flood hazard area may be more straightforward than other modifications, and people often create their own "social trails" by walking a new path when sections become impassable. If parks were permanently lost because of erosion or permanent flooding, finding more open space to relocate a park might be difficult; however, a park might be able to adopt different types of recreational activities. More details on the vulnerability of trails is provided in the AVP on the California Coastal Trail (CCT) (Appendix D, Asset Vulnerability Profiles).

Impacts and consequences of damage to or loss of recreational facilities

Damage to recreational facilities could require repair or replacement. Depending on the timing of use and storms, exposure could result in injury to visitors, though this risk is expected to be low. However, the greater concern related to damage to parks and recreational assets is the near- and long-term loss of recreational opportunities to nearby communities. In addition, many recreational opportunities, particularly those along the coast, draw many visitors and generate economic activity for businesses that serve them. A loss of recreational opportunities could therefore result in a loss of economic activity in the region.

Parks and recreation areas are Risk Class 1 assets that would pose a low risk to public health should they be inundated or exposed to erosion. Class 1 assets provide high value to the County, however, and include features that make the County a desirable place to live.

3B.2.3.12 Built Asset Conclusion

Assessing vulnerability according to asset categories is a critical approach in organizing and clarifying information, but this analysis is incomplete unless these individual snapshots of vulnerability are somehow assembled into a larger whole. The AVPs in Appendix D and Inventory in Chapter 3C provide even greater detail about specific assets and locations, yet one might still be left wondering what it all means. A more complete understanding of vulnerability centers on understanding how these assets are interlinked and what must occur systemically for these vulnerabilities to be addressed. To the extent possible, Section 3A.3, Cross-Cutting Vulnerability and Cascading Impacts in Chapter 3A, Setting and Context addresses the question of how one might begin to think system-wide about built asset vulnerability.

3B.3 From Vulnerability to Resilience

The County and each of its cities and communities are faced with a significant challenge in meeting sea level rise. Solutions must address infrastructural deficiencies and the environmental context that lead to vulnerability. To be truly pragmatic, however, they must also consider the broader picture of governance and policy-making. Approaching this slow-moving emergency one agency, department, or city at a time will not produce viable or timely solutions.

What does a solution for sea level rise look like? What should such a solution accomplish? Chapter 1 discusses resiliency and adaptive capacity as central concepts in the path forward. Our County will definitely continue to see the effects of sea level rise in the coming years, and our County will certainly continue to experience periodic and extreme storms. We can learn to adapt and to begin to cope with these matters in ways that preserve our society's "essential function, identity, and structure" (IPCC 2014). By building adaptive capacity into our systems, we can begin to adjust to and to respond skillfully to environmental change, rather than repeatedly suffer the catastrophic infrastructural and societal failures that will ensue if we do nothing.

How do we get there? Should we respond in a way that is reactive or planned? So far, our governing agencies have not had to deal with an issue of this magnitude, and planning far in advance for a single agency, much less a dozen, is a significant challenge. What will these responses look like, and how will the solutions that emerge function? And to what end? What kinds of risk and vulnerability are we willing to accept given the limitations we confront on a daily basis? This report cannot address these essential questions, but the next phase of planning within the County and each city will delve into them.

Our energy infrastructure, places of work and play, homes, roads, schools, emergency health facilities, wetlands, and much more will be affected by sea level rise. Chapter 3 makes this abundantly and unavoidably clear. Beyond the array of data that this chapter presents, several aspects of our path forward are clear. We, the County and every city and community within it, must engage in a collaborative planning process. What is done by one will affect the others. We should prepare truly long-term planning efforts that take sea level rise into account. These efforts will involve updating many policy documents and ordinances at multiple levels of government. And finally, as Chapter 4 discusses, we must forge ahead in researching a range of adaptation measures and investigate the feasibility of implementation.

"By building adaptive capacity into our systems, we can begin to adjust to and to respond skillfully to environmental change, rather than repeatedly suffer the catastrophic infrastructural and societal failures that will ensue if we do nothing."

CHAPTER 3C COMMUNITY AND HEALTH VULNERABILITY

CHAPTER 3C COMMUNITY AND HEALTH VULNERABILITY

3C.1 Introduction

Sea level rise poses acute challenges for the County and has the potential to create serious near- and long-term public health impacts. This could include aggravating existing health conditions and causing new health risks and diseases through direct and indirect exposure, as well as through social and economic disruption. Many of the County's cities and communities are home to residents and population groups that are especially vulnerable to the health impacts of sea level rise and near-term flooding.

This chapter describes the likely near-term direct and indirect impacts of flood inundation on public health-related infrastructure and on public health and safety, as well as the likely long-term impacts. This section first provides a high-level overview of the overall health impacts from flooding and then identifies existing health, demographic, and social characteristics that place a greater health burden on some groups than others. Though a separate public health analysis was not part of this study, general information for this section is provided by the AVPs, the additional data analysis, and existing health impacts research.

Photo credit: San Mateo County Flickr.

"Many of the County's cities and communities are home to residents and population groups that are especially vulnerable to the health impacts of sea level rise and near-term flooding."

Table 3C.1 Community health and vulnerability key findings.

COMMUNITY AND HEALTH VULNERABILITY DESCRIPTION	IMPACTS AND CONSEQUENCES OF SLR INUNDATION	CONCENTRATIONS OF VULNERABILITY	ADAPTIVE CAPACITY

Sea level rise will present a disproportionately severe impact to populations with existing social vulnerability characteristics including:
• Children and the elderly
• People of color
• People with
  • Limited English proficiency
  • Limited education
  • Low/limited income
  • Poor and/or unstable housing conditions
  • Limited access to vehicles
	In the event of a major flood event County communities could experience the following impacts:
	• Disruption of medical services and impairment of medical facilities
	• Physical injury or death resulting from flooding, infrastructural failure, and exposure to toxic substances
	• Spread of infectious diseases
	• Negative mental health impacts
	• Negative impact to individuals with chronic health conditions
		• Areas with increased community vulnerability (areas with three or more of the above characteristics) are located throughout the County but concentrated in the northern and coastal areas of the County, as well as along the Highway 101 corridor (i.e., East Palo Alto and Redwood City).
		• Even a small amount of flooding could be devastating to these residents because of limited access to emergency services, housing and employment instability, prevalence of chronic diseases, and other conditions.
			Adaptive capacity is highly dependent on specific community attributes. Overall, residents experiencing social and economic vulnerability will have less adaptive capacity than others.

3C.2 Overview of SLR Impacts to Public Health

Unless otherwise noted, the public health, and safety impacts and issues addressed in this chapter are found in the 2016 report, Climate and Health Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms (San Francisco Department of Public Health 2016) and were adapted to reflect issues and impacts specific to the County. According to this report, the near- and long-term health impacts of flood inundation, as observed through the aftermath of other extreme flooding events across the country, may be categorized into several types of impacts and are described in the paragraphs below.

Sea level rise and flooding increase the risk of injury, death, disease, mental stress, and displacement, as well as the risk of disruption of medical services and infrastructure (Public Health Institute and Center for Climate Change and Health 2016). The following section includes brief descriptions of each type of health impact, coupled with examples of the types of assets and population groups that would be affected by flooding as a result of sea level rise or storm surges.

3C.2.1 Disruption of medical services and health-supporting infrastructure

The County is home to dozens of public health facilities, which provide emergency and nonemergency health care to both inpatients and outpatients. These facilities include critical facilities such as police and fire stations, hospitals, hospices, clinics, recreation centers, emergency and homeless shelters, and doctor's offices. Many of these facilities, mostly police and fire stations, are located within the boundaries of the high-end sea level rise flood inundation scenario where they will be affected by flood inundation in the long-term. Generally, health-related infrastructure could be damaged and require replacement or repair in the case of inundation. Depending on the sensitivity and adaptive capacity of the infrastructure, the essential services these facilities and their staff provide, including bed capacity, could be reduced or lost for a period of time. Patients may need to be evacuated and hospitals may require an extended period of time to start functioning at full capacity (Public Health Institute and Center for Climate Change and Health 2016). Clients that are elderly or frail could experience considerable challenges in an evacuation.

In addition, the transportation network that connects people to public health facilities may become damaged or obstructed during flooding. Persons most vulnerable to the temporary loss of this infrastructure are the elderly, young children, and those with pre-existing medical conditions. Disruption to the chain of health care services in an emergency could prevent vulnerable persons from receiving or reaching the medical care they need. Depending on the extent of damage and the adaptive capacity of the facility, patients may even need to be evacuated from the affected facility, causing additional stress, injury, or fatality (Public Health Institute and Center for Climate Change and Health 2016). In addition, in-home care for residents dependent on operating medical equipment's to manage pre-existing health conditions could be disrupted due to loss of electricity and power outages.

3C.2.2 Physical Injury or death

Flooding and inundation can result in physical injury or death due to trauma or drowning. Physical injuries experienced as a result of flood inundation largely occur during or immediately after the flood event, typically due to wet, slippery, and flooded roads. Common injuries include sprains, blunt trauma, animal bites, and nonfatal electrocution (San Francisco Department of Public Health 2016). During inundation events, strong winds could knock over powerlines, and intense precipitation could cause streets to flood and stormwater and wastewater systems to overflow, increasing the risk of the common injuries mentioned above occurring. Local flooding events like the 1998 and 2013 flooding of the San Francisquito Creek and the 2014 Belmont Trailer Park flood endangered both lives and property. In seeking shelter, residents may experience blunt trauma from falling or floating debris. Motor vehicle collisions may occur in the event of flooding, also potentially causing blunt trauma or death, and people may trip on debris after the flood has subsided, get bitten by animals that are loose on the street, and may even experience electrocution from fallen powerlines hidden in pooled water or short-circuited wires in flooded basements.

In addition to the injuries or deaths caused during or right after the storm event, there is also a likely health risk caused through carbon monoxide poisoning throughout the flooding/storm event, that is, "pre-disaster, recovery and post recovery" (Waite et al. 2014). Indoor use of portable generators and cooking and heating appliances designed for outdoor use after power outages and continued use of damaged appliances such as boilers

Photo credit: Jack Sutton, Flickr.

can result in death, even months after the flood event. In 2008, eight people, including children were hospitalized for carbon monoxide poisoning due to use of a generator after power was cut off to their home (The Daily Journal 2008).

3C.2.3 Infectious Disease

Sea level rise influences the spread of infectious diseases through a number of mediums—food, water, and air. In addition to the direct health hazards associated with flooding and storm surges mentioned above, other indirect health hazards appear after the flooding event has occurred.

Vector-borne Diseases

Sea level rise will lead to more standing water as a result of inundation by major storm events. Standing water can provide a breeding place for disease-carrying insects like mosquitos, and increased populations can, in turn, spread diseases such as the West Nile Virus, dengue fever, and malaria. Homeless residents, residents living in high-risk flood zones or low-quality buildings, and farm workers and other outdoor laborers are among the more vulnerable to vector-borne diseases triggered by sea level rise.

Respiratory Diseases

Flood inundation along the Bayshore and/or rising groundwater tables could increase the rate of internal and external mold growth and fungi and decrease both indoor/outdoor air quality. Exposure to mold in damp or flooded buildings, roadways, and other infrastructure can increase the rates of respiratory illnesses such as asthma, respiratory allergies, and airway diseases (Florida Institute for Health Innovation 2016).

Contamination and Waterborne Diseases

Waterborne illnesses may occur both in the near-term and long-term following inundation. In the near term, flooding at facilities where hazardous materials are stored, including toxic waste or chemical storage sites and public health facilities such as hospitals, clinics, and hospices, could release harmful chemicals into the nearby environment. Such releases would pose a health and safety risk to those who may come into contact with the contaminated water.

Flooding in buildings where there is leaky or broken plumbing or overflow from sewer systems could result in the release of harmful bacteria, such as Escherichia coli (E. coli). In the case of a sewage or waste water treatment overflow, E. coli could contaminate drinking water and increase the risk of waterborne gastrointestinal disease. In 2014, the Belmont Trailer Park Flood forced the evacuation of people because of fears of water contamination. Heavy rains and flooding can also inundate the ability of sewage treatment plants to treat water, and partially treated water can overflow to the Bay, increasing the risk of diseases to humans and aquatic life. Other potential waterborne diseases may include: waterborne shigella, protozoal infections such as giardia, and parasitic, bacterial, and viral infections.

In the long-term, drinking water sources may become compromised from saltwater intrusion or from rising groundwater tables that mobilize contaminants. Areas more likely to experience these impacts include registered disposal sites, landfills, or other sites containing hazardous materials.

Foodborne Illness

Following extensive flooding and other extreme weather events, communities could experience an outbreak in foodborne illnesses. The illness may stem from spoiled perishable food being left at room temperature after a power outage disrupted refrigeration. In vulnerable populations with pre-existing conditions or allergies, foodborne illness and/or food contamination can aggravate or cause respiratory and/or allergic conditions. Combined with temporary disruption or loss of access to medical facilities, this situation could be fatal for vulnerable groups such as the young and elderly populations.

3C.2.4 Mental Health, Displacement, and Income Loss

Flooding can result in posttraumatic stress disorder, anxiety, depression, and other mental health and chronic health problems. Persons with existing mental health disorders will likely need more help than before the flooding. Flooding or other hazardous impacts of sea level rise could result in the permanent or temporary loss of homes, and potential job loss for people whose workplaces are flooded or otherwise affected by sea level rise. Income and housing are cornerstones of health, and people with financial stability and stable housing tend to be healthier (County of San Mateo et al. 2015). Loss of income and financial insecurity due to social and economic disruptions makes it difficult for people to afford and meet basic needs, including food and medical expenses leading to higher rates of depression and stress, and subsequently more health problems (County of San Mateo et al. 2015). Temporary or permanent housing displacement disrupts social support systems and job stability and increases risk of posttraumatic stress, depression and suicide and an overall increase in chronic illnesses and mental health problems.

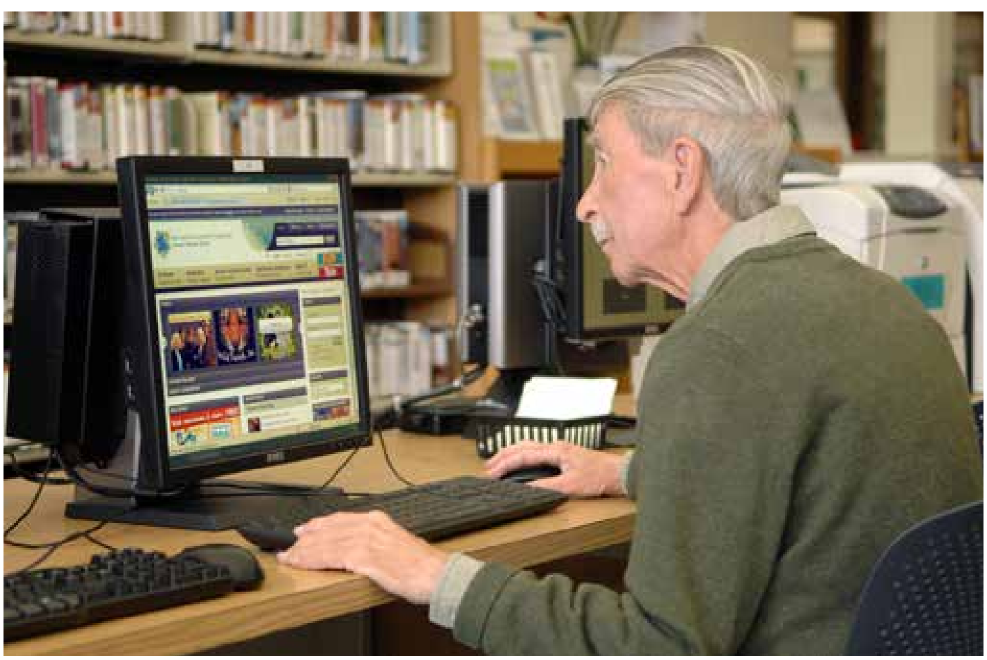


Photo credit: San Mateo County Flickr.

3C.3 Existing Health Conditions That Increase Vulnerability

Individuals with existing health conditions are most susceptible to the impacts of sea level rise and flooding. As a risk factor for sea level rise impacts, health conditions can exacerbate the negative effects of climate change (Florida Institute for Health Innovation 2016). Existing health conditions can present additional challenges for individuals in preparing for, responding to, and recovering from flooding.

3C.3.1 Chronic diseases

Chronic diseases are ones that typically last three months or more, such as asthma, diabetes, heart disease, obesity, and cancer. Chronic diseases are often exacerbated by climate change–related events; they are often a risk factor for increased illness and death due to events such as heat stress or flooding. Medication and access to care may be interrupted during and after flooding, and individuals with chronic diseases who lack necessary care may see exacerbated symptoms and require hospitalizations (San Francisco Department of Public Health 2016). Individuals with chronic disease are more likely to be low income or a person of color, heightening vulnerability to sea level rise (World Health Organization 2017, Centers for Disease Control and Prevention 2013a).

To minimize sea level rise vulnerability, chronic disease in the County must be taken into account (Table 3C. 2). Nearly 41% of adults (238,589) report one or more chronic health conditions like heart disease, diabetes, asthma, severe mental stress, or high blood pressure in the County (Maizlish et al. 2015).

Table 3C.2 Selected chronic diseases and sea level rise vulnerability.

CHRONIC DISEASE	ESTIMATED IN SAN MATEO COUNTY*	VULNERABILITY TO SEA LEVEL RISE**
Asthma	15% of adults (87,127) 11% of children (17,339)	Exacerbated by indoor dampness, mold, pollen, and poor air quality from air pollutants; medication and continuing care needs may increase vulnerability
Diabetes	8% of adults (43,852)	Increased sensitivity to heat stress; medication, continuing care, and dietary needs may increase vulnerability
Heart disease	6% of adults (32,312)	Increased sensitivity to heat stress; medication and continuing care needs may increase vulnerability
Obesity	19% of adults (108,476)	Increased sensitivity to heat stress

* Source: California Health Interview Survey 2014
** San Francisco Department of Public Health 2016 and U.S. Global Change Research Program (USGCRP) 2016.

3C.3.2 Disability

A disability is any condition of the body or mind (also considered an impairment) that makes it challenging for an individual to participate in normal life activities. There are multiple types of disabilities, such as impairments of vision, movement, thinking, communicating, hearing, and mental health, and the severity of a disability can vary greatly (Centers for Disease Control and Prevention 2015). According to the American Community Survey, 8% of County residents (or 58,592 residents) have a disability.

Persons with disabilities are more likely to experience demographic and social vulnerability compared with other groups. Disability status is most likely to occur among the elderly and those who experience social isolation, lower educational attainment, poverty, and poor housing conditions. This factor leads to further poor health outcomes and exacerbates sea level rise vulnerability (San Francisco Department of Public Health 2016, USGCRP 2016).

Persons with disabilities may be especially vulnerable to sea level rise and flooding. During and following flooding, they may experience challenges in evacuating to safety or accessing food, medicine, and necessary services. They are more likely to rely heavily on resources and services compared with other groups (San Francisco Department of Public Health 2016). Therefore, they may require certain accommodations and planning in preparing for, responding to, and recovering from flooding. Failure to accommodate these needs may cause injury or death (Kailes and Enders 2007).

3C.3.3 Mental illness

Mental illnesses are health conditions related to changes in thinking, mood, or behavior that lead to distress or impaired functioning. Mental illness, especially depression, is strongly associated with incidence of chronic diseases, creating additional health burdens for individuals with mental illness (Centers for Disease Control and Prevention 2013b). According to the 2014 California Health Interview Survey, 3% of adults in the County (or 16,733 adults) have experienced serious psychological distress. One in five adults experience some level of mental illness according to the 2012 California Mental Health and Substance Abuse Needs Assessment.

Experiencing a major hazard event such as flood can worsen existing mental illnesses or cause new episodes for many residents. Individuals with mental illnesses are especially vulnerable during flooding-related events, which often results in an increase in the percentage of adult population with posttraumatic stress disorder and severe to moderate mental illness (Public Health Institute and Center for Climate Change and Health 2016), requiring more assistance than prior to the event. The period immediately following the event will place a high demand on services because the general population will experience feelings of loss, helplessness, and anxiety, which may exacerbate the inability of residents to appropriately respond to the event or provide for their own safety.

Flooding and even a perceived threat of sea level rise can impact mental health. Mental and emotional effects of a flood or major event caused by sea level rise can include stress, anxiety, depression, posttraumatic stress disorder, and substance abuse. People with mental illnesses and those using medication to treat mental illnesses are particularly vulnerable to extreme climate-related events. The short- or long-term displacement that often results from floods can also create another mental health stressor. Residents that are socially isolated and low-income households are especially vulnerable to the mental health impacts associated with a flood event. Demand for services and supports will be high following a flooding event and will increase as residents run out of medications or are unable to get the support that they need.

3C.4 Existing Demographics That Increase Social Vulnerability

Some populations have a heightened vulnerability to sea level rise impacts due to having certain sensitivities, an increased likelihood of exposure, or a lower adaptive capacity (Association of Bay Area Governments [ABAG] 2015, Public Health Institute and Center for Climate Change and Health 2016, USGCRP 2016). Demographic and social characteristics may affect the abilities of an individual or household to prepare for, respond to, and recover from sea level rise, contributing to their overall vulnerability. Characteristics may include biological traits that affect physical ability and health or socioeconomic factors that amplify risk factors for poor health conditions (EPA 2017). Specific attributes may create additional stresses on individuals and communities contributing to reduced resiliency in the event of a flood. Many of these factors may also be exacerbated by the specific, localized nature of flooding, erosion, and other impacts associated with sea level rise.

Based on existing research on vulnerability to sea level rise, the following indicators represent key demographic and social characteristics of individuals and households that affect their ability to prepare for, respond to, and recover from sea level rise.

- Age
- Race and ethnicity
- Language
- Education
- Income
- Housing vulnerability
- Access to vehicles

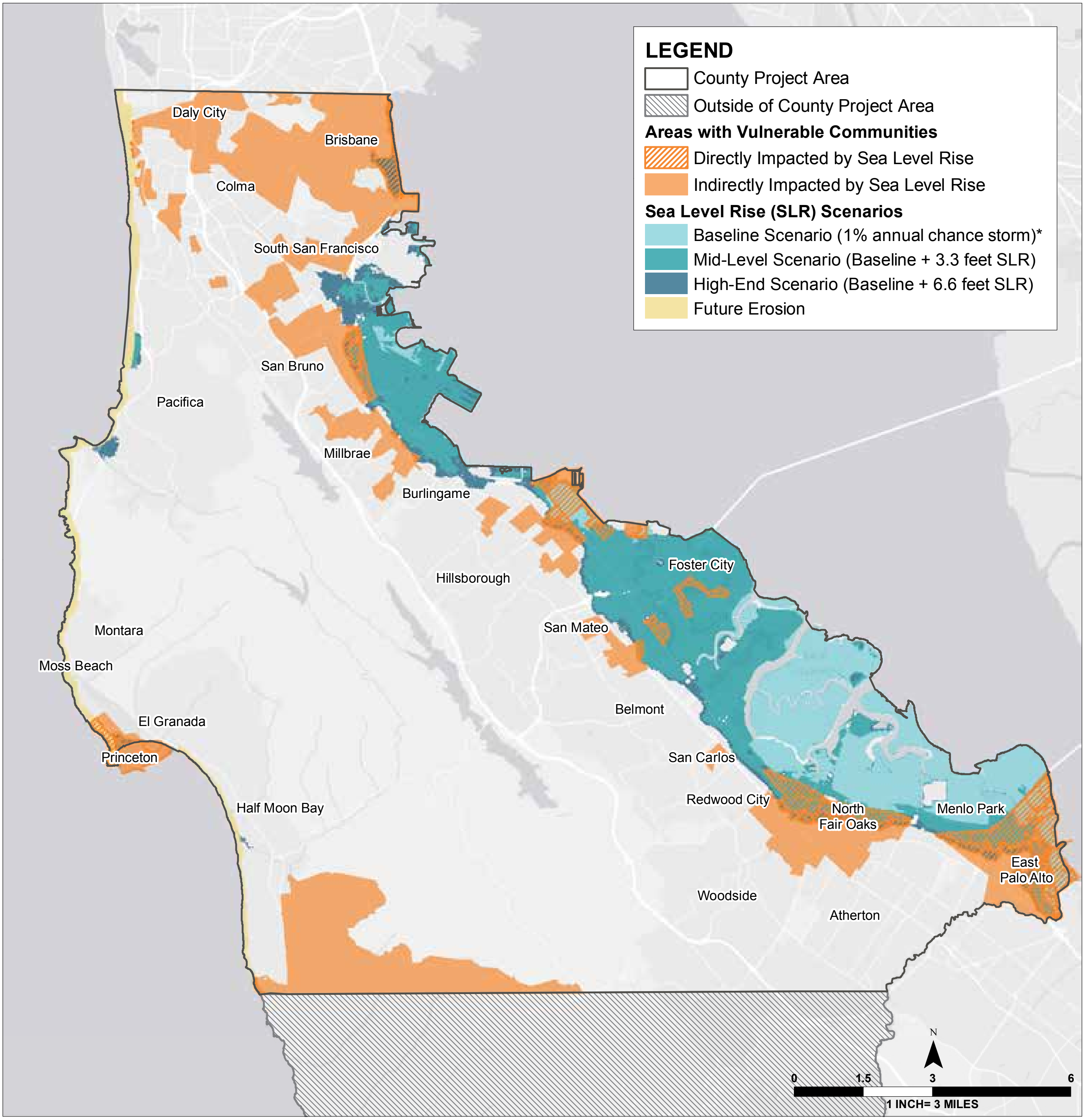
As part of the ABAG Resilience Program, the San Francisco Bay Conservation and Development Commission (BCDC) compiled community vulnerability indicators and established thresholds for each indicator. The project mapped where in the nine Bay area counties there are high rates of at least three vulnerability indicators present—young and elderly, people of color, non-English speakers, housing and transportation cost burden, homeownership, household income, low educational attainment, and transit dependence (Figure 3C. 1). Additional information about the indicators and associated thresholds for each indicator is available in the Community Vulnerability Indicators Table and Stronger Housing, Safer Communities Summary Report.

In San Mateo County: Areas with increased community vulnerability (where three or more community vulnerability indicators are present) are geographically dispersed but are located throughout the County but are mostly concentrated in the northern and coastal parts of the County, as well as along the Highway 101 corridor.

Photo credit: San Mateo County Flickr.

"Demographic and social characteristics may affect the abilities of an individual or household to prepare for, respond to, and recover from sea level rise, contributing to their overall vulnerability."

Figure 3C.1 San Mateo County BCDC Population in Vulnerable Communities Map



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

San Mateo Library. Photo credit: San Mateo County Flickr.

3C.4.1 Age: Children and Elderly

Age can affect the ability of individuals to prepare for a flood and to move safety before, during, or after a flood. Individuals under 18 years or 65 years and older (especially the very young and very elderly) are more vulnerable to sea level rise compared with the rest of the population (Association of Bay Area Governments 2015 and San Francisco Department of Public Health 2016). They are more likely to experience difficulties during flooding, as well as with preparing and responding to rapidly changing environments. Such stressors may also cause or aggravate physical and mental health issues. In the County, an estimated 161,284 children under the age of 18 years and 103,577 adults aged 65 years and older are vulnerable to climate change impacts (U.S. Census Bureau 2016).

As little as six inches of floodwater can make sidewalks, streets, and pathways difficult to navigate; the young and elderly may find withstanding such circumstances especially challenging. When public health infrastructure or services are affected by flooding or erosion, the young and elderly are more likely to be affected by a lack of services than other age groups and may be more physically compromised in seeking services.

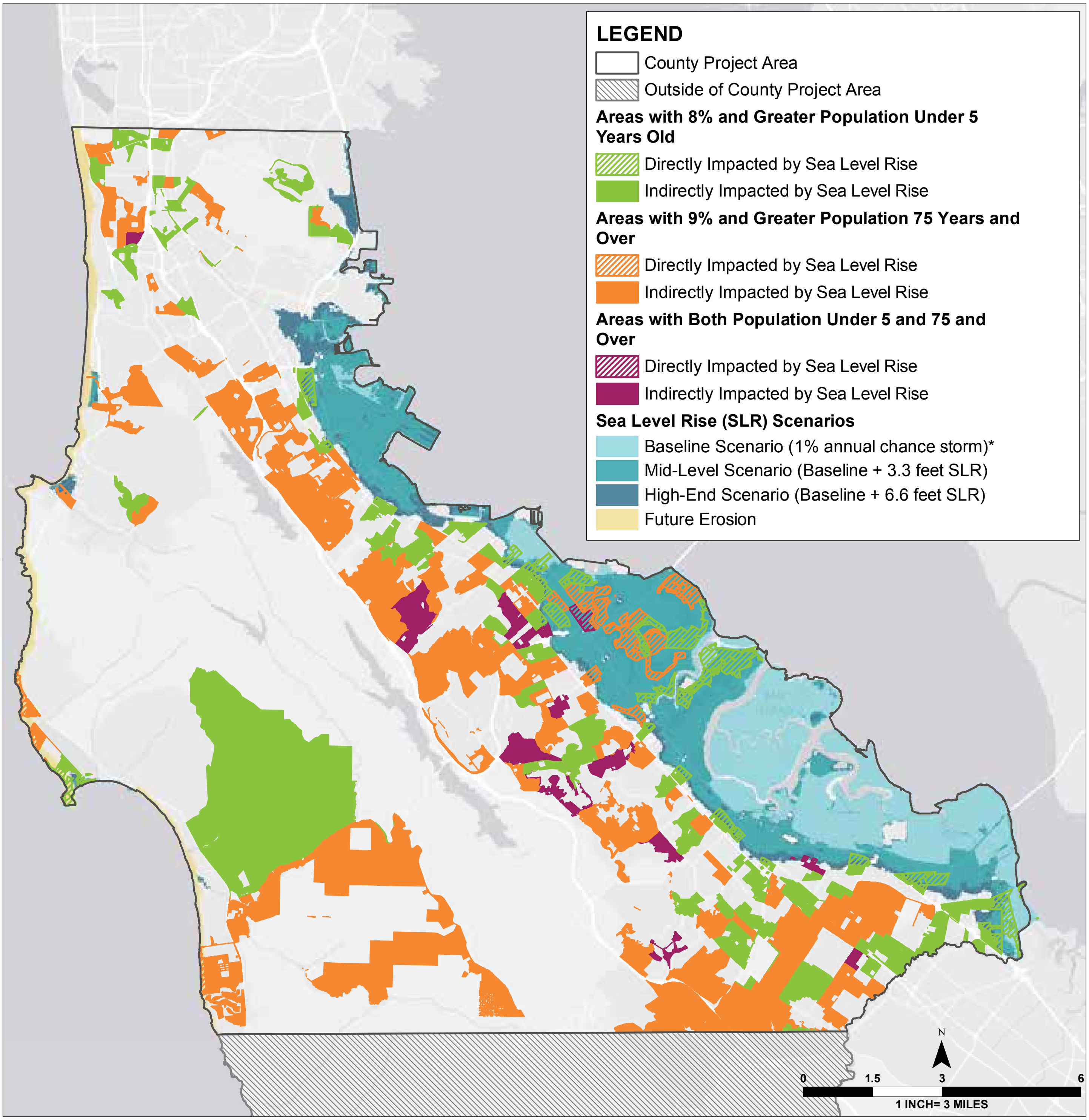
As sea level rise increases, inundation would become more frequent if no adaptation actions were taken. Over time, these vulnerable age groups would be required to adapt and re-adapt much more quickly to changing environments. The elderly and children are especially vulnerable to health impacts of inundation. Children, especially very young children, may have immature immune systems and easily develop respiratory illness, malnutrition, and exhaustion; they are also more sensitive to mental health stressors associated with a flood event (USGCRP 2016). The elderly are susceptible to respiratory illness and foodborne and waterborne disease, and they are more likely to be disabled or have preexisting medical conditions (EPA 2017).

Older adults may also experience challenges in moving to new locations or modifying their homes to avoid sea level rise impacts. Many older adults have retired and their assets, incomes, and savings may not be able to accommodate the cost of moving or repairing their property in the event of inundation.

Vulnerability to sea level rise is further exacerbated for individuals who live alone. They may have a greater risk of illness or injury in the event of a flood because they are "more likely to be socially isolated and could be especially vulnerable while sheltering in place" (San Francisco Department of Public Health 2016). Although this applies to individuals regardless of age, older adults (especially ones with disabilities) are at highest risk for social isolation (Cornwell and Waite 2009).

In San Mateo County: As shown in Figure 3C. 2, there are high concentrations of people over 75 and young children (under five) in several places that could be exposed to impacts from flooding and erosion. This population includes people in Menlo Park, Foster City, the coastal area north of El Granada, the South Coast, and small portions of Redwood City, San Carlos, Belmont, and San Mateo. There are several areas where high concentrations of young children could be exposed to sea level rise, including parts of East Palo Alto, Menlo Park, Redwood City, San Carlos, Belmont, Redwood Shores, Foster City, San Mateo, Burlingame, Brisbane, and El Granada. Many of these areas include the Bay shoreline and also the Highway 101 corridor.

Figure 3C.2 Community Vulnerability Indicator: Age



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

3C.4.2 Race: People of Color

Due to historic and systemic patterns of inequity, people of color tend to disproportionately experience poor health, social, and economic statuses (Bay Localize 2013). They are "more likely to suffer from pre-existing health conditions, live in poor quality housing in high hazard exposure zones, and lack the political access and economic resources to prepare for and recover from flood hazard events" (San Francisco Department of Public Health 2016).

People of color experience greater incidence of chronic medical conditions, including cardiovascular and kidney disease, asthma, and chronic obstructive pulmonary disease (Centers for Disease Control and Prevention 2013a). Such health disparities can be exacerbated during climate change–related events, during which illness onset and deaths may rise (Luber and McGeehin 2008). People of color also tend to have more distrust in government and may resist government outreach, information, or services as a result (Healthy Community Collaborative of San Mateo County 2013).

Poorer social and economic status also contributes to sea level rise vulnerability for communities of color. They are more likely to experience poverty, lower educational attainment, overcrowding in homes, limited health education, and lack of access to a vehicle. Such inequities increase vulnerability of people of color during and after a flood because they may be less connected to or less likely to receive disaster and recovery support services and funding to prepare for, respond to, and recover from sea level rise (Luber and McGeehin 2008, Younger et al. 2008, Centers for Disease Control and Prevention 2013a).

In San Mateo County: According to the American Community Survey, 55% of County residents are people of color. Communities of color are most concentrated in the northern and southern parts of the County: Daly City, Colma, South San Francisco, San Bruno, Millbrae, Redwood City, and East Palo Alto. See Figure 3C. 3.

3C.4.3 Language: Limited English Proficiency

Limited English proficiency (LEP) is a critical factor that affects vulnerability in multiple ways. LEP individuals are less likely to have access to resources that can help them address sea level rise and flooding, and they are more likely to suffer from health and social vulnerabilities that may exacerbate their challenges.

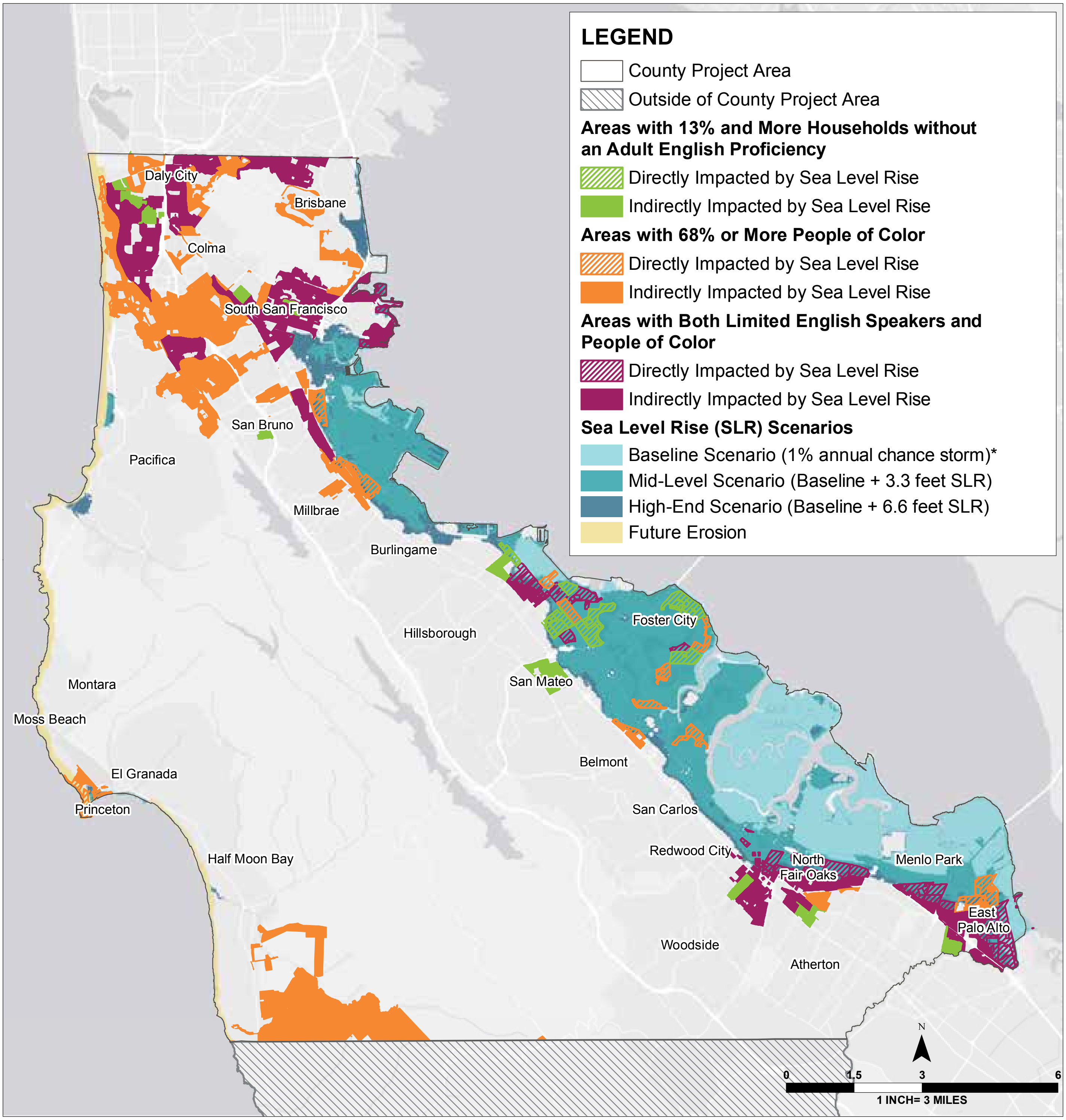
Particular to flooding and sea level rise, LEP people may not have access to important hazard-related information. This lack of access could affect their receiving timely emergency communications during a flood such as information about evacuation routes and shelter locations. Rescue operations and other emergency communications could be misunderstood unless the responders are also fluent in the other requisite languages. Because outreach materials are often in English, any outreach or risk communications prior to flooding may also be missed. In addition, an individual may be unable to engage in community-wide planning processes related to hazard mitigation and sea level rise adaptation.

Similarly to people of color, LEP individuals experience health and socioeconomic disparities. They see a greater incidence of most chronic medical conditions, including cardiovascular and kidney disease, asthma, and chronic obstructive pulmonary disease (Centers for Disease Control and Prevention 2013a). Such health disparities can be exacerbated during climate change events, which can lead to increased illness onset and deaths (Luber and McGeehin 2008). LEP individuals are more likely to experience poverty, lower educational attainment, overcrowding in homes, limited health education, and lack of access to a vehicle, and these factors may affect their ability to prepare for, respond to, and recover from sea level rise (Luber and McGeehin 2008, Younger et al. 2008, Centers for Disease Control and Prevention 2013a). Furthermore, LEP may also reduce the likelihood that individuals or families can consider factors such as flooding or erosion when deciding where to live, which can in turn increase their vulnerability to sea level rise impacts.

In San Mateo County: According to the American Community Survey, 19% of County residents are LEP. The most concentrated LEP communities are found in the northern and southern parts of the County: Daly City, Colma, South San Francisco, Redwood City, and East Palo Alto. See Figure 3C. 3.

"Historic and systemic patterns of inequity increase vulnerability of people of color during and after a flood because they may be less connected to or less likely to receive disaster and recovery support services and funding to prepare for, respond to, and recover from sea level rise."

Figure 3C.3 Community Vulnerability Indicator: Race, Ethnicity, and Language



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

3C.4.4 Limited Education

Education can directly and indirectly affect vulnerability to flood and erosion hazards. Limited education could hinder an individual's ability to understand prehazard warning information and access recovery resources (Hazards and Vulnerability Research Institute 2013), and those without a high school diploma are less likely to be aware of how to access government services. Educational advancement is strongly linked to individual and community health, wealth, and resilience (County of San Mateo et al. 2015). Overall, communities with high concentrations of individuals without high school diplomas are more vulnerable to the effects of sea level rise and extreme storm events (San Francisco Department of Public Health 2016, Appendix B).

Educational attainment is also related to health status, with lower educational attainment being associated with poorer health outcomes (Backlund et al. 1999, County of San Mateo et al. 2015). Individuals with lower educational attainment tend to experience higher morbidity and mortality rates and practice poorer health behaviors, potentially as a result of limited health education and lower health literacy (Zimmerman et al. 2015). Limited education is also associated with a lower income, suggesting that individuals with lower educational attainment may have less access to personal resources before, during, and after a flood due to their income status and limited means to afford and meet basic needs and practice healthy behaviors (Marmot 2002).

In San Mateo County: According to the American Community Survey, 12% of adults in the County have less than a high school diploma (37% have a high school diploma or less). The highest concentrations of lower educational attainment (adults with a high school degree or less) occur in East Palo Alto, Half Moon Bay, Colma, Redwood City, and San Mateo. See Figure 3C. 4.

3C.4.5 Low Income

Limited income or wealth affects vulnerability to flooding for multiple reasons. It can have negative impacts on individuals' abilities to prepare for, respond to, and recover from flooding, and it can be a risk factor for other health and social vulnerabilities.

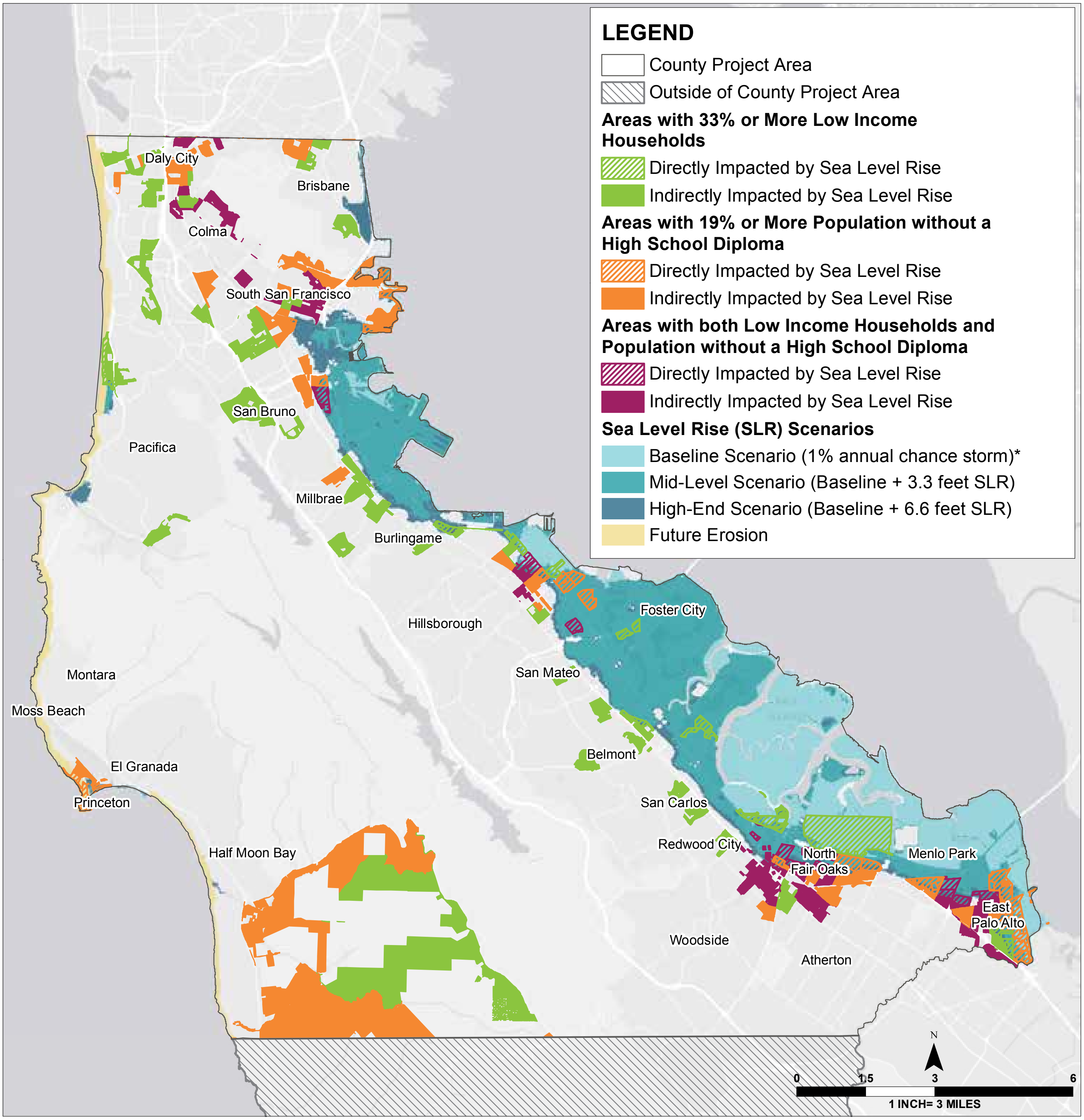
Low-income individuals may have limited resources to prepare for a flood and cope during and after flooding. They have fewer financial resources to address flooding and sea level rise needs amid other needs, such as housing, healthy food, health, and transportation. Low-income populations have an increased risk of exposure to sea level rise because they are more likely to live in risky areas (such as rural, coastal, and flood-prone areas), neighborhoods with older and poorly maintained infrastructure, and areas with increased air pollution (USGCRP 2016). In the wake of a flood or unexpected coastal erosion, private assets related to housing and recreation may very well have sustained water and other damages, and low-income residents may struggle to cover repairs and find temporary housing if needed.

Income can also affect individuals' health; studies have long documented the association with income and health. Low-income individuals are more likely to have higher rates of heart disease, diabetes, and stroke (Woolf et al. 2015). Being low-income also affects individuals' health because of limited means to practice healthy behaviors and access health care services (Marmot 2002). Stress from flooding and sea level rise can also cause mental health concerns, especially for low-income individuals that may need to divert wages from daily needs to pay for immediate impacts of flooding (San Francisco Department of Public Health 2016, Appendix A). Another health impact related to income is the likelihood of low-income populations to not evacuate in response to disaster warnings, potentially threatening their health and well-being.

In San Mateo County: Across the Bay Area, disposable income is likely primarily used for household spending on housing and transportation. According to the Center for Neighborhood Technology's H+T Index, the average percentage of income spent on housing and transportation in the County is 39% and 17%, respectively (Center for Neighborhood Technology 2017). A recent study in nearby Alameda County found that households that make less than $20,000 per year spend over half of their income on transportation, while households that make $100,000 per year spend 7% of their income on transportation (Haas et al. 2006). Less disposable income in both cases means households have fewer financial resources available to them to prepare for floods, replace damaged property, or find safe places to go during or after a flood. This factor also hinders recovery because these same individuals likely cannot afford the high price of alternate housing in the Bay Area if their property is damaged. See Figure 3C. 4.

In the County, 8% of households live below the federal poverty line (U.S. Census Bureau 2016). According to the San Francisco BCDC, high concentrations of low income households are scattered around the County, but the largest percentage that are located in the East Palo and North Fair Oaks Area (BCDC 2012a). Many other low income residents could also be exposed to sea level rise in Menlo Park, Redwood City, San Carlos, San Mateo, Burlingame, and some sections of Millbrae, San Bruno, and Brisbane. Along the coast, Pacifica, El Granada, and the South Coast area have the largest low-income areas exposed to flooding or erosion. Daly City has a small section of low income households on the coast.

Figure 3C.4 Community Vulnerability Indicator: Education and Income



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

3C.4.6 Housing Vulnerability

Individuals with poor housing conditions are at higher risk for vulnerability to flooding and sea level rise. Housing vulnerability can be affected by unstable housing conditions and housing tenure, as well as poor-quality housing infrastructure.

Renters are more vulnerable to sea level rise hazards than those who own their home. Renters may not have hazard-related information that a property owner would have, preventing them from adequately preparing themselves if they live in a potentially hazardous area. Renters may also lack the legal ability and financial resources to adapt their home to reduce vulnerability, or they may choose not to mitigate their homes if they do not consider the investment worthwhile given the often temporary status of rental homes.

Individuals who live and work in poor-quality or outdated buildings or buildings with many health and safety violations are also potentially more vulnerable to the impacts of inundation mentioned above. Mold growth is the most common occurrence in flood-damaged homes and buildings, especially in substandard housing and in housing with poor ventilation (Center for Disease Control and Prevention 2006). People with pre-existing respiratory conditions, infants, children, pregnant women, and the elderly are most susceptible to the adverse health impacts of mold, which can range from nose and throat irritation, wheezing, and coughing to asthma attacks or serious lung infections in individuals with pre-existing respiratory conditions (San Francisco Department of Public Health 2016). Older buildings have a higher likelihood of exposed or obsolete electrical systems that could pose a fire and shock hazard during flooding events (Mitchell 2011).

In San Mateo County: According to the American Community Survey, low-income renter households experience greater housing instability due to a greater rent burden (paying at least 30% of income on rent) compared to high income households. Rent-burdened individuals are likely to experience poorer health outcomes as a result of choosing to pay between paying rent or other basic need expenses (Bay Area Regional Health Inequities Initiative 2015). According to the San Francisco BCDC, a high concentration of renters occurs along the Highway 101 corridor on the bay side, including Redwood City, San Mateo, Burlingame, and parts of South San Francisco (BCDC 2012a). On the coast side, there is a high percentage of renter-occupied housing in Pacifica and Half Moon Bay.

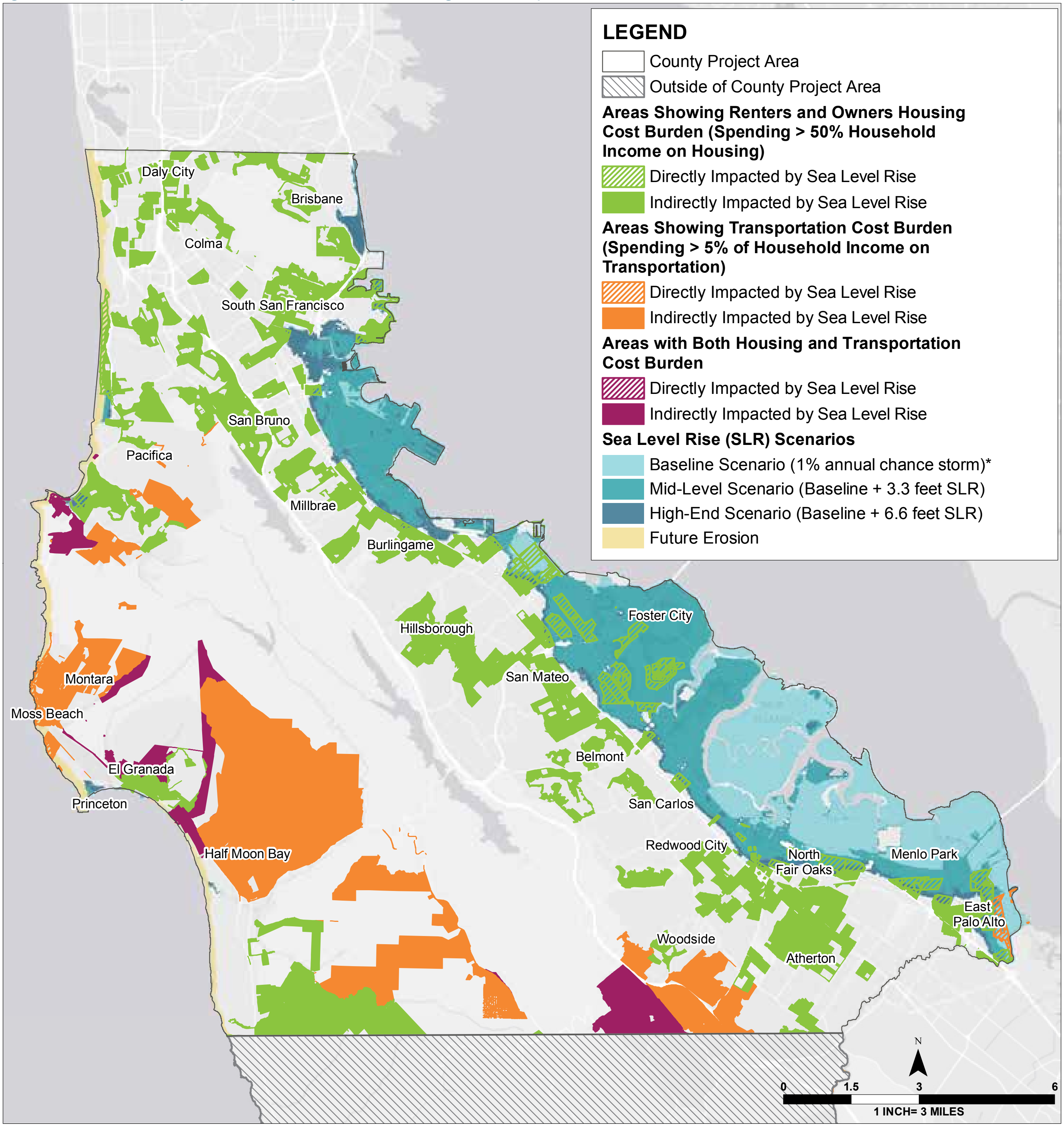
Individuals who experience the most unstable housing conditions, the homeless, are at a higher risk for flooding and sea level rise impacts. They are more likely to experience chronic health conditions and mental health issues, as well as to suffer from extreme weather conditions, without proper protections and resources to address these health vulnerabilities (Ramin and Svoboda 2009, San Francisco Department of Public Health 2016). There are over 1,200 single homeless adults in the County (San Mateo County Human Services Agency 2015), and some of the homeless shelters in the County could be vulnerable to sea level rise.

Overcrowded homes are also at a higher risk for health vulnerability due to sea level rise. Studies have documented the association between overcrowding and both physical illnesses (such as communicable and infectious diseases) and mental health conditions (Robert Wood Johnson Foundation 2008). According to the American Community Survey, 7% of households experience overcrowding, although East Palo Alto, Daly City, Colma, and Redwood City report much higher percentages. See Figure 3C. 5.

SMC Resilient By Design tour. Photo credit: Kingdom Young.

"Renters are more vulnerable to sea level rise hazards than those who own their home. Renters may not have hazard-related information that a property owner would have, preventing them from adequately preparing themselves if they live in a potentially hazardous area.

Figure 3C.5 Community Vulnerability Indicator: Housing and Transportation Cost Burden



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey and Center for Neighborhood Technology Housing and Transportation Affordability Index. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a lack of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

3C.4.7 Limited Access to Vehicles

A critical factor before, during, and after flooding is access to a vehicle. Households that are dependent on public transportation, whether due to financial resources or a desire to live a more active life or reduce GHG emissions, are more vulnerable to impacts of flooding and erosion than households that own vehicles. This vulnerability not only affects their ability to travel safely during or after a hazard has occurred, but may also compromise evacuation (including picking up family members) if they rely heavily on public transportation infrastructure that has been damaged by the hazard.

Flooding and sea level rise can affect public transportation services; any loss of service could prevent individuals with limited access to personal vehicles from accessing homes, jobs, schools, health care services, grocery stores, and other critical locations.

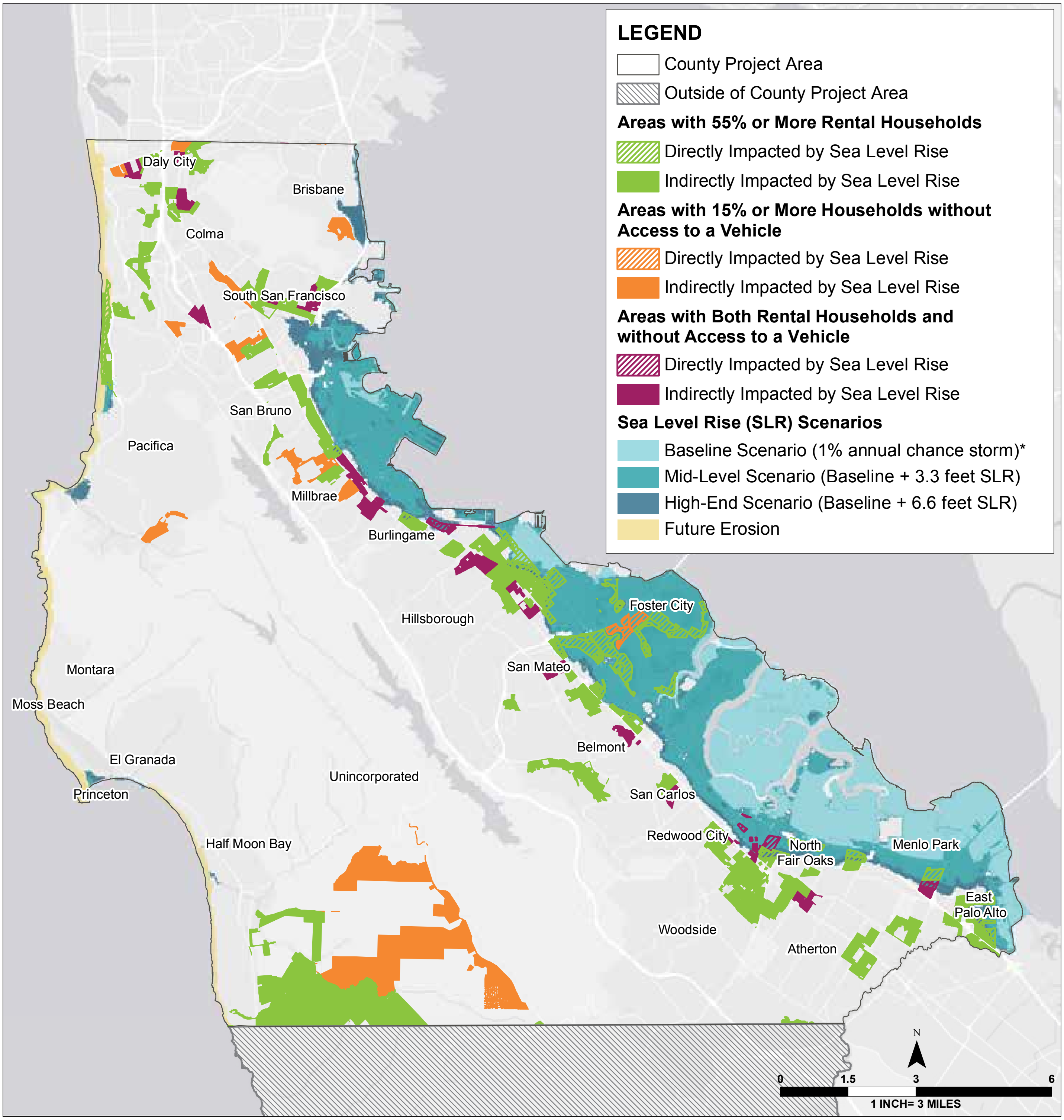
In San Mateo County: Six percent of households do not own a vehicle in the County, and approximately 46% of residents do not live close to frequent public transit (Maizlish et al. 2017). For individuals with unstable job situations, interrupted transportation service could threaten their jobs. Sea level rise may pose more frequent inundation of any low-lying transit infrastructure, especially along the Highway 101 corridor, which has the most high-frequency transit, and would more frequently and disproportionately affect people without access to cars.

According to the San Francisco BCDC, the areas in the County with the most people dependent on public transportation are in the central and northwestern parts of the county, including Brisbane, Millbrae, and Foster City, as well as a few communities along the Highway 101 corridor. The areas where there are both renters and people who do not have access to a car are shown in orange in Figure 3C.6, and include Menlo Park, Redwood City, San Carlos, and Burlingame. See Figure 3C.6.

Mirada Rd. Photo credit: Office of Sustainaility.

"Sea level rise may pose more frequent inundation of any low-lying transit infrastructure, especially along the Highway 101 corridor, which has the most high-frequency transit, and would more frequently and disproportionately affect people without access to cars."

Figure 3C.6 Community Vulnerability Indicator: Renters and Access to Vehicles



Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Data Source: 2010-2014 American Community Survey. Map created by SF Bay Conservation and Development Commission's Adapting to Rising Tides Program and County of San Mateo.

This map is intended to improve sea level rise awareness and preparedness by providing a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios. This map is not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses.

*1% annual chance storm is a storm that has a 1 in 100 chance of occurring in any given year, and on the Bayside generally results in about a 42 inch increase of total water levels. On the Coastside, the water level increase could be greater due to wave action.

Note on erosion modeling: Erosion modeling used in this study does not consider shoreline armoring due to a dearth of information on the condition and life expectancy of existing structures.The 2009 Philip Williams and Associates study recognizes that future shoreline protection is likely in general but could not predict where and how these would appear. In this case, developing predictive erosional models is impractical and exceedingly difficult.

Methods: Significant concentrations thresholds are based on the current share of the region's population plus half a standard deviation above the regional mean.

Areas in census tracts with low population density (i.e. open areas, large industrial areas) are not shown in map.

3C.5 Conclusion

The geographic location of the County places many at risk for health risks due to sea level rise. In addition, many populations in the County exhibit at least one or more health, demographic, or social vulnerability to sea level rise in the County due to factors such as age, race, income, housing vulnerability, and pre-existing health conditions. The combined impact of these vulnerabilities places some individuals and communities at great risk. While a review of the social, demographic, and health vulnerabilities in the County was included in this study, additional analysis is needed to estimate disease burden and health exposure from flooding and inundation and identify concentrations of vulnerable populations at the census tract or block level in the County that could be the focus of adaptation planning, community outreach and education, and emergency preparedness and response.

For recommendations on next steps for research, engagement, emergency preparedness, adaptation planning, and surveillance, please see Chapter 5, Getting Ahead of Sea Level Rise.

"Many populations in the County exhibit at least one or more health, demographic, or social vulnerability to sea level rise in the County due to factors such as age, race, income, housing vulnerability, and pre-existing health conditions."

SMC Resilient By Design tour. Photo credit: Kingmond Young.

CHAPTER 3D
CITY- AND COUNTY-SPECIFIC FINDINGS

CHAPTER 3D CITY- AND COUNTY-SPECIFIC FINDINGS

City- and County-Specific Analysis Introduction

The following asset exposure inventory tables provide a tally of the total number of each asset type and how many of those assets are expected to be exposed to the flooding, erosion, and sea level rise scenarios evaluated in the project area.

The Summary inventory table includes all natural assets and built assets for each city or town. Built assets, which are classified by American Society of Civil Engineers Risk Classes (1, 2, 3, and 4), are counted by both number (for individual assets) and in length (for assets that are linear, e.g., roads).

The remaining inventory tables provide a breakdown of specific natural and built asset types organized by (i) project area and then by (ii) city and town. More detail on the organization and classification of assets is provided in Section 2 of the Assessment and in Appendix F, Asset Categorization and Classification Report. Preceding the inventory charts is a brief paragraph describing some of the assets and areas that are at risk in each city and unincorporated area.

The baseline scenario is the 1% annual chance flood, the mid-level scenario is the 1% annual chance storm plus 3.3 feet of sea level rise, and the high-end scenario is the 1% annual chance flood plus 6.6 feet of sea level rise. The best available sea level rise data were used. Sea level rise data are from the U.S. Geological Survey and Point Blue's Our Coast, Our Future tool.

The tables are based on the best available data at the time of report development. For asset data, County staff considered the following in choosing the best available data:

- Data that are readily available at the finest scale possible, while being consistent Countywide
- Data that are peer reviewed and available from a reputable source
- Data that are consistent other vulnerability assessments
- Where existing datasets did not exist, County staff developed new datasets for key assets by identifying location of assets through Google Map searches, such as for mobile home parks and Ports.

In cases in which a Countywide dataset and city-specific datasets were both available for a specific asset type, this report used the Countywide dataset. The inventory is based on 2010 Census data, therefore, one important component to keep in mind is that both population and development in most communities has increased since 2010. Table 3D.1 provides descriptions of certain datasets used in the inventory that may prompt additional questions or require explanation. For a full list of datasets, descriptions, and sources see Appendix E: Data Sources.

"The inventory is based on 2010 Census data, therefore, one important component to keep in mind is that both population and development in most communities has increased since 2010."

Table 3D.1 Key datasets and descriptions.

DATASET OR ASSET TYPE	DESCRIPTION	DATA SOURCE
Coastal Erosion	Erosion hazard under a 1.4-meter sea level rise scenario (predicted for year 2100).	Philip Williams and Associates (2012). Developed and used in the Pacific Institute study
Flooding and Inundation	Low-lying coastal areas may experience more flooding (temporary) and inundation (permanent) along the Bayshore or the Coast due to sea level rise. The report uses data to determine the geographical extent and depth of inundation along the Coast and Bayshore. The report presents these data in its exposure maps through three different scenarios: Baseline (1% annual chance flood at mean higher high water); Mid-level (1% annual chance flood plus 3.3 feet of sea level rise); High-end (1% annual chance flood plus 6.6 feet of sea level rise).	Our Coast, Our Future study and tool, 2016
Hazardous Material Sites	Data include sites where recent or historical unauthorized releases of pollutants to the environment, including soil, groundwater, surface water, and sediment, have occurred, as well as locations that are relevant to emergency response risk planning. Hazardous materials include contaminated lands, closed and open landfills, clean-up sites, superfund sites, and areas with stored fuel or chemicals.	California Water Board; United States Environmental Protection Agency, via David Ford Consulting Engineers; California Department of Water Resources, Risk Characterization Study
Natural Land	Data include areas of • Native vegetation • Riparian vegetation • Barren and wasteland	California Department of Water Resources
Other Built Shoreline (miles)	Data include Bayside berms, embankments, shoreline protection structures, transportation structures, and water control structures, as well as coastal revetments and breakwaters. **Excludes levees, floodwalls, and coastal floodwalls; these structures are included in the "Levee and Floodwalls (miles)."**	San Francisco Estuary Institute, California Coastal Commission, National Oceanic and Atmospheric Administration
Population in Vulnerable Communities	Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level. Portions of a census block population were counted based on the percentage of the block's land in the particular hazard zone.	Association of Bay Area Governments (2014), 2010–2014 American Community Survey, Center for Neighborhood Technology Housing and Transportation Affordability Index
Roads (miles)	Data use centerline method and include the following road features: local neighborhood road, rural road, City Street, vehicular trail, service drive usually along a limited access highway, walkaway/pedestrian trail, private road for service vehicles, and internal census use.	United States Census Bureau (2015)
Storm Drain (miles)	Data include storm drains 2 feet in diameter and above.	City/County Association of Governments stormwater study (2015), compiled by EOA Inc. subcontracted with Fugro
Wastewater Pump Stations	Data were collected and compiled from County cities and towns. **Data are not available for every city and town in the project area.**	County of San Mateo (2015)

Project Area

The project area has 9,049 acres of land at risk in the baseline scenario, 22,063 acres in the mid-level scenario, 25,060 acres in the high-end scenario, and 1,690 acres in the erosion scenario. The project area includes the entire Bayshore and the Coastside areas of Half Moon Bay through Daly City, not including south of Half Moon Bay. There are approximately 3,570 parcels in the baseline scenario, 39,150 in the mid-level scenario, and 45,135 in the high-end scenario. The assessed value of parcels located within the erosion scenario is $932 million, with $3.6 billion in assessed value of parcels in the baseline scenario, $34 billion in the mid-level scenario, and $38 billion in the high-end scenario. These values represent 1%, 2%, 21%, and 24% of total assessed parcel values, respectively.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

Belmont

Map: Zone 5

The City of Belmont has 2 acres of land at risk in the baseline scenario, 190 acres in the mid-level scenario, and 263 acres in the high-end scenario. The baseline scenario shows inundation in six parcels and some of the City's wetlands. The mid-level scenario leads to inundation of the area east of Highway 101, including the City's corporation yard (see Asset Vulnerability Profile), and also overtops Highway 101 in the area south of Belmont Creek. The high-end scenario causes widespread overtopping of Highway 101 and inundation to approximately Irwin Street. Overall, a significant number of Belmont's built and natural flood protection assets are vulnerable under the mid-level scenario. All of its levees and floodwalls and over half of its other built shorelines (i.e., other protective infrastructure aside from levees and seawalls) will be affected. Approximately 40% of the outfalls will be affected as well, which could lead to disruption in drainage systems in the event of a significant rainstorm or flood event. Approximately 12% of the City's storm drains are vulnerable.

A significant majority of the City's wetlands are vulnerable, which will serve a role in helping the City adapt to sea level rise, though this natural asset's capacity to withstand sea level rise is unclear.

The single electrical substation and a limited amount of transmission lines (0.7 miles) within the City are vulnerable. One of 3 hazardous material sites within the City are at risk of inundation, which may pose a threat to public health in the event of a flood, even though only a small portion could be compromised. Both outpatient facilities located within Belmont will be affected in the mid-level scenario, which may also have repercussions for public health.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	**TOTAL**	**EROSION SCENARIO**	**BASELINE SCENARIO**	**MID-LEVEL SCENARIO**	**HIGH-END SCENARIO**
Land Area (acres)	2,967	0	2	190	263
Population	25,900	0	<100	1,600	2,400
Population in Vulnerable Communities[1]	<100	0	0	0	0
Urban Land (acres)	2,208	0	0	161	232
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	759	0	2	29	32
Residential Parcels[2]	--	0	0	567	708
Commercial Parcels[2]	--	0	1	14	20
Other Parcels[2]	--	0	1	20	29
Parcels with No Data Available[2]	--	0	4	15	15
Assessed Value of All Parcels at Risk ($ in Millions)	$5,623	$0	$34	$558	$637

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	2.7	0.0	0.0	2.6	2.7
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	6.0	0.0	0.0	1.2	1.3
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	35.7	0.0	0.7	29.2	31.3

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	14	0	0	0	1
Electric Substations	1	0	0	1	1
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	8	0	0	0	1
Fire Stations	2	0	0	0	0
Hazardous Material Sites	3	0	0	1	2
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	2	0	0	1	2
Highways (miles)	7.8	0.0	0.0	1.6	4.1
Levees and Floodwalls (miles)	0.1	0.0	0.0	0.1	0.1
Natural Gas Pipelines (miles)	1.4	0.0	0.0	0.2	0.3
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	2.7	0.0	0.0	1.5	1.9
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	2	0	0	0	0
Human Services Agency Partner Facilities	1	0	0	0	0

Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	17	0	3	7	7
Ports	0	0	0	0	0
Rail (miles)	3.1	0.0	0.0	0.0	0.0
Rail Stations	1	0	0	0	0
Roads (local) (miles)	77.6	0.0	0.0	5.1	6.9
Schools	13	0	0	0	1
Senior Centers	1	0	0	0	0
Storm Drains (miles)	19.3	0.0	0.0	2.3	2.7
Stormwater Pump Stations[3]	2	--	--	--	--
Transmission Lines (miles)	1.2	0.0	0.0	0.7	0.9
Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	1	0	0	0	0
Wastewater Pump Stations[3]	--	--	--	--	--
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	10	0	0	0	1
Health Care Facilities (outpatient)	2	0	0	2	2
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	11	0	0	0	2
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	1.8	0.0	0.0	0.3	0.3

Brisbane

Map: Zone 1

Brisbane has 7 acres of land affected in the baseline scenario, 18 acres in the mid-level, and 261 in the high-end scenario. In the baseline scenario, 1.5 acres of wetlands bordering Highway 101 are inundated, and small portions of the marina are inundated as well, along with one of Brisbane's eight outfalls. In the mid-level scenario, the shoreline begins to flood Highway 101 in a couple locations, and approximately 3 acres of wetlands and 1.3 miles of trails are inundated. Assets proportionally most vulnerable in Brisbane include outfalls, other built shorelines (neither levees nor floodwalls), wetlands, and trails. Recreational assets may be the most affected asset type in Brisbane, but other important infrastructural assets that are at risk, though proportionally low, may still pose significant challenges in a flood event. Nearly 22% of its "other built shorelines" (i.e., built protective shoreline features that are not levees), nearly 13% of its outfalls, and approximately 19% of its wetlands are affected at the mid-level scenario, all of which are assets that may play a role in adapting to sea level rise or coping with flood events when they occur.

In the high-end scenario, Highway 101 becomes overtopped in several locations, and the lagoon is flooded.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	2,008	0	7	18	261
Population	4,200	0	0	0	0
Population in Vulnerable Communities[1]	1,300	0	0	0	0
Urban Land (acres)	830	0	1	5	66
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	203	0	0	0	2
Natural Land (acres)	975	0	6	13	193
Residential Parcels[2]	--	0	0	0	0
Commercial Parcels[2]	--	0	2	3	6
Other Parcels[2]	--	0	6	10	68
Parcels with No Data Available[2]	--	0	0	0	74
Assessed Value of All Parcels at Risk ($ in Millions)	$1,601	$0	$53	$71	$172

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	113.2	0.0	0.0	0.0	112.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	0.0	0.0	0.0	0.0	0.0
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	15.1	0.0	1.5	2.9	14.2

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	32	0	0	1	2
Electric Substations	1	0	0	0	0
Emergency Operations Centers	1	0	0	0	0
Emergency Shelter Sites	2	0	0	0	0
Fire Stations	1	0	0	0	1
Hazardous Material Sites	8	0	0	0	1
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	4	0	0	0	1
Highways (miles)	7.1	0.0	0.0	0.3	3.6
Levees and Floodwalls (miles)	0.0	0.0	0.0	0.0	0.0
Natural Gas Pipelines (miles)	9.2	0.0	0.0	0.0	2.2
Natural Gas Storage	4	0	0	0	0
Other Built Shorelines (miles)	7.3	0.0	0.4	1.6	5.3
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	1	0	0	0	0
Solid Waste Facilities and Closed Landfills	3	0	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	0	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	8	0	1	1	3
Ports	0	0	0	0	0
Rail (miles)	5.4	0.0	0.0	0.0	1.7
Rail Stations	0	0	0	0	0
Roads (local) (miles)	29.5	0.0	0.0	0.0	1.2
Schools	2	0	0	0	0
Senior Centers	0	0	0	0	0
Storm Drains (miles)	9.4	0.0	0.0	0.0	0.4
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	8.2	0.0	0.0	0.0	0.0

Transmission Towers	55	0	0	0	0
Underground Chemical Storage Tanks	2	0	0	0	0
Wastewater Pump Stations[3]	4	--	1	1	2
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	4	0	0	0	0
Health Care Facilities (outpatient)	0	0	0	0	0
Marinas	1	0	1	1	1
Mobile Home Parks	1	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	1	0	0	1	1
Parks	9	0	0	0	1
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	5.7	0.0	0.4	1.3	2.8

Burlingame

Map: Zone 3

The City of Burlingame has 20 acres of land inundated in the baseline scenario, 452 acres in the mid-level scenario, and 813 acres in the high-end scenario. In the baseline scenario, a small portion of the Bayshore highway overtops and 25 parcels are inundated. In the mid-level scenario, nearly all of Bayshore Highway and Highway 101 are flooded, and inundation nearly reaches the Caltrain tracks. In addition, Burlingame's flooding and stormwater infrastructure (stormwater pump stations, levees and floodwalls, other built shorelines, outfalls, and storm drains) and energy transmission infrastructure are vulnerable in the mid-level scenario. Risk Class 4 assets that may be important in responding in the event of a crisis will also be affected. These assets include one fire station (one of three), communication towers (~32%), highways (~19%), highway and railway bridges (11%), and outpatient health care facilities (60%). Energy-related assets, including transmission lines (affected at 42%), transmission towers (affected at 29%), and natural gas pipelines (approximately 1.5 miles affected), will be affected in the event of a significant storm as well. A total of 17 hazardous material sites lie within Burlingame's boundaries, and 6 of these will be affected in the high-end scenario, which could pose a potential threat to public health and safety.

Nearly 30% of the City's wetlands that could serve a role in helping the City adapt to sea level rise will be affected, though this natural asset's capacity to withstand sea level rise is unclear. Recreational assets (parks and trails) may also be affected.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	2,855	0	20	452	813
Population	28,800	0	0	<100	2,400
Population in Vulnerable Communities[1]	6,300	0	0	0	<100
Urban Land (acres)	2,628	0	4	418	741
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	226	0	16	34	72
Residential Parcels[2]	--	0	0	23	604
Commercial Parcels[2]	--	0	19	277	333
Other Parcels[2]	--	0	6	67	89
Parcels with No Data Available[2]	--	0	0	58	64
Assessed Value of All Parcels at Risk ($ in Millions)	$8,624	$0	$253	$1,346	$1,973

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	0.0	0.0	0.0	0.0	0.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0

Streams (miles)	7.3	0.0	0.1	1.4	2.6
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	47.2	0.0	3.7	14.0	37.5

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	62	0	0	20	32
Electric Substations	1	0	0	0	1
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	11	0	0	0	1
Fire Stations	3	0	0	1	1
Hazardous Material Sites	17	0	0	3	6
Health Care Facilities (emergency)	1	0	0	0	0
Highway and Railway Bridges	9	0	0	1	4
Highways (miles)	11.1	0.0	0.0	2.1	6.8
Levees and Floodwalls (miles)	1.4	0.0	0.0	1.0	1.4
Natural Gas Pipelines (miles)	4.3	0.0	0.0	1.5	2.9
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	9.9	0.0	0.5	4.9	8.3
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	2	0	0	0	0
Human Services Agency Partner Facilities	0	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	23	0	0	7	10
Ports	0	0	0	0	0
Rail (miles)	6.9	0.0	0.0	0.0	2.4
Rail Stations	2	0	0	0	0
Roads (local) (miles)	77.2	0.0	0.0	6.9	15.2
Schools	11	0	0	1	1

Senior Centers	0	0	0	0	0
Storm Drains (miles)	27.6	0.0	0.0	6.1	11.3
Stormwater Pump Stations[3]	5	--	0	4	5
Transmission Lines (miles)	11.6	0.0	0.0	4.9	8.0
Transmission Towers	31	0	0	9	27
Underground Chemical Storage Tanks	13	0	0	1	4
Wastewater Pump Stations[3]	7	--	0	5	7
Wastewater Treatment Plants	1	0	0	0	1

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	6	0	0	0	2
Health Care Facilities (outpatient)	5	0	0	3	4
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	1	0	0	0	0
Parks	14	0	0	1	4
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	8.4	0.0	0.3	3.0	5.0

Daly City

Map: Zone 8

The City of Daly City has 20 acres of land inundated in the baseline scenario, 24 acres in the mid-level scenario, and 26 acres in the high-end scenario. The City has 279 acres that could be affected in the erosion scenario. Daly City's primary source of vulnerability is the Mussel Rock closed landfill, which is adjacent to the Coast and is protected by a rock slope. The area provides open space, trails, and space for paragliders. The rock slope protection (labeled as "other built shorelines") is vulnerable to overtopping with sea level rise. See the Asset Vulnerability Profile for more details.

Under the erosion scenario, a portion of Daly City's levees and/or floodwalls are vulnerable. Other infrastructure that may play a key role in the event of a flood, such as outfalls and one wastewater pump station, will be affected. Recreational assets including parks (20%) and trails (34%) will be affected under the erosion scenario.

Nearly 30% of Daly City's wetlands that could serve a role in helping the City adapt to sea level rise will be affected, though this natural asset's capacity to withstand sea level rise is unclear. Recreational assets (parks and trails) may also be affected.

*The erosion scenario represents the projected extent of coastal erosion with 4.6 feet of sea level rise; it does not take into consideration existing shoreline protection infrastructure. The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	4,873	279	20	24	26
Population	101,100	1,100	<100	<100	<100
Population in Vulnerable Communities[1]	53,600	<100	0	0	0
Urban Land (acres)	3,802	38	0	0	0
Agricultural Land (acres)	6	5	0	0	0
Industrial Land (acres)	4	0	0	0	0
Natural Land (acres)	1,062	236	19	23	25
Residential Parcels[2]	--	298	0	0	0
Commercial Parcels[2]	--	3	0	0	0
Other Parcels[2]	--	42	8	8	8
Parcels with No Data Available[2]	--	2	0	0	0
Assessed Value of All Parcels at Risk ($ in Millions)	$9,919	$118	$0	$0	$0

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	2.3	2.3	2.3	2.3	2.3
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	0.0	0.0	0.0	0.0	0.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	1.1	0.0	0.0	0.0	0.0
Surfgrass Habitat (miles)	0.6	0.6	0.6	0.6	0.6
Wetlands (acres)	0.0	0.0	0.0	0.0	0.0

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	60	1	0	0	0
Electric Substations	2	0	0	0	0
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	35	0	0	0	0
Fire Stations	5	0	0	0	0
Hazardous Material Sites	18	0	0	0	0
Health Care Facilities (emergency)	1	0	0	0	0
Highway and Railway Bridges	30	0	0	0	0
Highways (miles)	34.8	0.5	0.0	0.0	0.0
Levees and Floodwalls (miles)	0.5	0.2	0.0	0.0	0.0
Natural Gas Pipelines (miles)	8.0	0.0	0.0	0.0	0.0
Natural Gas Storage	2	0	0	0	0
Other Built Shorelines (miles)	0.3	0.1	0.0	0.1	0.3
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	1	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	2	0	0	0	0
Human Services Agency Partner Facilities	4	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	1	1	0	0	0
Ports	0	0	0	0	0
Rail (miles)	4.7	0.0	0.0	0.0	0.0
Rail Stations	1	0	0	0	0
Roads (local) (miles)	138.7	3.8	0.5	0.6	0.6
Schools	30	0	0	0	0
Senior Centers	3	0	0	0	0
Storm Drains (miles)	25.1	0.7	0.0	0.0	0.0
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	1.7	0.0	0.0	0.0	0.0

Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	18	0	0	0	0
Wastewater Pump Stations[3]	4	1	0	0	0
Wastewater Treatment Plants	1	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	11	0	0	0	0
Health Care Facilities (outpatient)	11	0	0	0	0
Marinas	0	0	0	0	0
Mobile Home Parks	2	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	20	4	0	0	0
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	8.9	3.0	0.3	0.4	0.4

East Palo Alto

Map: Zone 7

The City of East Palo Alto has 335 acres of land at risk in the baseline scenario, 714 acres in the mid-level scenario, and 992 acres in the high-end scenario. A significant portion of East Palo Alto's population (nearly 60%) is vulnerable to sea level rise in the mid-level scenario. Nearly all of the City's wetlands (a total of 237 acres) are vulnerable, but it is not clear to what extent they may withstand sea level rise.

Infrastructure that would be important in the event of a flood, such as outfalls, an electric substation, a stormwater pump, storm drains, and energy transmission lines, will also be affected. The City's existing shoreline infrastructure is not technically classified as a levee, but rather as berms or nonengineered structures. The vulnerability of this asset is captured by the "other built shoreline" data—approximately 66% of East Palo Alto's protective shoreline infrastructure is vulnerable. Approximately 34% of East Palo Alto's local roadways will be affected in the event of a flood in the mid-level scenario.

Other assets that serve the community on a daily basis may also be significantly affected. Sixty percent of its schools, nearly 60% of its emergency shelter sites, and half of its parks are vulnerable to flooding in the event of a major storm in the mid-level scenario.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	1,637	0	335	714	992
Population	28,100	0	2,400	7,600	12,700
Population in Vulnerable Communities[1]	28,100	0	2,400	7,600	12,700
Urban Land (acres)	1,336	0	112	459	725
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	301	0	224	254	266
Residential Parcels[2]	--	0	622	1,869	2,806
Commercial Parcels[2]	--	0	9	46	88
Other Parcels[2]	--	0	28	356	425
Parcels with No Data Available[2]	--	0	3	49	54
Assessed Value of All Parcels at Risk ($ in Millions)	$2,205	$0	$171	$631	$975

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	0.0	0.0	0.0	0.0	0.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	1.6	0.0	0.1	0.1	0.1
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	237.2	0.0	215.4	230.2	230.7

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	21	0	0	0	0
Electric Substations	1	0	1	1	1
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	12	0	2	7	9
Fire Stations	1	0	0	0	0
Hazardous Material Sites	44	0	4	39	44
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	7	0	0	1	2
Highways (miles)	6.8	0.0	0.0	0.0	0.1
Levees and Floodwalls (miles)	0.0	0.0	0.0	0.0	0.0
Natural Gas Pipelines (miles)	2.2	0.0	0.4	0.9	1.0
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	8.0	0.0	1.5	5.3	6.4
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	1

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	4	0	0	0	1
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	6	0	4	5	5
Ports	0	0	0	0	0
Rail (miles)	0.0	0.0	0.0	0.0	0.0
Rail Stations	0	0	0	0	0
Roads (local) (miles)	42.5	0.0	4.3	14.6	22.5
Schools	10	0	1	6	10
Senior Centers	1	0	0	0	0
Storm Drains (miles)	13.0	0.0	2.1	4.0	6.0
Stormwater Pump Stations[3]	2	--	1	1	1
Transmission Lines (miles)	2.8	0.0	0.6	1.4	2.0

Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	3	0	1	1	2
Wastewater Pump Stations[3]	--	--	--	--	--
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	8	0	0	0	2
Health Care Facilities (outpatient)	3	0	0	1	2
Marinas	0	0	0	0	0
Mobile Home Parks	1	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	5	0	1	2	4
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	1.3	0.0	0.5	1.2	1.3

Foster City

Map: Zone 5

The City of Foster City has 106 acres at risk in the baseline scenario, 2,630 acres at risk in the mid-level scenario, and 2,638 acres at risk in the high-end scenario. The City of Foster City is protected by a levee, which the City is actively working to raise in order to achieve Federal Emergency Management Agency accreditation and to protect against projected future sea level rise. In the baseline scenario, 84 acres of wetlands are inundated.

A significant number of built and natural assets would be affected in Foster City under the mid-level scenario should the levee be overtopped, and the majority of assets in each asset category and Risk Class would be affected. Overall, many of this city's built assets are vulnerable. In some cases, 100% or nearly 100% of an asset type is vulnerable (e.g., schools, outpatient health care facilities, communications towers, and storm drains) including infrastructure that may serve to protect residents in the event of a flood.

A significant portion of built assets that are lifeline facilities or highly important for the everyday functioning of society (Risk Class 3 and 4) are also vulnerable with no action taken; these assets include all local roads, the fire station, the police station, emergency shelter sites, communications towers, and highway and railway bridges. Hazardous material sites and underground chemical storage tanks could pose a significant threat to public health in the event of a flood. A majority of all energy transmission lines and towers are also vulnerable. Recreational land uses such as parks and trails will also be affected.

Other infrastructure designed to protect residents in the event of a flood is vulnerable. This infrastructure includes outfalls, storm drains, and a stormwater pump station. Approximately 90% of the City's wetlands, which will serve a role in helping the City adapt to sea level rise, will be affected, though this natural asset's capacity to withstand sea level rise is unclear.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	2,738	0	106	2,630	2,638
Population	30,600	0	<100	30,500	30,600
Population in Vulnerable Communities[1]	3,200	0	0	3,200	3,200
Urban Land (acres)	2,236	0	2	2,204	2,209
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	23	0	0	23	23
Natural Land (acres)	479	0	105	402	405
Residential Parcels[2]	--	0	0	8,849	8,849
Commercial Parcels[2]	--	0	0	148	148
Other Parcels[2]	--	0	37	213	213
Parcels with No Data Available[2]	--	0	5	210	210
Assessed Value of All Parcels at Risk ($ in Millions)	$7,712	$0	$1	$8,330	$8,330

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	231.9	0.0	0.1	231.1	231.1

Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	0.8	0.0	0.0	0.2	0.2
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	200.2	0.0	84.3	177.3	176.9

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	42	0	0	42	42
Electric Substations	0	0	0	0	0
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	4	0	0	4	4
Fire Stations	1	0	0	1	1
Hazardous Material Sites	4	0	0	4	4
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	9	0	0	9	9
Highways (miles)	12.6	0.0	0.0	3.9	3.9
Levees and Floodwalls (miles)	6.5	0.0	0.2	5.8	6.1
Natural Gas Pipelines (miles)	0.0	0.0	0.0	0.0	0.0
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	20.0	0.0	0.8	20.0	20.0
Police Stations	1	0	0	1	1
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	1	1

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	2	0	0	1	1
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	0	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	43	0	0	43	43
Ports	0	0	0	0	0
Rail (miles)	0.0	0.0	0.0	0.0	0.0
Rail Stations	0	0	0	0	0
Roads (local) (miles)	70.5	0.0	0.1	70.4	70.4

Schools	9	0	0	9	9
Senior Centers	2	0	0	2	2
Storm Drains (miles)	18.1	0.0	0.0	17.4	17.4
Stormwater Pump Stations[3]	1	--	0	1	1
Transmission Lines (miles)	16.4	0.0	0.4	12.0	12.0
Transmission Towers	29	0	1	17	17
Underground Chemical Storage Tanks	3	0	0	3	3
Wastewater Pump Stations[3]	--	--	--	--	--
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	11	0	0	11	11
Health Care Facilities (outpatient)	2	0	0	2	2
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	2	0	2	2	2
Fishing Piers	0	0	0	0	0
Parks	21	0	0	21	21
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	6.5	0.0	0.0	5.9	6.1

Half Moon Bay

Map: Zone 10

The City of Half Moon Bay has 32 acres of land inundated in the baseline scenario, 76 acres inundated in the mid-level scenario, and 103 acres inundated in the high-end scenario. There are 263 acres that are affected in the erosion scenario. Existing shoreline infrastructure within Half Moon Bay is vulnerable under the mid-level scenario. This infrastructure includes any engineered and protective construction along the coast, excluding levees. Two specific assets that are vulnerable, streams and storm drains, may exacerbate flooding in the event of a storm coupled with sea level rise. Recreational assets, such as trails and parks, will also be affected.

Under the erosion scenario, a different picture of vulnerability emerges. The Half Moon Bay Landfill (closed, owned and operated by the County, see associated Asset Vulnerability Profile in Appendix D), other protective infrastructure on the coast, and local roads may be affected. Natural assets, including wetlands and streams, and recreational assets, such as trails (over half of all trail miles), may also be vulnerable to erosion.

*The erosion scenario represents the projected extent of coastal erosion with 4.6 feet of sea level rise; it does not take into consideration existing shoreline protection infrastructure. The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	3,967	263	32	76	103
Population	11,100	200	<100	<100	<100
Population in Vulnerable Communities[1]	600	<100	0	0	0
Urban Land (acres)	1,448	40	1	1	3
Agricultural Land (acres)	552	0	0	0	0
Industrial Land (acres)	4	0	0	0	2
Natural Land (acres)	1,963	219	25	64	86
Residential Parcels[2]	--	19	1	1	4
Commercial Parcels[2]	--	7	2	39	46
Other Parcels[2]	--	139	62	73	84
Parcels with No Data Available[2]	--	3	1	27	27
Assessed Value of All Parcels at Risk ($ in Millions)	$2,585	$181	$6	$25	$30

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	4.2	4.2	4.2	4.2	4.2
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	3.6	0.0	0.0	0.0	0.0
Kelp Habitat (acres)	11.0	11.0	11.0	11.0	11.0
Streams (miles)	9.8	1.0	0.4	0.9	1.2
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	37.1	0.8	0.2	0.9	4.7

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	30	0	0	0	3
Electric Substations	1	0	0	0	0
Emergency Operations Centers	1	0	0	0	0
Emergency Shelter Sites	5	0	0	0	0
Fire Stations	1	0	0	0	0
Hazardous Material Sites	3	0	0	0	0
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	4	0	0	0	0
Highways (miles)	8.1	0.3	0.0	0.0	0.0
Levees and Floodwalls (miles)	0.0	0.0	0.0	0.0	0.0
Natural Gas Pipelines (miles)	0.9	0.0	0.0	0.0	0.0
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	0.2	0.1	0.0	0.1	0.2
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	1	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	1	0	0	0	0
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	2	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	10	0	0	0	1
Ports	0	0	0	0	0
Rail (miles)	0.0	0.0	0.0	0.0	0.0
Rail Stations	0	0	0	0	0
Roads (local) (miles)	49.4	1.7	0.0	0.0	0.0
Schools	6	0	0	0	0
Senior Centers	1	0	0	0	0
Storm Drains (miles)	13.0	0.6	0.3	0.6	0.9
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	0.6	0.0	0.0	0.0	0.0

Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	4	0	0	0	0
Wastewater Pump Stations[3]	4	0	0	0	0
Wastewater Treatment Plants	1	0	0	0	1

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	8	0	0	0	0
Health Care Facilities (outpatient)	2	0	0	0	0
Marinas	0	0	0	0	0
Mobile Home Parks	2	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	18	6	1	1	1
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	8.2	4.3	0.2	0.3	0.6

Menlo Park

Map: Zone 7

The City of Menlo Park has 2,006 acres inundated in the baseline scenario, 2,874 acres inundated in the mid-level scenario, and 3,037 acres inundated in the high-end scenario. In the baseline scenario, a portion of the Haven Avenue area is inundated, as well as the Ravenswood Pond Complex. In the mid-level scenario, the Bayfront Expressway is inundated, along with the Belle Haven neighborhood and the Bayfront area. Several built assets important in protecting residents and development from floods, such as levees, other built shoreline infrastructure, storm drains, outfalls, and stormwater pumps are vulnerable at the mid-level scenario. The wastewater pump station located in the City and significant portions of the energy transmission infrastructure (including electric substations, and transmission lines and towers) are vulnerable as well, which may exacerbate the longer-term impacts of an extreme flood event overall. Both outpatient health care facilities located in Menlo Park are vulnerable, which may have public health implications in the event of a significant storm. Recreation may also be affected because 8 out of 13 total miles of trails and 5 out of 14 parks will be affected in the mid-level scenario.

Wetlands, an important natural asset in adapting to sea level rise in the future, are also vulnerable—93% of the ~2,000 acres of wetlands will be affected, but the extent to which these wetlands may withstand sea level rise is unclear. One project that has been underway for several years is the South Bay Salt Pond Restoration Project (U.S. Fish and Wildlife Service), the largest tidal wetland restoration project on the West Coast. This effort is in the process of restoring wetland habitat at the Ravenswood Pond Complex, which is located within the City of Menlo Park's boundaries and is under the U.S. Fish and Wildlife Service jurisdiction. Here, project managers have restored a mixed wetland habitat by enhancing 240 acres to create a 155-acre pond with nesting habitat for shorebirds, including the snowy plover, as well as trails and displays for public access and recreational use.

Additional wetland restoration plans will improve the adaptive capacity of the Ravenswood Pond Complex. These plans include breaching the outermost pond to restore tidal marsh along the Bay and adding water control structures to manage water levels and improve circulation in the innermost ponds. The All American Canal levees will also be improved to maintain flood protection, and the remaining three ponds will continue to be managed for habitat. The project will also include upland transition zones to buffer wave action and provide wetland migration space.

The high-end scenario overtops Highway 101 on both sides of the Highway 101 and State Route 84 interchange.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	5,757	0	2,006	2,874	3,037
Population	29,500	0	<100	2,800	4,300
Population in Vulnerable Communities[1]	7,000	0	<100	2,800	4,300
Urban Land (acres)	3,388	0	41	703	851
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	1,648	0	1,586	1,642	1,646
Natural Land (acres)	721	0	379	528	540
Residential Parcels[2]	--	0	0	574	856
Commercial Parcels[2]	--	0	20	139	152
Other Parcels[2]	--	0	51	103	113
Parcels with No Data Available[2]	--	0	19	29	30
Assessed Value of All Parcels at Risk ($ in Millions)	$12,228	$0	$182	$1,288	$1,621

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	535.7	0.0	490.3	499.3	502.1
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	5.4	0.0	3.0	3.3	3.3
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	2,160.0	0.0	1,819.1	2,009.6	2,018.4

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	45	0	3	13	15
Electric Substations	5	0	0	2	3
Emergency Operations Centers	1	0	0	0	0
Emergency Shelter Sites	11	0	0	2	3
Fire Stations	3	0	0	1	1
Hazardous Material Sites	12	0	0	8	8
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	6	0	1	3	5
Highways (miles)	18.6	0.0	0.2	7.8	10.1
Levees and Floodwalls (miles)	1.4	0.0	0.5	1.1	1.4
Natural Gas Pipelines (miles)	2.5	0.0	0.0	0.0	0.6
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	34.5	0.0	11.9	31.6	33.0
Police Stations	1	0	0	0	0
Power Plants	1	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	2	0	0	0	0
Human Services Agency Partner Facilities	2	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	12	0	0	6	6
Ports	0	0	0	0	0
Rail (miles)	8.0	0.0	0.0	2.9	3.3
Rail Stations	1	0	0	0	0
Roads (local) (miles)	90.0	0.0	0.2	11.4	15.0
Schools	10	0	0	2	3
Senior Centers	2	0	0	1	1
Storm Drains (miles)	25.3	0.0	2.0	11.4	12.6
Stormwater Pump Stations[3]	6	--	0	2	3
Transmission Lines (miles)	13.6	0.0	5.0	8.3	8.6
Transmission Towers	11	0	5	9	9
Underground Chemical Storage Tanks	10	0	0	2	2
Wastewater Pump Stations[3]	1	--	0	1	1
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	6	0	0	1	1
Health Care Facilities (outpatient)	2	0	0	2	2
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	14	0	5	5	6
Salt Ponds and Crystallizers	8	0	8	8	8
Trails (miles)	13.1	0.0	2.6	8.4	10.1

Millbrae

Map: Zone 3

The City of Millbrae has 4 acres of land inundated in the baseline scenario, 187 acres inundated in the mid-level scenario, and 254 acres inundated in the high-end scenario. In the baseline scenario, only a small area is inundated, including wetlands and two parcels. In the mid-level scenario, Highway 101 is overtopped, and the inundation extent reaches the Millbrae Intermodal Station parking lot. In addition, infrastructure designed to prevent or minimize flooding is vulnerable in the mid-level scenario in Millbrae. One of the City's stormwater pumps and significant portions of its levees and other built shorelines are vulnerable. Energy transmission assets (natural gas pipelines and electrical transmission lines) will also be affected. The single wastewater treatment facility located within the City, as well as two out of three wastewater pump stations, are vulnerable to the effects of sea level rise. Thirty percent of the highways in the City will be subject to inundation and flooding with no action.

The high-end scenario, inundation could reach the BART and Caltrain station and overtop the tracks.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	2,098	0	4	187	254
Population	21,600	0	0	400	1,000
Population in Vulnerable Communities[1]	7,700	0	0	0	<100
Urban Land (acres)	1,853	0	0	127	187
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	2	0	0	0	0
Natural Land (acres)	244	0	4	60	67
Residential Parcels[2]	--	0	0	158	352
Commercial Parcels[2]	--	0	2	30	39
Other Parcels[2]	--	0	0	22	40
Parcels with No Data Available[2]	--	0	0	16	46
Assessed Value of All Parcels at Risk ($ in Millions)	$4,572	$0	$2	$230	$369

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	3.3	0.0	0.0	2.9	2.9
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	3.2	0.0	0.0	1.8	1.9
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	54.7	0.0	1.0	51.1	53.1

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	30	0	0	4	6
Electric Substations	3	0	0	1	1
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	7	0	0	0	0
Fire Stations	2	0	0	0	0
Hazardous Material Sites	12	0	0	1	1
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	6	0	0	2	2
Highways (miles)	8.7	0.0	0.0	2.4	2.4
Levees and Floodwalls (miles)	2.0	0.0	0.0	1.9	2.0
Natural Gas Pipelines (miles)	1.4	0.0	0.0	1.2	1.4
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	0.6	0.0	0.0	0.6	0.6
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	0	0	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	1	0	0	0	0
Human Services Agency Partner Facilities	0	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	3	0	0	0	3
Ports	0	0	0	0	0
Rail (miles)	3.8	0.0	0.0	0.0	1.1
Rail Stations	1	0	0	1	1
Roads (local) (miles)	57.1	0.0	0.0	3.1	4.9
Schools	8	0	0	0	0
Senior Centers	2	0	0	0	0
Storm Drains (miles)	11.0	0.0	0.0	1.7	2.8
Stormwater Pump Stations[3]	2	--	0	1	1
Transmission Lines (miles)	5.5	0.0	0.0	3.1	3.8

Transmission Towers	17	0	0	4	5
Underground Chemical Storage Tanks	7	0	0	1	2
Wastewater Pump Stations[3]	3	--	0	2	2
Wastewater Treatment Plants	1	0	0	1	1

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	2	0	0	0	0
Health Care Facilities (outpatient)	0	0	0	0	0
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	15	0	0	2	3
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	4.4	0.0	0.0	1.4	1.8

Pacifica

Map: Zone 9

The City of Pacifica has 38 acres of land inundated in the baseline scenario, 162 acres inundated in the mid-level scenario, and 297 acres inundated in the high-end scenario. Pacifica's natural assets, including wetlands and parks will be affected at the mid-level scenario. In the baseline scenario, significant inundation does not occur in any of the low-lying neighborhoods in Pacifica. In the mid-level scenario, a portion of the Sharp Park neighborhood and a small section of the Rockaway parking lot are inundated.

All 2 miles of beaches within Pacifica are vulnerable under the baseline, mid-level, and high-end scenarios.

In the high-end scenario, the Linda Mar neighborhood is inundated, as well as a larger portion of the Sharp Park neighborhood.

A different picture of vulnerability emerges under the erosion scenario. In this scenario, one of the two inpatient health care facilities is vulnerable. All of Pacifica's levees, floodwalls, and other built shoreline infrastructure are vulnerable, as well as 33% of its outfalls and 7% of its storm drains. Three of its five wastewater pump stations will also be affected. All of these assets may serve an important role in the event of a flood. Over half of Pacifica's 36 acres of wetlands will be affected, though the extent to which these wetlands may withstand sea level rise is unclear. All of Pacifica's beaches are vulnerable under this scenario as well. For more information on beaches in Pacifica, please see the Pacifica State Beach AVP in Appendix D.

Infrastructure related to mitigating and preventing floods is also vulnerable, including stormwater pumps, outfalls, a small portion of the City's sea wall, and other built shoreline assets.

*The erosion scenario represents the projected extent of coastal erosion with 4.6 feet of sea level rise; it does not take into consideration existing shoreline protection infrastructure. The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	8,015	416	38	162	297
Population	37,200	2,000	<100	500	1,600
Population in Vulnerable Communities[1]	<100	0	0	0	0
Urban Land (acres)	2,692	138	1	51	160
Agricultural Land (acres)	30	0	0	0	0
Industrial Land (acres)	12	0	0	0	0
Natural Land (acres)	5,282	277	36	109	136
Residential Parcels[2]	--	487	51	170	527
Commercial Parcels[2]	--	31	7	13	25
Other Parcels[2]	--	144	52	83	116
Parcels with No Data Available[2]	--	59	42	51	53
Assessed Value of All Parcels at Risk ($ in Millions)	$5,143	$361	$42	$136	$323

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	2.0	2.0	2.0	2.0	2.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	2.6	1.8	0.0	1.8	1.8

Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	16.7	0.3	0.0	0.2	0.4
Surfgrass Habitat (miles)	1.8	1.8	1.8	1.8	1.8
Wetlands (acres)	36.1	19.8	0.0	30.9	32.8

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	30	0	0	0	2
Electric Substations	1	0	0	0	0
Emergency Operations Centers	1	0	0	0	0
Emergency Shelter Sites	9	0	0	0	1
Fire Stations	2	0	0	0	0
Hazardous Material Sites	8	0	0	0	2
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	8	0	0	0	1
Highways (miles)	16.0	0.8	0.0	0.0	0.5
Levees and Floodwalls (miles)	1.1	1.1	0.1	0.2	0.6
Natural Gas Pipelines (miles)	0.7	0.0	0.0	0.0	0.0
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	1.7	1.7	0.2	0.6	1.1
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	2	1	0	0	0
Human Services Agency Partner Facilities	1	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	18	7	4	5	5
Ports	0	0	0	0	0
Rail (miles)	0.0	0.0	0.0	0.0	0.0
Rail Stations	0	0	0	0	0

Roads (local) (miles)	106.3	6.2	0.1	1.4	4.9
Schools	12	0	0	0	1
Senior Centers	1	0	0	0	1
Storm Drains (miles)	26.8	1.9	0.1	1.2	2.9
Stormwater Pump Stations[3]	3	3	0	1	2
Transmission Lines (miles)	6.8	0.0	0.0	0.0	0.0
Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	5	0	0	0	0
Wastewater Pump Stations[3]	5	3	0	1	2
Wastewater Treatment Plants	1	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	5	0	0	1	2
Health Care Facilities (outpatient)	0	0	0	0	0
Marinas	0	0	0	0	0
Mobile Home Parks	1	1	0	0	0

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	1	1	0	0	1
Parks	20	3	0	2	4
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	23.1	6.0	0.0	0.4	0.8

Redwood City

Map: Zone 6

The City of Redwood City has 5,624 acres of land inundated in the baseline scenario, 8,308 acres inundated in the mid-level scenario, and 8,667 acres inundated in the high-end scenario. In the baseline scenario, the Roble Avenue area and the area east of East Bayshore Road are inundated. In addition, a portion of Sea Port Boulevard, the salt pond complex adjacent to Seaport, a part of Maple Street, and the area near Bair Island Road are inundated. In the mid-level scenario, Redwood Shores is inundated, Highway 101 is overtopped, and portions of Woodside Road and downtown Redwood City are inundated.

Many built and natural assets are vulnerable in Redwood City in the mid-level scenario. Infrastructure designed to prevent and/or mitigate flooding in the event of a major storm will be significantly affected, such as stormwater pump stations (97%), levees and floodwalls (95%), other built shoreline features (95%), and outfalls (70%). Key energy and public health assets will be affected, including the power plant, approximately 80% of energy transmission lines and towers, one solid waste facility, electric substations (43%), the wastewater treatment plant, and all six wastewater pump stations.

Several assets within the community are also vulnerable, including the County jail, all six outpatient health care facilities and all three mobile home parks in Redwood City, nearly 50% of parks, and over 70% of all trail miles. Especially important from a regional perspective is the emergency health care center in Redwood City (Kaiser Hospital) that is vulnerable; one out of two of the emergency health facilities that Countywide residents rely on is vulnerable (the other is Sequoia Hospital). The hospital itself has high adaptive capacity to respond to a flood or disaster, but if the roads surrounding the hospital are inundated, accessing the emergency services may be challenging. Both highways and local roads will be affected (~37% of the total). Over half of all hazardous material sites within the City's jurisdiction will be affected by a flood event in the mid-level scenario.

Over 90% of Redwood City's 4,654 acres of wetlands are vulnerable, though the extent to which these wetlands may withstand sea level rise is unclear. These wetlands may play an important role in adapting to sea level rise in near- and long-term adaptation planning. The Port of Redwood City will also be affected, which may have wider regional business and economic impacts. For more detailed information about the Port, please see the corresponding Asset Vulnerability Profile.

In the high-end scenario, the Caltrain tracks are inundated in some areas, and the inundation extent is just east of West El Camino.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	14,043	0	5,624	8,308	8,667
Population	76,900	0	1,500	21,000	25,600
Population in Vulnerable Communities[1]	33,400	0	0	7,100	10,800
Urban Land (acres)	6,761	0	539	2,821	3,154
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	1,344	0	1,315	1,343	1,343
Natural Land (acres)	5,938	0	3,771	4,144	4,170
Residential Parcels[2]	--	0	302	5,826	6,490
Commercial Parcels[2]	--	0	85	568	643
Other Parcels[2]	--	0	147	342	377
Parcels with No Data Available[2]	--	0	347	3,725	3,739
Assessed Value of All Parcels at Risk ($ in Millions)	$17,263	$0	$936	$8,963	$9,481

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	1,549.8	0.0	1,299.6	1,509.7	1,524.4
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	35.2	0.0	3.6	5.6	5.9
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	4,654.2	0.0	3,968.6	4,298.9	4,330.0

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	121	0	10	76	79
Electric Substations	7	0	1	3	5
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	21	0	0	4	6
Fire Stations	5	0	0	3	3
Hazardous Material Sites	50	0	2	27	30
Health Care Facilities (emergency)	2	0	0	1	1
Highway and Railway Bridges	20	0	0	11	13
Highways (miles)	23.5	0.0	0.0	8.7	10.7
Levees and Floodwalls (miles)	7.3	0.0	1.3	7.0	7.2
Natural Gas Pipelines (miles)	6.5	0.0	0.0	4.0	4.1
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	83.0	0.0	35.0	79.1	81.4
Police Stations	1	0	0	1	1
Power Plants	1	0	0	1	1
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	3	0	0	1	3

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	1	0	1	1	1
Health Care Facilities (inpatient)	1	0	0	0	0
Human Services Agency Partner Facilities	5	0	0	1	2
Jails	1	0	0	1	1
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	69	0	13	48	52
Ports	1	0	1	1	1
Rail (miles)	9.3	0.0	0.8	2.5	4.3
Rail Stations	1	0	0	0	1
Roads (local) (miles)	200.0	0.0	6.0	72.8	82.2
Schools	27	0	0	6	9
Senior Centers	3	0	0	0	0
Storm Drains (miles)	61.7	0.0	6.0	32.6	34.5
Stormwater Pump Stations[3]	32	--	10	31	32
Transmission Lines (miles)	26.5	0.0	15.3	20.2	20.3
Transmission Towers	24	0	16	19	19
Underground Chemical Storage Tanks	23	0	0	13	14
Wastewater Pump Stations[3]	6	--	2	6	6
Wastewater Treatment Plants	1	0	0	1	1

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	29	0	0	7	11
Health Care Facilities (outpatient)	6	0	0	6	6
Marinas	8	0	8	8	8
Mobile Home Parks	3	0	0	3	3

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	2	0	2	2	2
Fishing Piers	1	0	0	0	0
Parks	27	0	3	13	15
Salt Ponds and Crystallizers	16	0	16	16	16
Trails (miles)	25.2	0.0	5.8	17.8	17.9

San Bruno

Map: Zone 2

The City of San Bruno has no land inundated in the baseline scenario, 65 acres inundated in the mid-level scenario, and 128 acres inundated in the high-end scenario. In the mid-level scenario, the 7th Avenue area is inundated up to around 5th Avenue. Lions Park and Belle Air Elementary School are inundated. In addition, natural and recreational assets in San Bruno may be affected by sea level rise in the mid-level scenario. Forty-four percent of the wetlands that will serve to help the City adapt to sea level rise will be affected, though this natural asset's capacity to withstand sea level rise is unclear. Two out of three of its parks are vulnerable. Limited vulnerability exists with the City's stormwater and flooding infrastructure, though 20% of its outfalls will be affected.

In the high-end scenario, inundation extends to the Caltrain and BART tracks.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	3,511	0	0	65	128
Population	41,100	0	0	1,300	2,400
Population in Vulnerable Communities[1]	14,400	0	0	1,300	2,400
Urban Land (acres)	2,813	0	0	61	114
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	1	0	0	0	0
Natural Land (acres)	698	0	0	4	14
Residential Parcels[2]	--	0	0	322	577
Commercial Parcels[2]	--	0	0	18	35
Other Parcels[2]	--	0	0	15	30
Parcels with No Data Available[2]	--	0	0	1	1
Assessed Value of All Parcels at Risk ($ in Millions)	$6,181	$0	$0	$119	$234

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	0.0	0.0	0.0	0.0	0.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	2.0	0.0	0.0	0.0	0.1
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	6.1	0.0	0.0	2.7	6.0

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	42	0	0	0	0
Electric Substations	3	0	0	0	0
Emergency Operations Centers	1	0	0	0	0
Emergency Shelter Sites	16	0	0	1	2
Fire Stations	2	0	0	0	0
Hazardous Material Sites	16	0	0	1	1
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	22	0	0	0	0
Highways (miles)	22.8	0.0	0.0	0.0	0.0
Levees and Floodwalls (miles)	0.0	0.0	0.0	0.0	0.0
Natural Gas Pipelines (miles)	8.2	0.0	0.0	0.2	0.3
Natural Gas Storage	6	0	0	0	0
Other Built Shorelines (miles)	0.5	0.0	0.0	0.0	0.5
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	1	0	0	0	0
Human Services Agency Partner Facilities	1	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	5	0	0	1	1
Ports	0	0	0	0	0
Rail (miles)	5.5	0.0	0.0	0.0	0.0
Rail Stations	2	0	0	0	0
Roads (local) (miles)	92.3	0.0	0.0	2.2	4.4
Schools	14	0	0	1	1

Senior Centers	1	0	0	0	0
Storm Drains (miles)	18.4	0.0	0.0	0.1	0.6
Stormwater Pump Stations[3]	1	--	--	--	--
Transmission Lines (miles)	6.3	0.0	0.0	0.0	0.1
Transmission Towers	19	0	0	0	0
Underground Chemical Storage Tanks	5	0	0	0	0
Wastewater Pump Stations[3]	5	--	--	--	--
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	3	0	0	0	0
Health Care Facilities (outpatient)	1	0	0	0	0
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	16	0	0	2	3
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	6.4	0.0	0.0	0.5	0.7

San Carlos

Map: Zone 6

The City of San Carlos has 2 acres of land inundated in the baseline scenario, 483 acres inundated in the mid-level scenario, and 593 acres inundated in the high-end scenario. In the mid-level scenario, the San Carlos Airport is inundated and Highway 101 is overtopped, with the Holly Street and Industrial Road area inundated. Impacts to the San Carlos Airport will have wider regional economic impacts. For more information, please see the corresponding Asset Vulnerability Profile.

Key infrastructure in preventing and mitigating flooding, such as levees and other built shoreline assets, a stormwater pump station, outfalls, and storm drains, will be affected at the mid-level scenario. The majority of the City's wetlands (3.4 acres affected out of 3.7 acres) are vulnerable, though the extent to which these wetlands may withstand sea level rise is unclear. Road and transportation related assets will be affected; approximately 60% of highway and railway bridges and nearly 60% of highway miles will be inundated in the event of a significant storm. Other assets that may play an important role in the event of a flood emergency and its aftermath are also vulnerable, such as communications towers, wastewater pump stations, electrical transmission lines, and an electric substation. A significant portion of the City's hazardous material sites (13 out of 43) are also vulnerable to inundation, which may have significant public health impacts in the event of a flood.

In the high-end scenario, inundation extends to just before Old County Road.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	**TOTAL**	**EROSION SCENARIO**	**BASELINE SCENARIO**	**MID-LEVEL SCENARIO**	**HIGH-END SCENARIO**
Land Area (acres)	3,457	0	2	483	593
Population	28,000	0	0	500	800
Population in Vulnerable Communities[1]	1,100	0	0	0	0
Urban Land (acres)	2,979	0	0	479	588
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	477	0	2	4	4
Residential Parcels[2]	--	0	0	207	321
Commercial Parcels[2]	--	0	2	325	392
Other Parcels[2]	--	0	1	28	34
Parcels with No Data Available[2]	--	0	0	9	12
Assessed Value of All Parcels at Risk ($ in Millions)	$8,228	$0	$0	$885	$1,051

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	**TOTAL**	**EROSION SCENARIO**	**BASELINE SCENARIO**	**MID-LEVEL SCENARIO**	**HIGH-END SCENARIO**
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	1.0	0.0	0.0	1.0	1.0
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0

Streams (miles)	5.5	0.0	0.1	0.7	0.9
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	3.7	0.0	2.0	3.4	3.4

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	1	0	0	1	1
Communications Towers	85	0	0	25	25
Electric Substations	1	0	0	1	1
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	7	0	0	0	0
Fire Stations	2	0	0	0	0
Hazardous Material Sites	43	0	0	13	19
Health Care Facilities (emergency)	0	0	0	0	0
Highway and Railway Bridges	5	0	0	3	5
Highways (miles)	10.1	0.0	0.0	5.8	6.1
Levees and Floodwalls (miles)	0.3	0.0	0.0	0.3	0.3
Natural Gas Pipelines (miles)	5.1	0.0	0.0	0.9	0.9
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	2.6	0.0	0.0	1.5	2.0
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	1	1

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	2	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	18	0	0	4	6
Ports	0	0	0	0	0
Rail (miles)	5.0	0.0	0.0	0.2	0.3
Rail Stations	1	0	0	0	0
Roads (local) (miles)	93.8	0.0	0.0	7.2	9.4
Schools	11	0	0	0	0

Senior Centers	1	0	0	0	0
Storm Drains (miles)	21.8	0.0	0.1	4.7	5.4
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	1.4	0.0	0.0	1.3	1.4
Transmission Towers	0	0	0	0	0
Underground Chemical Storage Tanks	3	0	0	0	0
Wastewater Pump Stations[3]	--	--	--	--	--
Wastewater Treatment Plants	0	0	0	0	0

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	6	0	0	1	1
Health Care Facilities (outpatient)	1	0	0	1	1
Marinas	0	0	0	0	0
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	0	0	0	0	0
Parks	13	0	0	0	0
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	2.1	0.0	0.0	0.1	0.1

San Mateo

Map: Zone 4

The City of San Mateo has 505 acres of land inundated in the baseline scenario, 3,132 acres inundated in the mid-level scenario, and 3,411 acres inundated in the high-end scenario. In the baseline scenario, the Poplar Golf Course and area south of the golf course are inundated, as well as part of Highway 101, Peninsula Avenue, and J Hart Clinton Drive. In the mid-level scenario, the levees that protect the City of San Mateo and Foster City are overtopped, leading to overtopping of Highway 101 and flooding of the Hayward Caltrain Station and surrounding areas (see information below on levee improvements underway).

San Mateo's flood and stormwater infrastructure is vulnerable to the effects of future sea level rise in the mid-level scenario. Over half of its levees, nearly 90% of its other built shorelines, 80% of its stormwater pump stations, and nearly 72% of its outfalls will be affected. Energy infrastructure will be significantly affected under the mid-level scenario, including energy transmission lines and towers, the power plant (Franklin Templeton San Mateo Natural Gas Plant), half of all electric substations, and over half of all natural gas pipelines. The wastewater treatment plant and the police station located within San Mateo will be affected. Recreational assets in the city such as one of the boat launches, the fishing pier, and 22 out of 37 parks will be inundated.

Transportation infrastructure, including bridges and highways, will also be affected by nearly 50%. Approximately 84% of wetlands within the City are vulnerable, though this natural asset's capacity to withstand sea level rise is unclear.

The City of San Mateo is protected by the Foster City levee and San Mateo levees. Foster City is in the process of raising its levee height to meet Federal Emergency Management Agency accreditation and to prepare for sea level rise, which will reduce the risk of inundation in some parts of San Mateo. In recent years, San Mateo has addressed its vulnerability to flooding. City officials evaluated its current levee system, identified low spots, and proposed a series of improvements based on the best available sea level rise projections for California developed by the National Research Council. Other flood prevention projects completed in 2012 include the South Bayfront Levee improvements at the following sites: the Detroit Drive Floodwall, the Seal Slough Floodwall, the San Mateo Creek Floodwall, and the East End Levee.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	7,974	0	505	3,132	3,411
Population	97,200	0	5,700	39,200	43,100
Population in Vulnerable Communities[1]	30,600	0	3,200	7,300	9,200
Urban Land (acres)	6,908	0	403	2,762	3,026
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	3	0	0	0	0
Natural Land (acres)	1,064	0	102	370	385
Residential Parcels[2]	--	0	1,251	12,005	12,709
Commercial Parcels[2]	--	0	36	336	403
Other Parcels[2]	--	0	39	145	166
Parcels with No Data Available[2]	--	0	19	322	439
Assessed Value of All Parcels at Risk ($ in Millions)	$19,810	$0	$619	$8,049	$8,404

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	5.9	0.0	5.9	5.9	5.9
Inland Water Features (acres)	11.4	0.0	7.3	11.4	11.4
Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	16.3	0.0	0.5	8.8	9.1
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	81.5	0.0	44.4	68.4	69.5

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	105	0	5	33	41
Electric Substations	4	0	1	2	2
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	23	0	0	7	8
Fire Stations	6	0	0	1	2
Hazardous Material Sites	38	0	2	12	12
Health Care Facilities (emergency)	2	0	0	0	0
Highway and Railway Bridges	49	0	2	24	27
Highways (miles)	43.7	0.0	1.8	20.8	23.4
Levees and Floodwalls (miles)	3.2	0.0	0.1	2.1	3.2
Natural Gas Pipelines (miles)	6.0	0.0	0.8	3.7	4.3
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	31.8	0.0	4.3	27.7	29.2
Police Stations	1	0	0	1	1
Power Plants	0	0	0	0	0
Refined Product Terminals	0	0	0	0	0
Solid Waste Facilities and Closed Landfills	0	0	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	0	0	0	0	0
Health Care Facilities (inpatient)	3	0	0	0	0
Human Services Agency Partner Facilities	3	0	0	0	1
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	0	0	0	0	0
Outfalls	71	0	5	51	52
Ports	0	0	0	0	0
Rail (miles)	8.9	0.0	0.0	1.1	2.5
Rail Stations	3	0	0	1	1
Roads (local) (miles)	216.5	0.0	11.2	83.3	91.4
Schools	32	0	1	9	10
Senior Centers	3	0	0	0	0
Storm Drains (miles)	59.4	0.0	4.0	25.3	27.5
Stormwater Pump Stations[3]	10	--	1	8	8
Transmission Lines (miles)	24.2	0.0	5.9	14.0	16.1
Transmission Towers	44	0	24	36	38
Underground Chemical Storage Tanks	8	0	0	0	0
Wastewater Pump Stations[3]	37	--	3	31	31
Wastewater Treatment Plants	1	0	0	1	1

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	26	0	0	5	7
Health Care Facilities (outpatient)	10	0	0	4	4
Marinas	1	0	1	1	1
Mobile Home Parks	0	0	0	0	0

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	2	0	2	2	2
Fishing Piers	1	0	0	1	1
Parks	37	0	5	22	24
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	11.6	0.0	0.6	4.2	5.6

South San Francisco

Map: Zone 1

The City of South San Francisco has 83 acres of land inundated in the baseline scenario, 588 acres inundated in the mid-level scenario, and 1,203 acres inundated in the high-end scenario. The baseline scenario leads to some inundation of the Oyster Point parking lot and inundation of the outer edge of the South San Francisco wastewater treatment plant. The mid-level scenario leads to inundation of the wastewater treatment plant, overtopping of Highway 101, and inundation of the area near Colma Creek. North Access Road also becomes inundated.

Key infrastructure in preventing and mitigating a flood, including levees and/or floodwalls and other built shoreline features, is vulnerable in South San Francisco in the mid-level scenario. Recreational assets, such as parks and trails, will be affected. Wastewater infrastructure, 5 of 15 pumps and the South San Francisco treatment facility, are vulnerable. The inventory below shows two wastewater treatment plants. One of these is owned by South San Francisco, and the other is at San Francisco International Airport but within the jurisdictional boundary of South San Francisco. Limited assets within the residential community are vulnerable, but a quarter of all outpatient health care facilities and one of the five fire stations may be affected. Over half of the 59 acres of wetlands within the City are vulnerable, though this natural asset's capacity to withstand sea level rise is unclear. The high-level scenario leads to inundation of the Caltrain tracks and around Colma Creek up to around Fir Avenue.

*The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	5,856	0	83	588	1,203
Population	63,100	0	<100	100	300
Population in Vulnerable Communities[1]	21,200	0	0	0	0
Urban Land (acres)	5,296	0	17	490	1,083
Agricultural Land (acres)	7	0	0	0	0
Industrial Land (acres)	1	0	0	0	0
Natural Land (acres)	552	0	66	98	120
Residential Parcels[2]	--	0	0	0	31
Commercial Parcels[2]	--	0	30	187	592
Other Parcels[2]	--	0	20	59	123
Parcels with No Data Available[2]	--	0	6	80	124
Assessed Value of All Parcels at Risk ($ in Millions)	$14,051	$0	$911	$2,379	$3,587

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.0	0.0	0.0	0.0	0.0
Eelgrass Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Inland Water Features (acres)	0.0	0.0	0.0	0.0	0.0

Kelp Habitat (acres)	0.0	0.0	0.0	0.0	0.0
Streams (miles)	5.3	0.0	0.1	0.6	2.0
Surfgrass Habitat (miles)	0.0	0.0	0.0	0.0	0.0
Wetlands (acres)	59.0	0.0	19.9	30.9	46.4

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	0	0	0	0	0
Communications Towers	114	0	1	16	37
Electric Substations	3	0	0	0	2
Emergency Operations Centers	0	0	0	0	0
Emergency Shelter Sites	15	0	0	1	1
Fire Stations	5	0	0	1	2
Hazardous Material Sites	68	0	0	5	30
Health Care Facilities (emergency)	1	0	0	0	0
Highway and Railway Bridges	27	0	0	3	9
Highways (miles)	22.8	0.0	0.0	3.0	5.3
Levees and Floodwalls (miles)	0.6	0.0	0.1	0.4	0.4
Natural Gas Pipelines (miles)	18.1	0.0	0.2	2.8	5.7
Natural Gas Storage	0	0	0	0	0
Other Built Shorelines (miles)	16.6	0.0	2.6	7.4	12.2
Police Stations	1	0	0	0	0
Power Plants	0	0	0	0	0
Refined Product Terminals	1	0	0	1	1
Solid Waste Facilities and Closed Landfills	3	0	0	0	1

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	2	0	0	0	0
Health Care Facilities (inpatient)	0	0	0	0	0
Human Services Agency Partner Facilities	5	0	0	0	0
Jails	0	0	0	0	0
Oil, Gas, and Geothermal Wells	1	0	0	0	0
Outfalls	40	0	2	3	13
Ports	0	0	0	0	0
Rail (miles)	22.8	0.0	0.1	1.9	7.6
Rail Stations	2	0	0	0	0
Roads (local) (miles)	150.0	0.0	0.3	5.6	15.2

Schools	18	0	0	0	0
Senior Centers	2	0	0	0	0
Storm Drains (miles)	44.8	0.0	0.1	1.9	8.2
Stormwater Pump Stations[3]	12	--	0	1	9
Transmission Lines (miles)	13.5	0.0	0.0	1.5	5.8
Transmission Towers	41	0	0	0	9
Underground Chemical Storage Tanks	15	0	0	10	10
Wastewater Pump Stations[3]	15	--	1	5	10
Wastewater Treatment Plants	2	0	0	2	2

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	15	0	0	0	0
Health Care Facilities (outpatient)	8	0	0	2	3
Marinas	2	0	2	2	2
Mobile Home Parks	1	0	0	0	0

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	0	0	0	0	0
Fishing Piers	1	0	1	1	1
Parks	18	0	0	2	2
Salt Ponds and Crystallizers	0	0	0	0	0
Trails (miles)	19.6	0.0	1.9	8.4	12.8

Unincorporated Area

Maps: Zones 2, 5, 6, 7, 8, 9, 10

The Unincorporated Area is divided into 11 sections: one for each of 10 at-risk unincorporated communities and one for the other unincorporated areas, excluding Coastside areas. The area south of Half Moon Bay, including Pescadero, is not included in this Assessment. The County is working with partners to develop data and anticipates completing a future assessment for the area south of Half Moon Bay. The at-risk unincorporated community areas for the current study include the following:

- El Granada
- Bayside Harbor/Industrial Area
- Miramar
- Mobile Home Parks along East Bayshore Road
- Montara
- Moss Beach
- North Fair Oaks
- Olympic Country Club
- Princeton/Pillar Point Harbor
- San Francisco International Airport
- Additional unincorporated areas (outside named community areas)

El Granada

El Granada has no assets located in the erosion scenario or any of the inundation scenarios. Surfers Beach and State Route 1 south of (adjacent to) El Granada are assets in the Princeton/Pillar Point Harbor profile. Since there are no assets located in the sea level rise scenarios, El Granada does not have tables.

The Pillar Ridge Mobile Home Park, located within El Granada, is not vulnerable under the erosion or sea level rise scenarios.

Bayside Harbor/ Industrial Area

Map: Zone 5

The Bayside Harbor/Industrial area is a 61-acre area between Belmont and San Carlos, near Highway 101. The area has no acres inundated in the baseline scenario, 2 acres inundated in the mid-level scenario, and 21 acres inundated in the high-end scenario. In the mid-level scenario 3% of land area is inundated, none of the area's population is affected, the one communication tower is inundated, and 25% of the shoreline protection (0.1 of 0.4 miles) is affected. In the high-end scenario, 50% of streams (0.1 of 0.2 miles) are inundated, nearly 100% of people living in the area are affected, 25% of shoreline protection ("other built shorelines") (0.1 of 0.4 miles), nearly 50% of local roads, and 30% of storm drains are affected.

*The erosion scenario represents the projected extent of coastal erosion with 4.6 feet of sea level rise; it does not take into consideration existing shoreline protection infrastructure. The baseline scenario shows a 1% annual chance flood at mean higher high water; the mid-level scenario shows a 1% annual chance flood plus 3.3 feet of sea level rise; and the high-end scenario shows a 1% chance annual flood plus 6.6 feet of sea level rise.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	61	0	0	2	21
Population	100	0	0	0	<100
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	61	0	0	2	21
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	0	0	0	0	0
Residential Parcels[2]	--	0	0	0	5
Commercial Parcels[2]	--	0	0	4	15
Other Parcels[2]	--	0	0	0	1
Parcels with No Data Available[2]	--	0	0	0	5
Assessed Value of All Parcels at Risk ($ in Millions)	$116	$0	$0	$6	$59

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Streams (miles)	0.2	0.0	0.0	0.0	0.1

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Communications Towers	1	0	0	1	1
Hazardous Material Sites	3	0	0	0	1
Natural Gas Pipelines (miles)	0.6	0.0	0.0	0.0	0.1
Other Built Shorelines (miles)	0.4	0.0	0.0	0.1	0.1

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Human Services Agency Partner Facilities	1	0	0	0	0
Rail (miles)	0.2	0.0	0.0	0.0	0.0
Roads (local) (miles)	1.3	0.0	0.0	0.0	0.6
Storm Drains (miles)	0.6	0.0	0.0	0.1	0.2
Stormwater Pump Stations[3]	--	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS – No Class 2 Assets at Risk

Miramar (Unincorporated)

Map: Zone 11

In Miramar, erosion is the greatest concern. The area has 5 acres at risk in the erosion scenario. Of particular concern is the Mirada Road area, where a portion of the road is at risk from erosion. In Miramar, 3% of the road and 5% of the people living in the area are located within the erosion scenario. No land is inundated in any of the sea level rise scenarios.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	110	5	0	0	0
Population	500	<100	0	<100	<100
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	92	5	0	0	0
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	17	0	0	0	0
Residential Parcels[2]	--	14	0	1	2
Commercial Parcels[2]	--	8	1	1	1
Other Parcels[2]	--	12	0	0	0
Parcels with No Data Available[2]	--	0	0	0	0
Assessed Value of All Parcels at Risk ($ in Millions)	$227	$27	$1	$3	$3

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Streams (miles)	0.3	0.0	0.0	0.0	0.0

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Communications Towers	1	0	0	0	0
Highways (miles)	0.5	0.0	0.0	0.0	0.0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Roads (local) (miles)	3.6	0.1	0.0	0.0	0.0
Stormwater Pump Stations3	--	--	-	-	-
Wastewater Pump Stations[3]	--	--	-	-	-

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Trails (miles)	0.2	0.1	0.0	0.0	0.0

East Bayshore Road Mobile Home Parks

Map: Zone 7

The Mobile Home Parks area is a 19-acre area adjacent to East Bayshore Road, with 16 acres inundated in the baseline scenario and all 19 acres inundated in the mid- and high-end scenarios. The area has 59 parcels, and all parcels are inundated in all scenarios. The area is located next to the Bayfront Canal and the Cargill Saltponds, and it has flooded in recent storms, such as in December 2014. In the Mobile Home Parks unincorporated area, 100% of the population living in the area are affected, as well as 100% of the levees and floodwalls, roads, storm drains, and transmission lines.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	19	0	16	19	19
Population	302	0	248	302	302
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	19	0	16	19	19
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	0	0	0	0	0
Residential Parcels[2]	--	0	21	21	21
Commercial Parcels[2]	--	0	2	2	2
Other Parcels[2]	--	0	2	2	2
Parcels with No Data Available[2]	--	0	55	55	55
Assessed Value of All Parcels at Risk ($ in Millions)	$19	$0	$19	$19	$19

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS – No Class 2 Assets at Risk

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Levees and Floodwalls (miles)	0.2	0.0	0.2	0.2	0.2

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Human Services Agency Partner Facilities	1	0	0	0	0
Rail (miles)	0.2	0.0	0.0	0.0	0.0
Roads (local) (miles)	1.3	0.0	0.0	0.0	0.6
Storm Drains (miles)	0.6	0.0	0.0	0.1	0.2
Stormwater Pump Stations[3]	--	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Mobile Home Parks	2	0	0	2	2

CLASS 1 ASSETS – No Class 2 Assets at Risk

Montara (Unincorporated)

Map: Zone 10

Montara has 3 acres inundated in the baseline scenario, 4 acres inundated in the mid-level scenario, 7 acres inundated in the high-end scenario, and 57 acres at risk in the erosion scenario. The area in the erosion scenario includes State Route 1 and over 150 parcels, with 89 residential parcels and 11 commercial parcels. In addition, Montara has 8% of the area's population and 10% of the land area affected in the erosion scenario. Nearly 80% of trails and all four parks are located within the erosion scenario. Half of the parks (two of four) are inundated by the mid-level and the high-end scenario. All of the beaches and the surfgrass could be affected in the erosion scenario and all three inundation scenarios. However, it is unclear what capacity there is for the natural assets to withstand sea level rise, due to the presence of high bluffs and other shoreline characteristics.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	597	57	3	4	7
Population	2,300	200	<100	<100	<100
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	427	37	0	0	0
Agricultural Land (acres)	6	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	164	20	3	4	7
Residential Parcels[2]	--	89	0	0	0
Commercial Parcels[2]	--	11	0	0	0
Other Parcels[2]	--	49	7	7	7

Parcels with No Data Available[2]	--	4	0	0	0
Assessed Value of All Parcels at Risk ($ in Millions)	$586	$71	$0	$0	$0

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.8	0.8	0.8	0.8	0.8
Streams (miles)	1.4	0.0	0.0	0.0	0.0
Surfgrass Habitat (miles)	0.7	0.7	0.7	0.7	0.7
Wetlands (acres)	1.9	0.2	0.0	0.0	0.0

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Hazardous Material Sites	1	1	0	0	0
Highways (miles)	0.7	0.7	0.0	0.0	0.0
Other Built Shorelines (miles)	0.1	0.1	0.0	0.0	0.0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Rail (miles)	0.0	0.0	0.0	0.0	0.0
Roads (local) (miles)	18.3	1.3	0.0	0.0	0.0
Schools	1	0	0	0	0
Storm Drains (miles)	1.6	0.0	0.0	0.0	0.0
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	0.0	0.0	0.0	0.0	0.0
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Parks	4	4	1	2	2
Trails (miles)	0.9	0.7	0.0	0.0	0.1

Moss Beach (Unincorporated)

Map: Zone 10

Moss Beach has 2 acres inundated in the baseline scenario, 3 acres inundated in the mid-level and high-end scenarios, and 45 acres inundated in the erosion scenario. Fitzgerald Marine Reserve may experience impacts to the rocky intertidal and sandy beach habitats, as well as loss of areas for seals to haul out and impacts to breeding areas for red-legged frogs. The bluff trails are also at risk of erosion. The Seal Cove area of Moss Beach is also designated as a Geological Hazard Area (due to active landslide processes), and development is not currently allowed in the area directly adjacent to the coastline by the County's Local Coastal Program (Parks 2016b).

In Moss Beach, 20% of the land area is within the erosion scenario, nearly 15% of the population, and all of the 0.1 miles of levees and floodwalls. In all three inundation scenarios, less than 1% of land area and population are at risk. Less than 15% of wetlands are inundated in all three inundation scenarios. Wetlands and other natural assets could serve a role in helping the area adapt to sea level rise, though it is unclear what capacity there is for the natural assets to withstand sea level rise because of the presence of high bluffs and other shoreline characteristics.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	210	45	2	3	3
Population	1,300	200	<100	<100	<100
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	184	31	0	0	0
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	26	14	2	3	3
Residential Parcels[2]	--	118	7	9	9
Commercial Parcels[2]	--	0	0	0	0
Other Parcels[2]	--	36	7	8	8
Parcels with No Data Available[2]	--	1	1	1	1
Assessed Value of All Parcels at Risk ($ in Millions)	$361	$92	$11	$16	$16

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Streams (miles)	0.6	0.1	0.0	0.0	0.0
Surfgrass Habitat (miles)	0.7	0.7	0.7	0.7	0.7
Wetlands (acres)	1.4	0.6	0.2	0.2	0.3

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Communications Towers	2	0	0	0	0
Fire Stations	1	0	0	0	0
Hazardous Material Sites	1	0	0	0	0

Health Care Facilities (emergency)	1	0	0	0	0
Highways (miles)	0.9	0.3	0.0	0.0	0.0
Levees and Floodwalls (miles)	0.1	0.1	0.1	0.1	0.1
Other Built Shorelines (miles)	0.1	0.1	0.0	0.0	0.0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Roads (local) (miles)	8.5	1.4	0.0	0.0	0.0
Storm Drains (miles)	0.6	0.1	0.0	0.0	0.0
Stormwater Pump Stations[3]	--	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Parks	2	1	1	1	1
Trails (miles)	0.9	0.6	0.0	0.0	0.0

North Fair Oaks (Unincorporated)

Map: Zone 6

In the unincorporated area of North Fair Oaks, no land is inundated in the baseline scenario, 8 acres are inundated in the mid-level scenario, and 50 acres are inundated in the high-end scenario. In the baseline scenario, 35 parcels are inundated, and portions of Bay Road are affected. One underground chemical storage site is vulnerable in the mid-level scenario. Roads and storm drains (~2% and ~4%, respectively) are also vulnerable in the mid-level scenario. In the high-end scenario, the extent of inundation includes parts of the Spring Street area. Less than 1% of the neighborhood's population is vulnerable under the mid-level scenario.

GENERAL INFORMATION

LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	766	0	0	8	50
Population	14,500	0	0	<100	300
Population in Vulnerable Communities[1]	13,000	0	0	<100	300
Urban Land (acres)	766	0	0	8	50
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	0	0	0	0	0

Residential Parcels[2]	--	0	0	0	56
Commercial Parcels[2]	--	0	0	33	102
Other Parcels[2]	--	0	0	2	5
Parcels with No Data Available[2]	--	0	0	0	0
Assessed Value of All Parcels at Risk ($ in Millions)	$1,586	$0	$0	$19	$100

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS – No Class 2 Assets at Risk

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Communications Towers	4	0	0	0	0
Emergency Shelter Sites	3	0	0	0	0
Fire Stations	1	0	0	0	0
Hazardous Material Sites	8	0	0	0	1
Highways (miles)	0.5	0.0	0.0	0.0	0.0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Human Services Agency Partner Facilities	3	0	0	0	0
Outfalls	1	0	0	0	0
Rail (miles)	6.9	0.0	0.0	0.0	0.0
Roads (local) (miles)	26.8	0.0	0.0	0.6	2.0
Schools	10	0	0	0	0
Storm Drains (miles)	2.7	0.0	0.0	0.1	0.3
Stormwater Pump Stations[3]	2	--	--	--	--
Underground Chemical Storage Tanks	3	0	0	1	1
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	7	0	0	0	0
Health Care Facilities (outpatient)	1	0	0	0	0
Mobile Home Parks	2	0	0	0	1

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Parks	1	0	0	0	0
Trails (miles)	0.5	0.0	0.0	0.0	0.0

Olympic Country Club (Unincorporated)

Map: Zone 8

The Olympic Country Club is a private athletic club and golf course, located mostly in San Francisco, with a portion in San Mateo County. The Olympic Club has 6 acres inundated in the baseline and mid-level scenario, 7 acres inundated in the high-end scenario, and 65 acres in the erosion scenario. Less than 3% of land is inundated in all three inundation scenarios. The beach in this area could be 100% affected by all three inundation scenarios, though it is unclear what capacity there is for this natural asset to withstand sea level rise. In the erosion scenario, 30% of the land area is affected, as well as 40% of highways (.4 of 1 miles), and 100% of trails (0.5 miles).

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	210	65	6	6	7
Population	<100	<100	0	0	0
Population in Vulnerable Communities[1]	--	--	--	--	--
Urban Land (acres)	138	6	0	0	0
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	72	58	6	6	7
Residential Parcels[2]	--	0	0	0	0
Commercial Parcels[2]	--	5	3	3	3
Other Parcels[2]	--	0	0	0	0
Parcels with No Data Available[2]	--	0	0	0	0
Assessed Value of All Parcels at Risk ($ in Millions)	$11	$11	$0	$0	$0

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.4	0.4	0.4	0.4	0.4

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Highways (miles)	1.0	0.4	0.0	0.0	0.0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Roads (local) (miles)	0.1	0.1	0.0	0.0	0.0
Stormwater Pump Stations3	--	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Trails (miles)	0.5	0.5	0.0	0.0	0.0

Princeton/Pillar Point Harbor (Unincorporated)

Map: Zone 11

Princeton has 1 acre inundated in the baseline scenario, 2 acres in the mid-level scenario, and 23 acres in the high-end scenario, with no land in the erosion scenario. In the baseline scenario, less than 2% of land area is at risk. Also, in the baseline scenario, all of the beach area is inundated, the built shoreline is overtopped, and 4% of roads (0.1 of 2.3 miles) and the one fishing pier are inundated. In the mid-level scenario, less than 3% of land area is at risk, and 20% of the wetland area becomes inundated. In the high-end scenario, about 35% of the land area is inundated and just over 30% of the population, with all of the population inundated considered part of a community of concern, or where the individuals or households have characteristics that affect ability to prepare for, respond to, and recover from a disaster (see Chapter 2 for more information). In the high-end scenario roughly 75% of the wetlands are inundated. The wetlands will serve a role in helping the area adapt to sea level rise, though it is unclear what capacity there is for this natural asset to withstand sea level rise because of bluff elevations and other shoreline characteristics.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	64	0	1	2	23
Population	<100	0	<100	<100	<100
Population in Vulnerable Communities[1]	<100	0	<100	<100	<100
Urban Land (acres)	49	0	0	0	17
Agricultural Land (acres)	9	0	0	0	2
Industrial Land (acres)	0	0	0	0	0
Natural Land (acres)	6	0	1	2	4
Residential Parcels[2]	--	0	2	0	12
Commercial Parcels[2]	--	0	8	10	50
Other Parcels[2]	--	0	23	24	87
Parcels with No Data Available[2]	--	0	0	0	1
Assessed Value of All Parcels at Risk ($ in Millions)	$73	$0	$6	$8	$39

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	0.2	0.0	0.2	0.2	0.2
Wetlands (acres)	3.8	0.0	0.0	0.8	2.9

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Communications Towers	3	0	0	0	2
Other Built Shorelines (miles)	0.3	0.0	0.1	0.1	0.2

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Roads (local) (miles)	2.3	0.0	0.1	0.1	0.9
Stormwater Pump Stations3	--	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Fishing Piers	1	0	1	1	1
Trails (miles)	0.6	0.0	0.0	0.0	0.4

San Francisco International Airport (Unincorporated)

Map: Zone 2

San Francisco International Airport (SFO) is owned and operated by the City/ County of San Francisco and located in unincorporated San Mateo County. SFO has 197 acres inundated in the baseline scenario, 2,044 acres inundated in the mid-level scenario, and 2,141 acres inundated in the high-end scenario. Within the boundaries of the Airport is also approximately 145 acres of wetlands, 130 of which (or 90%) is vulnerable in the mid-level scenario. These wetlands may be a significant asset in the Airport adapting to sea level rise, and it is unclear the extent to which these wetlands may withstand sea level rise. The airport is taking an active role in reducing the flood risk of its facility. SFO completed an Airport Shoreline Protection Feasibility Study in 2015.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	2,178	0	197	2,044	2,141
Population	<100	0	0	<100	<100
Population in Vulnerable Communities[1]	<100	0	0	<100	<100
Urban Land (acres)	1,948	0	189	1,854	1,932
Agricultural Land (acres)	0	0	0	0	0
Industrial Land (acres)	2	0	0	2	2
Natural Land (acres)	228	0	8	188	206
Residential Parcels[2]	--	0	0	0	0
Commercial Parcels[2]	--	0	13	34	34
Other Parcels[2]	--	0	0	1	3
Parcels with No Data Available[2]	--	0	0	4	4
Assessed Value of All Parcels at Risk ($ in Millions)	$91	$0	$328	$945	$945

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Inland Water Features (acres)	0.2	0.0	0.0	0.2	0.2
Streams (miles)	2.1	0.0	0.0	1.5	2.0
Wetlands (acres)	144.7	0.0	0.0	130.0	138.5

CLASS 4 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	1	0	1	1	1
Communications Towers	97	0	4	93	94
Electric Substations	1	0	0	1	1
Hazardous Material Sites	21	0	0	21	21
Highway and Railway Bridges	26	0	0	20	21
Highways (miles)	18.2	0.0	0.0	14.2	17.5
Levees and Floodwalls (miles)	1.4	0.0	0.0	1.1	1.3
Natural Gas Pipelines (miles)	2.5	0.0	0.0	2.3	2.5
Natural Gas Storage	1	0	0	1	1
Other Built Shorelines (miles)	7.1	0.0	1.0	5.4	6.1
Power Plants	1	0	0	1	1

CLASS 3 ASSETS

ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Outfalls	2	0	0	1	2
Rail (miles)	3.0	0.0	0.0	1.0	1.6
Roads (local) (miles)	5.3	0.0	0.0	4.8	5.0
Storm Drains (miles)	2.3	0.0	0.0	1.4	1.7
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	6.1	0.0	0.0	5.2	5.5
Underground Chemical Storage Tanks	2	0	0	2	2
Wastewater Pump Stations[3]	1	--	--	--	--
Wastewater Pump Stations[3]	--	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS – No Class 2 Assets at Risk

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Parks	2	0	0	2	2
Trails (miles)	2.8	0.0	0.0	1.2	1.6

Unincorporated Area

Map: Zone 10, 11

Additional unincorporated areas include nearly 56,000 acres of unincorporated land in the County that is not specifically named and not addressed above. In the baseline scenario, 39 acres of this area are inundated, 72 acres are inundated in the mid-level scenario, and 105 acres are inundated in the high-end scenario. Most vulnerable assets in the mid-level scenario within the additional unincorporated areas of the County are natural assets and/or recreational in nature. These assets include one park, limited trail miles, and one boat launch. However, 1.4 miles of built shoreline (that does not include levees) and less than 1% of storm drains will be affected. Less than 2% of the unincorporated areas' wetlands are vulnerable.

Under the erosion scenario, 10 out of 22 parks and a relatively small percentage of trail miles within the unincorporated areas will be affected. Communications towers (6%) and other built flood protection infrastructure (4%) may also be affected because of erosion. The bluffs in the coastal unincorporated area have experienced severe erosion in recent decades, with extensive erosion occurring during winter storms. According to a study conducted by San Mateo County Parks, the Pillar Point bluffs are eroding at a rate of approximately 1.5 feet/year (San Mateo County Parks 2016). Communications towers (6%) and other built flood protection infrastructure (4%) may also be affected by erosion.

GENERAL INFORMATION					
LAND USE, POPULATION, AND PARCELS	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Land Area (acres)	55,754	554	39	72	105
Population	7,000	400	<100	<100	<100
Population in Vulnerable Communities[1]	2,000	200	<100	<100	<100
Urban Land (acres)	1,796	54	0	0	4
Agricultural Land (acres)	1,408	0	0	0	0
Industrial Land (acres)	343	3	0	0	0
Natural Land (acres)	52,207	489	27	55	79
Residential Parcels[2]	--	97	2	2	2
Commercial Parcels[2]	--	14	5	5	5
Other Parcels[2]	--	168	63	72	76
Parcels with No Data Available[2]	--	5	0	1	2
Assessed Value of All Parcels at Risk ($ in Millions)	$705	$72	$7	$11	$11

[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.

NATURAL ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Beaches (miles)	3.0	3.0	3.0	3.0	3.0
Inland Water Features (acres)	35.9	0.0	0.0	0.0	0.0
Streams (miles)	173.0	0.8	0.1	0.4	0.4
Surfgrass Habitat (miles)	5.8	5.8	5.8	5.8	5.8
Wetlands (acres)	588.2	5.6	0.0	8.6	19.3

CLASS 4 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Airports	1	0	0	0	0
Communications Towers	211	12	0	0	0
Electric Substations	6	0	0	0	0
Emergency Shelter Sites	1	0	0	0	0
Fire Stations	3	0	0	0	0
Hazardous Material Sites	3	0	0	0	0
Highway and Railway Bridges	22	0	0	0	0
Highways (miles)	63.7	2.2	0.0	0.0	0.0
Levees and Floodwalls (miles)	0.1	0.0	0.0	0.0	0.0
Natural Gas Pipelines (miles)	52.0	0.0	0.0	0.0	0.0
Natural Gas Storage	4	0	0	0	0
Other Built Shorelines (miles)	2.6	0.1	0.5	1.4	1.9
Power Plants	1	0	0	0	0
Solid Waste Facilities and Closed Landfills	1	0	0	0	0

CLASS 3 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Caltrans Maintenance Facilities	1	0	0	0	0
Jails	2	0	0	0	0
Oil, Gas, and Geothermal Wells	9	0	0	0	0
Outfalls	1	0	0	0	0
Roads (local) (miles)	133.2	4.6	0.0	0.1	0.2
Schools	4	0	0	0	0
Storm Drains (miles)	36.2	0.7	0.1	0.3	0.6
Stormwater Pump Stations[3]	--	--	--	--	--
Transmission Lines (miles)	35.2	0.0	0.0	0.0	0.0
Transmission Towers	19	0	0	0	0

Underground Chemical Storage Tanks	1	0	0	0	1
Wastewater Pump Stations[3]	1	--	--	--	--

[3]Data not available for every city and town in the project area.

CLASS 2 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Buildings with Affordable Rental Units	1	0	0	0	0
Marinas	1	1	1	1	1
Mobile Home Parks	1	0	0	0	0

CLASS 1 ASSETS					
ASSET TYPE	TOTAL	EROSION SCENARIO	BASELINE SCENARIO	MID-LEVEL SCENARIO	HIGH-END SCENARIO
Boat Launches	1	1	1	1	1
Fishing Piers	4	0	3	3	3
Parks	22	10	1	1	2
Trails (miles)	110.6	6.7	0.2	0.3	1.0

CHAPTER 4 ADAPTATION PLANNING

CHAPTER 4
ADAPTATION PLANNING

4.1 What Is Adaptation Planning?

As Chapter 3 addressed in detail, distinct areas within the County are at risk from sea level rise. The assessed value of parcels located in the erosion scenario is $930 million and the assessed value of the parcels within the mid-level sea level rise scenario (3.3 feet of sea level rise and a 1% annual chance flood) is $34 billion. By taking precautionary measures, the County, cities, property owners, and others can reduce the risks from sea level rise[14] The significant negative impacts to communities and ecosystems include damage to essential facilities and natural habitats, inundation of major highways and railroads, a loss of vulnerable species, saltwater intrusion to groundwater, increased sedimentation, and exposure to hazardous materials. Given that large parts of the County are vulnerable to present and future flooding and erosion, physical alteration of the shoreline and assets is inevitable. However, with adequate planning, the amount of risk and damage to assets can be reduced.

Without preemptive planning, communities are limited to last-minute reactive and unplanned responses (Tam 2012). Such responses are not only more costly, but less effective for long-term planning (Tam 2012), and they can have damaging effects on the community and environment (BCDC 2011). If decision makers can begin planning for sea level rise now, communities and asset managers will be able to implement measures to reduce the risk of damage before severe flooding and erosion take place.

Adaptation planning is the process of creating a strategy to reduce a community's vulnerability to the negative impacts associated with sea level rise. The complex nature of sea level rise precludes having a singular methodology for adaptation planning (Mimura et al. 2014). Such planning can range from brief and preliminary to all-inclusive (California Emergency Management Agency and California Natural Resources Agency [CEMA and CNRA] 2012).

A vulnerability assessment is the most important part of adaptation planning in that it determines what needs to be done and where (Tam 2012). It completes the first steps of planning by outlining what is at risk in the County, what strategies exist and where they can be applied, and what to keep in mind when designing a plan.

This chapter provides information to help guide adaptation planning. City and County decision makers, individual asset owners, and developers can use it as guidance in planning for sea level rise.

4.2 Adaptation Planning Steps

Developing and implementing an adaptation plan for the County will ultimately require careful evaluation of the trade-offs across potential strategies,

"Adaptation planning is the process of creating a strategy to reduce a community's vulnerability to the negative impacts associated with sea level rise."

[14]Based on mid-level sea level rise scenario.

including an assessment of the long-term flood risk reduction benefits and an analysis of the cost of inaction. A strategy should also aim to reduce near-term flood and erosion impacts for assets with imminent risk, such as those associated with communities and natural and built assets exposed under the baseline scenario, or those already experiencing flooding during king tides or interior flooding.

A main challenge in developing a plan is the wide range of affected assets and systems (CEMA and CNRA 2012), including natural and built assets, economic vitality, equity, groundwater, wildlife, health, life safety, and transportation. To address this challenge, decision makers can utilize the expertise of stakeholder groups and develop an extensive plan that addresses the steps from Figure 4.1 (BCDC 2011).

Figure 4.1 outlines eight steps that the BCDC Adapting to Rising Tides program recommends for an adaptation planning process (BCDC 2011).

1. Scope & Organize	2. Choose an Approach	3. Do the Assessment	4. Summarize Findings
Define what to address in the project. Convene stakeholders. Set project goals.	Plan out the assessment methods. Select climate scenarios.	Conduct the vulnerability assessment and climate impacts exposure analysis.	Synthesize assessment findings on asset profile sheets, and share with the working group.
5. Identify Issues	**6. Develop Responses**	**7. Evaluate Responses**	**8. Advance Options**
Summarize asset-specific issues & identify key planning issues. Refine project resilience goals.	Develop adaptation responses for key planning issues and agency-specific vulnerabilities.	Evaluate adaptation responses for key planning issues against resilience goals.	Share outcomes. Explore options & develop recommendations for taking action.

Figure 4.1 Eight Steps to Planning from the Adapting to Rising Tides Process, San Francisco Bay Conservation and Development Commission (2011).

Steps 1–3 of Figure 4.1 have been completed in this Vulnerability Assessment, and steps 4–8 can be used to develop a plan for an at-risk asset or community. A decision maker should first determine which assets are at risk within their jurisdiction, what the anticipated damage will be, the barriers to project implementation, and the overall resiliency goals.

Another useful guide to adaptation planning is the CEMA and CNRA Adaptation Planning Guide (2012). Figure 4.2 is taken from this guide. It outlines nine steps in developing an adaptation plan along with questions that decision makers and stakeholders should ask themselves. Steps 1–5 represent the Vulnerability Assessment process, and steps 6–9 encompass four steps in adaptation planning. The latter four steps center on prioritizing needs for various impacts; identifying strategies and prioritizing the most essential components of an asset or community; and funding, monitoring, and implementing the chosen strategies.

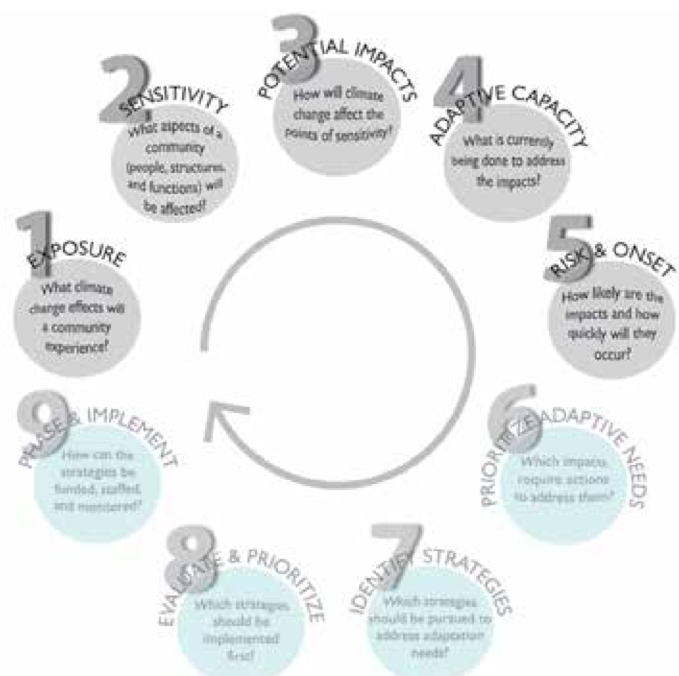


Figure 4.2 Nine Steps in Adaptation Planning Development as Presented in the Adaptation Planning Guide (CEMA and CNRA 2012).

4.3 General Considerations

4.3.1 Considerations by Sector

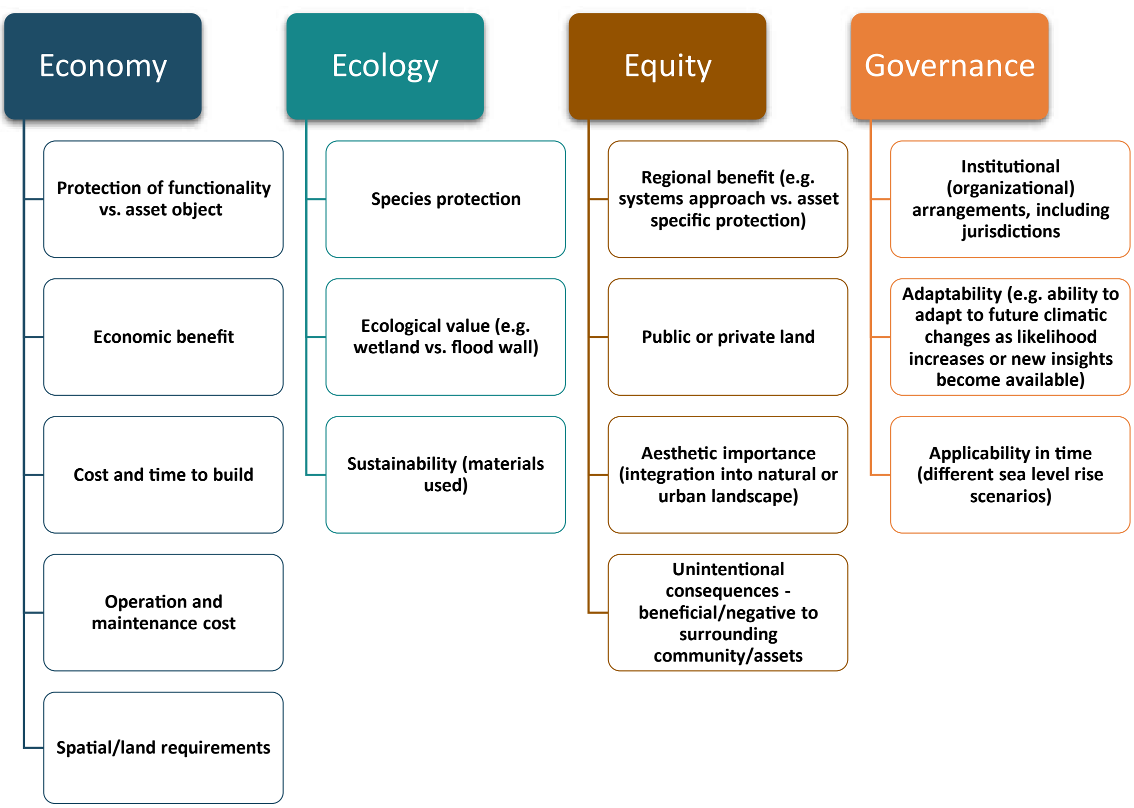
Adaptation measures will have various trade-offs and pros and cons, such as costs and the ability to be easily permitted, effectively reduce flood and erosion risks, enhance habitats and water quality, provide recreational opportunities, and improve community health outcomes. Ideal adaptation measures will minimize negative impacts and maximize benefits to the community and to the environment. To determine trade-offs, adaptation measures should be evaluated according to how well they perform across different criteria, including cost or economic impacts, ecological impacts or benefits, equity impacts or benefits, and governance implications. Criteria should represent the goals of the adaptation measure as well as the values of the community. Developing clear criteria then allows adaptation measures to be rated according to how well they meet them. Criteria can be weighted according to their importance relative to other criteria.

Some key elements to consider when evaluating the costs and benefits of adaptation measures include the following, which are outlined in more detail in Figure 4.3:

- Economics: From an economic standpoint, a strategy should consider the cost of the project (including operational functionality and maintenance) as well as the benefits associated with preserving assets.
- Ecology and the environment: Other land considerations are ecological in nature: whether protected species are present and the value of ecosystem benefits such as air and water quality improvements, recreation, buffering, habitat for native species, and flood reduction.
- Equity: A project should evaluate whether it has unintended consequences on an area's lower income communities or ethnically diverse communities. Does the project reduce impacts to disadvantaged communities? Does it provide relief to communities with characteristics that make them more vulnerable to flooding? A project should use an inclusive process to ensure that all groups are thoughtfully represented throughout the process.
- Ownership and governance: A project should also take into account land requirements, ownership, and whether a project needs special permitting. Projects should also consider any potential impacts that may affect another area. For example, homeowners who want to build a riprap to protect their property from erosion must consider how it may redirect the erosion to neighboring lands.

Section 4.4.5 provides more information on how planning to restore a complete tidal ecosystem can increase flood protection in an area, while also providing natural resource benefits.

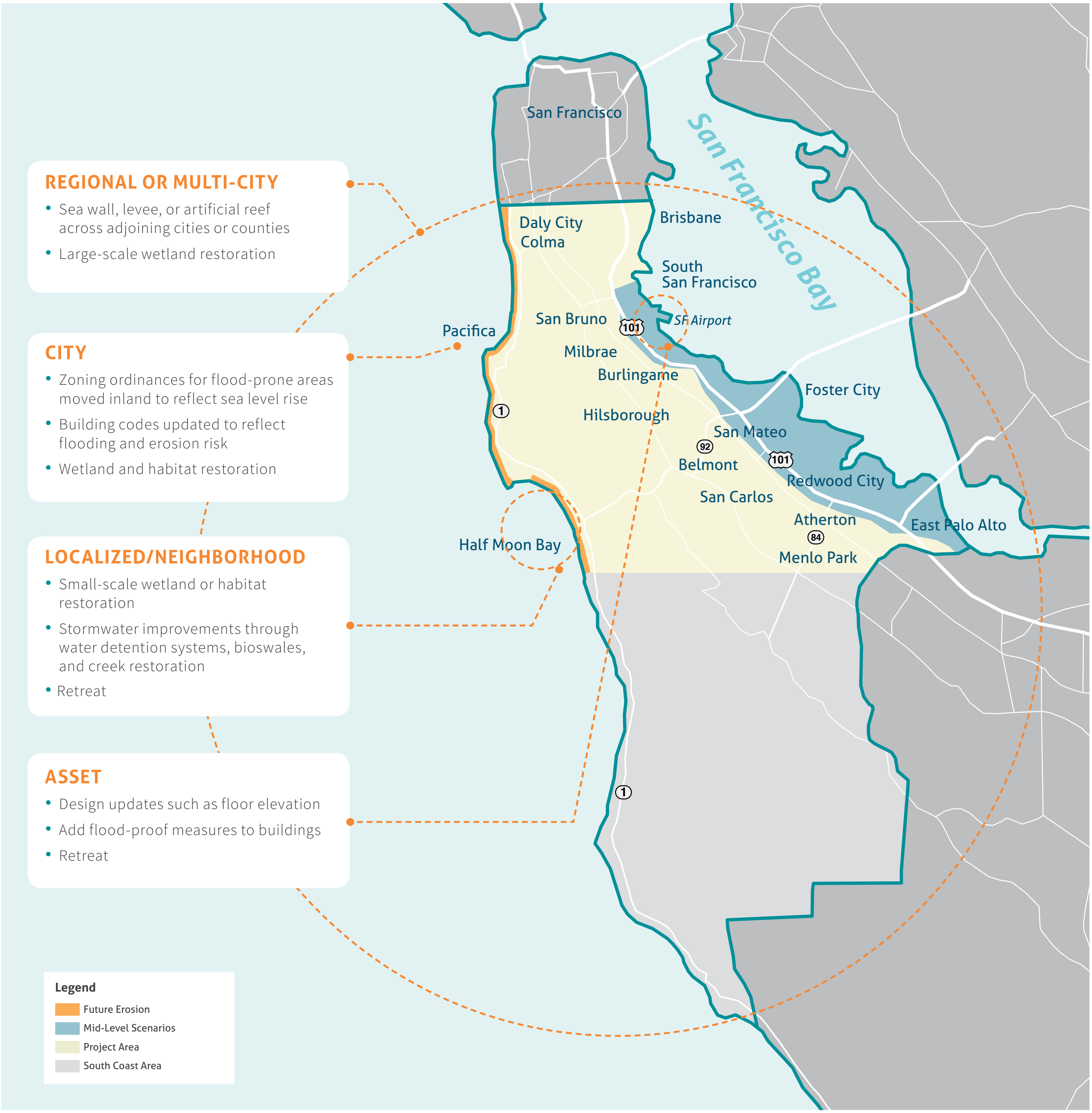
Figure 4.3 Items to Consider in the Development of an Adaptation Plan or Strategy.



4.3.2 Scale

Another important consideration in adaptation planning is geographic scale. Depending on the goals of the adaptation planning process and the scope of the impacts, different scales will be appropriate. Some adaptation measures will be site specific, while others will be on a regional or multi-jurisdictional scale. Figure 4.4 shows examples of how to develop adaptation strategies for different scales, from large to small. For example, a city manager may look at planning from a city or regional approach, while a hotel owner may use an asset-level approach. Some strategies can be utilized at more than one scale, such as wetland or habitat restoration projects.

Figure 4.4 Adaptation Planning by Geographic Scale.



4.3.3 Flexibility and Adaptive Management

Since sea level rise modeling and adaptation strategies are subject to scientific, technology, and methodology improvements, flexibility is an important component to build into the adaptation plan. By ensuring that the strategies chosen have some degree of flexibility, the adaptation plan can change as needed. This approach is known as adaptive management, in which decisions incorporate uncertainty and can be updated as new technologies and methods emerge. Adaptive management integrates regular monitoring and an adjustable action plan into the process.

An example of adaptive management includes designing flood protection so that it can be modified in the future as water levels increase because of sea level rise. For instance, planners in San Francisco Bay could decide to build a seawall to a height based on best available sea level rise projections, but also design a foundation that can accommodate an increase in the levee height should higher water levels occur. Adaptive management takes uncertainty into account by allowing for continual monitoring and adjusting as needed. Figure 4.5 shows the process and how it allows for monitoring, evaluating, reviewing, and adjusting to enhance a plan or project's success.

Figure 4.5 is from Reef Resilience's Coral Reef Module on Adaptive Management (Reef Resilience). It displays the cyclical nature in adaptive management and shows that a project is not finished after planning and implementation. An important part of the plan is the evaluation and adjustments to the strategy itself.

Figure 4.5 Adaptive Management Cycle (Reef Resilience).

"By ensuring that the strategies chosen have some degree of flexibility, the adaptation plan can change as needed. This approach is known as adaptive management, in which decisions incorporate uncertainty and can be updated as new technologies and methods emerge."

4.3.4 Multifunctional Shoreline Protection

Over time, global ecological values have shifted and the public is no longer satisfied with the opportunities afforded by concrete, single-purpose flood control infrastructure. The recently-passed Measure AA in the San Francisco Bay Area, a parcel tax that funds wetland restoration, is evidence that the region demands protection as well as restoration of its valuable natural resources. Dissatisfaction with single-purpose infrastructure has led to the development of a new concept in the last few years: multipurpose infrastructure, which integrates flood protection with other functions and benefits.

Multipurpose flood protection infrastructure can improve the urban ecosystem and enhance quality of life for local communities. In densely built urban areas, flood risk reduction efforts can provide additional value by integrating flood protection features with other urban functions, such as transportation, wastewater management, housing, recreation, nature, and tourism. For example, wetlands can provide ecosystem benefits, clean water, and recreational opportunities, while also helping to reduce wind-wave run-up during high tides and storms. A pilot project of the horizontal levee—a levee that uses ecological restoration and incorporates other open space and civic functions—is already underway in San Francisco Bay at the Oro Loma Sanitary District. Another example is the multifunctional dikes on the Dutch coastline that hold back storm surges while creating new land and waterfront property. The dikes serve as public spaces and parks, providing a range of recreational opportunities.

An additional and critical benefit offered by multipurpose flood protection is that it can combine several existing revenue and capital investment streams. It can generate additional financial resources, and it can create opportunities for urban development. An example can be seen in Katwijk, the Netherlands, where a coastal dune restoration project included the construction of a parking garage within the dune to meet parking needs for beach visitors. While attractive, these types of projects can also be complicated from a regulatory standpoint. For example, a restoration project in San Francisco Bay would need to comply with permitting and other, potentially conflicting, requirements from at least seven government entities.

Baylands Ecosystem Habitat Goals Report recommends combining multiple natural solutions with the goal of restoring complete wetland systems, including their interconnected habitat types and physical processes. When the full system is restored, from the subtidal (using adaptation methods such as living reefs) to the uplands (using adaptation methods such as horizontal levees), a more resilient landscape results. Otherwise, when wetlands cannot keep pace with the rise in sea level or do not have the room to migrate backward because of a lack of open space, and therefore become fully submerged, they become mudflats that are less effective at reducing wave action and storm surge. The health of the wetland will also depend on the rate of sedimentation. To ensure the health, longevity, and success of the wetland, one strategy would be to develop a sediment management plan. In addition to restoring complete baylands systems, with a goal of 100,000 acres of wetlands and additional targets for other habitat types, the Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) also recommends accelerating restoration of these complete baylands systems by 2030, planning for a dynamic future, and increasing regional coordination.

The Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) was produced through a collaboration of 21 management agencies working with over 100 scientists. It provides a climate change update to the first publication released in 1999, the Baylands Ecosystem Habitat Goals Report, and guidance for sustaining a healthy shoreline in the face of climate impacts.

Bay Trail, Millbrae. Photo credit: San Mateo County Flickr.

"The recently passed Measure AA in the Bay Area, a parcel tax that funds wetland restoration, is evidence that the region demands protection as well as restoration of its valuable natural resources."

The report divides the County into four shoreline segments and provides a list of recommendations for each section to increase shoreline resilience and ecological benefits. The recommendations account for both near- and long-term planning. The recommendations and opportunities can be found in Appendix K.

4.4 Adaptation Responses for San Mateo County

Adaptation strategies must be an appropriate fit for a given area or asset, and planning needs to recognize that some strategies are not always viable, whether for economic, geographic, or political reasons (Tam 2012). This section includes an overview of the different types of adaptation responses available. In addition to the specific strategies provided, this section introduces several policy measures that cities and jurisdictions can use in planning for sea level rise.

Adaptation response options in coastal areas generally fit into three categories of approaches—protect, accommodate, or retreat—or a combination of one or more of these approaches. Figure 4.6 illustrates the three different approaches and sections 4.4.1 to 4.4.3 provide greater detail on measures that fall within each general approach, along with example case studies.

Figure 4.6 depicts three popular adaptation responses to reduce an asset's risk to sea level rise. The arrow next to the building in accommodate demonstrates that making a change to the asset (in this case raising the house) is a way to reduce its exposure. The arrow next to the building in planned retreat represents moving the asset away from the coast.

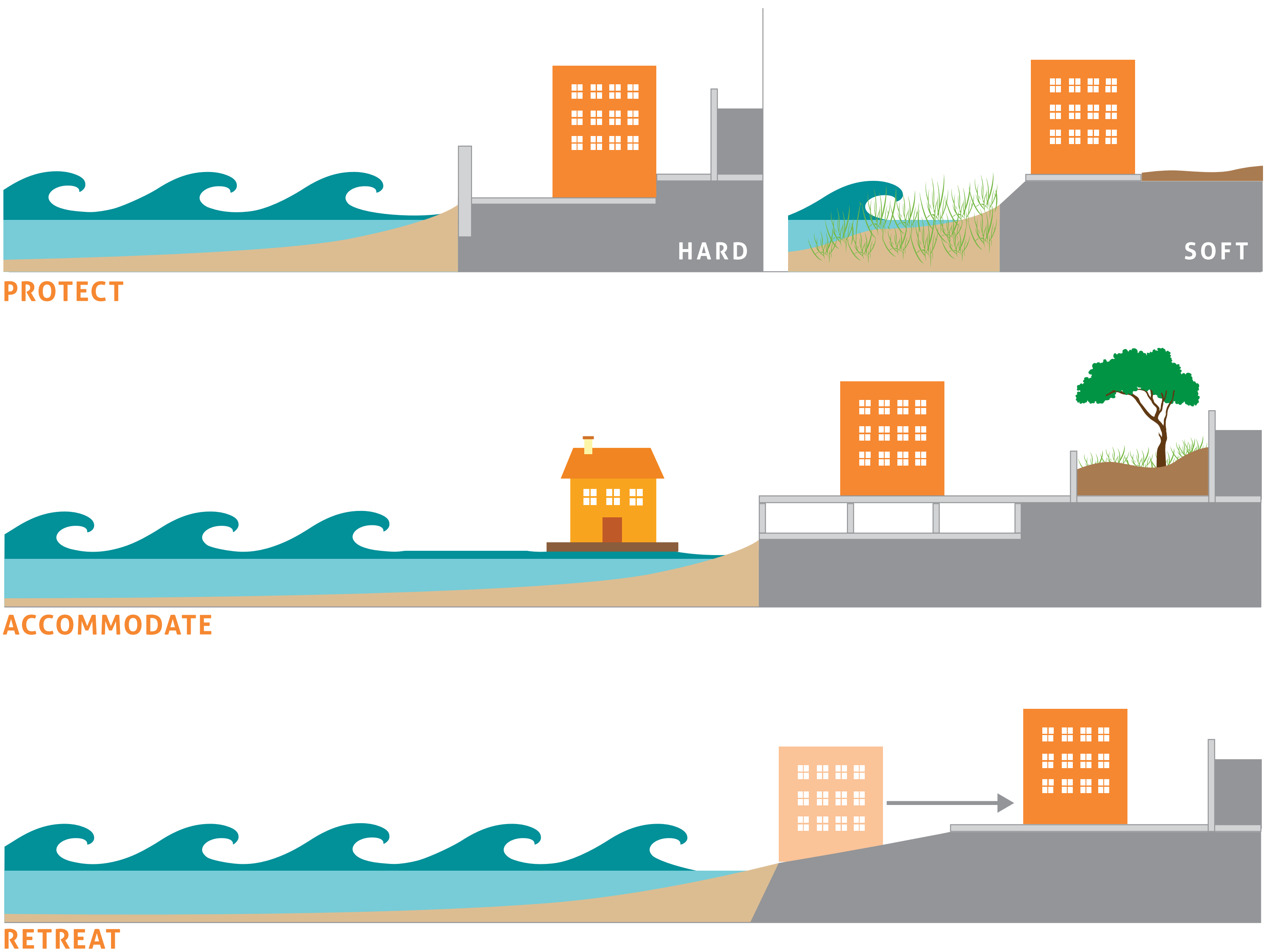


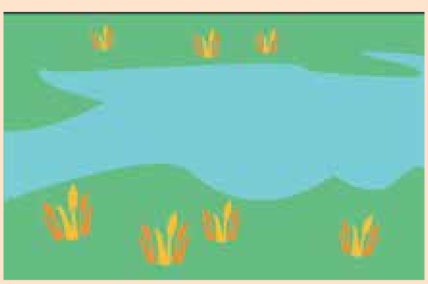
Figure 4.6 Common Approaches for Adaptation.

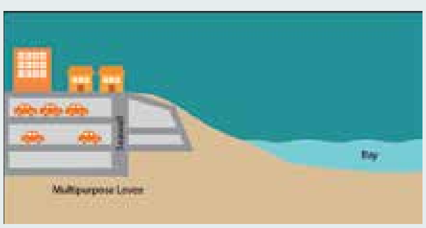
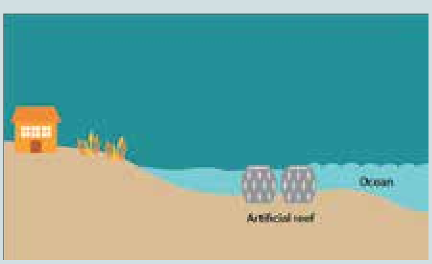
4.4.1 Protect

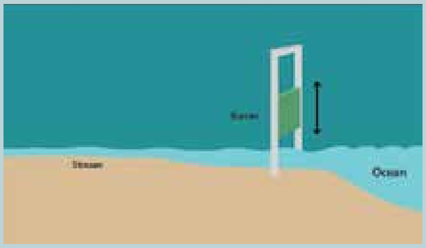
Protect involves placing a barrier between the asset and the Bay or Coast to reduce exposure to flood or erosion risk. Two categories are generally associated with protection—hard and soft. Hard, or traditional protection, requires a structural development to reduce the risk of sea level rise impacts on an asset. Soft protection uses natural barriers as a buffer against the rising water levels. Combining hard and soft measures for a hybrid measure is another way to shield an asset against flooding and erosion and potentially decrease the negative environmental impacts of hard measures.

Table 4.1 includes an overview of protection response options, as well as some advantages, disadvantages, and examples of where the options might be appropriate within the County.

Table 4.1 Protection measures for adaptation planning.

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
COASTAL ARMORING 	**Definition:** Physical structure designed to protect development. • Includes seawalls, revetments, groins, levees, and breakwaters • Can be aesthetically unattractive • Has potential negative impacts on water quality • Increases flooding and erosion in coastline adjacent to structures, which can create issues for neighboring stakeholders • Risks loss of beach sand and recreational area in front of armoring and land adjacent to the armoring • Blocks habitat migration and can lead to habitat loss and species decline	**Coast:** could be used to protect certain coastal dependent uses and existing development, as consistent with the **Coastal Act Bayshore:** could be used to protect critical infrastructure and existing development, as consistent with the McAteer Petris Act
HABITAT RESTORATION 	**Definition:** "The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration 2002). • Includes wetlands, dunes, marshlands, and other habitats • Improves water quality • Can provide recreational opportunities • Offers ecosystem benefits • Is not an engineered flood protection system • Might not be viable if there is not adequate sediment or space for the habitat to migrate inland	Former salt ponds, low-lying shallow areas, areas with degraded habitats including along the shorelines of East Palo Alto, Redwood Shores, Redwood City, and Menlo Park are suitable for wetland restoration. Some coastal beach areas may be suitable for dune restoration.

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
BEACH NOURISHMENT AND REPLENISHMENT 	**Definition:** Sand placed either on beaches or in front of the coast line to create a beach. • Lengthens beaches or reduces water depths • Needs to be repeated every few years • Can result in decline in health of beach ecosystem and species • Can be resource-intensive (e.g., multiple truck loads, tractor use to move sand) • May restore natural sand flow where it has been interrupted • Provides erosion protection for a large area over time • Preserves recreational areas for tourist-dependent communities and businesses	Some existing beach areas, such as Coyote Point Park, Half Moon Bay, and Pacifica
HORIZONTAL LEVEE 	**Definition:** New structure that uses layers of natural flood protection backed by an earthen levee (BCDC 2016) to provide a wave dampening effect, in contrast to a traditional levee that just holds the water back. • Adds to local biodiversity • Can be designed lower than a traditional levee and is thus less intrusive	Areas where wetlands already exist, or in low-lying areas suitable for wetland restoration. A horizontal levee is being explored along the San Francisquito Creek.
MULTIPURPOSE LEVEE/SEAWALL 	**Definition:** Physical structure that not only acts as a traditional levee/seawall but also incorporates multiple functions along the water such as recreation and transportation • Enables the community to be more closely connected to the water	Anywhere a levee or a seawall is an appropriate option. In particular, city waterfronts that are looking to upgrade their shoreline, but are pressed for space, and want to create more of a community connection to the waterfront.
ARTIFICIAL LIVING REEFS 	**Definition:** Manufactured underwater structure, typically parallel to the shoreline with the purpose of dissipating erosive wave energy and supporting marine life. • A benefit is that the structure can accommodate shellfish or finfish. • A drawback is that newly introduced reefs can attract not only native species, but also invasive species.	Shallow waters along the Bay or open Coast

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
TIDAL BARRIER 	**Definition:** Dam-like structure that limits high tides and storm surge traveling upstream, reducing potential overflow of creek banks and flooding. • A movable tidal barrier could be placed near or at the mouth of creeks to limit the high tides and storm surge traveling upstream and potentially causing flooding inland. • Drawbacks are that the physical structure is intrusive to the landscape and that creek water can no longer discharge into the Bay when the barrier is closed. • For this measure to work, sufficient water retention or green infrastructure should be in place or created behind the barrier to allow for temporary closure.	Areas where there are critical facilities that need protection from creek and bay flooding

Protect

CASE STUDY

Oro Loma and Castro Valley Sanitary Districts Horizontal Levee (under development)

The Oro Loma and Castro Valley Sanitary Districts Horizontal Levee project will transform a diked bayland area into a sloped levee with a transitional zone (see Figure 4.7). The degraded bayland area is behind a wastewater treatment plant, and the transitional zone is between tidal and terrestrial ecosystems. The transitional zone functions to both improve water quality and act as a short-term water storage system (Oro Loma Sanitary District 2016). The transitional zones could add improved habitat restoration areas along the Bay shoreline. The use of temporary water storage ability offers additional capacity of the wastewater treatment facility during heavy rainfall by storing primary treated wastewater until capacity of the facility returns to manageable levels.

Figure 4.7 Ora Loma Horizontal Levee in the Construction Phase. Photo Credit: Oro Loma Sanitary District.

4.4.2 Accommodate

Instead of protecting an asset from flooding, accommodation is a strategy in which an asset continues to function in an at-risk area by changes being made to the individual structures. Elevating floor levels, waterproofing assets, building houseboats and floating communities, and improving drainage are all examples of accommodation (see Table 4.2). Individual facilities and assets could also be floodproofed to tolerate temporary inundation. By incorporating building elevation standards and proper flood drainage into building codes, new development can be constructed in zones at risk of flooding. Existing buildings can also be retrofitted to include accommodation strategies to avoid damage from flooding or erosion. Infrastructure, roads, wetlands, and even communities can be raised or built on floating structures to accommodate rising water levels. Floating structures are anchored to the seafloor or tethered to the shoreline for stabilization.

Table 4.2 Accommodation measures for adaptation planning.

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
ELEVATION 	**Definition:** Raising buildings or assets • If only some buildings in a community are elevated, it can degrade community character. • Somewhat easily incorporated into new development; it can be more difficult to elevate existing development.	Areas where temporary flooding is expected; can apply to infrastructure, roads, homes, and other buildings
FLOODPROOFING 	**Definition:** Making foundations, doors, and windows watertight, or changing the use of groundfloor facilities to tolerate temporary inundation • Dry floodproofing makes assets waterproof (keeping water out). • Wet floodproofing ensures that key materials are water resistant or elevated above the designed flood elevation.	Can apply to most structures, but floodproofing critical facilities such as wastewater treatment plants, hospitals, power substations, and communications facilities is the most important.
FLOATING STRUCTURES 	**Definition:** Structures that are designed to sit upon the water and can incorporate roads, communities, bridges, homes, wetlands, and buildings.	Infrastructure, roads, wetlands, and communities can be built on floating structures.

Accommodate

CASE STUDY

Elevated Home, Stinson Beach, Marin County, CA

The photo below, of a home on Stinson Beach in Marin County, California, is an example of an elevated structure (see Figure 4.8). This particular home is raised with stilts to reduce the impact of several feet of flooding. A problem with elevating structures is that when extreme inundation occurs, the structure may be surrounded and difficult to access. Elevation can also make structures inconsistent with the character of the surrounding community.

Figure 4.8 Home Located at Stinson Beach, Marin County, California. Photo credit: Copyright © 2002-2017 Kenneth & Gabrielle Adelman - Adelman@Adelman.COM

4.4.3 Retreat

Managed retreat is an adaptation approach in which assets are relocated inland and away from the coast. Managed retreat does not mean abandoning the coastline. It rather includes a proactive approach of converting vulnerable land uses, such as critical facilities or residential uses, to ones that are more tolerant to erosion or flooding, such as open space or temporary structures. A managed retreat strategy may include near-term protection to avoid the loss of assets while a relocation plan is put in place (see Table 4.3). City or Countywide planning and zoning is an important part of this strategy in that it can guide development by identifying land uses that minimize impacts to life and safety given sea level rise. Another type of retreat is rolling easements. A rolling easement prevents the construction of coastal protection projects such as levees and sea walls along the shoreline. The coastal area becomes an easement (land available for public use despite ownership) that maintains its size and progresses inland as the sea level rises.

Table 4.3 Retreat and relocation measures for adaptation planning.

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
SETBACKS	**Definition:** The location of new development away from a hazardous or sensitive landform • Development can be located a certain distance from a bluff edge, line of vegetation, dune crest, roadway, or path. • Development can also be located a certain elevation above which development must be sited.	Applicable for areas where erosion or flooding is currently an issue, or where it could pose hazardous conditions to development over the life of planned development
ROLLING EASEMENTS	**Definition:** Privately owned coastal land that is available for public use that maintains its size and migrates inland as the sea level rises • Protects sensitive habitat and other shoreline areas	Applicable for areas where hardening the shoreline would have negative consequences on coastal resources, and where there is space for the easement to move inland over time

APPROACH/MEASURES	DESCRIPTION AND CONSIDERATIONS	LOCATION EXAMPLES
PLANNED RETREAT AND RELOCATION	**Definition:** Physically moving an asset or facility that is at risk • Could include government or land trust acquisition of the property, if the land is privately owned • May be most feasible to combine relocation when an asset is at the end of its useful life or requires significant capital improvement	Applicable for areas that have experienced repetitive losses from hazards. Publicly owned facilities may be more feasible for relocation.

Relocation

CASE STUDY

Relocation of State Route 1 in San Luis Obispo County (in progress; inland relocation, conversion of old highway to a trail)

In San Luis Obispo County, a section of State Route 1 was at risk of erosion near Piedras Blancas. To avoid costly repairs and to protect against sea level rise, the California Coastal Commission worked closely with Caltrans, California State Parks, and San Luis Obispo County officials to relocate nearly 3 miles of State Route 1 beyond the projected eastern extent of coastal erosion (by 2100), roughly 500 feet inland (see Figure 4.9). This process took nearly a decade given the multiple parties involved and because the area adjacent to the highway contained sensitive coastal resources and private property. Once complete, the area between the relocated highway and the coast will be converted to State Park and will include 3.5 new miles of the California Coastal Trail. Caltrans started construction in the fall of 2015 and estimates that the project will be complete in the winter of 2018 (National Oceanic and Atmospheric Administration [NOAA] 2016, Caltrans 2016).

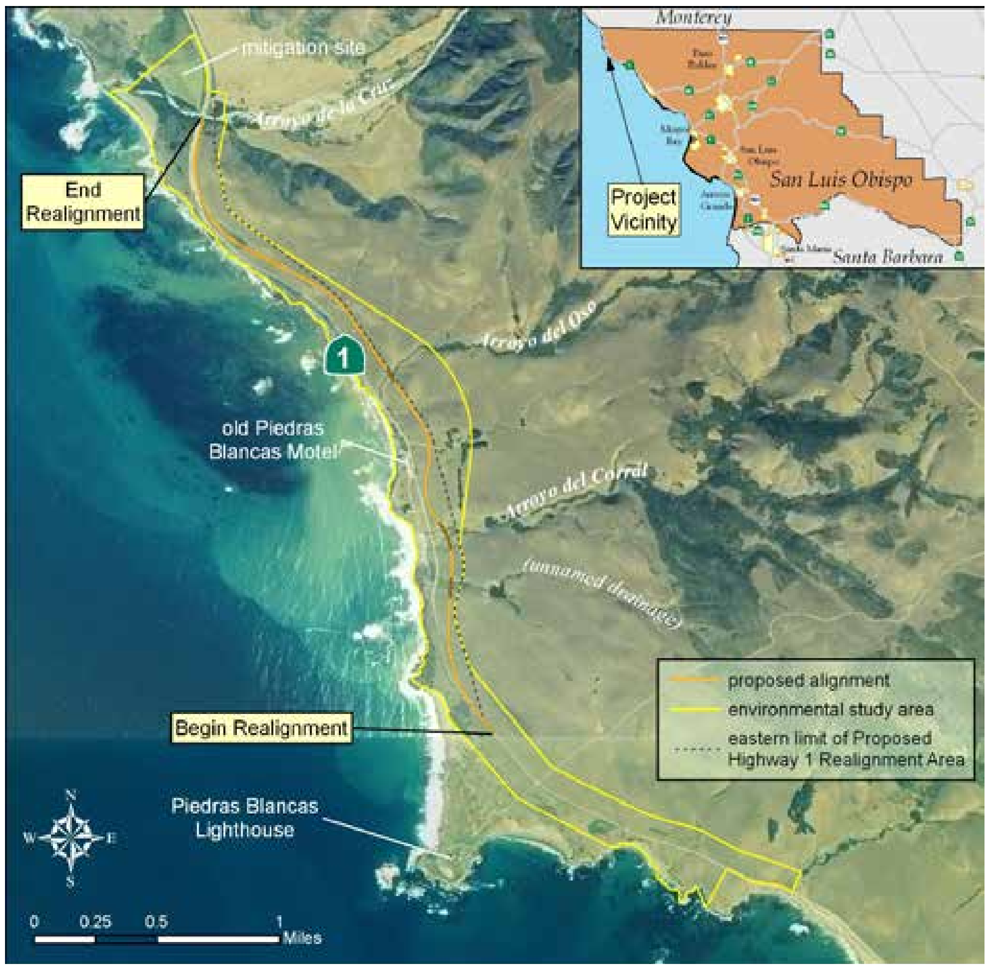


Figure 4.9 The light brown line shows the existing State Route 1 in San Luis Obispo County, while the black line shows the new location. Photo Credit: California Department of Transportation.

4.4.4 Hybrid Approach and Layers of Defense

Adapting to sea level rise in the County requires using the full range of adaptation tools available. Protection measures such as storm surge barriers, sea walls and levees, or coastal green infrastructure such as ecologically enhanced revetments, oyster reefs, and hybrid levees will reduce the frequency or probability of inundation, wave run-up, and erosion. Meanwhile, using accommodation or retreat measures can reduce the consequences of flooding. These measures can include elevating or floodproofing assets, relocating assets and people, buying flood insurance to reduce economic loss associated with damaged property, or implementing more restrictive land use controls to discourage new growth (people and property) in at-risk zones.

Combining approaches can increase the level of protection for an asset or area. This process includes using multiple layers of protection, or a multilayered approach of integrated solutions, with each contributing to reducing overall flood risk. Figure 4.10 displays the multiple layers of protection and how a combined approach can benefit a vulnerable asset and community.

As shown in Figure 4.10:

- **The inner layer** focuses on what can be done inland from the shoreline and includes local, mostly nonstructural solutions designed to protect life safety and critical infrastructure. Flood protection in this layer requires integrated watershed management that addresses stormwater or interior drainage in addition to land use planning and design within an urban environment. Green infrastructure can be considered in this layer through stormwater management practices such as upstream detention or retention areas and bioswales.
- **The middle layer** is the typical transition zone from land to water that addresses the shoreline itself; this layer comprises mostly structural alternatives. Infrastructure (both “gray” and “green”) structural alternatives can be accompanied by additional features in front of the shoreline or adjacent to it. This layer can include waterways, barriers like seawalls, and beach fortification or armoring. Integrating nature-based and more ecologically enhanced or sustainable coastlines can be considered in this layer where feasible through beach nourishment, marsh and wetland restoration, oyster reefs, multifunctional levees, and so forth.
- **The outer layer** of flood protection is mostly water-based and includes large engineered solutions such as large-scale levees or seawalls. This layer could also be integrated with the construction of barrier islands.

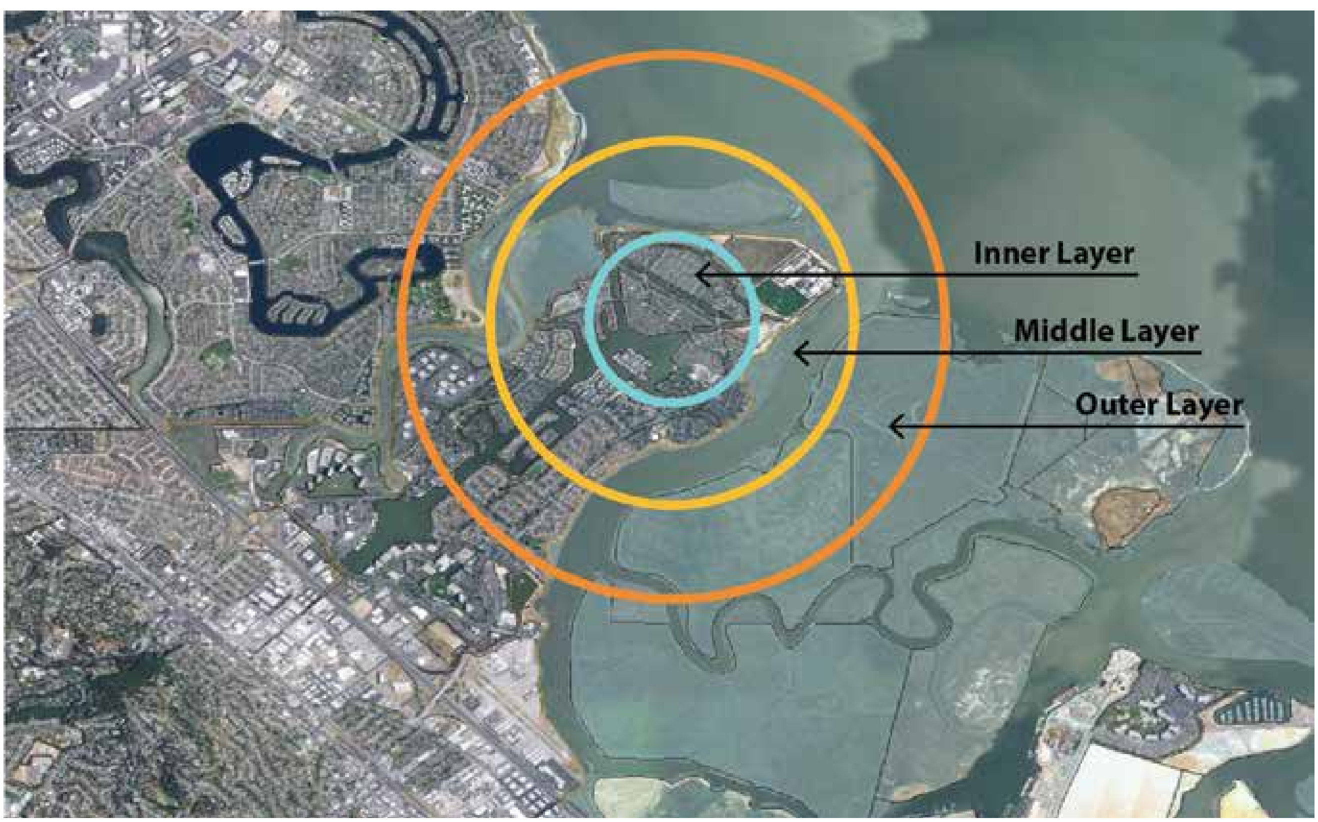


Figure 4.10 Multiple Layers of Protection. The map used in this figure serves as a conceptual example of multiple layers of protection, not as a recommendation of where planning should occur. Source: Esri, DigitalGlobe, Earthstar Geographics, CNES/Airbus DS, GeoEye, USDA FSA, USGS, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community.

4.4.5 Incorporating Sea Level Rise Responses in Planning and Policy Documents

In San Mateo County, some areas have already begun to incorporate sea level rise into local planning. To continue implementing sea level rise into city and County planning, Table 4.4 suggests applicable areas for integration. Table 4.4 is adapted from the Adaptation Planning Guide (CEMA and CNRA 2012) and describes nine policy or planning documents for communities seeking to integrate sea level rise measures.

Chapter 5 builds on Chapter 4's adaptation planning options by recommending a course of action for the County, its cities, and asset managers.

Table 4.4. How to incorporate sea level rise into planning and policy documents for communities. (Taken from Adaptation Planning Guide 2012, prepared by California Emergency Management Agency, and California Natural Resources Agency.)

POLICY/PLAN	DESCRIPTION
Administrative Policy, Procedures, and Initiatives	Planning that does not require governing board action can be implemented by a coordinated approach within an agency.
General Plan	The community general plan, especially the safety element, is an appropriate document for codifying goals, objectives, and policies related to climate change adaptation. Other relevant policy areas within the general plan usually include land use, transportation, conservation, recreation and open space, public safety, and noise.
Local Hazard Mitigation Plan (LHMP)	If the community has adopted an LHMP pursuant to the federal Disaster Mitigation Act of 2000, it would be an appropriate document for incorporating adaptation strategies related to the mitigation of natural or human-caused hazards such as wildfire, flooding, coastal storms and erosion, drought, and heat emergencies.
Climate Action Plan (CAP)	If the community has a CAP or other similar plan, it can be an appropriate document for codifying adaptation strategies.
Zoning Code and Other Land Development Codes, Ordinances, and Resolutions	Adaptation strategies that affect zoning and land use can be acted on through adjustments in the regulations and procedures governing these areas.
Local Coastal Program (LCP)	Local governments in the coastal zone must prepare a guide to development in the coastal zone that is consistent with the Coastal Act and certified by the Coastal Commission. LCPs contain the ground rules for future development and protection of coastal resources. Climate change issues, particularly sea level rise and associated effects, should be addressed in the LCP.
Capital Improvement Plan/ Program (CIP)	For adaptation strategies that require capital expenditures (e.g., relocating a wastewater treatment plant, building a cooling center), the community CIP is an appropriate place to address priorities, funding, and scheduling of implementing adaptation strategies.
Climate Change Adaptation Plan	A community can choose to create a stand-alone adaptation plan to contain all of the background data and analysis as well as the adaptation strategies. With a stand-alone plan, all other plans and programs would be adjusted to be consistent through normally occurring periodic updates.
Integrated Regional Water Management (IRWM) Groups	The regional approach supports local jurisdictions by providing coordination and information. The associated grant funding for the IRWM program supports adaptation strategy development and implementation.

CHAPTER 5
GETTING AHEAD OF SEA LEVEL RISE

CHAPTER 5 GETTING AHEAD OF SEA LEVEL RISE

5.1 Introduction

Given the severity of the risks from sea level rise in San Mateo County, actions to prepare for and reduce risks are needed at multiple scales. No single step or entity will mitigate the issue of flooding and erosion due to sea level rise. A combination of shoreline protection strategies, individual property and facility modifications, land use policies, and emergency flood preparedness actions will be needed to reduce impacts over the near and long term. To be effective, shoreline protection measures, such as horizontal levees, wetland restoration, levees, and seawalls, will need to span multiple cities and possibly counties. Adaptation measures will need to be designed for local conditions based on feasibility assessments and with the relevant local, state, and federal agencies, community representatives, and property owners involved in the decision-making process.

This Vulnerability Assessment discusses the types of facilities or natural assets that are at risk from sea level rise and the consequences that may occur if no action is taken. It is the first step in a multiyear process to prepare for sea level rise. This chapter includes a list of potential actions that the County, cities, and others can take to prepare for the challenges associated with sea level rise. The actions are organized by

1. Countywide actions
2. Actions for individual cities, special districts, and the County
3. Site-specific actions
4. Research needs

The County developed these next steps based on needs shared by the Technical Working Group, Policy Advisory Committee, and Community Task Force at the July 2016 Sea Change SMC stakeholder meeting, the April 2016 Technical Working Group Meeting, and the October 2015 Policy Advisory Committee meeting. At these meetings, County staff solicited input on what needs cities, agencies, businesses, and others have with regard to sea level rise, and what outcomes they would like to see from the Sea Change SMC Initiative. Sea Change SMC is a Countywide sea level rise initiative led by the County of San Mateo, which includes this Vulnerability Assessment. For a summary of these comments, see Appendix N.

5. 2 Countywide Actions

5.2.1 Continue the Sea Change SMC Initiative (Near Term)

As described in the Introduction, the Sea Change SMC Initiative was established by the County Office of Sustainability in spring of 2015 to facilitate coordinated Countywide action on sea level rise. The efforts to date have included completion of this study, development of a website, and implementation of public outreach and education efforts. The Office of Sustainability envisions a three-phase process (see Figure 5.1): (1) completing this Vulnerability Assessment and assisting willing partners with further evaluating vulnerability at the city level and by sector; (2) assisting with the development of a Countywide adaptation planning framework and strategy; and (3) assisting with implementation of adaptation strategies.

> "No single step or player will mitigate the issue of flooding and erosion due to sea level rise. A combination of shoreline protection strategies, individual property and facility modifications, land use policies, and emergency flood preparedness actions will be needed to reduce impacts over the near and long term."

Figure 5.1 Sea Change SMC Phases.

SMC Resilient By Design tour. Photo credit: Kingdom Young.

5.2.2 Establish a Steering Committee and Collaborative Sea Level Rise Working Group (Near Term)

Issue: As described in Chapter 2, the development of the Vulnerability Assessment included city and stakeholder involvement through three different working groups: the Technical Working Group, the Policy Advisory Committee, and the Community Task Force. For the next phase, a continuation or evolution of these working groups will be needed to ensure effective coordination across cities and other entities.

Action: After completion of the Vulnerability Assessment, County staff or others involved in the Sea Change SMC process could first evaluate the existing city and stakeholder collaboration structure and other examples to determine whether the structure should be modified for the next phase. Staff could then finalize a structure for the next phase.

Many different city collaboration and stakeholder groups exist throughout the County. As part of this analysis, staff could evaluate the different related groups in the County, learn what has been most successful, and solicit recommendations from the Technical Working Group, Policy Advisory Committee, and Community Task Force. One question to evaluate is whether a separate sea level rise group is needed, or whether it would be more efficient to merge as a subgroup of other, related efforts, such as the climate action planning group known as the Regionally Integrated Climate Action Planning System.

5.2.3 Develop a Countywide Adaptation Framework (Near Term)

Issue: Cities throughout the County are grappling with similar questions about how to address sea level rise in planning documents, projects, and shoreline protection strategies. A need exists to address sea level rise in a coordinated way throughout the County to ensure shoreline protection strategies are effective, do not have unintended consequences on neighboring jurisdictions, are in line with existing building codes, and increase funding possibilities. An action in one part of the Bay or ocean shoreline, such as a new seawall or breaching an existing levee for wetland restoration, can affect water levels, sediment movement, and erosion patterns in areas adjacent and across the Bay. Therefore, actions will need to be evaluated in terms of impacts on neighboring communities and other locations throughout the Bay. Cities have recommended that the County play a leadership role in establishing a standardized process for addressing sea level rise.

Action: The County could take the lead on working in partnership with cities, asset managers, businesses, organizations, and others to develop a Countywide Adaptation Framework and Strategy to enhance coordination and identify priority actions.

An adaptation framework establishes a system for how to incorporate sea level rise and resilience principles into County and city plans, projects, and operations. The County has identified the following steps for developing a Countywide Adaptation Framework:

1. **Develop Countywide goals and long-term vision for addressing sea level rise.** Using a facilitator, the County could work in partnership with cities and stakeholders to develop goals and a long-term vision to reduce risk based on County and city values.
2. **Identify existing plans and processes through which sea level rise can be addressed.** Sea level rise is not something that should be planned for in isolation. It can be incorporated into existing planning plans and processes. Plans that should incorporate sea level rise include Climate Action Plans, General Plans, Local Coastal Programs, Capital Improvement Plans, and Transportation Plans. The City/County Association of Governments has already completed this step of evaluating all plans and processes in the County as part of the Countywide Stormwater Resource Plan. This evaluation can be used as a starting point for this step.
3. **Develop criteria for prioritizing vulnerable areas.** This step involves establishing criteria for prioritizing the most vulnerable areas in the County. Priority areas could include concentrations of areas with a high number of critical (or other types of) facilities or habitat areas where adaptation actions may be warranted.
4. **Identify planning areas.** Effective sea level rise planning should occur at a landscape scale in order to understand the combined impacts from fluvial and coastal flooding throughout an entire watershed or multiple watersheds. Landscape scale refers to a comprehensive approach that goes beyond site-specific actions. It looks at the ecological, political, and geological landscape, along with future climate change, to determine the appropriate scale for actions. The cities and County should work together to determine the appropriate scale for adaptation planning, building upon any existing resources such as the Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) and the Operational Landscape Unit concept developed by the San Francisco Estuary Institute. Operational Landscape Units are planning areas that are appropriate for adaptation planning according to ecology, geology, and political factors, similar to a watershed. Planning areas could include a single watershed or multiple adjacent watersheds, depending on the nature of the area and development patterns. These broader planning areas will then likely need to be divided into different shoreline stretches appropriate for developing specific shoreline strategies.
5. **Identify funding options for resilience efforts/adaptation projects.** It is imperative that adaptation planning also include an evaluation of funding and financing options for adaptation projects. This evaluation could include an investigation into the specific funding and financing mechanisms that are available to the County, cities, special districts, and others in the County. Some potential funding sources include federal, state, and local grants; private foundations; traditional bond measures; resilience or catastrophe bonds; assessment districts; geological hazard abatement districts; sales tax measures; and development impact fees.

5.2.4 Develop an Adaptation Strategy (Near to Long Term)

Issue: Reducing impacts from sea level rise will involve a range of measures, from flood protection infrastructure (such as pumps, levees, tide gates) to wetland restoration, green infrastructure, floodproofing, policy changes, public education, and others. A combination of measures will likely be needed, and trade-offs will likely exist among different options. Identifying a preferred strategy for reducing risks for relevant planning areas in the County will assist cities and property owners in securing funds, proactively implementing mitigation measures before a disaster occurs, and understanding different roles and responsibilities in reducing risks.

Action: Cities and the County can work together to determine the best scale for development of an adaptation strategy. The strategy is an action plan with specific measures. Depending on staff capacity and stakeholder interest, the strategy can address issues that compound the impacts of sea level rise or are related, such as riverine flooding, seismic events, and drought. Specific actions associated with this step include the following:

1. Develop adaptation options for each planning area, beginning with prioritized areas
2. Evaluate options and develop preferred alternatives, including input through public processes
3. Coordinate across flood, stormwater, groundwater, and sea level rise impacts

An Adaptation Strategy includes near-term and long-term measures to reduce risk for relevant planning areas in the County (shoreline sections, watersheds, basins, etc.) as well as asset-specific adaptation and regional adaptation measures. It should be developed through a public process and include measures to reduce the vulnerability of the County by targeting each component of vulnerability: reducing the exposure of the County to sea level rise hazards, reducing the sensitivity of the County and its assets to sea level rise hazards, and improving the adaptive capacity.

5.2.5 Develop an Adaptation Policy Toolkit and Guidance Document with Templates to Assist Cities and the County (Near Term)

Issue: The issue of sea level rise is complex, the science is evolving, and multiple mapping and modeling systems are available to communities in the County. In addition, there is no standard amount of sea level rise to plan for and no standard scenarios to analyze in a project or plan. Cities and the County need assistance in interpreting sea level rise science information and developing policy language for General Plan updates and other plans. In meetings with cities and community stakeholders, many suggested that the County work with cities to develop a coordinated approach to sea level rise policy development.

Action: The County and cities could evaluate existing models for coordinated policy development, such as 21 Elements and the Regionally Integrated Climate Action Planning System, and determine the best method for coordinating on sea level rise policy development. The County and cities could work together on a guidance document and policy toolkit that summarize standard scenarios, modeling systems, minimum analyses needed for projects, and policy options. This effort could include the development of adaptation plan templates, model policies and ordinances, and planning recommendations for Climate Action Plans, General Plans, and Local Coastal Program updates that are in line with achieving the goals and objectives set forth in the Adaptation Plan Framework.

5.2.6 Continue to Facilitate Coordination, Collaborations, and Partnerships (Near to Long Term)

Successful sea level rise preparedness work includes collaboration and coordination among public and private entities, among different sectors and various levels of government. It includes an open public process, with new and innovative partnerships. Many efforts are already occurring in the County, including the following:

- **Sea level rise and flood management efforts in the County**
    1. San Mateo County Flood Resilience Program
    2. Stormwater and Green Infrastructure Planning Efforts
    3. Look Ahead San Mateo: A partnership with Federal Emergency Management Agency (FEMA), Climate Access, Owlized, and Dr. Susanne Moser to raise awareness about sea level rise through an interactive viewer showing sea level rise impacts at Coyote Point Park
    4. Local projects, such as levee improvements, wastewater system upgrades, and General Plan and Local Coastal Program updates
- **Bay Area Regional Efforts**
    1. San Francisco Resilient By Design: Coming in 2017, a new international design competition, the Bay Area: Resilient By Design Challenge, will include interdisciplinary teams and Bay Area communities working together to design solutions to address sea level rise and climate change for up to 10 locations.
    2. Coastal Hazards Adaptation Resiliency Group (CHARG)
    3. BCDC Adapting to Rising Tides vulnerability assessment and adaptation planning
    4. BCDC Transportation Assessment
    5. University of California Berkeley, Stanford, and other academic and nonprofit research organizations
- **State and Federal Efforts**
    1. Coastal Resilience Workshop with FEMA, National Oceanic and Atmospheric Administration (NOAA), and coastal counties
    2. Coastal Commission Sea Level Rise Guidance and planning grants
    3. State Coastal Conservancy sea level rise project funding criteria and grants
    4. Ocean Protection Council sea level rise planning and grants
    5. State Lands Commission sea level rise analysis requirements for leases
    6. Caltrans incorporation of sea level rise in projects
    7. State Parks sea level rise analysis

Bair Island. Photo credit: Toby Roessingh.

8. NOAA/Greater Farallones National Marine Sanctuary Climate Smart Adaptation Planning recommendations
9. Adaptation planning efforts by federal agencies including U.S. Army Corps of Engineers, National Parks, and others.

5.2.7 Evaluate Policy, Permitting Processes, and Regulations for Potential Conflicts or Challenges to Adaptation (Long Term)

Issue: In many cases, existing regulations and permitting requirements can be a challenge to reducing flood exposure and risk in the near and long term.

Action: The Asset Vulnerability Profiles (AVPs) (see Appendix D) identify some of the necessary permits and agencies that are involved in shoreline modification or hazard mitigation. However, the cities and counties should work with agencies and research groups to conduct a more comprehensive evaluation of existing policies and permits to identify how policies and permitting procedures may need to be modified to better enable adaptation locally.

5.2.8 Public involvement, Engagement, and Outreach (Near to Long Term)

Issue: A need exists to increase awareness of sea level rise and engagement in Countywide efforts. To be most effective, adaptation planning should be completed in a transparent, public process and in partnership with community representatives, especially those living in the most vulnerable areas.

Action: The County, cities, businesses, community groups, and others can all take steps to raise awareness about the issue and become more engaged in adaptation planning efforts. For example, the County could establish a sea level rise training program with a series of talks and workshops to share best available information, answer questions and concerns, and foster engagement of local agencies and the general public in planning efforts. Outreach and education efforts should address health impacts of sea level rise and include specific goals for inclusion of especially vulnerable populations. Medical personnel and facilities should be equipped with both the appropriate information to share with the public and an adequate capacity to address health impacts related to sea level rise. Training opportunities, such as a Public Health and Emergency Preparedness Training Series for Community-serving Organizations, should be increased, and an overall improvement is needed in the capacity of the public, especially vulnerable communities, to prepare, respond, and recover from related health risks. Funding for low-income and senior home retrofits and the development of neighborhood response centers could also increase community resilience. In its outreach efforts, the County should focus on developing materials and outreach events in multiple languages and in different geographical locations throughout the County. In addition, innovative community engagement projects should be encouraged, for example, through public art installations or citizen science projects.

5.3 City/County Actions

This Vulnerability Assessment provides a template that the County, cities, and others can use to further evaluate vulnerabilities within local areas of responsibility and across areas of shared interest geographically. Key next steps for Sea Change SMC include completion of sea level rise risk evaluation for the South Coast of the County and for specific sectors across the County such as transportation, housing, and critical facilities.

5.3.1 South Coast Vulnerability Assessment (Near Term)

Issue: As described in Chapter 1, the current Vulnerability Assessment does not include the area south of Half Moon Bay because of the lack of detailed sea level rise modeling and mapping for the area. The current extent of the U.S. Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) and Our Coast, Our Future tool is Half Moon Bay. The vulnerability assessment needs to be completed for the South Coast portion of the County, which includes the unincorporated town of Pescadero.

Action: Thanks to funding from the Ocean Protection Council, USGS and Point Blue are working on completing CoSMoS modeling for the area south of Half Moon Bay. The estimated completion date for the modeling is 2018. The County plans to initiate the South Coast vulnerability assessment as soon as the modeling is completed. The Board of Supervisors has allocated funds toward this effort.

5.3.2 Further Evaluate Key Sectors and Community Risks (Near Term)

Issue: The Vulnerability Assessment includes an evaluation of 30 case study assets, but it does not fully evaluate the vulnerability of key assets in the County. A better understanding is needed with regard to the vulnerability of County facilities, critical facilities, housing, transportation assets, habitats (including beaches and wetlands), health care facilities, and other key sector assets. We also need a better understanding of community and health risks.

Action: To meet this need, the County and partners can take several next steps. The AVPs serve as a template for the County, cities, and asset managers to further evaluate the vulnerability of other facilities and areas throughout the County. In future studies that cities conduct throughout the County, it would be helpful to ensure they receive adequate technical support through channels including consultant or agency expertise and County staff. See Appendix C for a survey of questions to ask and information needed to evaluate vulnerability.

1. **Evaluate County Facilities and unincorporated areas.** Impacts of sea level rise to County facilities and

unincorporated areas need to be assessed more thoroughly.

2. **City-specific analyses.** Cities in the County can use the data in this Assessment to further understand their jurisdiction's risks and vulnerabilities. This report recommends that cities and the County develop local vulnerability assessments with the County's support of online resources, guidance, and open-source data.
3. **Evaluate key sectors.** This report provides a detailed analysis on 29 assets across different sectors. Although the results of the study provide some next steps to reduce risks to individual facilities, additional analysis is needed to fully understand vulnerability of different sectors, such as wastewater treatment facilities, hazardous sites, health care, housing and priority development areas, transportation networks, and habitat areas. The AVPs can be used as templates to evaluate the risks associated with other assets. Depending on the sector, different local agencies and organizations will need to be involved, along with various regional, state, and federal agencies.
4. **Assess public health impacts from sea level rise and climate change.** A detailed assessment of the potential vulnerabilities and impacts to public health was not part of this effort but will be crucial for adaptation planning. A study should be performed to evaluate the potential near- and long-term effects and direct and indirect impacts to public health and public health infrastructure described in Chapter 3. The study should provide information about potential interventions and measures to mitigate health impacts of sea level rise. The information should be developed for use by governmental agencies, community-based organizations, and affected residents. In addition, the study should include an assessment of the current capacity of health-serving organizations to respond to sea level rise and how this capacity can be improved. In addition to the study, public health preparedness and emergency response to sea level rise and flooding should be improved, including mechanisms for robust surveillance of environmental conditions and health impacts of sea level rise.
5. **Analysis of other climate change impacts.** Sea level rise cannot be planned for in isolation. It is important to evaluate other climate change impacts in order to facilitate and prioritize the development of multibenefit strategies that address multiple impacts. Other climate change impacts in the County include changes in precipitation and fluvial flows, drought impacts, heat effects, wildfire, and ocean acidification. An example of a project that has multiple benefits is an urban forestry program that increases stormwater retention, sequesters carbon, decreases heat island effect, and improves air quality.
6. **Identify funding options for resilience efforts/adaptation projects:** The need to identify funding options was identified in the first County sea level rise conference and working group in 2013 (initiated by County Supervisor Dave Pine, California Assemblyman Rich Gordon, and U.S. Congresswoman Jackie Speier), has been an ongoing topic of research for Sea Change SMC. It is imperative that adaptation planning also include an evaluation of funding and financing options for adaptation projects. This evaluation could include an investigation into the specific funding and financing mechanisms that are available to the County, cities, special districts, and others in the County. Some potential funding sources include federal, state, and local grants, private foundations, traditional bonds, resilience or catastrophe bonds, assessment districts, geological hazard abatement districts, sales tax measures, and development impact fees. Continued research and work on options for funding resilience and adaptation measures will be conducted in Phase II of Sea Change SMC.

The County and its cities can use the Asset Exposure Maps and Asset Exposure Inventories developed in this study (Appendices B and C, respectively), as tools to (i) identify the priority areas and/or (ii) understand how many, which type, and what specific assets could benefit from proposed adaptation projects.

A mapping package (with GIS data) provided to the City and County stakeholders will have access to the mapping package developed for this study, which will enable all to perform these preliminary analyses; the package was developed so users can sort GIS data by asset risk class, asset type, and asset category.

5.3.3 Update Policy and Land Use Planning Documents (Near and Long Term)

Issue: California jurisdictions are currently required to develop multiple different plans to meet different agency requirements. The plans are generally completed independent of one another, but they share a lot of the same information and address sea level rise from different perspectives. Some of these plans include Local Hazard Mitigation Plans, Urban Water Management Plans, Stormwater Management Plans, Climate Action Plans, Local Coastal Programs, and General Plans.

Action: The results from this Vulnerability Assessment should be coordinated with and incorporated into the relevant plans, including Local Hazard Mitigation Plans (LHMPs). Projects that are identified in the LHMPs will be more likely to receive federal funding in the event of a federal disaster declaration.

To reduce near- and long-term risks, cities and towns could consider flood risk management in policy and land use planning decisions. For example, as local jurisdictions update General Plans and Local Coastal Programs, maps and findings from this Vulnerability Assessment that identify future flood-prone areas should be considered in land use and development decisions as well as in building codes. As a policy, cities and towns could consider reducing "who and what are in harm's way," by prohibiting or discouraging new development or new critical facilities (Class 3 and 4 built assets) in present or future flood- and erosion-prone areas. Policies could also recommend that all existing Class 3 and 4 infrastructure in hazardous areas be mitigated for flooding and erosion risk. The mitigation strategies should include public health co-benefits. In general, cities and counties should incorporate health and equity considerations in their updates to local hazard mitigation plans as well as General Plan Safety Elements.

5.3.4 Incorporate Results from Vulnerability Assessment into Capital Improvement Plans (Near Term)

Issue: Capital planning provides two major opportunities for integrating the valuable information provided in this sea level rise Vulnerability Assessment. First, retrofitting an existing structure is much more expensive than building it to be resilient in the first place. Second, capital planning provides an opportunity to designate future funds for highly needed maintenance and modifications. This designation means that asset managers could earmark funds specifically to mitigate essential facilities or components.

Plans to incorporate sea level rise into include the following:

- Local Coastal Programs
- General Plans
- Local Hazard Mitigation Plans
- Stormwater Management Plans
- Urban Water Management Plans
- Capital Improvement Plans
- Transportation Plans
- Climate Action Plans

Bair Island. Photo credit: Toby Roessingh.

Action: Asset managers and cities can use the information from this Assessment to inform the location or construction style of new/upgraded facilities. Prior to building or upgrading a facility, asset managers have the power to influence that asset's future exposure, sensitivity, or adaptive capacity (and ultimately, its risk). Specifically, asset managers could ensure that new facilities are not in harm's way or that they are built with sea level rise hazards in mind, for example, by ensuring that a new power feed or critical evacuation route is elevated or floodproofed.

5.3.5 Enhance Community Participation in the National Flood Insurance Program Community Rating System Program (Near Term)

Issue: The Community Rating System (CRS) program was developed to encourage participating National Flood Insurance Program communities to further reduce their flood risk by taking actions ranging from outreach to mapping and preserving open space and taking additional mitigation. In exchange for taking these actions, communities receive a CRS rating that entitles them to discounts of up to 45% on their flood insurance premiums. Achieving the highest rating is difficult, but some communities are already taking necessary actions and are not getting the credit (or insurance discount) because they do not have the staff resources to submit the necessary paperwork.

Action: One way that County communities could become more resilient to present-day flooding would be to assess CRS activities and submit supporting paperwork on the CRS activities for credit. This effort could increase a community's CRS rating and ultimately result in a reduction on flood insurance premiums. In addition, a community could assess its ability to undertake new CRS activities, which could benefit them by reducing risk and earning the community a higher rating.

5.4 Critical Facilities and Property Owner Actions

5.4.1 Develop Site-Specific Plans for Critical Facilities (Near Term)

Issue: The vulnerability of some facilities in the County can be greatly reduced by making structural, operational, or shoreline changes. This Vulnerability Assessment found, for example, that floodproofing electrical transformers could greatly increase the resilience of various facilities. Also, in some cases, fixing a small low point in a levee can reduce flood risk to a large area.

Action: To reduce near-term risks, asset managers could work with the County, consultants, and other entities to identify potential structural, shoreline, or operational changes and to apply for funding to implement them. In many cases, mitigation of a small component could provide far-reaching benefits and reduce the likelihood of damage or service outages. As designed, many of the AVPs provide specific next steps an asset manager could take to reduce risks at the facility and lay the groundwork for grant or other funding assistance applications.

Asset exposure maps and inventories also provide information on the location of critical facilities in each city and town.

5.5 Research Needs

Although sufficient information is available to understand the county's vulnerabilities, more detailed information is needed in some areas to better inform project owners/sponsors and policy makers in their investment decision for sea level rise planning and the design and construction of risk-reduction measures. Table 5.1 provides a snapshot of what areas of research are needed, with more detailed descriptions to follow.

Table 5.1 Summary of research needs.

NO.	ACTION
5.5.1	Evaluate feasibility of nature-based adaptation options in San Mateo County
5.5.2	Further evaluate community vulnerability, adaptation, and equity
5.5.3	Refine Habitat Vulnerability Results
5.5.4	Better Understand Subsidence and Vertical Land Movement
5.5.5	Groundwater and Water Quality
5.5.6	Coastal Erosion
5.5.7	Watershed Analysis: Combined Coastal and Fluvial Analysis
5.5.8	Economic Analysis

5.5.1 Evaluate Feasibility of Nature-Based Adaptation Options in San Mateo County

Issue: The San Mateo County Energy Efficiency Climate Action Plan and its Local Hazard Mitigation Plan give priority to nature-based adaptation strategies or green infrastructure where possible, but little understanding exists on the feasibility of these options in the County.

Action: Conduct research on the feasibility of nature-based adaptation options. This action includes developing a research plan that builds on existing studies in order to evaluate each segment of the Bayshore and Coastal shoreline for the potential to implement wetland restoration and other nature-based shoreline protection strategies.

Background on nature-based strategies. Nature-based strategies protect shorelines from coastal flooding by creating, restoring, or emulating natural coastal features, such as wetlands, dunes, or reefs. These strategies reduce erosion and mitigate storm surge, wave action, and still-water flooding associated with coastal flood events. They are also known as nature-based features because they mimic natural coastal features and provide habitat, water quality, and ecosystem value.

Nature-based options are an important adaptation tool for the County and further research is needed to understand their feasibility. To better understand research needs and support a collaborative research and learning process, the County could convene a working group of state and city agencies, academics, nonprofits, and consultants to develop or work on a County-specific research plan. This group would survey and review available literature to determine the status of the science related to different nature-based strategies, including review of hazard mitigation potential, ecological benefits, and reasons for failure, in addition to unknowns and data gaps. The working group could engage stakeholders and experts through a series of workshops to identify research priorities. This group could also evaluate how the outcomes from the Baylands Ecosystem Habitat Goals Science Update 2015: *The Baylands and Climate Change: What We Can Do* (Conservancy 2015), the Gulf of the Farallones Climate-Smart Adaptation Project for the North-Central California Coast and Ocean (see http://farallones.noaa.gov/manage/climate/adaptation.html), and existing nature-based pilot projects in San Mateo County and the San Francisco Bay can be integrated into overall adaptation strategies.

A research plan would comprise two sections. The first section outlines research needs that apply across all nature-based strategies. Examples of cross-cutting research needs include (i) mapping which nature-based strategies are most appropriate for specific shoreline reaches and developing baseline data (e.g., wake, wave, sediment) and (ii) monitoring protocols that are consistent across agencies. The second section addresses research needs that are specific to a single nature-based strategy or a selected group of nature-based strategies, such as improving understanding of which types of wetland vegetation work best to attenuate waves in San Francisco Bay. A similar investigation was recently completed in New York City following the damages caused by Hurricane Sandy (Zhao et al. 2014).

Mirada Rd. Photo credit: Office of Sustainability.

5.5.2 Further Evaluate Community Vulnerability, Adaptation, and Equity

Issue: Some adaptation will reduce the exposure of communities through infrastructure. However, reducing the sensitivity and improving the adaptive capacity of communities are also key components to building community resilience and reducing overall community risk to flooding, erosion, and sea level rise. Chapter 3 of this report provides a high-level description of the social and demographic factors that affect an individual's ability to respond to impacts from sea level rise. Since the data are only available at the census-block level, a more detailed analysis is needed to understand the spatial distribution of individuals and communities with characteristics that make them more vulnerable to sea level rise.

Action: Prior to adaptation planning, the County, cities, or partners should conduct more detailed studies at a neighborhood scale to enable targeted outreach, risk communication, and crisis management. For example, understanding where people who do not have access to vehicles live or where people who have limited mobility and other functional or access needs live will be critical for evacuation planning. Knowing where non–English-speaking communities live and what language they speak will be essential in targeting outreach materials and activities. The County is currently engaged in identifying nonprofit organizations that work with populations in vulnerable communities to improve their resilience, but the resources of these groups are limited.

5.5.3 Better Understand Habitat Vulnerability

Issue: Sea level rise modeling tools do not account for the dynamic nature of shoreline habitats or on changes to the ecosystem services and functions that habitats provide, and therefore may under- or overestimate vulnerability. More information is needed on how wetlands might evolve with sea level rise, and how the flood protection and carbon sequestration benefits of wetlands might change over time. In addition, more information is needed on options to mitigate loss of rocky intertidal habitat and beach habitat in the County.

Action: The County could partner with Point Blue or other organizations with habitat-modeling expertise to better understand vulnerability of wetlands and other habitat types and to develop solutions to reduce vulnerability.


Linda Mar State Beach. Photo credit: Office of Sustainability.

5.5.4 Better Understand Subsidence and Vertical Land Movement

Issue: Much of the County is low lying, and any natural or built assets atop fill or wetland could be subject to subsidence, settlement, or other vertical land movement. This movement could increase the exposure of natural and built assets to both groundwater and surface water. However, information on these processes is limited or anecdotal.

Action: The County and cities should work in partnership with neighboring counties, state and federal agencies, and researchers to better understand subsidence in the San Francisco Bay. Subsidence, settling, or any other vertical land movement should be studied in detail prior to designing or implementing any flood or erosion mitigation or adaptation measure.

5.5.5 Further Evaluate Groundwater and Water Quality

Issue: Groundwater depths reported for environmental contamination sites are available on the Geotracker website (State Water Resources Control Board 2015). Sea level rise could affect many contaminated sites (some regulated by the U.S. Environmental Protection Agency) as previously described. This possibility is a concern because of the potential public health concerns, the volume of storage that could be contaminated, and the potential risks associated with the increased number of contaminated sites that would discharge through sewer and storm pipes, which has implications for National Pollutant Discharge Elimination System permits.

Action: A review of the potential for these sites to contaminate shallow aquifers and interact with storm and sewer pipes as a result of flooding should be conducted.

5.5.6 Further Evaluate Coastal Erosion

Issue: USGS is developing detailed erosion projections data for the County's coast, which will be available in Google Earth files. These data will help fill existing data gaps on future erosion rates. In addition to projected future erosion rates, local jurisdictions need to be able to understand how different management actions, such as a seawall, dune restoration, beach nourishment, living reefs, and so forth, affect erosion and sediment movement.

Action: Once the USGS data are available, the County could partner with USGS researchers or other scientists to improve understanding of how erosion risk varies with and without existing seawalls along the County's coast, how erosion and sediment movement changes with different management responses, and where along the Coast nature-based options might be effective in reducing risks.

5.5.7 Watershed Analysis: Combined Coastal and Fluvial Flooding

Issue: Although a major cause of present-day flooding is the combination of high tides (coastal flooding) with high rainfall events (leading to creek or riverine flooding and overtopping of the County's many creeks, such as flooding of the San Francisquito Creek in 1998 and 2012), the two are often evaluated separately. This divide provides an incomplete picture that underestimates frequency, extent, depth, and duration of flooding in the County.

Action: Because future adaptation will need to account for both coastal and riverine (including when both events occur concurrently), updated analysis is needed to map and understand the combined impact of fluvial and coastal flooding. Such an approach could then effectively account for a reduction in combined coastal-rain flood impacts from the implementation of risk reduction measures upstream.

5.5.8 Conduct Additional Economic Analysis

Issue: The Vulnerability Assessment does not provide an economic analysis for specific assets, adaptation strategies, future assessments, or other projects that may arise from the Vulnerability Assessment. In order to determine whether or not a project is economically viable, an economic analysis is an essential step.

Action: Although economic analyses will be done on a case by case basis, the County and cities could partner with economists, and state and federal funders to develop a standardized methodology for these assessments, and conduct research on the costs and benefits of different adaptation strategies. Working with funders would ensure that analyses are done in a way that is compatible with grant application requirements.

5.6 Conclusion

Sea level rise presents challenges that in many ways are not new: San Mateo County currently deals with flooding and erosion impacts on a regular basis. We already know how to prepare for flooding and have land use policies in place to set development away from eroding bluffs and other hazardous locations. The County also already has plans in place to respond to flooding and other disasters. However, sea level rise will increase the magnitude and the frequency of flooding and erosion events in the County, which calls for increased coordination across the 20 cities and the County, as well as across businesses, asset owners, state and federal agencies, community groups, and others. This type of coordination is also not new. The County of San Mateo has worked across all 20 cities and the County to address housing challenges through 21 elements and through the Home for All Initiative. The County and cities also work together through the Regionally Integrated Climate Action Plan System, which provides a consistent climate action plan template and a forum for working through common issues that arise throughout the process.

Sea level rise has the potential to affect every sector in the County: the economy, critical habitats and species, health care, wastewater treatment facilities, transportation, stormwater, as well as our neighborhoods, parks, and schools. We will need to address the impacts through large-scale shoreline protection strategies as well as through site-specific adaptations and land use policies.

As a next step, we suggest that the County convene a working group and steering committee to develop an action plan for the Sea Change SMC Initiative. While preparing for long-term sea level rise, it is also important to remember that the County is vulnerable to flooding and erosion today; preparation for near-term flooding and erosion emergencies, as well as the combination of multiple disasters, such as an earthquake and a flood, is necessary. This preparation will help ensure our economy, habitats, transportation systems, wastewater treatment facilities, and ports can recover after disasters and are prepared to cope with sea level rise.

Fitzgerald Marine Reserve. Photo credit: San Mateo County Flickr.

"Sea level rise has the potential to affect every sector in the County: the economy, critical habitats and species, health care, wastewater treatment facilities, transportation, stormwater, as well as our neighborhoods, parks, and schools."

WORKS CITED

American Society of Civil Engineers (ASCE). 2013. ASCE 7-10. Minimum Design Loads for Buildings and Other Structures. Available from: http://dx.doi.org/10.1061/9780784412916.

American Society of Civil Engineers (ASCE). 2015. 24-14 Flood Resistant Design and Construction. ISBN-978-0-7844-1379-1.

American Water Works Association (AWWA). 2010. AWWA J100-10 (R13) Risk and Resilience Management of Water and Wastewater Systems (RAMCAP).

Association of Bay Area Governments. 2015. Resilience Program. Stronger Housing, Safer Communities: Strategies for Seismic and Flood Risks. Available from: http://resilience.abag.ca.gov/projects/stronger_housing_safer_communities_2015/

Association of State Floodplain Managers (ASFPM). (2011). Critical Facilities and Flood Risk. Available from: https://www.floods.org/ace-files/documentlibrary/Whitepapers/ASFPM_Critical_Facilties_and_Flood_Risk_Final_Feb_2011.pdf

Backlund E, Sorlie P D, and Johnson N J. 1999. A comparison of the relationships of education and income with mortality: The National Longitudinal Mortality Study. Social Science & Medicine 49(10):1373–1384. PMID: 10509827

Ballard G, Barnard P L, Erikson L, Fitzgibbon M, Moody D, Higgason K, Psaros M, Veloz S, and Wood J. 2016. Our Coast Our Future (OCOF). [data downloaded from web application]. Petaluma, California. Available at: http://www.ourcoastourfuture.org (Last accessed: May 2016).

Bay Area Regional Health Inequities Initiative (BARHII). 2015. Applying Social Determinants of Health Indicator Data For Advancing Health Equity: Guide for Local Health Department Epidemiologists and Public Health Professionals. Oakland, CA. Available from: http://barhii.org/download/publications/barhii_sdoh_indicator_guide_v1.1.pdf

Bay Localize. 2013. Mapping our future: A workplan for public engagement and equity in the Climate Adaptation Planning the San Francisco Bay Area. Available from: http://bayarearegionalcollaborative.org/pdfs/Task%207c1%20Social%20Equity.pdf

Beavers R L, Babson A L, and Schupp C A. [eds.]. 2016. Coastal Adaptation Strategies Handbook. NPS 999/134090. National Park Service. Washington, DC. Available from: https://www.nps.gov/subjects/climatechange/coastalhandbook.htm

California Coastal Commission (CCC). 2015a. Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. May.

California Coastal Commission (CCC). 2015b. California Coastal Commission Staff Report: CDP Hearing; Application Number 3-14—488. Available from: http://documents.coastal.ca.gov/reports/2015/11/th19c-11-2015.pdf

California Department of Transportation (Caltrans). 2016. Project Update-San Luis Obispo County. Available from: http://www.dot.ca.gov/dist05/paffairs/sanluisobispo/slo_construction_updates.pdf

California Department of Water Resources (DWR). 2013. California Water Plan Update. Available from: http://www.water.ca.gov/waterplan/cwpu2013/final/index.cfm

California Health Interview Survey. 2014. CHIS 2014 Adult and Child Public Use File. Los Angeles, CAL UCLA Center for Health Policy Research.

California Regional Water Quality Control Board, San Francisco Bay Region, Groundwater Committee. 2003. A Comprehensive Groundwater Protection Evaluation for the South San Francisco Bay Basins. Available from: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/groundwater/report.pdf

California State Coastal Conservancy (Conservancy). 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland.

California Emergency Management Agency and California Natural Resources Agency (CEMA and CNRA). 2012. California Adaptation Planning Guide: Planning for Adaptive Communities. Available from: http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf

Cayan D R, Kalansky J, Iacobellis S, and Pierce D. 2016. Creating Probabilistic Sea Level Rise Projections to support the 4th California Climate Assessment. California Energy Commission. Available from: http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-04/TN211806_20160614T101823_Creating_Probabilistic_Sea_Leve_Rise_Projections.pdf

Census. 2010. TIGER/Line with selected Demographic and Economic Data. Available from: https://www.census.gov/geo/maps-data/data/tiger-data.html

Center for Neighborhood Technology. 2017. Affordable Index. Available from: http://htaindex.cnt.org/map/

Centers for Disease Control and Prevention. 2006. Health Concerns Associated with Mold in Water-Damaged Homes After Hurricanes Katrina and Rita — New Orleans Area, Louisiana, October 2005. Morbidity and Mortality Weekly Report 55(2):41–44. Available from: https://www.cdc.gov/mold/pdfs/mmwr55241-44.pdf

Centers for Disease Control and Prevention. 2013a. CDC health disparities and inequalities report. Morbidity and Mortality Weekly Report 62(Suppl. 3):1–184.

Centers for Disease Control and Prevention. 2013b. Mental Health. Available from: https://www.cdc.gov/mentalhealth/basics.htm

Centers for Disease Control and Prevention. 2015. Disability and Health. Available from: https://www.cdc.gov/ncbddd/disabilityandhealth/disability.html

City of Burlingame. 2011. City of Burlingame Urban Water Management Plan. Prepared by Erler and Kalinowski, Inc. Available from: http://www.water.ca.gov/urbanwatermanagement/2010uwmps/Burlingame,%20City%20of/Burlingame%20UWMP.pdf

City of East Palo Alto. 2015. Groundwater Management Plan for the City of East Palo Alto. Prepared by Todd Groundwater in August 2015. Available from: http://www.water.ca.gov/groundwater/docs/GWMP/SF-7_CityofEastPaloAlto_GWMP_2015.pdf

City of Half Moon Bay. 2017. Half Moon Bay Coastal Trail: Existing Conditions & Trail Planning Recommendations. Prepared by NCE. Available from: http://www.half-moon-bay.ca.us/index.php?option=com_docman&task=doc_download&gid=3431&Itemid=68

City of Morro Bay. 2013. Wastewater Treatment Plant Project: Updated April 29, 2013. Available from: http://www.morro-bay.ca.us/352/WWTP-Upgrade-Project

City of Pacifica. 2016. Coastal Hazards Study 2212 Beach Boulevard, Pacifica: Technical Report with Executive Summary. Available from: http://www.cityofpacifica.org/civicax/filebank/blobdload.aspx?BlobID=10833

Coastside County Water District. 2016. Water Supply. Available from: http://www.coastsidewater.org/53-your-water.html

Cooley H, Moore E, Heberger M, and Allen L. 2012. Social Vulnerability to Climate Change in California. Prepared for California Energy Commission (CEC). Prepared by Pacific Institute. Publication number: CEC-500-2012-014.

Available from: http://www.energy.ca.gov/2012publications/CEC-500-2012-013/CEC-500-2012-013.pdf

Cornwell E Y and Waite L J. 2009. Social disconnectedness, perceived isolation, and health among older adults. Journal of Health and Social Behavior 50(1):31–48. doi: 10.1177/002214650905000103

County of San Mateo et al. 2015. Get Healthy San Mateo County: Strategies for Building Healthy, Equitable Communities. Health Policy and Planning Division. San Mateo County Health System. Available from: http://www.gethealthysmc.org/sites/main/files/file-attachments/get_healthy_smc_strategic_plan_2015-2020_final.pdf

Cutter S L, Emrich C T, Webb J J, and Morath D. 2009. Social Vulnerability to Climate Variability Hazards: A review of the literature. Final Report to Oxfam America. Hazards and Vulnerability Research Institute, Department of Geography, University of South Carolina. June 17, 2009.

Delta Programme Commissioner, The Hague. 2015. Working on the Delta: Decisions to Keep the Netherlands Safe and Livable. Available from: http://www.klimatilpasning.dk/media/849051/nl_-_delta_programme_2015_en.pdf

Ekstrom J A and Moser S C. 2012. Climate Change Impacts, Vulnerabilities, and Adaptation in the San Francisco Bay Area: A Synthesis of PIER Program Reports and Other Relevant Research. California Energy Commission. Publication number: CEC- 500- 2012- 071

Environmental Protection Agency (EPA). 2001. Fact Sheet Functions and Values of Wetlands. Office of Water, Office of Wetlands, and Oceans and Watersheds. Available from: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=200053Q1.TXT

Environmental Protection Agency (EPA). 2006. Economic Benefits of Wetlands. Office of Water. Available from: http://nepis.epa.gov/Exe/ZyPDF.cgi/2000D2PF.PDF?Dockey=2000D2PF.PDF

Environmental Protection Agency (EPA). 2016. Climate Change, Health, and Environmental Justice. May 2016. Available from: https://archive.org/details/ej-health-climate-change-print-version_0

Environmental Protection Agency (EPA). 2017. Climate Change Impacts: Climate Impacts on Human Health. Available from: https://archive.org/details/impactonhealthoverview

Environmental Science Associates et al. 2016. San Francisco Littoral Cell: Coastal Regional Sediment Management Plan—DRAFT. Environmental Science Associates, Kearns and West, San Francisco, CA. Available from: http://www.sfestuary.org/wp-content/uploads/2015/11/Draft_SFLC_CRSMP_20160104.pdf

Executive Order 11988 Amendment. 2015. Opportunities to Enhance the Nation's Resilience to Climate Change. Council on Climate Preparedness and Resilience. October. Available from: https://www.whitehouse.gov/the-press-office/2015/01/30/executive-order-establishing-federal-flood-risk-management-standard-and-

Fimrite P. 2016. Perilous cliffhangers of Pacifica tell a cautionary tale. San Francisco Chronicle. January 29, 2016. Available from: http://www.sfchronicle.com/bayarea/article/Perilous-cliffhangers-of-Pacifica-tell-a-6794785.php

Florida Division of Emergency Management. 2015. Public Facilities Flood Hazard Mitigation Assessment Manual. Funded by FEMA. Florida Division of Emergency Management, Tallahassee, FL. Available from: www.floridadisaster.org/Mitigation/SMF/documents/Draft%206%20FULL%20Guidebook.pdf

Florida Institute for Health Innovation. 2016. Health and Sea Level Rise: Impact on South Florida. Available from: http://flhealthinnovation.org/wp-content/uploads/2016/07/Health-and-Sea-Level-Rise-Full-Report-2016.pdf

Fuller T. 2011. Thailand Flooding Cripples Hard-Drive Suppliers. New York Times. Retrieved November 6, 2016, from http://www.nytimes.com/2011/11/07/business/global/07iht-floods07.html

Graham M, Halpern B, and Carr M. 2008. Diversity and dynamics of Californian subtidal kelp forests. McClanahan, T.R., and G.R. Branch (eds), Food Webs and the Dynamics of Marine Benthic Ecosystems, Oxford University Press, pp. 103–134.

Graham M H, Dayton P K, and Erlandson J M. 2003. Ice ages and ecological transitions on temperate coasts. Trends in Ecology and Evolution 18(1):33–40.

Graham M H. 2007. Sea-level change, effects on coastlines. Denny, M.W. and SD Gaines (eds), Encyclopedia of Tidepools and Rocky Shores, University of California Press, pp. 497-498.

Haas P M, Makarewicz C, Benedict A, Sanchez T W, and Dawkins C J. 2006. Housing and transportation Cost Trade-offs and Burdens of Working Households. Center for Neighborhood Technology. Available from: http://www2.nhc.org/media/documents/chp-pub-hl06-cnt-report.pdf.

Hansen J et al. 2015. Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous. Atmospheric Chemistry and Physics Discussions, 15, 20059–20179. Available from: http://www.atmos-chem-phys-discuss.net/15/20059/2015/

Hauer M E, Evans J M, and Mishra D R. 2016. Millions projected to be at risk from sea-level rise in the continental United States. Nature Climate Change 6: 691–695. Available from: http://dx.doi.org/10.1038/nclimate2961

Hazard Mitigation Plan. 2016. San Mateo County. Prepared by Tetra Tech. July. Available from: http://planning.smcgov.org/sites/planning.smcgov.org/files/documents/files/San%20Mateo%20HMP%20-%20Volume%20I%20-%20Final%20APA.pdf

Hazards and Vulnerability Research Institute. 2013. Social Vulnerability Index Website: Frequently Asked Questions. Available from: http://artsandsciences.sc.edu/geog/hvri/faq

Health and Safety Executive. 2001. Reducing Risks, Protecting People. HSE's Decision-making Process, Risk Assessment Policy Unit, HSE books, Her Majesty's Stationary Office, London, England. ISBN 0 7176 2151 0. Available from: http://www.hse.gov.uk/risk/theory/r2p2.htm

Healthy Community Collaborative of San Mateo County. 2013. 2013 Needs Assessment: Health & Quality of Life in San Mateo County. Available from: http://www.smchealth.org/sites/main/files/file-attachments/2013fullreportlow.pdf

Hutto S V, Higgason K D, Kershner J M, Reynier W A, and Gregg D S. 2015. Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp. Available from: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/science/conservation/pdfs/vulnerability-assessment-gfnms.pdf

Insurance Institute for Business & Home Safety (IBHS) 2017. Vulnerable Populations. Available from: https://disastersafety.org/ibhs-public-policy/vulnerable-populations/

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Intergovernmental Panel on Climate Change (IPCC). 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Kailes J I and Enders A. 2007. Moving Beyond "Special Needs": A Function-Based Framework for Emergency Management and Planning. Journal of Disability Policy Studies. Vol 17, Issue 4. Available from: http://journals.sagepub.com/doi/abs/10.1177/10442073070170040601

King P G, McGregor A R, and Whittet J D. 2011. The Economic Costs of Sea-Level Rise to California Beach Communities. California Department of Boating and Waterways. Available from: http://dbw.parks.ca.gov/pages/28702/files/CalifSeaLevelRise.pdf

Lawrence Livermore National Laboratory (LLNL). 2004. California Aquifer Susceptibility: A Contamination Vulnerability Assessment for the Santa Clara and San Mateo County Groundwater Basins. January.

Luber G and McGeehin M. 2008. Climate change and extreme heat events. American Journal of Preventive Medicine. 35 (5): 429–435. doi: https://dx.doi.org/10.1016/j.amepre.2008.08.021

Ludy J and Kondolf G M. 2012. Flood risk perception in lands “protected” by 100-year levees. Natural Hazards 61(2): 829–842. doi:10.1007/s11069-011-0072-6.

Maizlish N, English D, Chan J, Dervin K, and English P. 2017. Climate and Health Profile Report: San Mateo County. Sacramento, CA: Office of Health Equity, California Department of Public Health. Available from: https://archive.cdph.ca.gov/programs/Documents/CalBRACE%202015CHPR/CHPR081SanMateo_County2-23-17.pdf

Marmot M. 2002. The influence of income of health: View of an epidemiologist. Health Affairs. 21(2): 31–46. doi: 10.1377/hlthaff.21.2.31

Metzger L F. 2002. Streamflow Gains and Losses along San Francisquito Creek and Characterization of Surface-Water and Ground-Water Quality, Southern San Mateo and Northern Santa Clara Counties, California, 1996-7. USGS Publications.

Mimura N, Pulwarty S, Duc M, Elshinnawy I, Redsteer H, Huang Q, Nkem N, and Sanchez-Rodriguez A. 2014. Adaptation planning and implementation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 869-898. Available from: https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap15_FINAL.pdf

Mitchell D. 2011. Early Electrical Wiring System in American Buildings, 1890-1930. APT Bulletin, 42(4):39-45. Available from: https://macaulay.cuny.edu/eportfolios/bird2012/files/2012/07/Early-Electrical-Wiring-Systems-in-American-Buildings.pdf

Moser C, Davidson A, Kirshen P, Mulvaney P, Murley J, Nuemann J, Petes L, and Reed D. 2014. Coastal zone development and ecosystems. In: Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, pp. 579–618. doi: 10.7930/J0MS3QNW.

National Climate Assessment (NCA). 2014. U.S. Global Change Research Program. Available from: http://nca2014.globalchange.gov/report/our-changing-climate/sea-level-rise#intro-section

National Geodetic Survey. 2017. Vertical Datums. NOAA. Available from: https://www.ngs.noaa.gov/datums/vertical/

National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management. 2016. Relocation of Highway 1 in San Luis Obispo County.

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Available from: http://www.nap.edu/catalog/13389/sea-level-rise-for-the-coasts-of-california-oregon-and-washington

New York City Department of City Planning (NYC Planning). 2013. Urban Waterfront Adaptive Strategies. Available from: http://www1.nyc.gov/assets/planning/download/pdf/plans-studies/sustainable-communities/climate-resilience/urban_waterfront.pdf

Oro Loma Sanitary District. 2016. Oro Loma Wet Weather Equalization and Ecotone Slope Demonstration Project, Overview. Available from: https://oroloma.org/wp-content/uploads/horizontal-levee-overview.pdf

Pacific Institute. 2009. The Impacts of Sea Level Rise on the California Coast. A paper from: California Climate Change Center. http://pacinst.org/app/uploads/2014/04/sea-level-rise.pdf

Pacific Institute. 2012. The Impacts of Sea Level Rise on the San Francisco Bay. Available from http://www.energy.ca.gov/2012publications/CEC-500-2012-014/CEC-500-2012-014.pdf

Philip Williams and Associates, Ltd. 2009. Dataset for Pacifica Institute 2012 reference. Erosion hazard with a 1.4 meter sea-level rise, 2100: The Impacts of Sea-Level Rise on the California Coast, Pacific Institute, Oakland, CA.

Public Health Institute and Center for Climate Change and Health. 2016. Rainfall & Storms, Climate Change and Health. Available from: http://climatehealthconnect.org/wp-content/uploads/2016/09/RainfallStorms.pdf

Ramin B and Sviboda T. 2009. Health of the homeless and climate change. Journal of Urban Health 86(4): 654–664. Available from: https://link.springer.com/article/10.1007%2Fs11524-009-9354-7

Robert Wood Johnson Foundation. 2008. Where We Live Matters for Our Health: The Links Between Housing and Health. Issue Brief 2: Housing and Health. Available from: http://www.commissiononhealth.org/PDF/e6244e9e-f630-4285-9ad7-16016dd7e493/Issue%20Brief%202%20Sept%2008%20-%20Housing%20and%20Health.pdf

San Francisco Bay Conservation and Development Commission (BCDC). 2011. Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline. BCDC, San Francisco, CA. Available from: http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf

San Francisco Bay Conservation Development Commission (BCDC). 2012a. Adapting to Rising Tides: Chapter 1. Introduction to the ART Vulnerability and Risk Assessment. Available from: http://www.adaptingtorisingtides.org/wp-content/uploads/2014/12/ART_VR_Chapters12.pdf.

San Francisco Bay Conservation Development Commission (BCDC). 2012b. Adapting to Rising Tides Project. Available from: http://www.adaptingtorisingtides.org

San Francisco Bay Conservation Development Commission (BCDC). 2016. Policies for a Rising Bay Project Final Report. Available from: http://www.bcdc.ca.gov/prb/Policies-for-a-Rising-Bay.pdf

San Francisco Bay Conservation Development Commission (BCDC). 2017. Wastewater. Available from: http://www.adaptingtorisingtides.org/portfolio/waste-water/

San Francisco Bay Regional Water Quality Control Board. 1996. 1996. Groundwater Committee. San Francisco and Northern San Mateo County Pilot Beneficial Use Designation Project. April 4.

San Francisco Bay Regional Water Quality Control Board. 2007. South Bay Basins Groundwater Protection Evaluation website. Available from: http://www.swrcb.ca.gov/sanfranciscobay/water_issues/programs/groundwater/sobayground.shtml (accessed July 20, 2016).

San Francisco Department of Public Health. 2016. Climate and Healthy Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms. Prepared by Matt Wolff and Cynthia Comerfold. San Francisco Department of Public Health, San Francisco, CA. Available from: https://extxfer.sfdph.org/gis/Flooding/SFDPH_FloodHealthVulnerability2016.pdf

San Francisco Estuary Institute (SFEI). 2016. San Francisco Bay Shore Inventory GIS Data. Available from: http://www.sfei.org/data/sf-bay-shore-inventory-gis-data#sthash.JYLZgIrH.dpbs

San Francisco International Airport (SFO). 2015. San Francisco International Airport Shoreline Protection Feasibility Study: Evaluation and Recommendations Report. Prepared by Moffat and Nichol, AGS, Schaaf & Wheeler, AECOM, Meridian Surveying, M Lee Corporation. June.

San Francisco Public Utilities Commission. 2014. Annual Groundwater Monitoring Report Westside Basin San Francisco and San Mateo Counties in 2013. May.

San Francisco Sea Level Action Plan. 2016. City and County of San Francisco. Available from: http://default.

sfplanning.org/plans-and-programs/planning-for-the-city/sea-level-rise/160309_SLRAP_Final_ED.pdf

San Mateo County et al. 2013. Energy Efficiency Climate Action Plan. Supported by U.S. Department of Energy. Prepared by PMC. June.

San Mateo County et al. 2016. Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore. Available from: http://seachangesmc.com/wp-content/uploads/2015/08/SanMateoCo_Bayshore_Final_Report_w_Appendices.20160523_web.pdf

San Mateo County Human Services Agency. 2015. 2015 San Mateo county Homeless Census and Survey. Final Report. July 2015. Available from: https://hsa.smcgov.org/sites/hsa.smcgov.org/files/2015%20SMC%20Homeless%20Count%20%20Final%20Report.pdf

San Mateo County Parks Department (Parks). 2016a. Coyote Point Illustrative Site Plan. Available from: http://parks.smcgov.org/sites/parks.smcgov.org/files/documents/files/Coyote%20Point%20Illustrative%20Site%20Plan.pdf

San Mateo County Parks Department (Parks). 2016b. Geotechnical Hazard Assessment. Available from: http://parks.smcgov.org/sites/parks.smcgov.org/files/Final%20Pillar%20Point%20Geotechnical%20Hazard%20Assessment%2062316.pdf

Sneed D. 2014. Stretch of Hwy. 1 near Piedras Blancas to be moved inland. The Tribune [San Luis Obispo]. June 17, 2014. Available from: http://www.sanluisobispo.com/news/local/community/cambrian/article39489234.html

State Water Resources Control Board. 2015. Groundwater Ambient Monitoring and Assessment Program. Geotracker Website: http://geotracker.waterboards.ca.gov/gama/gamamap/public/default.asp?CMD=runreport&myaddress=4143+rowland+avenue

Tam L. 2009. Strategies for Managing Sea Level Rise. Available from: http://www.spur.org/publications/urbanist-article/2009-11-01/strategies-managing-sea-level-rise

Tam L. 2012. Climate Adaptation and Sea-Level Rise in the San Francisco Bay Area. Available from: https://www.planning.org/planning/2012/jan/waterwarriorsside2.htm

The Daily Journal. 2008. Carbon monoxide sickens eight. Available from: http://www.smdailyjournal.com/news/local/carbon-monoxide-sickens-eight/article_f73109a4-f1c1-5a7a-b0ac-7acc71ab103d.html

U.S. Army Corps of Engineers (USACE). 2014. North Atlantic Coast Comprehensive Study Report. Available from: http://www.nad.usace.army.mil/CompStudy/

U.S. Army Corps of Engineers (USACE). 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing.

U.S. Army Corps of Engineers (USACE). 2016. Flood Risk Management: Partners in Shared Responsibility program website. Available from: http://www.iwr.usace.army.mil/Missions/Flood-Risk-Management/Flood-Risk-Management-Program/Partners-in-Shared-Responsibility/

U.S. Census Bureau. 2016. 2010-2014 American Community Survey 5-Year Estimates, Tables B01001, B03002, B08201, B15003, B25003, B25091, B19001, S1602; generated by Elizabeth Felter, using American FactFinder (March 2016).

U.S. Geological Survey (USGS). 2014. Coastal Groundwater Systems. Figure GW1. Available from: https://woodshole.er.usgs.gov/project-pages/sea-level-rise_hazards/physical-systems/coastal-groundwater.html

U.S. Global Change Research Program (USGCRP). 2016. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. http://dx.doi.org/10.7930/J0R49NQX

Waite T, Murray V, and Baker D. 2014. Carbon monoxide poisoning and flooding: Changes in risk before, during and after flooding require appropriate public health interventions. PLOS Currents 6: pii: ecurrents.dis.2b2eb9e15f9b982784938803584487f1.

White House Resilience Report. 2016. Opportunities to Enhance the Nation's Resilience to Climate Change. Council on Climate Preparedness and Resilience. October. Available from: https://toolkit.climate.gov/sites/default/files/finalresilienceopportunitiesreport.pdf

Winter T, Harvey J, Franke O and Alley W. 1998. Ground Water and Surface Water A Single Resource. U.S. Geological Survey Circular 1139. Available from: https://pubs.usgs.gov/circ/circ1139/htdocs/title.htm

Wolfe S H, Aron L, Dubay L., Simon S M, Zimmerman E, and Luk K X. 2015. How are income and wealth linked to health and longevity? Urban Institute. Center of Society and Health. Available from: http://www.urban.org/sites/default/files/publication/49116/2000178-How-are-Income-and-Wealth-Linked-to-Health-and-Longevity.pdf

World Health Organization. 2017. Chronic diseases and health promotion. Part Two. The urgent need for action. Available from: http://www.who.int/chp/chronic_disease_report/part2_ch2/en/

Younger M, Morrow-Almeida H R, Vindigni S M, Dannenberg A L. 2008. The built environment, climate change, and health. American Journal of Preventive Medicine 35(5): 517–526. doi: http://dx.doi.org/10.1016/j.amepre.2008.08.017

Zhao H, Roberts H, and Ludy J. Arcadis. 2014. Coastal Green Infrastructure Research Plan for New York City. Available from: http://www.dec.ny.gov/docs/remediation_hudson_pdf/cginyc.pdf

Zimmerman E B, Woolf S H, and Haley A. 2015. Population Health: Behavioral and Social Science Insights. Understanding the Relationship Between Education and Health. Agency for Healthcare Research and Quality. U.S. Department of Health and Human Services. Available from: https://www.ahrq.gov/professionals/education/curriculum-tools/population-health/zimmerman.html