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APPENDIX A

Imagine the result

San Mateo County Vulnerability Assessment

Appendix A: Methodology Report

September 14, 2015

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1. Introduction

ARCADIS was selected by San Mateo County (the County) and the State Coastal Conservancy (the Conservancy) to perform a sea level rise (SLR) vulnerability assessment for San Mateo County and advise the County on assets of concern. This document describes the method that will be used to assess vulnerability of San Mateo County to current and future flooding, and identifies the deliverables that will be produced.

1.1 Project Background

Recent reports by the Pacific Institute[1], the US Army Corps of Engineers (USACE) and the California Department of Water Resources (DWR)[2], and a Grand Jury report[3] have pointed out that San Mateo County is extremely vulnerable to the impacts of flooding. San Mateo County is working in partnership with the Conservancy to assess the County's vulnerability to current and future flooding due to SLR. Concurrent local efforts within the County have begun to address similar issues, but focus on smaller geographic areas, such as San Francisco International Airport, Foster City, Redwood City, and Half Moon Bay. This will be the first comprehensive County-wide vulnerability assessment. The project boundary includes the area in San Mateo County that would be inundated inland of the Pacific coastline from Half Moon Bay northward (and including Half Moon Bay) to the San Francisco County line and the San Francisco Bay shore.

1.2 Project Vision/Goals

ARCADIS will assess the overall vulnerability of San Mateo County to current and future floods due to SLR, and will provide decision makers with useful information that can lead to actionable outcomes. The team will produce maps and inventories of built and natural assets in the County exposed to current and future inundation (for which data are available). Organized by city, these inventories will also estimate the number of individuals that may be exposed to flooding, as well as the total monetary value of exposed built assets, and impacts to natural and coastal resources that could result from inundation of the assets. ARCADIS will also develop detailed asset vulnerability profiles (AVPs) for 30 key assets in the County to

[1] The Pacific Institute. (2012). The Impacts of Sea Level Rise on the San Francisco Bay. Accessible from: http://www.energy.ca.gov/2012publications/CEC-500-2012-014/CEC-500-2012-014.pdf

[2] California Department of Water Resources (DWR) and USACE. (2013). Floodsafe California: California's Flood Future: Recommendations for Management the State's Flood Risk.

[3] San Mateo County Civil Grand Jury. (2014-2015). Accessible from: http://www.sanmateocourt.org/documents/grand_jury/2014/sea_level_rise.pdf

provide more insight into the scale and magnitude of the economic, societal, environmental, and other consequences of inundation.

The project team includes Lisa Wise Consulting, Inc. to assist with the stakeholder engagement efforts; specifically, the assessment will engage local experts through public meetings, workshops, mapping exercises, guided discussions, personal interviews, and site visits. In particular, the team will work with businesses, asset managers, civic leaders, elected officials, and representatives from agencies and special interest groups. This will augment scientific and archival information to provide a more comprehensive perspective on sea level rise vulnerability in San Mateo County.

Lastly, ARCADIS will provide a framework for next-steps in a risk analysis, and will recommend high-level adaptation measures to reduce vulnerabilities to selected assets.

Because assets will be categorized according to risk-based criteria that are informed by nationally-accepted guidance (as described later), this vulnerability assessment will identify *what* the risks to the community are, *where* the risks are, and *how large* the potential flooding impacts could be. The results of the vulnerability assessment will:

- Lay the foundation for future, more detailed analyses to be conducted by San Mateo County or its cities;
- Help the County formulate an efficient, strategic 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[4]";
- Quantify the value of built assets exposed to flooding, and where possible, quantify direct damages, thereby establishing a baseline against which to compare the effectiveness of future sea level rise adaptation and flood risk-reduction measures;
- Provide a baseline inventory of natural assets and potential ecosystem services, against which to compare future sea level rise adaptation and flood risk reduction measures;
- Employ a risk-based methodology, thereby helping the County be more competitive in its future funding requests (because State and Federal Agencies are moving toward a risk-based approach in allocating funds for infrastructure and hazard mitigation.).

[4] San Francisco Bay Conservation Development Commission (BCDC). (2012). Adapting to Rising Tides: Chapter 1

1.3 Methodology Development

This methodology is adopted from common best practices in both sea level rise (SLR) vulnerability assessments (VA) and flood risk management. Concerning the former, it is complimentary to and informed by regional SLR planning efforts, and is consistent with the California Coastal Commission's May 2015 Sea Level Rise Guidance document *Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits*.

At its core, the methodology incorporates strategies from other national and regional SLR VA studies[5] [6] [7] [8] [9] [10]; including the San Francisco Bay Conservation Development Commissions' *Adapting to Rising Tides (ART)* project[11]. It varies from the ART methodology in that it also integrates a flood risk management component. This risk component (described in step 3

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[5] Delaware Department of Natural Resources and Environmental Control (2012). Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware

[6] San Francisco Bay Conservation Development Commission (BCDC). (2012). *Adapting to Rising Tides* project. Accessible: http://www.adaptingtorisingtides.org/

[7] US Federal Highway Administration. (2012). Climate Change and Extreme Weather Vulnerability Assessment Framework. Accessible: http://trid.trb.org/view.aspx?id=1302417

[8] National Oceanic and Atmospheric Administration (NOAA). 2010. Adapting to Climate Change: A Planning Guide for State Coastal Managers. NOAA Office of Ocean and Coastal Resource Management.

[9] Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. (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.

[10] Grifman, P.M., J.F.Hart,, J. Ladwig, A.G. Newton Mann, M. Schulhof. (2013). Sea Level Rise Vulnerability Study for the City of Los Angeles. USCSG-TR-05-2013

[11] San Francisco Bay Conservation Development Commission (BCDC). (2012). *Adapting to Rising Tides* project. Accessible: http://www.adaptingtorisingtides.org/

below) is adapted from flood risk and public facilities mitigation assessments[12]. It is intended to provide decision makers and asset owners/managers with a clear understanding of flood risk, and to set San Mateo County up for developing a long term flood risk management strategy. The approach described below ensures that San Mateo County's vulnerability assessment utilizes best available science and captures the population at risk, as well as built assets like infrastructure and buildings as well as and natural assets like habitat types.

A review of many regional efforts to-date suggests that this SLR vulnerability assessment is an appropriate next step in the future of San Mateo County's climate change adaptation. Further, San Mateo County's 2013 climate action plan and 2013 general plan both recommend a SLR vulnerability assessment. While not all of San Mateo County's cities have performed SLR vulnerability assessments, detailed studies or planning efforts in the County are beginning to incorporate SLR. The outcomes and relevant data sources identified in these studies may be utilized in this vulnerability assessment. Where appropriate, potential adaptation measures will be considered in San Mateo County's adaptation planning phase of this project. Looking at many local SLR planning efforts can encourage coordination and cooperation between San Mateo County's work and other ongoing activities. Detailed studies within San Mateo County that incorporate SLR in some manner include Half Moon Bay, San Francisco International Airport, San Bruno and Colma Creeks, San Francisquito Creek, Redwood City, and Foster City. Most studies reviewed to-date utilize sea level rise range projections identified in the 2012 National Research Council Report[13] and many follow the most recent guidance used by the City and County of San Francisco.

Summaries of the local efforts used to inform San Mateo County's SLR vulnerability assessment are found in Attachments A and B. Additional reports may be reviewed to support the vulnerability assessment, as appropriate, and corresponding references will be provided in the final report.

[12] Florida Division of Emergency Management (2015). Public Facilities Flood Hazard Mitigation Assessment Manual. Accessible: http://www.floridadisaster.org/Mitigation/SMF/Index.htm

[13] National Research Council (NRC). (2012): Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future Accessible from: http://www.nap.edu/catalog/13389/sea-level-rise-for-the-coasts-of-california-oregon-and-washington

2. Methodology

This section describes the step-by-step process that will guide San Mateo County's SLR vulnerability assessment.

2.1 Step 1: Identify the Data/Data Types Needed for the Vulnerability Assessment

Two types of data will be incorporated into the vulnerability assessment; flood hazard data and asset data.

The flood hazard data will be the results from prior modeling effort (described in step 5 below) and will include the geographical extent of the flood hazard on the landscape for a given inundation scenario, the depth of flooding for that scenario, and will include a temporal component that addresses whether the flood is temporary or permanent (in the case of SLR). Flood hazard data includes all of the components of total water level: sea level rise, in addition to mean higher high water or a king tide, elevated water levels due to a 1% annual chance storm (surge), and wind waves. Existing data on shoreline change and erosion will be incorporated into the analysis on the open coast to evaluate erosion hot spots and areas where increased erosion due to sea level rise would cause problems.

Examples of asset types considered in this analysis include (but are not limited to) infrastructure, buildings, natural resources, cultural resources, recreational assets, and human assets. The availability of data varies across the County or across asset types. In general, however, the types of data collected on these assets include the location, elevation, and foundation information of built assets; the level and type of service; asset function; economic replacement values; environmental benefits and impacts; the effects of loss of use of an asset; and additional local or regional consequences resulting from temporary or permanent inundation of the asset. Discussed in detail in section 5, this information informs the exposure of an asset to flooding, the sensitivity of that asset to flooding, as well as the adaptive capacity of that asset.

The flood hazard and asset data that will be considered in this vulnerability assessment are consistent with and align with other asset exposure and vulnerability assessments as previously mentioned. Data will be made available for local use following completion of this vulnerability assessment.

2.2 Step 2: Collect Data from Various Sources

The vulnerability analysis will rely on existing data. These data may be obtained through multiple sources. The primary format for these data will be a Geographic Information Systems

(GIS)-compatible format. Flood inundation data will primarily be derived from the Our Coast Our Future (OCOF) tool, and data on shoreline change and erosion may come from the Pacific Institute or a Coastal Sediment Management Study Group. To the extent that inundation data are available from other sources identified below, these data will be collected to compare to the OCOF results.

Data are expected to come from San Mateo County, online GIS databases like the State of California's GIS Portal, and additional stakeholders, cities, or agencies such as the San Francisco Estuary Institute (SFEI), the San Francisco Bay Conservation Development Commission (BCDC), USACE, Federal Emergency Management Agency (FEMA), United States Geological Survey (USGS), and the California Department of Water Resources.

Supplemental detailed information on assets chosen for the AVPs (see Step 7) may be collected from interviews or discussions with local agencies and asset owners or managers. A survey will be developed to elicit this information on assets from stakeholders and asset managers, as appropriate. Data to support the assessment of potential economic consequences (such as the cost of replacing damaged infrastructure or buildings), environmental consequences, and societal consequences may come from prior asset or habitat exposure analyses in California, from interviews with experts or asset managers, and from supplemental studies provided by the County and Conservancy. Input will also be gathered from key stakeholders in the community through participation in a Technical Working Group and a Policy Advisory Committee. Together, these data will provide an insiders' perspective on assets and risk.

A final list of all data sources used in the study, as well as a discussion on data gaps and uncertainties in the study, will be provided in the final project report.

2.3 Step 3: Categorize and Classify Assets

The purpose of categorizing and classifying assets is to provide a high-level understanding (and inventory) of what is at risk in the County and where that risk is. Rather than treating all assets equally, this type of categorization and classification can focus future risk analyses and prioritize flood risk management investments or adaptation strategies. The approach taken in this SLR VA varies slightly from and is complimentary to regional SLR VA methodology,[14] in that in addition to categorizing all assets by their similar function or sector, this method integrates a risk component for built assets whereby prior to any assessment or evaluation of an asset, and following nationally accepted guidance concerning design requirements for built assets in

[14] BCDC. (2012). *Adapting to Rising Tides*. Accessible: http://www.adaptingtorisingtides.org/

flood hazard areas[15], the asset will be assigned to a risk class (1, 2, 3, or 4) according the severity or magnitude of the consequences if it were to flood. Natural and human assets will be addressed differently as described below.

It should be clear that asset *classification* is different from asset *prioritization*. Asset classification is an objective way to organize assets that could be exposed to inundation, and the process is briefly described below. Asset *prioritization* would be the part of an overall flood risk reduction and sea level rise adaptation strategy that is informed by the results of a risk analysis and incorporates stakeholder values and preferences. A report on asset categorization and classification explains the following process in greater detail.

First, all assets will be categorized according to the 12 categories developed in the ART project and listed below.

- Airport
- Community land use, services, and facilities
- Contaminated lands
- Energy infrastructure and pipelines
- Ground transportation
- Hazardous materials
- Natural areas
- Parks and recreation areas
- Seaport
- Structural Shorelines
- Storm water
- Wastewater

All built asset types will also be organized into four classes considering guidance and criteria established by the American Society of Civil Engineers (ASCE) in *ASCE 24-14 Flood Resistant Design and Construction* and *ASCE 7-10 Minimum Design Loads for Buildings and Other Structures* (see Table 1 below). Therefore, in the end, each asset will be assigned both a category and a class. The type of criteria considered in identifying classifications in these documents or legislation generally include function, type of occupancy, and level of use of an asset as it relates to public safety, health, and welfare. As such, the categories align well with best practices in flood risk management, including FEMA's hazard mitigation and public

[15] American Society of Civil Engineers (ASCE). (2015). 24-14 Flood Resistant Design and Construction

assistance programs. It is also consistent with the State of Florida Department of Emergency Managements' Public Facilities Flood Mitigation Initiative.[16]

To date, no guidance exists to assign *natural assets* to a risk class (low to high) as in the built asset method, and the best available science does not agree on which ecosystem types are more critical or more valuable than others. However, natural assets such as wetlands, marshes, beaches, and endangered species are of great importance to San Mateo County, the State of California, and the federal government (see executive order 11990 on the protection wetlands, Executive Order 11988 on the wise use of floodplains, and the Federal Endangered Species Act). Not only are they recognized for their intrinsic value, but natural assets are also recognized for the services they may provide, including biodiversity, flood and erosion control, water quality improvement, and carbon sequestration.[17] Therefore natural assets will be included in this vulnerability assessment, and will be classified as simply N, 'Natural,' with a descriptor such as *N-beach*, or *N-wetlands*, or *N-species of concern* (Table 2). This provides an inventory of natural assets to support future flood risk analyses, and 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 assets.

Human assets, including people exposed to sea level rise and socially vulnerable communities will not be assigned to a risk-class or a natural-class. However, inventories will count the number of people exposed to inundation, and both inventories and maps will identify the number and location of socially vulnerable populations, (disadvantaged communities).

Classifying assets will consider input from the project management team (PMT) and additional stakeholders, as appropriate.

Table 1 Classifications for built assets identified in ASCE in 24-14 (summarized)

Risk Category	Description
I	Buildings and other structures that represent a low risk to human health in the event of failure (flood)
II	All buildings and other structures except those listed in categories I, III, IV

[16] Florida Division of Emergency Management (2015). Public Facilities Flood Hazard Mitigation Assessment Manual. Accessible: http://www.floridadisaster.org/Mitigation/SMF/Index.htm

[17] BCDC (2012). *Adapting to Rising Tides: Chapter 4*

III	Buildings and other structures, • The failure of which could pose a substantial risk to human health • Not included in category IV, 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 category IV (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 where their quantity exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
IV	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 where the quantity exceeds a threshold quantity 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 category IV structures

Table 2 Draft Classification for natural assets in San Mateo County

Class	Natural Asset Descriptor	Natural asset type and examples
N-W	Natural Assets – Wetlands	Wetlands, marshes, etc.
N-B	Natural Assets – Beaches	Beaches
N-S	Natural Assets – Species identified in CNNDB	Federally or State-listed, threatened, or endangered species; or other species of concern
N-G	Natural Assets – Groundwater	Groundwater basin or source
N-O	Natural Assets – Other	Natural assets not listed in any other category

The organization of human assets is shown in table 3 below.

Table 3 Draft Classification for human assets in San Mateo County

Class	Asset Description	Example or description
H-P	Human – Person	Number of individuals exposed to current or future inundation will be counted
H-DC	Human–Disadvantaged Community	Disadvantaged communities identified in existing social vulnerability indices

2.4 Step 4: Select Inundation Scenarios

Three inundation scenarios will be selected that are based on the guidance in the California Coastal Commission's May 2015 Sea Level Rise Guidance document *Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits*. This is consistent with many of the local SLR planning efforts (Attachments A and B). It is the intent to select scenarios that provide an overview of today's flood risk as well as realistic future scenarios that account for sea level rise.

While scenarios are still to be selected, the baseline scenario will likely be the flood resulting from a 1% chance flood (also known as "100 year flood") using today's mean higher high water level (MHHW). The second scenario could then be the flood resulting from a 1% chance flood using today's MHHW + a realistic SLR scenario for 2050. The third scenario used could be the flooding resulting from a 1% chance flood using MHHW + the most likely SLR scenario for 2100. The three scenarios may change pending guidance from the County and Conservancy during project execution as well as input from the Technical Working Group.

Each scenario will include quantitative projections of the geographic extent and depth of inundation. There are some portions of the OCOF tool in San Mateo County that may not accurately reflect the shoreline elevation and could over or underestimate the risk from sea level rise. The United States Geological Survey (USGS) will identify key areas where discrepancies might exist, and ARCADIS will work with USGS, County staff, and city engineers to correct the errors in the mapping.

The final project report will provide an explanation of the selected scenario.

2.5 Step 5: Inundation Mapping and Asset Exposure Analysis

The asset exposure analysis will use GIS to identify those assets that will be exposed to flood waters during each of the three selected inundation scenarios. Inundation pathways may be identified by BCDC's overtopping analysis for the 30 assets selected for Asset Vulnerability Profiles described below in step 7.

Three GIS layers will be created from the corrected OCOF tool to show the extent of flooding in San Mateo County. As currently planned, the first layer will be the baseline scenario flood extent, the second layer will be the mid-century scenario flood extent, and the third layer will be the 2100 flood extent. These flood extent layers will be overlain on a map of San Mateo County that includes the identified assets. Those assets that fall within the flood extent will be considered exposed to flooding and may be selected for further analysis.

2.6 Step 6: Prepare Asset Exposure Maps

To illustrate the assets exposed to flooding in San Mateo County, maps will be prepared for each coastal city that experiences inundation under one or more of the selected scenarios. Both regional and local maps will be prepared, and the coverage will be sufficient to display adjacent inundated areas in the unincorporated area of the County. Assets will be visually represented in the maps according to the four classes detailed in Step 3.

2.7 Step 7: Prepare Asset Exposure Inventories

An asset inventory provides an outline of resources in San Mateo County that will be affected by current or future flooding. Asset inventories will be prepared for each of San Mateo County's cities that will experience inundation under one or more of the three SLR scenarios. Each inventory will include a brief summary that describes the at-risk assets within the city boundaries, including the location of socially vulnerable populations. The inventory will also list all assets exposed to flooding in that city according to both category and class. Each asset inventory will correspond with the asset exposure map prepared for that city described in step 6 above.

A prototype/example asset inventory is provided in Attachment C.

2.8 Step 8: Prepare Asset Vulnerability Profiles

The PMT, with input and feedback from the Technical Working Group and asset managers where appropriate, will establish asset selection criteria and select 30 representative assets from the exposed asset inventories. Detailed AVPs will be prepared for each selected asset. A least one exposed asset will be chosen from each city, and at least one asset will be chosen from each of the following asset types: hospitals; other critical facilities types; waste water treatment plants; a groundwater extraction well; transportation infrastructure; beaches; and wetlands areas. Criteria used to select assets will be detailed in the final report.

Detailed information on the assets collected in Step 2 and from the surveys will inform the AVPs (working with the Technical Working Group and asset managers, where appropriate). Prior studies such as those that address the impacts of SLR on ecosystems[18] may also inform the AVPs. Each AVP will present the exposure of an asset to the water surface elevation associated with each inundation scenario, including flood depth and duration (i.e., permanent or temporary inundation). The AVP will describe an asset's function or service, along with the sensitivity of the asset and its function to the flood depth and duration. The AVP will also characterize the adaptive capacity of that asset or function, and will discuss the potential consequences (economic, social/equity, environmental, or otherwise) that could result from the loss of the asset or function. The asset managers or other stakeholders will also be included to provide a sense of potential management or adaptation challenges.

[18] Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. (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.

Exposure is defined as whether and to what degree a particular area will be inundated,[19] and will discuss the degree to which the physical structure, or natural/human asset is subject to high water under each of the three inundation scenarios. This will be based on the water surface elevation, the elevation of the asset itself, and the potential duration of the inundation (temporary or permanent).

Sensitivity is the degree to which an asset is impaired by inundation,[20] and will explain whether and how the assets' function or service will be impaired. Characteristics that affect sensitivity include things like age of the asset, elevation of the asset, the level of use, condition of the asset, etc. For natural assets, sensitivity may include the type of vegetation or other species present. If an asset's function is compromised by inundation, it would be considered highly sensitive. This will be a qualitative description and will address built, natural, and human assets.

Adaptive Capacity will describe the assets' ability to accommodate or adjust to an impact to maintain its primary function while inundated.[21] It also addresses how quickly an asset can be restored. If an asset that it exposed to flooding can still maintain function or can offer an alternate means to providing a function, it would have a high adaptive capacity. If an asset cannot function while inundated, it would have a low adaptive capacity. This will be a qualitative discussion and will address built, natural, and human assets.

Following the guiding risk questions in BCDC's *Adapting to Rising Tides* project (2012), assessing the *consequences* provides an understanding of the scale of the impacts from inundating an asset, or the consequences from inaction. Where information is available, consequences will include the direct damages from asset repair and asset replacement costs (as is standard in most flood risk analyses), asset contents losses, and asset inventory losses. Where available, this section may also include *in*direct damages from inundation – for example, a substation that floods may cut off power for 100,000 customers, including businesses, which could in turn have additional local and regional economic consequences. Identifying indirect or secondary consequences helps target those "cross cutting" vulnerabilities, or those assets whose inundation may cause broader impacts. The consequences discussion will be both qualitative and quantitative in describing the impacts to individuals and the community, to the local and regional economy, and to the environment.

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[19] BCDC. (2012). *Adapting to Rising Tides: Chapter 1*

[20] ibid

[21] ibid

To identify issues of equity, the VA will consider information, including social vulnerability indices such as those from the University of South Carolina's Hazards and Vulnerability Research Institute, to assess how SLR may affect socially vulnerable populations in the County. As mentioned, these socially vulnerable communities will be identified in the inventories in Step 7 and can be evaluated in more detail in an AVP.

The project will evaluate the potential impacts to municipal and industrial groundwater extraction wells from salinity intrusion that may result from SLR. The locations and completion details of municipal and industrial groundwater extraction wells will be provided by local officials or other stakeholders. These data may be supplemented with discussions with local groundwater managers to identify potential vulnerability concerns associated with SLR.

Attachment D shows an AVP from the City of Los Angeles identifying one format that may be used.

2.9 Step 9: Adaptation Planning

The project will identify *conceptual* adaptation measures to reduce risk to San Mateo County and its assets. Both structural and non-structural adaptation measures will be explored, as well as both conventional "gray" infrastructure solutions and "green" infrastructure solutions – those that are often referred to as natural or nature-based features, where appropriate. Each AVP will identify one or two conceptual adaptation strategies. In addition, two to three artist renderings of regional adaptation measures (developed to reduce risk to more than one asset at a time) will be prepared to provide a vision for how adaptation measures may look when implemented in San Mateo County.

Results from current local sea level rise adaptation efforts, from the inundation mapping, and the outcomes of the AVPs will inform where both regional and asset-specific adaptation strategies may be appropriate. Where many assets are spatially concentrated, for example, it may make sense to take a regional approach and select a strategy that protects a larger number of assets at once. On the other hand, where a critical facility is isolated from other facilities, an asset-specific approach may be more prudent.

3. Deliverable Summary

As mentioned, the ARCADIS team will develop a final report detailing the vulnerability assessment methodology and findings, a discussion of the data that were used, including the OCOF tool, as well as an overview of the conceptual adaptation strategy for San Mateo County. The report will provide brief discussions of gaps in available information, limitations of this effort and the associated uncertainties, and recommendations for next steps. It will also include the following interim deliverables as described above: a report on asset categorization, regional and city-specific asset exposure maps with sufficient coverage; asset exposure inventories for each city that will experience inundation under at least one of the three SLR inundation scenarios, AVPs for 30 assets, and a GIS geodatabase with all of the information used in this analysis.

4. Change Management

The methodology is subject to change as new data become available or with input and guidance from the PMT during project execution. Mutual agreement will be reached regarding any technical changes to the methodology and any corresponding changes to the project schedule and/or budget. Certain tasks in this methodology may be modified based on future support that could be provided by USACE.

5. Attachments

5.1 Attachment A. Summary of Local Sea Level Rise Planning Efforts

5.1.1 Half Moon Bay SLR Planning Efforts

The City of Half Moon Bay is currently updating their general plan and local coastal program (LCP) in order to account for sea level rise. Further, a sea level rise vulnerability assessment to inform the General Plan update and support adaptation is ongoing and expected for completion by February 2016. At the time of this document, Half Moon Bay is still in the process of selecting three scenario to use for the SLR VA and general plan. To date, areas of concern include Surfer's Beach due to its low elevation, as well as multiple bluff areas that are prone to erosion.

5.1.2 City of Foster City Levee Protection Planning Study

Many of the Foster City levees are no longer accredited under the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA), resulting in 17,000 properties being placed in the Special Flood Hazard Area (SFHA) and subject to the mandatory flood insurance requirement. As a result, Foster City initiated the Foster City Levee Protection Planning Study to review and better assess the current state of its levee system, and to propose alternatives to improve the levees to meet FEMA accreditation standards. The study was recently completed and the city is moving to the design process. After the design process (2015) the permitting process should take two years (2016-2018) followed by two years of construction (2018-2020).

The study compared current survey data (elevations) of the levee system to surge levels from the California Coastal Analysis and Mapping Program (CCAMP) that were prepared in July 2014. The study found 85% of the city's levees do not meet the required freeboard elevation to retain FEMA accreditation by an average of approximately two feet and a maximum of four feet. These numbers do not consider sea level rise (SLR) or land settlement, which could add another 1.5 feet to the freeboard requirement. Approximately 17,000 properties are at risk in Foster City and the City of San Mateo if levees are insufficient to protect against flooding. Widening of levees would be on the landward side due to the sensitive habitats and endangered species on the bay side of the levee.

Concerning SLR, the report references the 2012 National Research Council Report "Sea-Level Rise for the Coasts of CA, OR, and WA: Past Present Future" (NRC Report) as the best available science and is supported by both the City and County of San Francisco (CCSF) and the California Coastal Commission (CCC). The NRC Report provides a range of SLR estimates for years 2030, 2050, and 2100. CCSF and Foster City recommend using the mean of each range:

0.5 foot for 2030, 1 foot for 2050, and 3 foot for 2100. Levee improvements should be built to last until at least 2050, meaning they should have an extra foot of freeboard to accommodate for SLR.

Data used in this work that may be relevant to San Mateo County include LIDAR surveys and levee profiles for the region. Foster City's work is confirmation that the San Mateo County Vulnerability Assessment is relevant and necessary. The SLR component provides a good baseline of an approach and assumptions that can be built upon, and levee designs may be useful in the Adaptation Planning phase of the San Mateo Vulnerability Assessment. Coordination of efforts between the San Mateo County study and the Foster City assessment is encouraged.

5.1.3 San Francisco International Airport Shoreline Protection Feasibility Study Evaluation and Recommendations

CCSF recently entered into the NFIP in 2010, and preliminary flood insurance rate map (FIRM) data suggests the entire airport property is in the 1% flood zone (requiring flood insurance) with flood elevations ranging from 10-14ft NAVD along the shoreline. San Francisco International Airport (SFO) has undertaken a shoreline protection study aimed at removing the Special Flood Hazard Area (SFHA) designation for the airport property. Moffatt and Nichol with AGS Inc. performed the shoreline protection study with the following objectives: identify deficiencies in the current flood defense/protection system (levees), provide recommendations to correct deficiencies along with preliminary cost estimates, and address SLR by providing solutions for the increase in water level.

Regarding SLR scenarios for design, SFO defers to CCSF's recommendation of using the NRC Report. Because the NRC Report indicates a maximum of 2 feet of SLR by 2050, two scenarios were examined: 2ft of SLR and greater than 2ft of SLR. Moving forward, SFO plans to apply for A99 certification through planned improvements to their flood protection system.

Potential data from this study that may be useful in San Mateo County's work include results from modeling of storm surge along San Francisco Bay. This work is confirmation that the San Mateo County study is relevant and necessary. It provides a good baseline of approach and assumptions that can be built upon. Coordination of efforts between the San Mateo County study and the SFO assessment is encouraged.

5.1.4 San Bruno Creek and Colma Creek Resiliency Study

The purpose of the study was to assess the vulnerability of SFO and its neighbors to flooding from sea level rise and storms along the Bay shoreline directly northwest of the airport where San Bruno Creek and Colma Creek meet the Bay. The scope of the study includes establishing an interagency working group, data collection, surveying, hydrologic and hydraulic modeling, and identifying vulnerable reaches and potential adaptation measures for the project area.

The study considers three scenarios for sea level rise: one foot (expected to occur between 2030 and 2080), two feet (expected to occur between 2050 and 2125), and three feet (expected to occur between 2065 and 2155). These estimates are taken from the NRC Report.

This study is an example of a smaller scale assessment and provides a good baseline of approach and valuable insight into that region of the County. Potential data from this study that may be useful in San Mateo County's work include LIDAR data for the project area, locations of flood control and other drainage infrastructure, and hydrologic and hydraulic modeling results from HEC-HMS and HEC-RAS models. Adaptation measures recommended may also be considered in the adaptation planning phase of the San Mateo County vulnerability assessment.

5.1.5 Climate Change Vulnerability Assessment for the North-central California Coast and Ocean (Farallones)

This vulnerability assessment aims to identify how habitats, species, and ecosystem services are likely to be affected by future climate conditions. The goal is to provide an assessment for marine resource managers to use to plan, manage, and respond to impacts of climate change. The study area included coast and ocean ranging from the southern edge of San Mateo County up to Alder Creek in Mendocino County. The study reviewed adaptive capacity, degree of exposure, and sensitivity for eight habitat types, 31 species, and 5 ecosystem services. Vulnerability was equated with decreased adaptive capacity, and increased exposure and sensitivity of the resource. In addition, 32 stressors were listed and scored according to the degree of sensitivity the resources exhibited to that stressor. The number of resources impacted by each stressor was also recorded. The most vulnerable habitats, species, and ecosystems were those existing at the land-sea interface. Climate information referenced in the study was from Climate Change Impacts Report from the Cordell Bank and Gulf of the Farallones National Marine Sanctuary Advisory Councils. The study also included the NRC Report's estimates of 5-24 inches of SLR by 2050 and 17-66 inches of SLR by 2100.

We are currently waiting to hear what data sources may be available from this study. This work may be useful to San Mateo's vulnerability assessment by providing insight into relevant ecosystem vulnerabilities and impacts from SLR inundation. This will be useful in developing the Asset Vulnerability.

5.1.6 SMC Climate Action Plan

The report describes a vulnerability assessment that focused on six distinct types of county assets: agriculture, built infrastructure in coastal zone, coastal ecosystems, property and safety threats due to wildfire, public health threats from increased temperatures, and impacts on water supply. The four major hazards analyzed were increased temperature, increased variability in precipitation, sea level rise, and increased chance of wildfire. Key findings and recommendations include a variety of 'warnings' regarding erosion risk along the coastline. Specifically, bluffs, low-lying beaches and trails, major roads including Highway 1, and coastal wetlands all are at risk of being eroded or destroyed. More irregular precipitation cycles will affect the water table, which will affect flooding patterns.

The SLR portion references the NRC report and establishes sea level rise averages for 2030 (7"), 2050 (14"), 2100 Low greenhouse gas (GHG) (40"), and 2100 High GHG (55"). Next steps include transitioning from the key vulnerability areas identified in the report to developing adaptation actions to address these areas.

The report lays out the various changes that will increase vulnerability across the region and lays out the need for a more focused sea level rise vulnerability assessment for the County.

5.1.7 Energy Efficient Climate Action Plan (EECAP)

EECAP intends to illustrate the County's continued commitment to reducing GHG emissions. The purpose of the report is to inventory GHG emissions, provide reduction strategies, discuss adaptation measures to future climate change impacts, and provide implementation strategies for reducing GHG emissions. The adaptation section summarizes the analysis provided in the SMC Climate Action Plan. The section recognized special vulnerabilities to increased temperature, increased variability in precipitation, increased wildfire risk, decreased supply of fresh water, and increased sea level rise. It also identifies adaptation measures such as updating the Local Hazard Mitigation Plan, updating the resource management plans, updating emergency operations plan, and developing programs to educate residents and businesses of anticipated changes.

This report lays out the expected changes that will increase vulnerability across the region and emphasizes the need for further vulnerability assessment for the County.

5.1.8 San Mateo County General Plan: Energy and Climate Change Element

The purpose of the Energy and Climate Change Element of the General Plan is to demonstrate the County's commitment to energy efficiency and mitigate impact on climate change by reducing GHG consistent with state legislation (Assembly Bill AB32 – The Global Warming

Solutions Act of 2006). The section on Potential Impacts of Climate Change references the NRC Report, which estimates 5-24 inches of SLR by 2050 and 17-66 inches of SLR by 2100. A series of adaptation goals were detailed as well, the first of which is to identify and prepare for climate change impacts by tracking and funding climate change assessments, integrate the assessments into the planning process, and develop a county-wide adaptation strategy. The second goal is to enhance the adaptive capacity of natural and man-made systems by encouraging future construction to consider climate change risks, as well as implementing generic monitoring and adaptation strategies and programs.

This report is relevant as it makes clear the need for further vulnerability assessment for the County. The report lays out the various changes that will increase vulnerability across the region.

5.1.9 Climate Snapshot San Mateo County

The Snapshot lists programs across the County that are addressing climate impacts and building community resiliency. It identifies Bay Area cities that have Climate Action Plans. Finally, a summary is provided of input from San Mateo stakeholders regarding forms of resources and assistance that would be useful for the community and these programs. Common themes from stakeholders include praise for the Regionally Integrated Climate Action Planning Suite (RICAPS), requests for planning guidelines or mandates from the state, desire to build political support for adaptation and resilience initiatives, requests for accessible and sustainable funding streams for local agencies, getting insurance industry more involved in adaptation, need for assistance with energy projects, and a push to focus outreach to the most vulnerable communities.

This report does not contain specific data relevant to use in the vulnerability assessment, but it is useful and relevant for the public outreach section of the County's vulnerability assessment and to identify vulnerable communities. The Snapshot can be used as a summary or glimpse into the local stakeholders' interests and viewpoints.

5.1.10 SAFER Bay Project

Motivated by preliminary NFIP maps which put a large number of properties in the SFHA adjacent San Francisco Bay shoreline and San Francisquito Creek, and following high projections for SLR (released 2010), San Francisquito Creek Joint Powers of Authority initiated the Strategy to Advance Flood protection Ecosystems and Recreation (SAFER Bay). The SAFER Bay project was initiated in order to reduce the risks from flooding and "remove" 5,000 properties from the SFHA while accounting for future sea level rise. The project also plans to restore historical marshes and improve trail access along the shoreline. The study area includes East Palo Alto and Menlo Park, and covers roughly nine miles of bay shoreline. The SAFER Bay project proposes alternatives for shoreline protection irrespective of individual vulnerabilities in East Palo Alto or Menlo Park. Specifically, the shoreline protection approach aims to protect everyone. Design criteria for the shoreline project include water surface elevations for the 1% annual chance flood (base flood) with two feet of additional freeboard and three more feet to account for SLR over the project lifespan (50 years, consistent with US Army Corps of Engineers design processes).

LIDAR and parcel data for the project area may be available. The results from this study may be used in the adaptation planning phase of the San Mateo vulnerability assessment to ensure regional coordination. Completion of the feasibility analysis of alignment alternatives and features, and selection of preferred alternative is planned to be done January 2016.

5.1.11 Silicon Valley 2.0

The Silicon Valley 2.0 project was developed to address regional climate adaptation planning for Santa Clara County. The purpose of the project was to identify the region's climate vulnerabilities (including flood but also other hazards), catalogue assets, map climate impacts, analyze the gaps in climate preparedness, and create a decision-support tool that maps assets with impact zones to assess the potential risk and cost of losing those assets. The Project does not provide any coverage outside of Santa Clara County.

The Project involved nine sectors from across the county: transportation, water, energy, telecom, shoreline assets, waste and waste treatment, super fund sites, state fund sites, and public health. Rather than using discrete SLR scenarios, the tool provides a sliding scale for storm surge and SLR. The tool aimed to address a number of uncertainties associated with SLR estimates such as: the estimates are too speculative, the existing data are too uncertain, the impacts are too far in the future to address now, resiliency projects cost too much, and we can rely on federal organizations to step in and protect the region. The online tool is expected to go live within the next few months.

5.2 Attachment B. Draft Summary Table of Local Sea Level Rise Planning Studies or Efforts

Study or Project	Year	Sponsor	Geographic Area	Participants	Goals
City of Half Moon Bay Local Coastal Program Update (ONGOING)	2015/2016 (ONGOING)	California Coastal Conservancy	City of Half Moon Bay	City of HMB, Coastal Conservancy, Consulting team	Not yet developed
City of Foster City Levee Protection Planning Study	2015	Foster City	Foster City	Schaaf and Wheeler	Review levee system to regain FEMA accreditation
San Francisco International Airport Shoreline Protection Feasibility Study Evaluation and Recommendation s Report	2015	SFO	SFO	Moffatt and Nichol + AGS Inc.	Removing the Special Flood Hazard Area (SFHA) FEMA designation for the airport property
Climate Change Vulnerability Assessment for the North-central California Coast and Ocean	2015	Gulf of the Farallones National Marine Sanctuary California Landscape Conservation Cooperative	North-central California coast and ocean	NPS, Point Reyes National Seashore, EcoAdapt, California Landscape Conservation Cooperative, Bay Area Ecosystems Climate Change Consortium, Golden Gate National Recreation Area, Point Blue Conservation Science	The goal is to provide an assessment for marine resource managers to use plan, manage, and respond to impac of climate change.

Study or Project	Year	Sponsor	Geographic Area	Participants	Goals
San Mateo County Climate Action Plan	2011	San Mateo County	San Mateo County	ICLEI	Identify key areas that the County can focus on to increase resilience to climate change.
Energy Efficient Climate Action Plan	2013	San Mateo County	San Mateo County	DOE PMC DNV KEMA Fehr and Peers ICLEI	The purpose of the report is to inventory GHG emissions, provide reduction strategies, discuss adaptation measures to future climat change, and provide implementation strategies for reducing GHG emission
SMC General Plan. Energy and Climate Change Element	2013	San Mateo County	San Mateo County	PMC	Demonstrate commitment to energy efficiency and mitigate impact on climate change by reducing GHG consistent with state legislation.
SAFER Bay Project	2014-ongoing	San Francisquito Creek JPA	Shoreline, San Francisquito Creek Watershed, including East Palo Alto and Menlo Park	City of Palo Alto, City of East Palo Alto, Menlo Park	Remove properties from SFHA, reduc flood risk, restore marshes, enhance restoration

Study or Project	Year	Sponsor	Geographic Area	Participants	Goals
San Bruno and Colma Creek Resilience Study	2015	SFO	San Bruno and Colma Creeks	SFO and interagency groups	Assess vulnerability of SFO and its neighbors to flooding from sea level rise and storms along the Bay shoreli directly northwest of the airport wher San Bruno Creek and Colma Creek meet the Bay

5.3 Attachment C. Sample Asset Exposure Inventory

	[CITY NAME]: INVENTORY OF EXPOSED ASSETS	
	Total Area	34.62 mi^2
	Area exposed to inundation	00.00 mi^2
	Total population	XX,XXX
	Population exposed to inundation	X,XXX
	Minimum and Maximum depth of inundation with SLR	XX feet
	Summary: This section will summarize the key vulnerabilities in each city, including identification of any socially vul important issues.	

CLASS	CATEGORY	ASSET TYPE	QUANTITY	DESCRIPTION
(1, 2, 3, 4)		Residential parcels/ buildings		
		Commercial parcels/buildings		
		Buildings with large # occupants		
		Waste Water Treatment Plants		
		Sewage Treatment Plants		
		Hazardous Materials/Sites		
		Hospitals		
		Elder Care Facilities		
		Police Department		
		Fire Department		
		Schools		
		Listed Species (threatened/endangered)		i.e., red legge

		Industrial facilities		
		Emergency shelters		
		Evacuation Routes		
		Marinas		
		Ports		
		Cell phone towers		
		Gas fields		
		Power plants		
		Substations		
		Transmission lines		
		Transmission towers		
		Air strips/airports		
		Oil pipelines		
		Historic Places/Landmarks		
		Cultural resources/landmarks		
		Agricultural area (acres)		
		Storm water Infrastructure		

	TOTAL CLASS 1 ASSETS	XX
	TOTAL CLASS 2 ASSETS	XX
	TOTAL CLASS 3 ASSETS	XX
	TOTAL CLASS 4 ASSETS	XX

5.4 Attachment D. Prototype of Potential Asset Vulnerability Profile (Taken from City of Los Angeles)

Bureau of Sanitation

Venice Storm Water / Urban Runoff Pumping Plant (VSPP)
1600 Main Street
Venice, CA 90291

Asset Overview

Owner:
City of Los Angeles

City Department and Point of Contact:
Department of Public Works, Bureau of Sanitation

Regulatory Oversight:
Regional Water Quality Control Board
State Water Resources Control Board
Environmental Protection Agency

Summary of Asset:
The Venice Storm Water / Urban Runoff Pumping plant is a low flow diversion pump designed to move urban runoff and, in the wet season, stormwater flows from a lower elevation up to a higher one, so that it can be transported through pipelines by gravity for eventual processing at a treatment plant during low flows and discharge into the ocean during storm flows.

Current Observed Vulnerabilities

Pumping plant may be damaged if an extreme wet weather event floods electrical components. It is in the Tsunami Warning Area. Severe tidal condition could flood the plant.

Physical Vulnerability to Sea Level Rise Based on USGS Exposure Analysis

Sensitivity (LOW)	Adaptive Capacity (HIGH)	Consequences (LOW)
The VSPP is not sensitive to storm-related flooding, tidal flooding, and erosion. Discharge during each storm season continues as designed and does not impact pumping capacity. The pump does not operate during rain events and the flow is conveyed to the discharge locations by gravity. The plant is located between the beach and a channel, so the plant could potentially be inundated by sea level rise from both sides.	The plant has been identified as an asset that is functioning as intended. Any flooding would not be related to function of the low flow pump. The BOS is evaluating the need to make the plant more resilient to storm-related flooding through functional and reliability improvements. The BOS has emergency plans in place to restore function. A study to better understand the impacts of groundwater and seawater intrusion into the VSPP is underway.	Any localized flooding would not be related to function of the low flow urban runoff diversion pump. Flooding would have high social consequences including displacement and public health concerns. The replacement value of the plant itself is ten million dollars however impacts to individual pieces of equipment would cost significantly less than the loss of the entire facility.

Replacement value (e.g., cost of inaction): $10 million

APPENDIX B

APPENDIX C

Appendix C: Asset Questionnaire Example – Wastewater Treatment Plant

Design & Consultancy for natural and built assets

SAN MATEO COUNTY SEA LEVEL RISE VULNERABILITY ASSESSMENT

Asset Questionnaire

Asset Name:

Asset Type: Wastewater Treatment Plant

Thank you for participating in San Mateo County's Sea Level Rise Vulnerability Assessment. As an asset manager, owner, or subject matter expert, your responses to this questionnaire provides the County with critical insight on the specific vulnerabilities to and potential consequences of present day and future hazards (such as flooding or erosion) due to sea level rise. The information you provide will support the development of an Asset Vulnerability Profile that describes the exposure, sensitivity, and adaptive capacity of this facility and others like it.

INSTRUCTIONS

Please fill out the questionnaire below and answer all of the questions to the best of your ability. This should take approximately 1-2 hours. Once completed, please return the survey via email to Hilary Papendick. If you have any questions while filling out the questionnaire please do not hesitate to contact Hilary Papendick by phone or email.

Disclaimer: No information from this questionnaire will be published or released without prior review and approval by the asset owner or operator. However, please indicate if any of the information you share below is sensitive or confidential. For more information, or if you have questions about how information from this questionnaire will be used in the County's Vulnerability Assessment, please contact Hilary Papendick.

FACILITY FUNCTION AND SERVICE

1. **Briefly describe the function of the facility and type of wastewater treated.** (industrial, residential, commercial)

2. **Please describe the service area, jurisdiction, and population served by the facility**.

   Service area:

   Jurisdiction(s):

   Population served (# of people):

3. a) **What is the level of use or capacity of the facility?** *(i.e., average treatment in MGD)*

   b) **Is the facility functioning at capacity, or is there additional capacity to meet future conditions?** *(Yes/no)*

4. a) **How many staff or other individuals are on site during the day?**

   b) **At night?**

FACILITY CHARACTERISTICS AND EXISTING CONDITIONS

5. a) **What year was this facility built and what is its expected remaining service life?**

Year built:

Remaining service life (in years):

b) **When and what was the last major repair or improvement?**

Year:

Improvement/repair:

6. **What is the ground floor elevation (in feet) of the facility?** *(provide datum if known)*

7. a) **Please identify the major components of this facility** (i.e., screen buildings, pump stations, substations, etc.). *Please provide the elevation and building material of each major component if known.*

Component and Description	*Elevation*	*Building Material*

b) **Which of the above are *essential** components or are interdependent?**
*(*Essential components are those that are required for maintaining the level of service; loss of essential components may impact other parts of the facility and ultimately disrupt the level of service; i.e., conveyance and collection system into plant or treatment bypass; conveyance though the plant or disinfection; primary/secondary treatment; etc.)*

Essential components:

Please explain any interdependencies:

8. **What additional external services, assets, or materials does the facility rely on? (***Such as power/fuel/materials/supply chain issues, and/or any nearby assets or roads etc.) Explain, or write "none."*

9. **Briefly describe the power supply and backup power supply to the facility.**

Power Supply:

Backup Power Supply:

10. **How large is the facility/asset site?** *(Square feet)*

11. **What is the general condition of facility?** *(Check one)*

☐ (1) *Newly Constructed* ☐ (2) *Excellent* ☐ (3) *Good* ☐ (4) *Fair* ☐ (5) *Poor*

12. **Does the facility have any special historical or cultural designation?** *If yes, please explain.*

13. **What is the most recent valuation of the facility** (and its components, if applicable)**?**

Facility:

Other Components:

Source and year of valuation:

COASTAL HAZARD EXPOSURE AND PHYSICAL VULNERABILITIES

Consider the following coastal hazards and exposures that are associated with sea level rise when completing this section. If your facility has previously experienced any coastal flooding or related hazards, please answer the following questions based on what happened. If your facility has not experienced any of the following hazards, please answer to the best of your ability based on what you think could reasonably happen if the following hazards were to occur.

- Rising water table
- Temporary flooding
- Wave impacts
- Beach/cliff erosion
- Saltwater intrusion
- Permanent flooding
- High winds impacts

14. a) **Has this facility or site experienced any flooding or disruption from any other coastal hazard in the past?** *(Yes/no)*

b) **If yes, please describe the following.**

What happened?

When?

c) **How did flood water enter the site?** *How might floodwater enter the facility/site?*

d) **If known, how deep/high was the floodwater?** *(Height of water if possible; otherwise, relative to some landmark, i.e., top of doorway)*

15. **Which components from question 14 were flooded?** *If never flooded, which components might you expect to be flooded/affected by another coastal hazard?*

16. **If flooded, did/would water drain from the site, or did/would it have to be pumped from the facility?** *(Yes/no)*

17. **If known, please identify any additional site vulnerabilities or pathways for floodwaters.** *(not mentioned in Question 14c above)*

18. a) **Does the facility have openings at-grade or below-grade that are entry points for coastal flooding or saltwater intrusion?** *(Yes/no)*

    b) **Are there other ways might it be possible for this asset or its essential components to be affected by flooding or other coastal hazards?** *(i.e., creek overflow, stormwater backup, sewage back-up etc. Yes/no)*

19. a) **Please share any relevant information related to groundwater at your facility; or, write "does not apply."** *(i.e., has groundwater ever been the source of flooding? Are there concerns about contaminants from this facility getting into the groundwater?)*

    b) **Are there any systems in place to keep water away from below-grade systems, basements, and foundations?** *(Yes/no)*

    c) **If yes, would systems have adequate capacity to remove additional groundwater if levels increase?** *(Yes/no)*

20. **Have there been locally observed changes in land elevation?** *If yes, describe location, degree subsidence or uplift, and timeframe over which it occurred.*

POTENTIAL IMPACTS FROM COASTAL FLOODING AND OTHER HAZARDS RELATED TO SEA LEVEL RISE

Consider the following coastal hazards and exposures that are associated with sea level rise when completing this section. If your facility has previously experienced the effects from any coastal hazards, please answer the questions based on what happened. If your facility has not previously experienced coastal flooding or related hazards, please answer to the best of your ability based on either some prior disruption, or on what could reasonably occur in the future as a result from the hazards below.

- *Rising water table*
- *Temporary flooding*
- *Wave impacts*
- *Beach/cliff erosion*
- *Saltwater intrusion*
- *Permanent flooding*
- *High winds impacts*

21. What is your primary concern related to sea level rise and this facility?

22. a) Has facility been disrupted in the past due to any unplanned event*? (i.e., flood, weather-related closure, emergency repair or improvement, or other event, etc. Yes/no)*

If yes, when did this event occur and what happened? (*If this is the same event described in Question 14 above, please write "same event")*

How long did disruption last?

b) What types of damages or consequences were caused or, what types of damages might be caused? *If possible, please quantify.*

23. a) If the facility experienced or were to experience any of the above hazards, did/could it perform its primary function? *(Yes/no)*

b) Was there (would there be) an impact on the level of service? *(Yes/no)*

c) If yes, for how long? *Please check one and explain if necessary.*

☐ (i) Maintained with minimal disruption

☐ (ii) Use of facility is maintained, but ingress or egress is lost; costs are limited to emergency protective measures only

☐ (iii) Use of facility or service is lost and restored within 24 hours

☐ (iv) Use of facility or service is lost and inoperable for 1-7 day

☐ (v) Use of facility/service is lost and inoperable for 7 days or

more *Please provide details as necessary.*

d) If the facility were disrupted for any reason, please describe the previously experienced or potential consequences from partial or complete <u>loss of service</u>.

e) Were (or could there be) other assets or systems at risk due to a loss of service of this facility? *If yes, please list and provide details.*

f) If known, roughly how much revenue (in dollars) was/would be lost per day?

g) How many people were/*(would you expect)* to be affected? (*number of employees, customers, etc.)*

h) Were there (could there be) any injuries? *If yes, how many?*

i) **If the facility or its site experienced flooding, would vehicle or foot access to the facility/site be limited/restricted**? *(Yes/no)*

j) **Is there a potential for impacts to water quality if the facility were damaged, disrupted, or failed? (***e.g., release of pollutants to nearby waters, release of hazardous materials stored on site) Please explain.*

k) **Please list/describe any other damages, if any, that could/did occur to the immediate surroundings or to the community due to flooding or a loss of service** *(i.e., injuries, fatalities, or other cascading impacts; such as impacts to power supply that may damage electrical components and result in power loss to facility; fuel shortage jeopardizing ability to operate generators over extended period of time, then causing impairment in removing influent wastewater from collection system, etc...)*

l) **If known, how were any vulnerable populations affected (could any vulnerable populations be affected) as a result of this facility being flooded, or out of service from a coastal hazard?** *(Yes/no/unknown) Please explain.*

m) **How much would it cost to repair or replace this facility if it were significantly-damaged? If this facility has been exposed to flooding or other coastal hazard in the past, how much did it cost to repair/replace?** *(Please provide a dollar range if you know it; if you do not know, or if your facility has never been damaged, then please state the price per square foot of your facility)*

COASTAL HAZARD MITIGATION AND RISK REDUCTION

24. a) **Is there a backup system or backup facility available to maintain function/level of service if this facility were disrupted for any reason?** *(Yes/no)*

    b) **If yes, is that asset also vulnerable to flooding?**

    c) **If yes, what percentage of customers does the backup facility serve?**

    d) **What is the cost to operate the back-up system?** *(per day, customer, etc.)*

25. **Are there any emergency response, or flood mitigation measures in place in order to maintain the asset's function/level of service, or to minimize damage in the event of a flood or other disruption? If your facility experienced flooding in the past, were there measures in place?** *(i.e., components flood-proofed, barriers to water entry-points, sand bags, critical equipment stored at higher elevation, etc.) Please explain.*

26. **Are there any future improvements, capital investments, mitigation, or proposed developments/modifications to the facility or to the site?** *If yes, please explain.*

    If yes, do future plans consider sea level rise? How? Are there any related planning documents you could share with us?

27. **Does this facility or any of its components on the site carry flood insurance?** *(Yes/no)*

FACILITY MANAGEMENT

28. a) **Who owns and manages this facility?** *Please note if owner and manager are different.*

b) **If facility owner and manager are different, what is the relationship between them?** *(i.e., a legal agreement: lease, right-of-way, access easement, JPA, MOU, MOA)*

29. **Are there any other organizations or stakeholders that have management, decision-making, funding, or other responsibilities related to this facility**? *If so, what are they?*

30. **What are the total annual operation and maintenance costs of the facility?**

31. **What types of permits (and from which agencies) are necessary to maintain, repair, or improve the facility? Are there special processes for emergency repairs?**

32. **Please describe any management or permitting challenges that might be expected with adaptation**. *(i.e., building codes not up to date, endangered species, angry neighbors, etc.)*

33. **Are there any other stakeholders we should know about who may be concerned with this facility?** *If yes, please list.*

34. **If known, what funding sources currently exist that may be used to assess hazard risk or vulnerability to climate change?**

ANYTHING ELSE

Is there anything else you would like to share about the impacts from coastal flooding and sea level rise to your facility?

DOCUMENTATION

If available, please provide any/all of the following:

- Photos of asset and its critical elements
- Documentation or photos of previous flooding
- Site plans *(structure locations, sizing, interconnections between structures)*

Thank you very much for your participation and involvment in our ongoing vulnerability assessment.

APPENDIX D

ASSET VULNERABILITY PROFILE
Table of Contents
30 ASSETS

The assets selected for the AVP profiles are a representative sample of the assets exposed throughout the County and not a list of priority or inclusive sites. The AVP profiles below are in order of their appearance:

ASSET VULNERABILITY PROFILE
PROJECT BACKGROUND

PURPOSE

This Vulnerability Assessment draws on the best avilable science and research tools 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. The Assessment had the following primary goals: 1) assess vulnerability; 2) identify consequences; 3) provide actionable results; 4) build awareness; and 5) build a collaborative network.

ASSET AND HAZARD DATA

Assets refer to useful or valuable things in the County, such as structures, buildings, infrastructure, or habitats. Asset Vulnerability Profiles (AVPs) were developed for 29 assets and one community. The AVPs are a representative sample of the assets inventoried across asset categories and location. Each profile provides an analysis of how, why, and the degree to which each asset is vulnerable to sea level rise. It also includes an analysis of the ability of the asset to cope with sea level rise and potential adaptation strategies to reduce impacts.

SELECTION PROCESS

The 30 AVPS were selected through stakeholder group meetings, surveys housed on the project website, and public input. The criteria used to select the assets for the AVPs included: 1) geographic coverage of asset; 2) representative across asset types, classes, and categories; 3) representative across agencies and jurisdictions; 4) service area; 5) availability of data; and 6) willingness of asset owner to participate in the study. The assets selected for the AVP profiles are a representative sample of the assets exposed throughout the County and not a list of priority or inclusive sites**.**

APPLICABILITY

Overall, the AVPs provide initial research as to how an asset may be affected by sea level rise and can help the asset owner and others start the conversation about how to increase resilience of the asset to sea level rise.

KEY TERMS (For more information see Appendix P: Glossary)

Adaptation - The process of adjustment to actual or expected climate and its effects
Beach Nourishment - Placement of sand and/or sediment on a beach to provide protection from storms and erosion
Effluent - Treated or partially treated wastewater that is discharged into the environment from a treatment plant, sewer, or industrial facility
Embankment - An artificial bank or mound built to hold back water or to carry a roadway
Erosion - The wearing away of land by natural forces (e.g. wave action, currents, or the wind)
Exposure - Magnitude of change in climate and other stressors that a resource, asset, or process has already or may experience in the future
Green Infrastructure - The use of natural systems to provide flood and erosion protection, stormwater management, and other ecosystem services while contributing to the enhancement natural habitat areas
Groundwater Seepage - Inflow of water to a ground-water reservoir from the surface
Influent - The flow of untreated wastewater into a treatment process
Inundation - The process of dry land becoming permanently drowned or submerged
Levee - A man-made structure designed to control or divert the flow of water and provide temporary flood protection
Managed realignment (also Managed retreat) - Reduces coastal flooding and erosion by setting back the flood defenses to allow flooding of a presently defended area
Mean higher high water (MHHW) - The average of the higher high water height of each tidal day observed over the national tidal datum epoch
Mitigation - Human intervention to reduce the human impact on the climate system
Nature Based Solutions - Characterized natural features created by human design to provide specific functions such as coastal risk reduction
North American Vertical Datum 88 (NAVD 88) - The vertical control datum established in 1991 by the minimum-constraint adjustment of the Canadian-Mexican United States leveling observations
Overtop - Water carried over the top of a coastal defense due to wave and surge action exceeding the crest height
Resilience - The capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment
Revetments - A sloped retaining wall built to protect a bluff or development against erosion by wave action or currents
Riprap - Loose boulders placed on or along the shoreline as a form of armoring
Saltwater intrusion - Displacement of fresh or ground water by the advance of salt water due to its greater density
Sea level rise - Changes in the shape of the ocean basins, changes in the total mass of water and changes in water density
Seawall - Structure separating land and water areas designed to prevent erosion and other damage due to wave action
Sensitivity - The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli
Storm surge - A rise above normal water level on the open coast due to the action of wind stress on the water surface
Vulnerability - The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts

ASSET VULNERABILITY PROFILE READER GUIDE AND SUMMARY

Asset Manager

VULNERABILITY SUMMARY

This section identifies the **overall vulnerability** of the asset to present day flooding, erosion, and the future impacts of sea level rise as determined by the analysis. It provides a high-level overview and identifies the key drivers of vulnerability based on three components: sensitivity, exposure, and adaptive capacity. The boxes below (and their color bars) indicate whether the vulnerability components were determined to be Low, Moderate, or High; the last box identifies the level of consequences associated with loss of service for the asset. Each component of vulnerability is described in more detail in the following sections of the profile. 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, there are cases that will be 'moderate,' depending on the combination of components. To be conservative, 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.' The assessment of consequences does not factor into final vulnerability. Vulnerability summaries are not rankings or priorities.

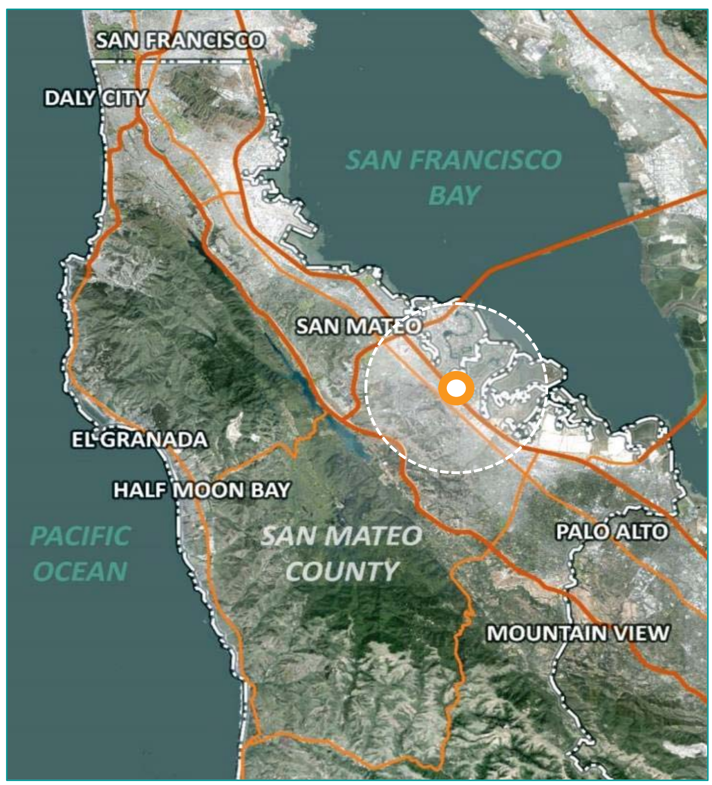
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Low	Moderate	Low	Moderate

ASSET CHARACTERISTICS

Asset Description and Function:

This section provides a brief description of the asset, its functions, and its service area. It also identifies several important characteristics: Type, Risk Class according to the American Society of Civil Engineers, Size, Year of Construction, Elevation, Annual O&M Cost, whether the asset is in a FEMA Special Flood Hazard Area, the Physical Condition, and the Landowner(s). Most of this information was provided by the asset manager through surveys and interviews. The map below identifies the location of the asset with a white and orange circle.

Asset Type	Varies
Asset Risk Class	1-4 from ASCE
Size	
Year of Construction	
Elevation	
Level of Use	
Annual O&M Cost	
Special Flood Hazard Area	From FEMA maps
Physical Condition	
Landowner	From Assessor's database



Underground Facilities

This section generally identifies underground facilities that relate to or are part of the asset. This is not a comprehensive list of all underground facilities nearby.

Environmental Considerations

This section identifies particular species or habitats as identified by the asset manager.

ASSET VULNERABILITY PROFILE READER GUIDE AND SUMMARY

ASSET SENSITIVITY

Sensitivity explains the asset's level of impairment if flooded temporarily or permanently, or if affected by erosion. This section identifies specific features or weaknesses of the asset that make it more impaired or less impaired. In general, an asset that is highly sensitive would lose its primary function if exposed to any degree of flood or erosion whatsoever. If an asset can maintain its primary function(s) during inundation, it would have low sensitivity. If an asset will lose only part of its function or would suffer minimal damage, it is considered, for the purposes of this assessment, moderately sensitive.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

This section is present only for assets along the bayshore. For assets on the bayshore, we used the Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore inundation study (2016) developed by AECOM to evaluate the lowest sea level rise condition (water surface elevation increase) under which the asset would be inundated. The analysis goes one step further by identifying the level of overtopping that would be likely to first cause significant impacts. For each asset, we also identified a potential flowpath from this first overtopping location. To date, no data are available to support an identical analysis for the coastside.

Cross-Cutting Vulnerabilities

This section identifies outside factors that may contribute to the vulnerability of the asset of concern. It also describes ways in which the loss of service or flooding of this asset could lead to disruption of other services or networks, sometimes called cascading impacts.

Erosion Extent

For assets along the coast side, information from the Pacific Institute's study indicates the potential eastern extent of future erosion expected and with 4.6 feet (1.4 meters) of sea level rise. The erosion maps show the asset with respect to the eastern extent of potential future erosion. Where available, this section also identifies whether an asset is in a current erosion hot spot or area for concern based on local erosion data. These two studies are the best regional data available to date. Further study is needed to better understand erosion hazards and vulnerabilities.

ASSET VULNERABILITY PROFILE READER GUIDE AND SUMMARY

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

This section describes an asset's exposure to present day and future flooding or erosion expected with sea level rise. It explains how water may be expected to reach or inundate the asset, including any groundwater issues that have been identified. The three maps show potential flood extents and depths for the baseline, mid-level, and high-end sea level rise scenarios discussed in Section 2. The asset is outlined with a dashed white line. The corresponding table below presents the expected minimum and maximum water depths at the asset (within the white dotted line) for each scenario. The depths of First Significant Impacts correspond with the figure on the previous page. Because the shoreline overtopping analysis was only performed on the bayshore, the first row does not have data for assets along the coast. The last three flood depths (baseline, mid-level and high-end scenarios) correspond to the maps on the right and use the Our Coast, Our Future tool to determine flood depths.

To determine the level of exposure of an asset:
If an asset has already experienced surface flooding, ground water intrusion, or would be affected with less than 12 inches of sea level rise, exposure is considered 'high.' If an asset is expected to be inundated with sea level increases between 12 and 36 inches, exposure is 'moderate.' Finally, if an asset is unlikely to be inundated until sea level rises more than 36 inches, exposure is considered 'low.'

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Asset under 0 to 5 feet of water.

High-End Scenario: Asset under 4 to 8 feet of water.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(48 inches)*	***0***	***3***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***5***
High-End *1% + 6.6 feet*	***4***	***8***

ASSET VULNERABILITY PROFILE READER GUIDE AND SUMMARY

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

This section describes the ability of the asset to function during or recover quickly from any temporary flooding (either with no or very little intervention), and the ability of the asset to adapt to any potential long-term or permanent flooding. An asset with high adaptive capacity may have backup generators and emergency plans, or an ability to move its primary functions to other locations. An asset with a low adaptive capacity would be one that does not have any plans in place to maintain or quickly restore operations following flooding. The text focuses on details of a particular asset and its ability to change with rising sea levels; this section does not make recommendations as to future measures to decrease vulnerability.

Consequences

This section describes the potential type and scale of adverse effects that could occur if an asset were exposed to flooding or erosion. The discussion includes direct damages to the asset and the effects of a full or partial loss of service of the asset. Where available, rough estimates of damage or repair costs are included. Potential public health and life safety issues are discussed as well. This section also identifies potential secondary or indirect effects of a partial or complete loss of the asset, which includes any cascading impacts. This includes losses to local and regional communities and considers issues of economy, social equity, and environment.

Additional Important Information

This section addresses special concerns or considerations raised through discussion with the asset manager or project team. This may include historical notes, management challenges, and planned or ongoing maintenance and improvement projects.

Asset-Specific Adaptation

This section identifies potential adaptation options to reduce present and future vulnerabilities and flood/erosion risk. The vulnerability assessment revealed that there are many low-lying assets at risk and that impacts to assets and the community will increase if no action is taken. In most cases, regional and cross-jurisdictional approaches may be the most efficient means of building resilience to impacts of sea level rise. However, there are also smaller efforts that can be implemented on an asset-by-asset level to improve the resilience and function of many assets themselves. These asset-specific adaptation options are identified here. More discussion on adaptation consideratoins and on integrating nature-based solutions into adaptation is found in Section 4, Adaptation. Specifically, Appendix K discusses the Baylands Goals (Conservancy 2015) segments specific to San Mateo County so that they can be considered in adaptaton planning.

"Structural" measures reduce flood and erosion risk by addressing the flood or erosion hazard, typically by keeping water away from the asset, reducing its exposure. This includes 'gray' measures like levees or floodwalls and 'green' nature-based solutions like hybrid levees, ecologically enhanced revetments, or other living shoreline approaches.

"Nonstructural" measures, on the other hand, describe options that address the asset itself, aiming to minimize sensitivity, improve adaptive capacity, or reduce the consequences of flooding and erosion. Nonstructural measures could include elevating an asset or its water-sensitive components, or making the asset or its electrical systems flood-proof so that they could still operate or be quickly restored after flooding. Other examples include relocating an asset to high ground, developing backup systems, assigning emergency protocols, warnings, and response systems, implementing flood damage resistant building codes, zoning codes, flood insurance, and flood risk communication. This section identifies what may be possible for the asset. The feasibility, costs, evaluation, and efficacy of adaptation measures are not part of this phase.

Details on specific measures (such as floodproofing or elevation) are provided in Chapter 4 of the main body of the report.

Vulnerable Assets of the Same Type

This section identifies the total number of similar assets that are vulnerable to sea level rise under the erosion, baseline, mid-level, or high-end scenarios. This gives the reader a sense of how pervasive the issues described in a given asset vulnerability profile are. Since many similar vulnerable assets are likely to have some of the same components of sensitivity, exposure, and adaptive capacity, it also provides insight to managers of similar assets into the types of issues they may need to address in the future.

1. CALIFORNIA COASTAL TRAIL
Kelly Avenue to Seymour Street

County of San Mateo & City of Half Moon Bay

VULNERABILITY SUMMARY

The vulnerability of this segment of the California Coastal Trail (CCT) is **moderate**. The CCT's uses can be highly sensitive to erosion if it becomes severe enough to cause a collapse of the trail or bluff; however, some uses can be sustained with minor erosion or cracking along the trail. To date, the extent of coastal erosion to this segment is moderate and has not yet forced closures. The adaptive capacity of this section of the CCT is high because it would be relatively easy to relocate the trail away from the eroding bluff and there are other alternative inland routes to support the CCT's transportation function, even if recreational uses would be reduced.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Moderate	High	Moderate

ASSET CHARACTERISTICS

Kelly Avenue to Seymour Street | Half Moon Bay

Asset Description and Function:

This 1.2-mile section of the CCT is designated a Class 1 bike trail and includes the Poplar Beach parking lot. It is part of the 1,200-mile-long CCT, and is a popular asset in the area that provides beach access and supports bike, pedestrian, and equestrian uses for commuting, recreation, and tourism. Parts of the CCT are pavement and asphalt, while others are packed earth. The CCT passes near long-established neighborhoods: Alsace Lorraine and Arleta Park.

Asset Type	Recreation/Trail
Asset Risk Class	1
Size (length) (width)	1.2 miles, 10 feet wide
Years of Construction	1995-2005
Elevation	54-60 feet
Level of Use	Year round, but more heavily used in the summer
Annual O&M Cost	$23,000
Special Flood Hazard Area	N/A
Physical Condition	Fair
Landowners	County of San Mateo, City of Half Moon Bay
Underground Facilities	None

Environmental Considerations

The CCT traverses an area that has potential for the occurrence of special status plant and animal species and is shown on City maps to contain environmentally sensitive habitat areas (ESHA) as well as potential ESHAs where habitat may be present.

CALIFORNIA COASTAL TRAIL
Kelly Avenue to Seymour Street

ASSET SENSITIVITY

The sensitivity of this segment of the CCT is moderate; however, the sensitivity of any individual section depends fully on the extent and severity of erosion. For example, this segment of the CCT is considered to be in fair condition; it is fully open and usable today, despite the erosion, settling, and cracking. However, the areas directly along the bluff are more sensitive to erosion; once a section erodes away, or if a part of the trail falls off the bluff, the section will be closed, forcing users to take alternate routes either temporarily or permanently. Alternate routes will decrease level of service or quality of the recreational, tourism, and commuting functions.

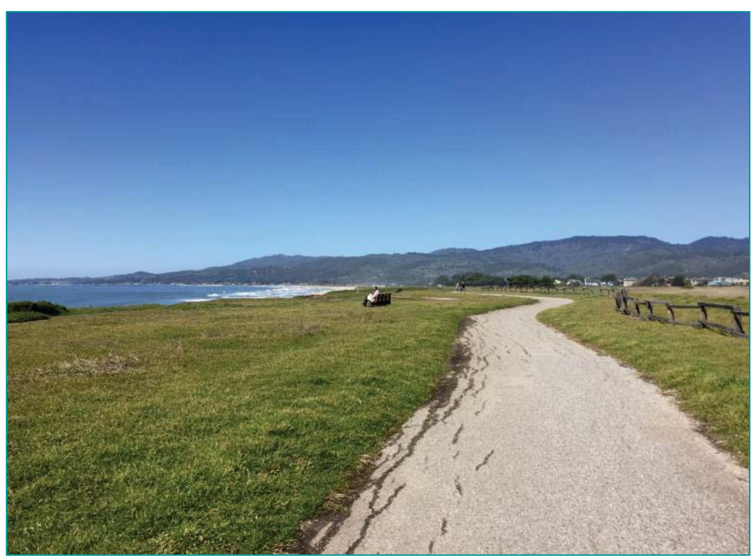
SEA LEVEL RISE EXPOSURE ANALYSIS

Erosion Extent and Exposure

Present-day exposure to erosion is moderate, as this section of the CCT is subject to regular, and in some places severe, erosion due to daily tidal, wind, and wave effects, as well as storm conditions. The erosion study showed that human activity caused accelerated erosion rates even beyond those attributed to weather and other events. Future exposure is likely to increase with sea level rise, as much of the segment is located within the area identified by the Pacific Institute study (2012) as the possible extent of erosion by 2100 (light yellow band). Evidence shows cracking in many places, and while this segment remains intact, other parts of the bluff trail have collapsed entirely. Foot traffic off the CCT trail has contributed to soil erosion. There is evidence that shows areas of soil compaction and associated changes to grading and drainage result in many small inlays along the bluff edge. Erosion is exacerbated by runoff and is most severe where the CCT crosses several drainages including Kelly, Miramontes, Central, Myrtle, Magnolia, and Seymour Drainages. In particular, severe erosion over the last 10 years near the bridge over Seymour Drainage now threatens the long-term safety of the bridge, and it will be relocated. Poplar Beach parking lot and beach access are also exposed to erosion. Sections of the CCT farther inland have not yet been exposed, but the physical extent of erosion of this section of the CCT is likely to increase with the future wind and wave action expected with sea level rise. This segment is not vulnerable to coastal inundation.

Asset is nearly entirely within the 2100 erosion zone.

Paved section of trail with coastal views.



Cross-Cutting Vulnerabilities

Some of the overall value of this asset lies in its connectivity with the rest of the 1,200-mile-long CCT along the coast. This segment in particular provides trail connection between various neighborhoods and downtown Half Moon Bay via Kelly Avenue and Poplar Street. Nearby Half Moon Bay State Beach receives roughly 1 million visitors annually. The southern end of this segment of CCT abuts a closed Half Moon Bay landfill (see AVP #7). Impacts that affect this section of CCT could affect nearby assets and vice versa.

CALIFORNIA COASTAL TRAIL
Kelly Avenue to Seymour Street

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of this section of the CCT is high, as it would be relatively easy to relocate the trail inland or use an alternate path, and most functions of the CCT could be maintained, albeit with reduced levels of service. For example, it would be possible for trail users to through-connect by taking Railroad Avenue or the Highway 1 Naomi Patridge Multi-Use Parallel Trail. However, both options are less desirable and less safe for pedestrians and cyclists. Railroad Avenue is not a Class 1 bike trail, and the Naomi Patridge trail has numerous street crossings, in contrast to the CCT, which is undisrupted by street crossings. Both are less scenic options, which could discourage recreational use, and Railroad Avenue requires winding through neighborhoods to get from point to point, which could be inconvenient and take longer. If erosion were to affect the parking lot or access to Poplar Beach, pedestrians and cars could access the beach at other access points. This segment provides the only ADA access to the bluff tops and ocean views in this area.

Consequences

The consequences of the loss of this unique segment of the CCT and parking lot are moderate. While interruption of any segment of the CCT could be considered a regional loss to an important state recreational asset, the geographic scale of the direct impact would be local. It is likely that closure of the CCT could impact the quality of life most acutely for nearby residents. However, the level of use of adjacent parks suggests that thousands of trail users could be affected, making the scale of impact more broad. Despite the availability of other routes and beach access points, permanent loss of the CCT would result in the loss of public lands along with unique public recreational options in the area. Loss of this section would also reduce recreational opportunities for people in wheelchairs or access and functional needs. Economic costs of rebuilding the section of trail would depend on the size and location of the particular segment, and whether repairing it would require realigning it into private property (which would be more expensive or impractical). For example, preliminary estimates based on similar projects indicate that the bridge replacement would cost around $500,000; meanwhile, emergency erosion repair would cost roughly $80,000. An incomplete CCT would also result in fewer visits of many types, including hotel stays, camping, day visits, dining, and shopping at local businesses. Relatively speaking, though recreation would be lost, direct and indirect economic damages from a loss of the section of CCT are small, and it is unlikely that loss of this section of CCT would significantly affect public health and safety.

Additional Important Information

The City of Half Moon Bay has completed an erosion study that examined the existing conditions and trail planning recommendations. The Seymour Bridge has been replaced, however erosion continues to be an issue, and the City is conducting additional studies to address this. The City's next steps are to engage with local partners, residents, and trail users before making trail management decisions. Nearby, in the Wavecrest area, plans are underway for a Coastal Trail Improvement Project, led by the Coastside Land Trust. The $3 - 5 million project has encountered habitat and sensitive species issues and includes stairs funded by Ocean Colony Partners. Coastside Land Trust plans to finalize permit application in 2017.

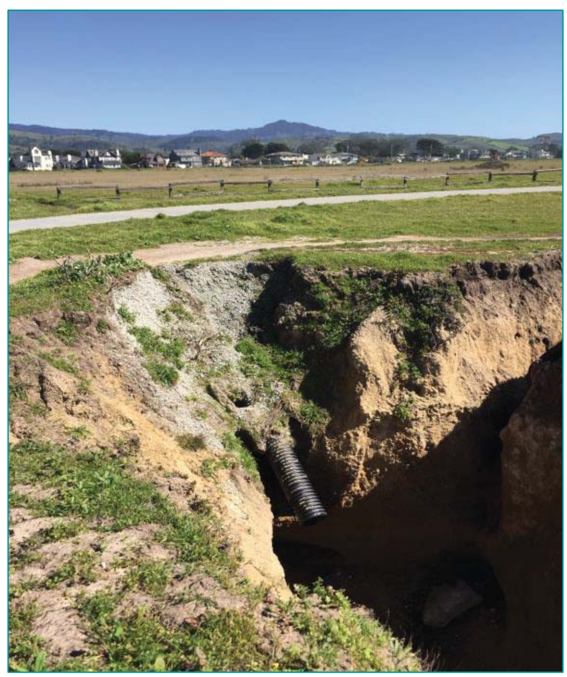
Asset-Specific Adaptation

Alternatives to adapt this segment of the CCT include removing the existing section of trail and gradually relocating it inland of the anticipated “erosion retreat zone” on the bluff. While most of the land is publicly owned, relocation inland could be challenging in some locations due to private property ownership. Other potential, but likely more costly, measures to minimize erosion include beach nourishment and revetment placement. Drainage, vegetation and other management techniques could be beneficial for reducing human-induced erosion.

Vulnerable Trails

This is the only Asset Vulnerability Profile focusing on vulnerable trails in the County. The vulnerability assessment analysis shows that there are 91.2 miles of vulnerable trails in San Mateo County, including sections of the CCT, the San Francisco Bay Trail, the West Belmont Slough Trail, and the Pillar Point Trail.

Severe erosion adjacent to CCT at drainage.



2. SEWER AUTHORITY MID-COASTSIDE WASTEWATER TREATMENT PLANT

Operated by Sewer Authority Mid-Coastside

VULNERABILITY SUMMARY

The Sewer Authority Mid-Coastside Wastewater Treatment Plant (SAM Plant) is **highly vulnerable** to the impacts of sea level rise. The facility's essential power distribution system is very sensitive to inundation, and would cause a loss of service at the plant if flooded. Adaptive capacity is low as there are no other plants to treat wastewater from this service area, and the power system redundancies are also low-lying. Exposure to coastal flooding is low; however, overall exposure is moderate as the plant is presently subject to groundwater intrusion, and can be vulnerable to creek backup caused by heavy rainfall that coincides with high tides.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	Low	High

ASSET CHARACTERISTICS

Bev Cunha's Country Road | Half Moon Bay

Asset Description and Function:

The SAM Plant is operated by a Joint Powers Authority of Half Moon Bay, Granada Community Services District, and the Montara Water and Sanitary District and serves 25,000 customers in those communities. It collects sewage and pumps up to the Portola lift station, where wastewater is conveyed through a gravity-fed force main to the treatment plant. The SAM Plant provides primary and secondary treatment, and then discharges effluent to the Pacific Ocean through an outfall.

Asset Type	Wastewater Treatment Plant
Asset Risk Class	3
Size	4.3 acres
Year of Construction	1978
Elevation	18 feet
Level of Use (Dry Weather)	1.2 million gallons/day
Annual O&M Cost	$2,125,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Fair
Landowner	City Of Half Moon Bay

Underground Facilities

Pipe galleries and a generator are underground.

Environmental Considerations

The western snowy plover, northern coastal salt marsh, and the coast iris may be present, in addition to other species.

SEWER AUTHORITY MID-COASTSIDE WASTEWATER TREATMENT PLANT

ASSET SENSITIVITY

The SAM Plant is highly sensitive to inundation. The SAM Plant's most critical and essential component is Mechanical Building No. 1, which houses the plant's electrical equipment and its power distribution system, if damaged the plant cannot function. Mechanical Building No. 1 also contains the influent (untreated wastewater) pumping equipment, the headworks, and a generator. These components are extremely sensitive to a significant flood event or permanent inundation; if flooded, the SAM Plant would lose power and pumps would not work, causing untreated effluent to overflow on site.

The fuel tanks onsite are not sensitive to flood events because they're above ground and have secondary containment; they do not pose a threat if the site were inundated.

Pipe gallery, primary sludge pumps, and grit pumps.

SHORELINE VULNERABILITY

Erosion Extent

At this time, the best available data (2012) suggest that this site is not vulnerable to the erosion that would be expected by 2100 (and with 4.6 feet of sea level rise) as it lies well east of the easternmost extent of erosion.

Erosion Extent: Future coastal erosion does not reach asset.

Cross-Cutting Vulnerabilities

Loss of service could affect the SAM Plant and collection system. Additionally, pump or lift stations off site that are exposed to flooding or sea level rise would affect the conveyance system. Particularly, if saltwater were to enter the treatment equipment, it would cause a disruption of the biological treatment process. This could occur if saltwater were to enter pipes in the collection system, through which the lift station would pump this saltwater into the plant. Road access, though currently not threatened, is critical to maintain chemical truck access and allow staff to access the site.

SEWER AUTHORITY MID-COASTSIDE WASTEWATER TREATMENT PLANT

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The SAM Plant is moderately exposed to sea level rise impacts. It has no prior experience with coastal flooding or erosion, though the plant's underground facilities, including a piping gallery, are already experiencing groundwater and saltwater intrusion. The SAM Plant is also exposed to creek flooding during storms, which could be worse with higher tides. Pilarcitos Creek runs south along the west side of the plant and cannot discharge during extremely high tides, causing creek floods. The plant is surrounded by non-engineered berms that prevent creek flooding on the property; however, creek backup has caused pooling adjacent to the treatment plant.

Sea level rise will increase the frequency with which the underground facilities are exposed to ground and saltwater intrusion, and a combination of future higher tides and rain events could force Pilarcitos Creek to back up enough to spill into the plant's property. Eventually, the plant may be directly exposed to coastal flooding in the high-end scenario (a 1% flood with 6.6 feet of sea level rise), though flooding from Pilarcitos Creek (posing a threat to back up, pond, and flood the plant) is more likely. Water that gets on the site would likely reach the plant's transformer and power distribution systems, and Mechanical Building No. 1, as they are low-lying or underground.

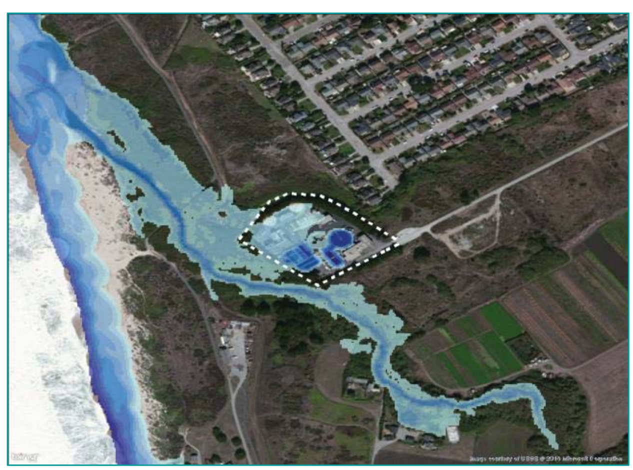
Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts	***Area Not Included in Overtopping Analysis***	
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***0***
High-End *1% + 6.6 feet*	***0***	***15***

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Asset not yet inundated.

High-End Scenario: Asset under 0-15 feet of water.



SEWER AUTHORITY MID-COASTSIDE WASTEWATER TREATMENT PLANT

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The SAM Plant has low adaptive capacity, as there is no alternate treatment facility to perform the same service, though it could minimize effects from temporary or minor inundation. Small interventions could be made to improve the overall resilience of the plant, like protecting the electrical system, but these would not be a long-term solution. Though the underground wastewater pumps are sensitive to water, sump pumps are in place to keep equipment dry. Electrical conduits were built to tolerate marine environments, so they should not be affected by minor flooding. Backup generators are available in case of power outage, but they are only usable if the power distribution system remains dry. The SAM Plant has an emergency response plan, but if it were to lose service completely, the pumps at the Montara and Portola lift stations could divert sewage into temporary storage for over half a day assuming normal wastewater inflow.

Consequences

The consequences of inundation at the SAM Plant are high. The scale of impacts from sea level rise could be both local and county-wide, as direct damages to the SAM Plant may require repairs to various components, but loss of wastewater treatment service could affect the plant's conveyance system as a whole (including lift and pump stations), and the customers (up to roughly 25,000) in the region. Temporary flooding of the SAM Plant could damage any number of plant components that would then have to be replaced. If Mechanical Building No. 1 were subject to a major event, and if the generators flooded, then the SAM Plant could lose service altogether. If the SAM Plant lost service, there would be overflow in the southern half of San Pablo lift station, as the plant operators have temporary storage at the Montara and Portola Lift stations for over half a day assuming normal wastewater flow. The full economic damages have not been quantified, and full replacement cost of the facility is unknown.

Additional Important Information

The SAM Plant is part of an interdependent system called the Intertie Pipeline System (IPS), which includes 8 miles of forcemain and gravity interceptors and three pumping stations. The satellite collection systems - Montara Water and Sanitary District, the Granada Community Services District, and the City of Half Moon Bay - own, operate, and maintain the collection systems in their respective areas.

Asset-Specific Adaptation

Adaptation could include measures in the plant itself such as elevating water- or salt-sensitive equipment like the lower electrical systems above water levels or floodproofing individual critical structures like Mechanical Building No. 1. Outside the plant, a long-term adaptation measure would be to enhance the existing berms on the west and south sides of the plant, and build a berm on the east and north sides to fully protect the perimeter.

Vulnerable Wastewater Treatment Plants

There are Asset Vulnerability Profiles on the following vulnerable wastewater treatment plants: Silicon Valley Clean Water (AVP #14) and SSF-SB WQCP (AVP #23). The vulnerability assessment analysis shows that there are seven vulnerable wastewater treatment plants in the project area, including those in the City of Millbrae, the City of San Mateo, the City of Burlingame and at SF International Airport.

Digester control room.

Chemical tank facility.

3. STATE ROUTE 1 at Surfer's Beach

California Department of Transportation (Caltrans)

VULNERABILITY SUMMARY

State Route 1 (SR1) at Surfer's Beach is **highly vulnerable** to sea level rise. The section of road offers access to residential communities and recreational areas, serving approximately 28,000 vehicles per day. It is currently exposed to erosive forces, such as waves and water levels, that will only grow more severe with sea level rise. The highway's level of service is very sensitive to erosion damage and any inundation caused by waves. The section of the highway has low adaptive capacity because of its exposure to the open coast and the lack of nearby alternatives for the level of traffic it supports. Consequences from temporary or permanent loss of the highway are high.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*High*	*Low*	*High*

ASSET CHARACTERISTICS

Cabrillo Highway (SR1) | El Granada

Asset Description and Function:

In El Granada, SR1 passes Coronado Street and Pillar Point RV Park at Surfer's Beach, primarily serving automobile, truck, and bicycle travel. The road is on a small cliff above the beach. Surfer's Beach serves 20,000 people locally, and the road accommodates an average of 28,000 cars per day. SR1 provides regional and wider tourist access to many small businesses, residential communities, beaches, and coastal state parks. There is a stormwater line under SR1 which runs north of the highway.

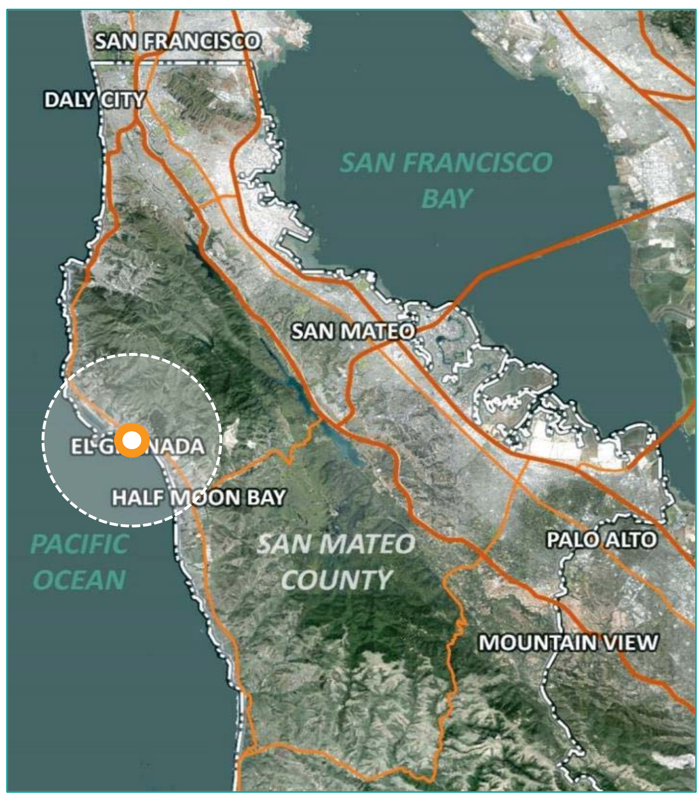
Asset Type	Transportation Infrastructure
Asset Risk Class	4
Size	153,479 square feet
Year of Construction	1949
Elevation	15 feet, MSL
Level of Use	28,000 vehicles/day
Annual O&M Cost	$145,445
Special Flood Hazard Area	N/A
Physical Condition	Fair
Landowner	State of California

Underground Facilities

A stormwater force main associated with Sewer Authority Midcoastside Plant runs under the highway (see AVP #2).

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



STATE ROUTE 1 at Surfer's Beach

ASSET SENSITIVITY

SR1 is well maintained and in fair condition. Nevertheless, it remains extremely sensitive to both present day and future impacts of flooding, erosion, and sea level rise. When temporarily inundated or damaged by erosion, this section of the road would be closed due to public safety concerns. For example, when waves have washed away riprap in the past, Caltrans has shut down the section of the SR1 entirely. The section of SR1 is reopened once water has drained and any damaged sections have been rebuilt.

Temporary flooding or damage from erosion would require the use of side streets, but those roads were not designed to accommodate the traffic demand on SR1. This detour would result in a reduction in level of service. If this segment of SR1 were permanently lost due to erosion or inundation, use of these side streets would not be viable, and recovering the level of service would require significant traffic rerouting.

California Coastal Trail west of SR1 at Surfer's Beach.

SHORELINE VULNERABILITY

Erosion Extent

This segment of SR1 is within the area identified by the Pacific Institute study (2012) as susceptible to erosion by 2100 (the eastern extent of which is shown in yellow). The site was identified in the Santa Cruz Littoral Cell Sediment Management Plan as an Area of Concern due to its high usage and current bluff erosion during high tides and storm wave activity. See the "Exposure Discussion" section for more details.

Erosion Extent: Future erosion zone extends far east of SR1.

Cross-Cutting Vulnerabilities

A force main for the storm sewer runs under SR1 to the SAM Plant in Half Moon Bay (see AVP #2). When the force main backs up from overloads at the treatment plant, there can be a sewage overflow at the open the grates north of SR1 at Surfer's Beach, which then drains through a culvert to Surfer's Beach, forcing the beach to close. Any disruption at Surfer's Beach affects recreation as the site is popular for beach access and offers connection to the California Coastal Trail.

STATE ROUTE 1 at Surfer's Beach

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

SR1 is highly exposed at Surfer's Beach. The beach itself is subject to daily high tides and wave action, which have caused significant beach erosion and created the need for repair and ongoing slope protection maintenance along this section of SR1. Since 1964, the beach has lost roughly 140 lateral feet due to erosive forces and a loss of neighboring sediment sources that could have supported beach replenishment. The presence of the jetty (US Army Corps of Engineers) north of Surfer's Beach that protects Pillar Point Harbor further exacerbates erosion because waves are redirected toward Surfer's Beach and are amplified as they approach the beach.

Long-term disruption of natural sediment processes in the Santa Cruz Littoral Cell contributes to the vulnerability at this spot because beach renourishment (an otherwise natural process) is insufficient to compensate for the sand loss.

This segment's exposure to high tides and wave action is likely to increase with sea level rise. Additionally, storm and sewer backup at the water treatment plant in Half Moon Bay has caused backup in stormwater lines, which then spill out of the grates north of the road, releasing water to cover the road and Surfer's Beach on its way to the Pacific Ocean.

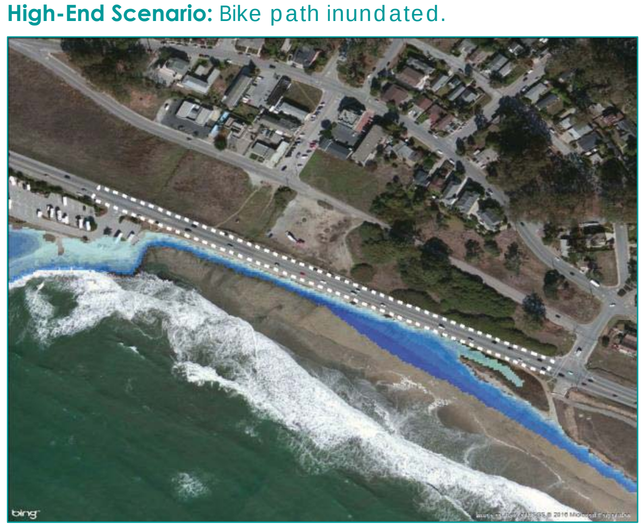
Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts	***Area Not Included in Overtopping Analysis***	
Baseline 1% Flood	*0*	*0*
Mid-Level 1% + 3.3 feet	*0*	*0*
High-End 1% + 6.6 feet	*0*	*0*

Baseline Scenario: Asset not inundated.

Mid-Level Scenario: Asset not inundated.

High-End Scenario: Bike path inundated.



STATE ROUTE 1
at Surfer's Beach

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The overall adaptive capacity of the asset is low. However, in the near-term, adaptive capacity is moderate as Caltrans is engaged in routine maintenance to maintain road access and repair the road expeditiously following a disruption. Future adaptive capacity to sea level rise is low because alternate routes, such as Avenue Alhambra and Obispo Road, are a slow and short-term alternative during temporary closures on this section of road. These routes are not considered suitable permanent alternatives for the volume of SR1 traffic, and they do not provide beach access.

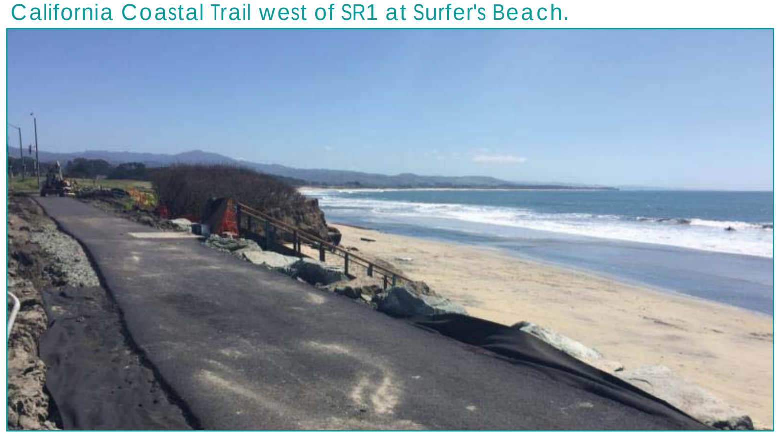
Consequences

SR1 is an essential asset of local, county-wide, and regional importance. Direct damages to the road could require costly repairs (around $2.7 million) and lead to considerable traffic delays due to detours. Traffic accidents may also occur on flooded or damaged roadways (prior to road closure). Delays could cause additional secondary economic impacts that are not yet quantified, including the value of time lost on a daily commute, or the loss of revenue for local businesses along the route. A permanent loss of this section of SR1 could potentially isolate the coastal communities that depend on it for daily transit to and from work, and elsewhere. If the rate of beach erosion continues, Surfer’s Beach itself could be used less and less, until it is eventually forced to permanently close. Frequent traffic delays and beach closures would severely affect recreational activity in the area, and consequently reduce recreation- and tourism-related economic activity.

Additional Important Information

Emergency work has been underway to repair damage to the bike lane, and Caltrans is working on a long-term plan to address erosion to SR1 at this location. Erosion prevention and mitigation is challenging due to ongoing coastal processes (exacerbated by the jetty) and financial constraints. Currently, permit regulations restrict the size of the riprap that can be used to fortify the bank that supports the highway. This means a larger riprap could better protect the highway, but it is not presently allowed, presumably because it may increase erosion in adjacent areas; therefore, erosion continues at the site.

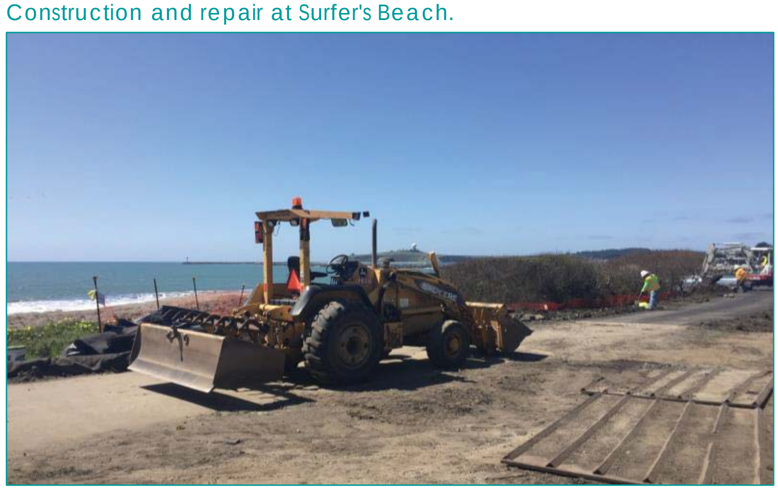
California Coastal Trail west of SR1 at Surfer's Beach.



Asset-Specific Adaptation

Potential near-term adaptation measures include nourishing the beach or building a bridge over the erosion-sensitive areas. Long-term adaptation options are limited. It may be possible to implement a bypass for SR1, though the location options are limited. If the nearby jetty were to be removed, waves would be reduced, thus improving sediment transport, environmental conditions, and an overall decrease in erosion rates. Because erosion mitigation can have impacts "downstream", any armoring or other type of coastline solution will need to be coordinated.

Construction and repair at Surfer's Beach.



Vulnerable Coastal Highways

There are Asset Vulnerability Profiles on the following vulnerable highways: Highway 101 (AVP #9) and SR 84 - HWY 101 Interchange (AVP #19). The vulnerability assessment analysis shows that there are 99.6 miles of vulnerable highways in the project area, including State Routes 54, 92, and 114.

4. FITZGERALD MARINE RESERVE

County of San Mateo

VULNERABILITY SUMMARY

Vulnerability of the James V. Fitzgerald Marine Reserve (Reserve) is **high**. The Reserve contains unique rocky intertidal habitat in the County, which hosts many rare species and habitats that are sensitive to sea level rise. The Reserve is highly exposed to erosion; sea level rise will reduce the availability of the intertidal habitat, bluff, and beach extent. Adaptive capacity is low due to the low occurrences of most protected species on site, and limited refuge habitat. The loss of this asset has high consequences, impacting the amount and distribution of biodiversity, recreational and educational opportunities, and adjacent private property.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	High	Low	High

ASSET CHARACTERISTICS

200 Nevada Avenue | Moss Beach

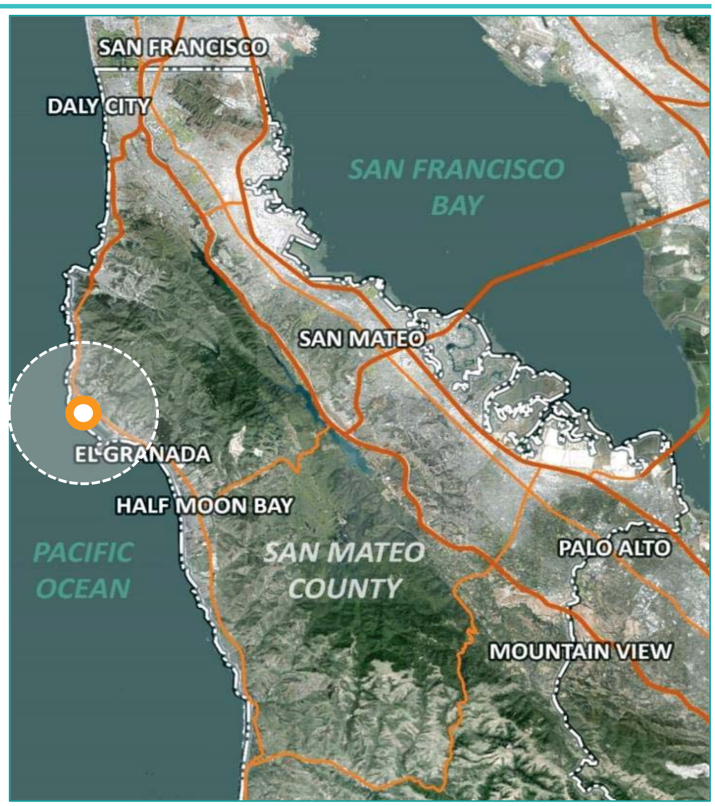
Asset Description and Function:

The Reserve is a popular natural and recreational asset that hosts a range of unique visitor opportunities, habitats, and protected species. It includes seal haul-out areas, tide pools, beach and shoreline access, and a visitor center. Ecosystems present include coastal strand habitat, a reef, grassland mosaics, central coast arroyo willow riparian forest, freshwater marsh, northern coastal scrub, northern coastal bluff scrub, and coastal terrace prairie. The foundation of a historical homestead is also onsite.

Asset Type	Marine Reserve
Asset Risk Class	1, N-Rocky Intertidal
Size	402 acres, 3 linear miles
Year of Construction	1969
Elevation	Tide pools & seal haul-out at grade; bluffs at 31-38 feet
Level of Use	175,584 year-round visitors
Annual O&M Cost	$300,000 (2014-2015)
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	County of San Mateo and nine other private owners
Underground Facilities	None

Environmental Considerations

The Reserve is one of the very few areas for harbor seal haul-out in Northern California. Other protected species include California red-legged frog, bluff and coastal leptosiphon, blasdales bent grass, johnny-nip, harlequin lotus, and various marine mammals.



FITZGERALD MARINE RESERVE

ASSET SENSITIVITY

The asset's diverse features are highly sensitive to the impacts of sea level rise. Higher sea levels will reduce beach for seal haul-out areas. Habitats of rare and/or protected species could vanish due to permanent inundation or bluff erosion. Many of the County's coastal species have limited occurrences, both the yellow leptosiphon and blasdale's bent grass have a record of one to two occurrences. Tide pools and species in the intertidal zone may not survive permanent inundation and warmer water temperatures. With sea level rise these dynamic habitats that sustain sessile and other intertidal species would no longer undergo tidal fluctuations. This may lead to further reduction to biodiversity or loss of habitat for species that depend on those variable conditions. It is expected that the bluff retreat will result in the loss of coastal prairie habitat, and could also impact the Smith-Dolger historic homestead.

Saltwater intrusion at the San Vicente Creek could threaten the California red-legged frog habitat and breeding areas farther upstream. The restoration area is sensitive to flooding and a portion was damaged by the king tides in 2016. Educational uses of the site are moderately sensitive to sea level rise impacts; the presence of tide pools, seal haul-outs, beach access, and protected species influence the visitation rates. Built structures on site, including a ramp access, are sensitive to flooding as they were damaged during recent storms (2016), making them unusable until they could be repaired.

Fitzgerald Visitors use the tide pools and access the beach.

SHORELINE VULNERABILITY

Erosion Extent

The entire western boundary of the Reserve is located within the area identified by the Pacific Institute study (2012) as potentially exposed to erosion. The yellow band represents the eastern extent of erosion that can be expected by 2100. See the "Exposure Discussion" section for more details pertaining to the effects of coastal erosion on this asset.

Erosion Extent: Reserve is and will be exposed to coastal erosion.

Cross-Cutting Vulnerabilities

The native marine resources have recently been impacted by warmer ocean temperatures and as a result species; long term impacts could lead to reduced biodiversity. Sea star wasting syndrom has further simplified the marine tidepool ecosystem. The upland habitat has undergone significant invasion by noxious weeds over the last several years. These additional factors further contribute to the vulnerability of the asset's vegetation communities and their ability to adapt.

FITZGERALD MARINE RESERVE

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Reserve is highly exposed to the impacts of sea level rise. The asset experiences daily wave action and erosion. In addition, the king and storm tides have historically eroded the bluff areas and inundated both the low-lying tide pools and seal haul-out areas on the beach. The 2016 storms affected the ramp access and the habitat restoration area. The visitor center and bluff habitats are not currently exposed to inundation, but may be subject to erosion as the bluffs retreat inland. Higher water levels will likely cause saltwater intrusion into San Vicente Creek, which supports California red-legged frogs (including their breeding area upstream outside of the reserve) and drains to the Pacific Ocean at the Reserve.

Baseline Scenario: Beach and tide pool inundation.

Seal haul-out areas at the reserve.

Mid-Level Scenario: Growing extent of inundation.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First significant impacts	***Area not included in Overtopping Analysis***	
Baseline *1% Flood*	***0***	***11***
Mid-Level *1% + 3.3 feet*	***0***	***16***
High-End *1% + 6.6 feet*	***0***	***17***

High-End Scenario: Reduced beach and tide pool area.

FITZGERALD MARINE RESERVE

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Reserve's functions and habitats have low adaptive capacity. The beaches and bluff have limited space for retreat, causing permanent loss to any beach, bluff, or associated habitat. It is unclear whether the protected and/or rare occurrence species will be able to adapt to sea level rise. Furthermore, these species have limited or no options to move to another location at present. Specifically, additional haul-out areas for seals are limited, and establishing successful rare plant populations is also very difficult. Tide pools cannot be recreated because they were formed as the geologic result of a rocky shelf outcrop. As the California red-legged frog habitat is limited within the Reserve, these frogs would have to rely on nearby habitat on private property that may have alternate land management objectives. Beach and recreational access is available in other parts of the County; however, the environmental education opportunities associated with this unique reserve are not available in the immediate vicinity.

Consequences

The consequences of the loss of the Reserve are high. Inundation and erosion resulting from sea level rise will cause permanent loss of some site features, such as beach extent, the seal haul-out areas, and tide pools. Site infrastructure, including benches or tables, could also be damaged. While economic and structural damages to the asset caused by sea level rise would likely be low, environmental impacts from the loss of the Fitzgerald Marine Reserve and its features are high, and would be felt regionally. A loss of any of the critical habitats could cause permanent loss of a species in the immediate region if there aren't any, or are very limited, alternative habitats available for reintroduction or translocation. Educational or recreational opportunities tied to these essential features are also likely to decline in quality and quantity, thereby reducing the experiences of visitors in the long run. This would have associated economic impact and could reduce the fees that support the education and programs at the Reserve.

Additional Important Information

A habitat restoration plan is underway for the San Vicente Creek riparian corridor and buffer area. The Reserve and its environmental assets are also extremely vulnerable to other impacts associated with climate change including increasing water temperatures and the presence of invasive species. Management and permitting at the site are particularly challenging and could potentially involve many additional agencies including the California (CA) Coastal Commission, the CA State Lands Commission, the National Marine Fisheries Services, the US Army Corps of Engineers, and the CA Department of Fish and Wildlife.

Asset-Specific Adaptation

Adaptation is very challenging at this site as many of the vulnerabilities of species are tied to broader issues, including regional habitat loss and other impacts from climate change. A regional habitat management approach may be needed to address environmental concerns. However, opportunities to make species' habitat more resilient to sea level rise should be explored, and solutions will be needed to protect the long-term viability of habitats. Buildings on site can be elevated, relocated, or reinforced as needed.

Vulnerable Rocky Intertidal Areas

This is the only Asset Vulnerability Profile on vulnerable rocky intertidal areas in the County. At the time of this assessment, an exhaustive dataset of Rocky Intertidal Areas in San Mateo County is unavailable.

Bluff habitat at Fitzgerald Marine Reserve.

5. LINDA MAR
PACIFICA STATE BEACH

City of Pacifica

VULNERABILITY SUMMARY

Pacifica State Beach (Beach) is **moderately vulnerable** to sea level rise. The Beach, which is a heavily used recreational asset, is directly exposed to higher water levels and wave action from sea level rise, and State Route 1 makes coastal retreat challenging at this location. Most of the Beach would recover from temporary flooding or erosion damage, though the pump stations to the north and south are highly sensitive to flooding. Permanent inundation on site would lead to loss of beach access, loss of the pump stations (and associated spills), and a loss of habitat for the population of the federally threatened snowy plover, which is already limited in the region.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Moderate	Moderate	Moderate

ASSET CHARACTERISTICS

5000 Pacific Coast Hwy | Pacifica

Asset Description and Function:

The Beach is located on the west side of State Route 1 in the City of Pacifica. This section, from Crespi Drive to San Pedro Creek, is a very popular recreational asset, provides habitat for endangered snowy plovers, and provides water quality and flood protection (for State Route 1) benefits. Two pump stations (Linda Mar for Wastewater and Anza for Stormwater) are on the southern and northern ends of the beach, respectively. The Beach is also the site of the Portola Discovery.

Asset Type	Beach
Asset Risk Class	1, N-Beach
Size	2,000 linear feet
Year of Construction	N/A
Elevation	0 feet (sea level)
Level of Use	1 million visitors/year
Annual O&M Cost	Unknown
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Fair
Landowner	State of California and City of Pacifica

Underground Facilities

There are underground stormwater and sewer lines on site. These are not directly associated with the asset and this profile.

Environmental Considerations

For this asset, the snowy plover, steelhead trout, sandy beach tiger beetle, and beach layia may be present.

LINDA MAR
PACIFICA STATE BEACH

ASSET SENSITIVITY

The site is moderately sensitive to temporary and permanent inundation, as well as erosion. If the Beach were flooded, it would not be accessible for recreational use until water levels receded. Furthermore, if the pump stations were flooded, they could become inoperable and spill effluent onto the Beach, creating a water quality hazard or leading to longer beach closures. Whether temporary or permanent, inundation and erosion could prevent access to the trails, the parking lot, the pump stations, and the Beach itself. It could also cause the pump stations to lose power, though this has not happened in the past.

From an ecosystem perspective, snowy plover habitat is very sensitive to flooding and sea level rise, as they require dry ground during nesting season. Sea level rise could permanently inundate the Beach, reducing the available habitat, which is limited in this region.

Pacifica State Beach, looking north.

SHORELINE VULNERABILITY

Erosion Analysis

Historical erosion data and projected future erosion (USGS, Pacific Institute) indicate that Pacifica State Beach, and the surrounding area, are particularly at risk from erosion. The asset is located within the area identified by the Pacific Institute study (2012) as susceptible to erosion (eastern extent by 2100 in yellow). See the “Exposure Discussion” section for more details.

Erosion Analysis: Asset is entirely within 2100 erosion zone.

Cross-Cutting Vulnerabilities

The Beach depends on local sediment supply and coastal processes to balance out the losses of beach area caused by erosion; any reduction in sediment supply will make the Beach increasingly vulnerable to erosion and flooding.

With very severe erosion or high water, State Route 1 could also flood. This could disrupt transportation and egress, and could potentially isolate nearby coastal communities, see Surfer's Beach profile.

LINDA MAR
PACIFICA STATE BEACH

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Beach is moderately exposed to sea level rise. The Beach is exposed to regular wave impacts and erosion from high tides and storms, but there is a large body of sand to absorb these impacts, and the Beach has not been fully flooded to date. Under current conditions, the pump stations have never flooded or spilled sewage, and water levels have not overtopped State Route 1.

Exposure and erosion are likely to increase in the future with sea level rise. This could expose both pump stations to temporary inoperability (from flooding) or permanent loss of service (from failure, erosion, or wave damage).

With sea level rise or a large storm, the Beach and trail access, the parking area, swathes of snowy plover habitat, and stormwater and pump stations could all be temporarily or permanently flooded. The high-end scenario suggests that State Route 1 may be overtopped by flood water or waves, exposing the properties and people behind it to flooding. Though the bridge at San Pedro Creek was designed for a 1% annual chance flood event, future water level or tidal conditions could reach or exceed the design water level in the creek more frequently. As a result, the creek could overflow during a future 1% annual chance flood event or smaller.

Baseline Scenario: Beach is partially flooded.

Mid-Level Scenario: Beach and creek flooded.

High-End Scenario: Regional inundation.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts	***Area Not Included in Overtopping Analysis***	
Baseline *1% Flood*	***0***	***7***
Mid-Level *1% + 3.3 feet*	***0***	***12***
High-End *1% + 6.6 feet*	***0***	***15***

LINDA MAR
PACIFICA STATE BEACH

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Currently, the Beach has moderate adaptive capacity, as flood waters would recede after events have passed, and would likely not create permanent losses or a loss of access to the Beach. However, as sea level rises and as flooding occurs more frequently, the number of days each year when the Beach could be used by native species and visitors would be limited. In particular, snowy plover populations and habitats are already limited in the area, and there are few, if any, alternatives for nesting. The pump stations have emergency plans for high water events, and are relatively adaptable to temporary flooding. They would, however, likely need to be relocated in the long term when the extent of erosion moves far enough east. There are other coastal access opportunities that could likely accommodate the additional visitors if the Beach were closed, though other locations for beginning-level surfers are sparse. Coastal retreat is limited by the presence of State Route 1 at the eastern edge of the Beach, and while the parking lot, trails, and pump station walls could be elevated to adapt to sea level rise, erosion could destroy the Beach or make it less appealing for recreational use.

Consequences

Consequences of the loss of the Beach are moderate from an economic damage, health, and safety perspective, and the geographic scale of impact would likely be local. Sea level rise and increased erosion could cause permanent loss of this important regional recreational asset, as well as of rare snowy plover habitat. The low-lying State Route 1 and other multipurpose trails could also be interrupted if flooded or damaged by beach erosion. With high enough water levels, State Route1 could be inundated, and properties behind it would likely flood because they are low-lying and considered protected by the highway. If flooding of the Beach or associated power loss rendered the pump stations inoperable, sewage and stormwater overflow onto the Beach is possible. This could affect water quality near San Pedro Creek, home to threatened steelhead trout; it could also pose risks to human health, and could result in Beach closure. Under severe erosion, properties on the south side of the Beach would also be lost.

Additional Important Information

Any built adaptation measure that affects the Beach could affect neighborhood flooding south of the Beach, and a strategy would need to be coordinated to protect these communities to ensure they are not adversely affected by adaptation at the Beach.

Asset-Specific Adaptation

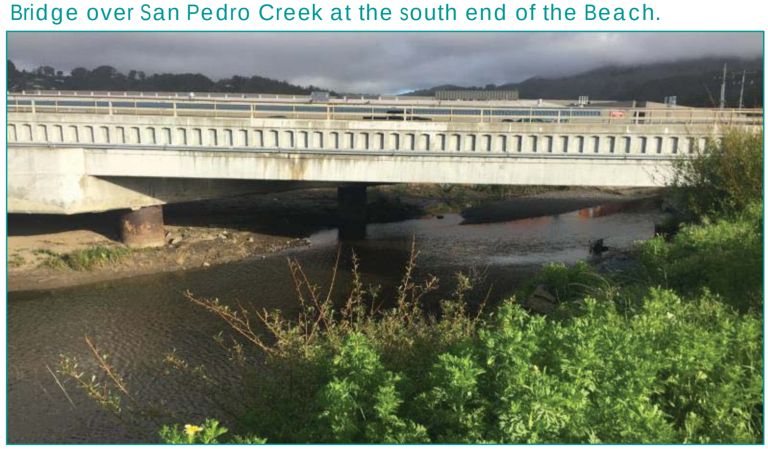
Shoreline retreat is limited by State Route 1, but it has happened in recent years when the parking lot was removed and dunes were restored. The highway and pump stations could be reinforced with floodwalls or riprap, and the snowy plover habitat could be nourished with sand to mitigate erosion temporarily. The trails and parking lot may need to be elevated.

Vulnerable Beaches

This is the only Asset Vulnerability Profile on vulnerable beaches in the County. The vulnerability assessment analysis shows that there are 123 parks exposed to sea level rise in the near- or long-term; other vulnerable beaches include Half Moon Bay State Beach, Montara State Beach, and Thornton State Beach.

Pump station outlets near the south end of the Beach.

Bridge over San Pedro Creek at the south end of the Beach.



6. CLOSED LANDFILL AT MUSSEL ROCK

City of Daly City

VULNERABILITY SUMMARY

Vulnerability of the closed landfill at Mussel Rock (Landfill) is **high**. The asset is highly sensitive to coastal erosion, as collapse of the seawall could expose the contents of the Landfill, potentially releasing garbage into surrounding areas. Because of its location on the open Pacific Coast, the revetment at Landfill is already exposed to erosion and wave impacts, both of which are likely to increase as sea level rises in the future. Adaptive capacity of the Landfill is moderate, as maintenance can reduce vulnerability. Some of the asset's recreational uses are less vulnerable to sea level rise impacts, as they could be migrated inland or potentially accommodated elsewhere.

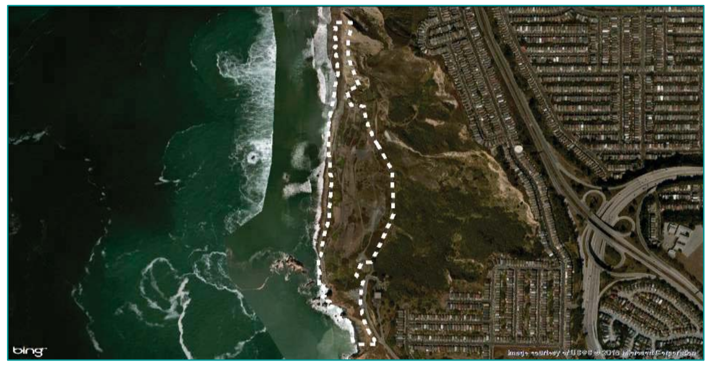
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	*Moderate*	*Moderate*	*High*

ASSET CHARACTERISTICS

Westline Drive | Daly City

Asset Description and Function:

The Landfill contains an unlined municipal landfill in the City of Daly City that operated from 1958 until 1978. It is closed, and is now a valued recreational asset with access to trails, paragliding, and birding. The Landfill lies on a terrace between steep, unstable slopes above the Pacific Ocean. The terracing and the revetments at the base of the Landfill were designed to prevent landslides and the Landfill's contents from being released into the ocean. While there is no official designation, remains of an Ohlone settlement were found on site.



Asset Type	Closed landfill
Asset Risk Class	4
Size	29 acres
Year of Construction	1950s
Elevation	10-60 feet
Level of Use	NA (closed)
Annual O&M Cost	$1,000,000
Special Flood Hazard Area	Asset not in SFHA
Physical Condition	Good
Landowner	City of Daly City

Underground Facilities

The volume of buried waste is estimated at 1 million cubic yards. The Landfill extends up to 75 feet below grade.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

CLOSED LANDFILL AT MUSSEL ROCK

ASSET SENSITIVITY

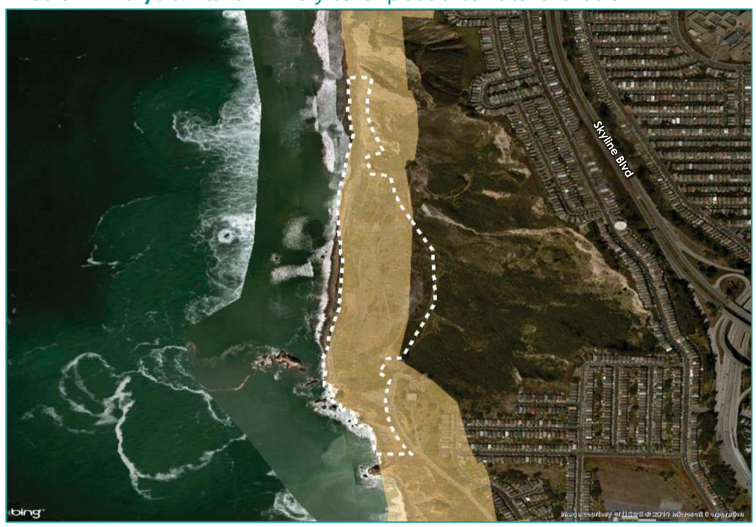
The Landfill's primary function (storing waste) is highly sensitive to erosion because a landslide or cliff collapse (caused by erosion or failure of the seawall and revetment) could cause garbage to be exposed. This would significantly affect the level of service provided by the Landfill, and possibly lead to the release of waste material. The site's other uses are less sensitive to erosion, as trails or other public recreational uses could continue in the area even if some sections of the former landfill collapsed.

SHORELINE VULNERABILITY

Exposure Analysis and Erosion Extent

Exposure to erosion at the Landfill is moderate. The 30- to 35-foot-high revetment at the base of the cliff is exposed to daily wave action and high tides requiring spot repairs every few years. The 2016 storms caused erosion in a few areas on the north side that necessitated emergency repair. However, because the landfill is set back slightly from the cliff, and due to the revetment at the base of the cliff, the Landfill and its materials themselves have never been exposed. As sea level rises, however, more frequent severe storms and wave impacts will increase erosion of the revetment and armoring, potentially leading to landslides. Historical erosion data and future erosion projections indicate that this asset and the surrounding area are particularly at risk from erosion (yellow band on the right). The asset will not be exposed to coastal inundation because it is elevated and slopes upward away from the ocean. A groundwater table increase due to sea level rise may expose the Landfill's contents to water from below ground, but this is being monitored.

Erosion Analysis: Landfill likely to exposed to future erosion.



Erosion at Mussel Rock; though landfill protected by revetment.

Cross-Cutting Vulnerabilities

Continued maintenance of the seawall and revetments are imperative to preventing future landslides and thus exposure of the Landfill, which could create environmental or regional effects.

CLOSED LANDFILL AT MUSSEL ROCK

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the Landfill is moderate. Culverts onsite address drainage to minimize erosion that could be caused by rain, which ultimately helps maintain the structural integrity of the site. However, severe storms and waves could facilitate coastal erosion, reduce slope stability, and increase the likelihood of landslides. Ongoing monitoring of erosion hot spots and drainage issues reduces the likelihood that a major event will erode the hillside, and enables intervention via additional riprap, gabions, or other adaptation solutions. Ultimately, if erosion were significant enough to expose garbage, it would likely be necessary to relocate the Landfill inland, or remove and distribute all its contents to other sites.

Consequences

Consequences of the loss of the Landfill and spill of garbage would be high; however, the scale of the impact would be local. Exposed landfill materials could spill directly into the ocean, creating an environmental hazard and impact water quality or nearby wildlife. If this occurred, trash would need to be removed and the Landfill set back, or the trash would have to be relocated and the site remediated. Trash release or landslides could have secondary impacts on recreational uses of the site and reduce public access to open space. Any environmental damage could reduce the abundance of wildlife on site, including birds. The costs associated with the latter impacts have not been quantified, but removal of the Landfill is estimated at $200 million. Annual routine site maintenance, which includes the repair of drainage infrastructure averages around $200,000, and repair of the revetment ranges from $1,000,000 upward to $6,000,000.

Additional Important Information

A short section of the revetment will be raised 5 feet. As a requirement of the permit application to raise the revetment, the California Coastal Comission (CCC) requested the City of Daly City consider a long-term solution to the potentially hazardous issues raised by the continued protection of the Landfill. The CCC requested that the City consider various options for the managed retreat of the landfill and associated infrastructure, including a detailed feasibility study and cost assessment to potentially relocate all or some portion of the landfill and remove the seawall at some future date. Additionally, funding for work in the area is limited.

Asset-Specific Adaptation

Near-term solutions include maintaining the revetments to keep the landfill in place. Alternatives like sand placement on the beach to reduce erosion may bring some short-term relief. In the mid- to long-term, severe armoring or relocation may be required.

Vulnerable Landfills

There is another Asset Vulnerability Profile on vulnerable closed landfills: Half Moon Bay Landfill (AVP#7). The vulnerability assessment analysis shows that there are nine vulnerable solid waste facilities in the County. Three of these facilities are active, while six are closed.

Drainage line above the gabions.

Path looking south. Rock revetment on right, landfill on left.

7. HALF MOON BAY LANDFILL

County of San Mateo

VULNERABILITY SUMMARY

The Half Moon Bay closed landfill (Landfill) is **highly vulnerable** to erosion and future impacts of sea level rise. Stored waste could potentially be exposed in the future following severe erosion or slope collapse, making the asset highly sensitive; the asset is already exposed to daily wave action and scour. Adaptive capacity of the asset is moderate, as erosion can be reduced through protective measures such as a seawall. However, consequences from the exposure of waste could be detrimental to the surrounding habitats and special status species, and could create a public health hazard for nearby residents or recreationists who use the site for its trails and open space.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*High*	*Moderate*	*High*

ASSET CHARACTERISTICS

End of Magnolia St & Pacific Ocean | Half Moon Bay

Asset Description and Function:

The Landfill is an unlined Class III solid waste disposal site that was an illegal dump and burning site until 1958. The County assumed management responsibilities and operated the site as a landfill from 1971-76. It was graded and capped in 1978, and designated officially closed in 1997. Waste is underground and includes primarily inert material, yard waste, and small amounts of residential trash. The site perimeter is an important recreational asset and the California Coast Trail (CCT) crosses its western edge.

Asset Type	Closed Landfill
Asset Risk Class	4
Size	14 acres
Year of Construction	Pre-1958 (illegal use)
Elevation	Cover at 50 feet Waste depth unknown
Level of Use	NA (closed)
Annual O&M cost	$150,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Good
Landowner	County of San Mateo

Underground Facilities

Waste is underground along with stormwater and drainage outlets that empty at the beach. Gas monitoring wells are underground on site.

Environmental Considerations

The Landfill is located in an area that has potential for the occurrence of special status plant and animal species and is shown on City maps to contain environmentally sensitive habitat areas (ESHA) as well as potential ESHAs where habitat may be present.

HALF MOON BAY LANDFILL

ASSET SENSITIVITY

The asset is highly sensitive to erosion, as past storm events have exposed waste. Furthermore, the Landfill was created by filling ravine gullies with waste, and it is unlined, making it easily erodible. A concrete block mat revetment protects the bank of the Landfill to a certain extent to minimize the likelihood of the landfill eroding and exposing waste. The recreational uses of the site (trails) may be moderately sensitive to erosion as waste exposure could create a public health hazard and could result in a decrease of visitors to the area. Furthermore, erosion that causes bank failure near the section of the CCT could affect trail use and trail connectivity at the site as well. See profile on California Coast Trail for more information (AVP #1).

SHORELINE VULNERABILITY

Erosion Extent and Exposure Analysis

The western edge of the Landfill is located within the area identified by the Pacific Institute study (2012) as susceptible to erosion by the year 2100. The yellow band (see map on the right) represents the eastern extent of erosion that can be expected. The site is located near a residential neighborhood as shown in the photo.

The site is highly exposed to coastal erosion and wave action, and the most recent significant erosion occurred in 2010. Waves in the early 1990s also eroded portions of the marine terrace, exposing the Landfill along the cliff face, which warranted repairs and regrading, including the installation of a concrete block steel chain mat revetment on the slope to reduce future erosion.

Groundwater seepage into the Landfill is occurring, but it is unknown whether saltwater could intrude in a way that would compromise the Landfill.

It is likely that the inland extent of erosion into the Landfill will increase with sea level rise, especially in areas where there is already erosion and headcutting, such as at the southern drainage outlet which is migrating upstream at a rate of 7-10 feet per year.

Cross-Cutting Vulnerabilities

The Landfill is owned by the County, but maintenance of the surrounding drainage system, the trail, the parking lot, and the bridge are in the jurisdiction of the City of Half Moon Bay. As sea level rise exacerbates erosion and headcutting at the drainage outlet, the Landfill will become more susceptible to damage; any solutions to address one issue will likely require coordinating across both entities, nearby residents, and the CCT.

Western edge of landfill within future erosion extent.

Historical slide/bank failure area.

HALF MOON BAY LANDFILL

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the asset is moderate, as there is some ability to protect against erosion; for example, the County built a concrete block steel chain mat revetment on the slope to protect the Landfill from wave erosion and scour, and to minimize the likelihood that waste could be exposed. Furthermore, County staff engage in regular monitoring of the site and its revetment to minimize the potential for future erosion, waste exposure, and pollutant leaching. The recreational uses of the site have a high adaptive capacity because, if waste were exposed or a section of the trail eroded, visitors could still use the site (after waste removal) and take an alternate path set farther back from the cliff.

Consequences

If the coastal bluff adjacent to the Landfill eroded severely enough, it could cause a landslide and subsequently expose waste. To date, waste exposure has been minor and no impacts to water quality have occurred. However, severe erosion could cause waste to spill into surrounding areas. This would pose both environmental and public safety hazards to local habitat (coastal and semi-aquatic) and special status species, to recreationists, and to residents in nearby houses. Water quality could be negatively affected as well. The associated cleanup costs could be large, and any waste exposure could result in a fine for violations of waste discharge requirements. It is unknown if there are hazardous materials in the Landfill; if there were, then environmental and public health impacts could be even more severe. Furthermore, waste exposure could reduce tourism. The scale of impact would likely be local; however, potential environmental impacts could affect a greater region, particularly if water quality were affected.

Additional Important Information

Many regulatory agencies are involved in the asset's management, making adaptation challenging. Agencies include: State Regional Water Quality Control Board, CalRecycle, County Building and Planning Department, County Environmental Health Services, US Army Corps of Engineers, California Coastal Commission, California Department of Fish and Wildlife, City of Half Moon Bay, and Bay Area Air Quality Management District.

Asset-Specific Adaptation

In the near-term, it may be necessary to reinforce and enhance the seawall protecting the asset and preserving its recreational benefits. In the long-term, however, it may make more sense to perform a clean closure, and relocate the waste away from a vulnerable area (for example, to Ox Mountain). The land could then be returned to a county Park, and this segment of the CCT could be relocated inland if needed.

Vulnerable Closed Landfills

There is another Asset Vulnerability Profile on vulnerable closed landfills: Mussel Rock Landfill (see AVP #6). The vulnerability assessment analysis shows that there are 9 vulnerable solid waste facilities in the County. Three of these facilities are active, such as the Shoreway Environmental Center, while six are closed.

Headcut and severe erosion at southern drainage outlet.

Landfill cap, looking west.

8. PUMP STATION NUMBER 4

City of South San Francisco

VULNERABILITY SUMMARY

Pump Station Number 4 (Pump Station 4) is a **highly vulnerable,** critical facility that is a key component of the wastewater collection and treatment system for the South San Francisco (SSF) Service Area. The electrical and power distribution system is a key vulnerability and highly sensitive, whereby severe inundation could compromise the electrical system and cause the pump station to lose service altogether. The adaptive capacity of the facility to a flood hazard is low, as there is no alternate pump station that could serve its 30,000 customers (and industrial area). Loss of service could impact the service area and also the surrounding businesses.

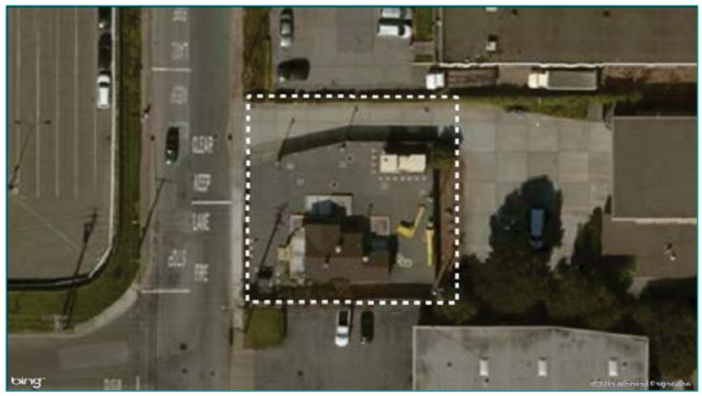
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	Moderate	High

ASSET CHARACTERISTICS

249 Harbor Way | South San Francisco

Asset Description and Function:

Pump Station 4 collects wastewater from five smaller pump stations in the industrial area of SSF, and conveys it to the SSF San Bruno Water Quality Control Plant (SSF SB WQCP) through a force main for treatment. Pump Station 4 has four pumps, two sewage grinders, and a backup generator. It serves roughly 30,000 people in the area of SSF, east of Highway 101.



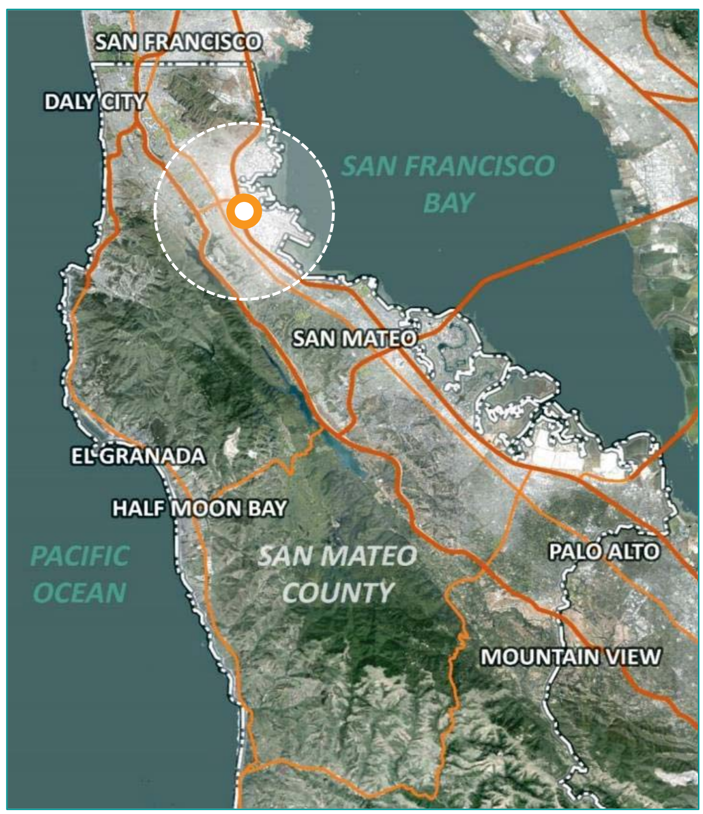
Asset Type	Wastewater Pump Station
Asset Risk Class	3
Size	2,000 square feet
Year of Construction	1957
Elevation	Pump room floor: -11 ft (Datum unknown)
Level of Use	1.6 million gallons/day
Annual O&M Cost	$125,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	City of South San Francisco

Underground Facilities

There are underground sewer pipes, electrical system, pumps, and sewage grinders.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



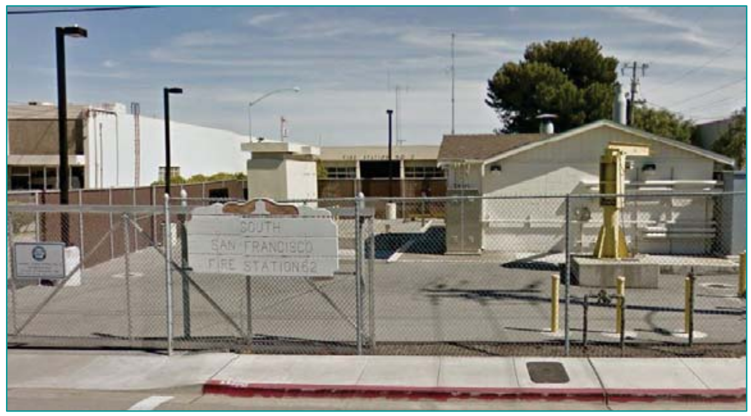
PUMP STATION NUMBER 4

ASSET SENSITIVITY

Though the Pump Station 4 is in good condition and many of its components were built to tolerate waterlogged conditions, it is highly sensitive to flooding. To date, the pump station has never been closed for any reason, in part because it has not experienced a major coastal flood, and also because many underground components, including pumps and grinders, were designed to operate in waterlogged conditions. In 2008, Pump Station 4 was rehabilitated and the wet well (the underground area storing sewage) was sealed to prevent groundwater intrusion. However, Pump Station 4 is very sensitive to a loss of power. Its street level electrical system is considered its most sensitive component and would be compromised if exposed to floodwaters.

If the electrical system were compromised, the Pump Station 4 would lose the ability to pump effluent (sewage) through the force main to the Water Quality Control Plant. Wires connecting the transformer pad to the pump house run underground, and if exposed to groundwater or saltwater, the wires and power transfer could potentially be corroded. If the site were to experience 48 inches of sea level increase, the nearby manholes could be overwhelmed, causing saltwater intrusion into Pump Station 4, and subsequently to the Water Quality Control Plant. This would significantly decrease the level of service because saltwater disrupts biological wastewater treatment processes.

Google Street View of Pump Station Number 4.



SHORELINE VULNERABILITY

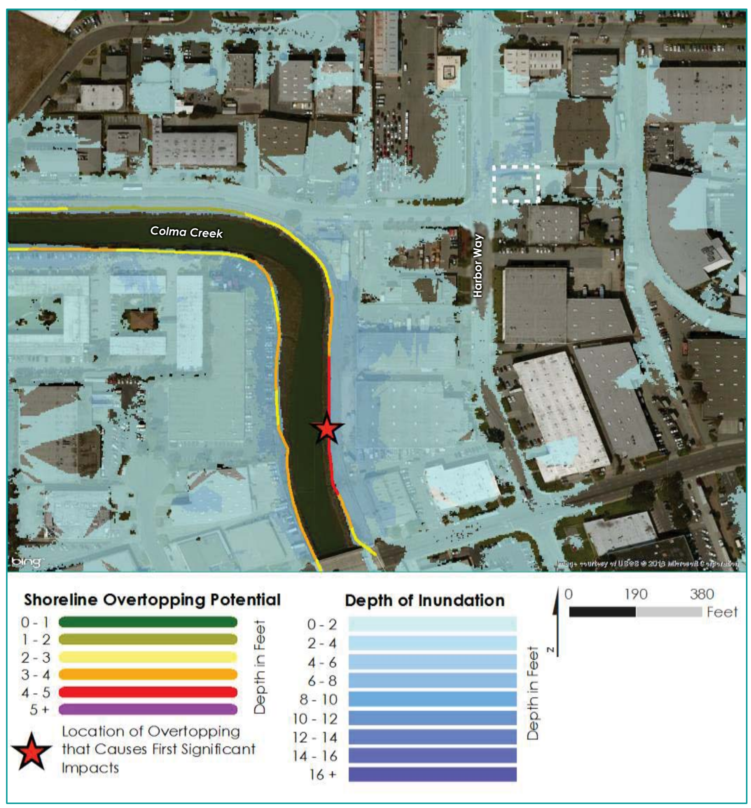
Shoreline Overtopping Analysis

Colma Creek is a likely source of coastal flooding at the Pump Station 4. When water surface elevations increase between 0 and 12 inches above the current mean higher high water (MHHW) level, the creek may overtop the embankment roughly 750 feet southwest of the site (indicated by a red star on the map), creating a potential flow path to the asset. The first damaging inundation to the Pump Station 4, however, would not likely occur until water elevations reach between 36 and 48 inches above MHHW.

Cross-Cutting Vulnerabilities

Pump Station 4 collects sewage from Pump Stations 8, 2, and 14 (Station 14 pumps to Station 2). Stations 8 and 14 are low-lying and close to San Francisco Bay, which makes them vulnerable to saltwater intrusion. Any saltwater or additional stormwater that gets into manholes or those pump stations would make its way to Pump Station 4 and ultimately to the SSF SB WQCP. Saltwater at the plant can ultimately disrupt biological treatment processes at the SSF SB WQCP (see AVP #23).

First Significant Impacts: 48 inches above MHHW.



PUMP STATION NUMBER 4

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

Exposure of Pump Station 4 is moderate. Though it has not yet been subject to coastal flooding, Pump Station 4 is subject to groundwater seepage as the pump station and its components were built at and below grade. It is also susceptible to saltwater intrusion because waves and saltwater can leak into the underground sewer pipes through manholes, and then be pumped to Pump Station 4. In addition, vulnerabilities at nearby Pump Stations 14 and 8 could have consequences at Pump Station 4. Pump Stations 14 and 8 are both low-lying and close to San Francisco Bay; making them subject to wave action and surface flooding. If either were exposed to saltwater, they would convey that saltwater directly into Pump Station 4.

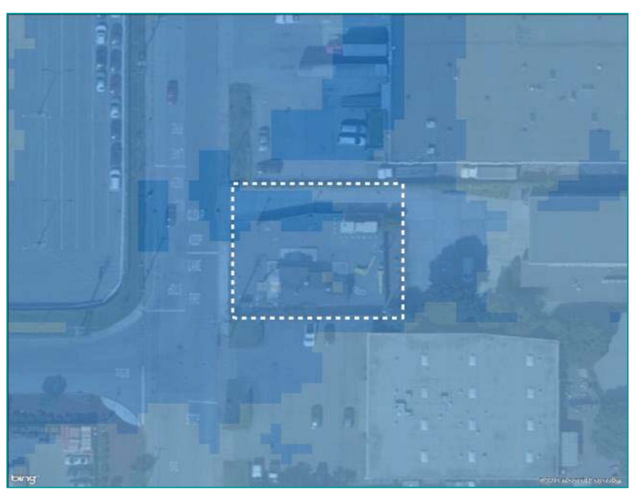
Pump Station 4 could also be exposed to surface water flooding from Colma Creek, which is tidally influenced. High tides combined with extreme or high rainfall events can prevent Colma Creek from discharging to San Francisco Bay. Water would instead back up and overflow onto the Pump Station 4 site. Though the function of the plant was not impacted during the major storm in December 2014, small amounts of standing rainwater splashed into the Pump Station 4 from passing motorists on Harbor Way.

With rising sea level, groundwater seepage is expected to increase, as well as the frequency with which saltwater could affect Pump Stations 14 and 8 (thereby conveying saltwater to Pump Station 4).

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Asset flooded 1-4 feet deep.

High-End Scenario: Asset under 6-9 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(48 inches)*	***0***	***3***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***1***	***4***
High-End *1% + 6.6 feet*	***6***	***9***

PUMP STATION NUMBER 4

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The adaptive capacity of Pump Station 4 is moderate; if the asset lost function all together, there is no alternate pump station to serve the same industrial region. There is an elevated backup generator to provide temporary power to the plant and ensure level of service for a limited time, as long as the generator and critical electrical system components (i.e., the power distribution system) stay dry. A remote-controlled monitoring system is connected to each major component of the pumping station, enabling real-time, 24/7 observation of conditions, processes, and functionality, and improving overall adaptive capacity of the asset. Staff receive alarms and have the ability to respond quickly to any abnormal conditions, thus reducing the likelihood of a loss of service. Under non-flooding conditions, the Pump Station 4 has three standby pumps for redundancy and additional capacity.

Consequences

The consequences of a temporary or permanent loss of this asset are high, and the scale of the impacts caused by disruption would be widespread as explained below. If inundated, direct damages to the Pump Station 4 components and operating equipment, or failure of the pumping station could range from $45,000 to $250,000. Given Pump Station 4 is the only conduit between this particular area and the Water Quality Control Plant, loss of service would affect function of the plant as a whole and could shut down the entire service area east of Highway 101. If customers continue to use the system, water could begin to back up in manholes. Overflows in the collection system could end up in the storm drain system, eventually discharging into San Francisco Bay, or could require evacuation of surrounding businesses, the SSF Caltrain Station, and the nearby fire station. If untreated sewage discharged directly into San Francisco Bay, this could cause environmental damages to water quality or adjacent habitat (and result in fines). Nearby businesses would likely be closed until the overflow could be pumped away, the buildings cleaned, and reopened for occupancy; this has economic impacts, as well. Though injuries are unlikely, on-site staff could be exposed to electrocution and hazardous waste during and shortly after inundation.

Additional Important Information

The Pump Station 4 is in good condition and has never been closed, shut down, or out of operation for any reason to date.

Asset-Specific Adaptation

One option is to floodproof the Pump Station 4 directly by building a wall and elevating critical components. It will also be necessary to address the manholes and other pump stations that feed the system to reduce their vulnerabilities.

Vulnerable Wastewater Pump Stations

This is the only Asset Vulnerability Profile on vulnerable wastewater pump stations in the County. The vulnerability assessment analysis shows that there are 66 vulnerable wastewater pump stations (based on available data) in the project area, including those in Daly City (1), Menlo Park (1), Millbrae (2), Pacifica (3), Redwood City (6), San Carlos (3), and SSF (10).

Underground pumps.

Power distribution system.

9. HIGHWAY 101
Whipple Avenue to Pulgas Creek

California Department of Transportation (Caltrans)

VULNERABILITY SUMMARY

The section of Highway 101 (HWY 101) between Whipple Avenue and Pulgas Creek is a critical ground transportation route and is **highly vulnerable** to sea level rise. This section runs along the edge of San Francisco Bay and is particularly exposed to creek backup combined with high tides. It is highly sensitive to flooding, as it could close if inundated and force traffic to use alternate routes, leading to congestion, reduced levels of service, and economic impacts precipitated by these issues. Impacts from a permanent loss of the asset could be felt at an interregional level.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	Moderate	High

ASSET CHARACTERISTICS

Highway 101 | Redwood City

Asset Description and Function:

This low-lying section of HWY 101 runs within the City of Redwood City and City of San Carlos. It's part of the primary north-south artery through the San Francisco Peninsula and provides access to the East Bay via State Routes 92 and 84. It serves local, regional, and inter-regional automobile and truck travel, averaging 222,000 vehicles per day. There are two essential bridges along this section that cross Cordilleras and Pulgas Creeks. HWY 101 is maintained by the CA Department of Transportation (Caltrans).

Asset Type	Ground Transportation
Asset Risk Class	4
Size	1 mile long, 160 feet wide
Year of Construction	Prior to 1964
Elevation	11.3-11.8 feet, NAVD88
Level of Use	222,000 vehicles/day
Annual O&M Cost	$1,050,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Fair
Landowner	State of California

Underground Facilities

Drainage and electrical conduits.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

HIGHWAY 101
Whipple Avenue to Pulgas Creek

ASSET SENSITIVITY

This section of HWY 101 is highly sensitive to flooding and inundation, and the road is already at capacity. To date, there have not been any flood-related road closures, but traffic slow-downs have occurred due to water on the freeway. When water surface elevations reach 48 inches above the current mean higher high water (MHHW) level, northbound traffic will be disrupted (due to flooding on the roadway) or stopped altogether. Southbound traffic is less sensitive to water levels in the San Francisco Bay because the 3-foot barrier dividing northbound and southbound flows delays the onset of floodwaters in the southbound lanes.

However, creek backup would likely flood these lanes from the west before the barrier was overtopped. Flooding could require the use of alternate routes, which are available but not designed to accommodate the high traffic volumes equivalent to HWY 101. Both the road and the bridges are essential components, and flooding of either would reduce the road capacity, requiring the use of alternate routes. Permanent inundation would require permanent road closure.

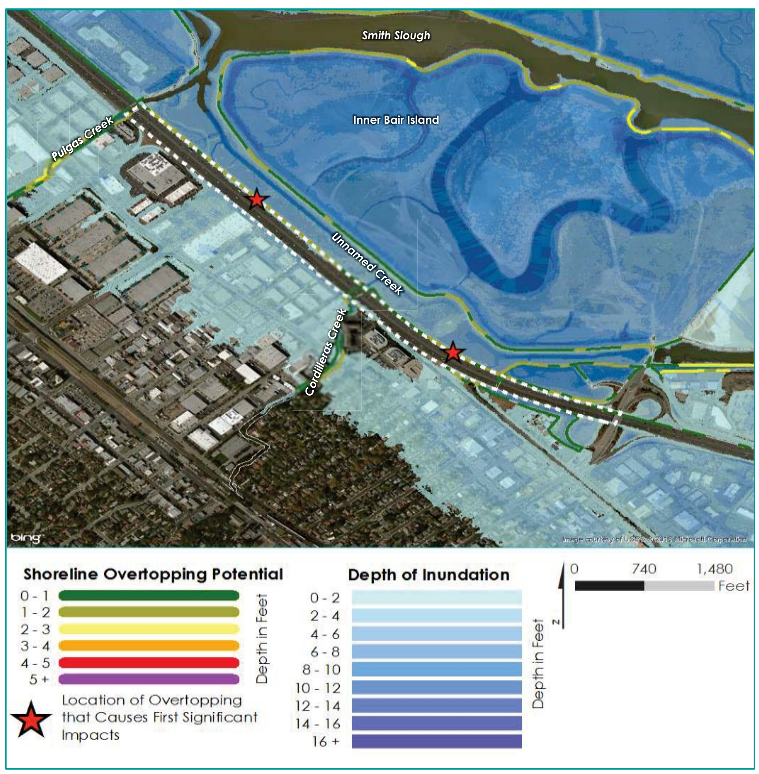
Aerial view of Highway 101 section adjacent to wetlands.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

The unnamed creek between Pulgas Creek and Smith Slough at the southern border of Inner Bair Island will likely lead to coastal flooding along HWY 101. When water surface elevations reach 24-36 inches above MHHW, the creek overtops HWY 101 (locations indicated by the two red stars on the map to the right), though the first inundation that is expected to cause significant or disruptive impacts to HWY 101 occurs when water reaches 36-48 inches above MHHW.

First Significant Impacts: 48 inches above MHHW.



Cross-Cutting Vulnerabilities

This section of HWY 101 connects north and south bay communities and provides access to the east bay for commuters, trucks, and others. Loss of service could have rippling economic impacts as commuters were delayed, and it would significantly slow shipping through the region. This includes reduced bus service for SamTrans and reduced access to Caltrans facilities, which would have a disproportionate effect on those dependent on public transportation, including low-income residents and those with access needs.

HIGHWAY 101
Whipple Avenue to Pulgas Creek

SEA LEVEL RISE EXPOSURE ANALYSIS

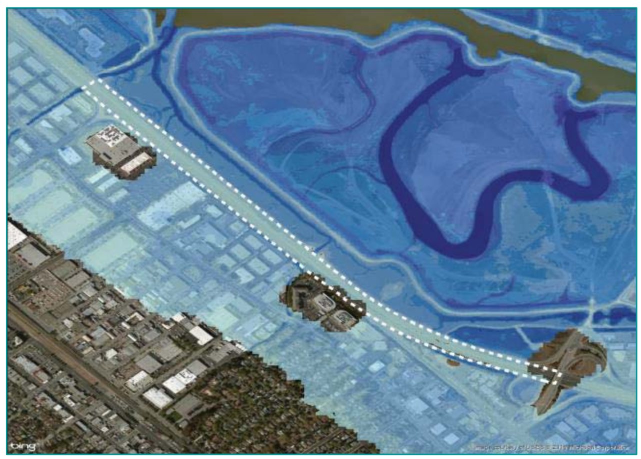
Exposure Discussion

This section of HWY 101 is moderately exposed to sea level rise. HWY 101 section lies roughly between 11.3 and 11.8 feet (NAVD88), and already experiences temporary, localized nuisance flooding when high tides coincide with larger storms. This has occurred near the northbound shoulder of HWY 101 near Cordilleras Creek. Because there are no tide gates, the two creeks that empty at the bay can back up when the tide is too high to allow them to discharge, flooding neighboring areas and causing more severe or widespread flooding west of HWY 101. The area near Pulgas Creek regularly ponds during high tides.

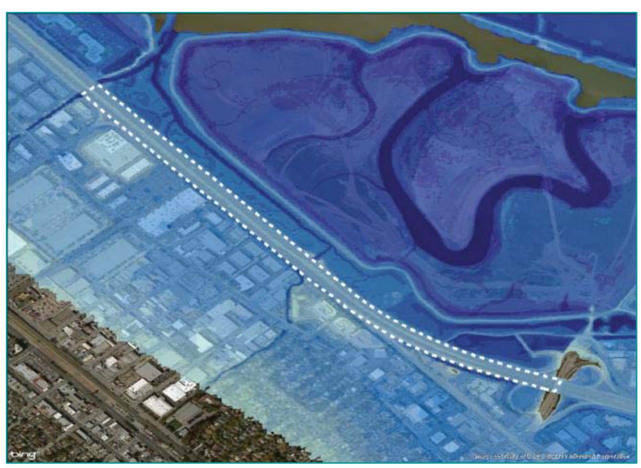
With sea level rise, higher tides will flood the freeway and back up the creeks (inundating neighborhoods) more frequently, and the depth and extent of flooding will likely increase as well. With 48 inches of sea level rise, water may flood the eastern portions of HWY 101 to a depth of up to 2 feet. This may also cause flooding on the entrance and exit ramps at Whipple Road. Inundation will also occur on the western side of HWY 101 because of the culverts and creeks that connect under HWY 101. After 77 inches of sea level rise, the barrier in the middle of HWY 101 will also overtop, though at this point, the rest of HWY 101 will likely have flooded from high water on the east and west sides.

Baseline Scenario: Asset is not inundated.

Mid-Level Scenario: Asset is extensively inundated.



High-End Scenario: Asset is under 11 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(48 inches)*	***0***	***5***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***10***
High-End *1% + 6.6 feet*	***3***	***11***

HIGHWAY 101
Whipple Avenue to Pulgas Creek

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

This section of HWY 101 has moderate adaptive capacity. If temporarily disrupted, traffic could use alternate routes such as Industrial Rd and El Camino Real, though those detours were not designed to accommodate high traffic flows (HWY 101 is already near capacity, which exceeds side road capacity). To date, there is no long-term adaptive capacity, as these routes are not suitable as permanent alternatives. There are no tide gates along this section of HWY 101 to prevent creek backup during high tides. If there were significant flooding, such as that caused by a 10% annual chance (or 10-year) storm coincident with a 2% annual chance (or 50-year) high tide, Caltrans would need to deploy a portable pumping system to clear the roadway. Exacerbating this flooding is the fact that most drainage systems in the area are functioning below design capacity due to sedimentation, and the presence of protected species limits the times during which the sediment can be cleared from the system.

Consequences

This section of HWY 101 would be expected to experience high consequences from flooding. Temporary flooding is not likely to damage the roadway, though it could affect underground facilities, such as electrical conduits. The more immediate effect is to the roughly 222,000 vehicles per day that use this section, including critical commercial vehicles. Flooding on this section could cause major delays due to detours and reduced highway speeds, both of which would have an economic impact on commuters and shipping. Implementation of detours would increase traffic and accelerate wear on alternative routes. Drivers attempting to cross the flooded HWY 101 could also be injured or killed (i.e., hydroplaning accidents). If the entire HWY 101 were damaged or permanently inundated, it could cost up to $52,530,000 to replace or move the section of roadway. Finally, urban development (including businesses and neighborhoods) west of HWY 101 lies below the freeway grade and could be inundated by freeway overflow or creek backup.

Additional Important Information

There are plans by Caltrans to replace Cordilleras Creek Bridge that incorporate sea level rise considerations, though these focus on the Caltrans infrastructure, not the region. This is the link for SamTrans service among north, south, and east bay communities, offering public transportation to the region, including disadvantaged communities. Additionally, in current preliminary Federal Emergency Management Agency (FEMA) maps, the highway is shown as having a Special Flood Hazard Area of "AE11".

Asset-Specific Adaptation

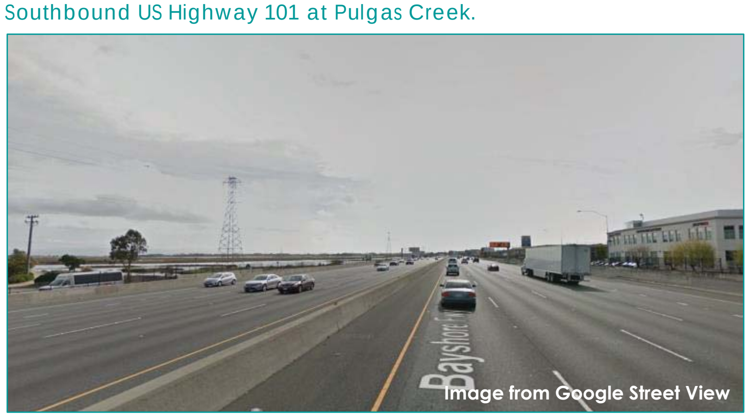
While it is more likely that HWY 101 will be part of a regional strategy, asset-specific measures include a barrier along HWY 101 and creek flow controls (tide gates or levees). Relocating HWY 101 inland is less feasible and undesirable because of surrounding dense urban development. Constructing traditional flood protection options to the east side of HWY 101 are limited and complicated because of the presence of wetlands; however, these wetlands could play a role in attenuating wave and surge energy during high tides. Regional strategies to reduce flood risk to HWY 101 could incorporate natural benefits.

Vulnerable Highways

There are Asset Vulnerability Profiles on the following vulnerable highways: SR 1 (AVP #3) and SR 84/HWY 101 Interchange (AVP #19). The vulnerability assessment analysis shows that there are 99.6 miles of vulnerable highways in the project area, including SR 54, 92, and 114.

Northbound US Highway 101 at Whipple Road exit.

Southbound US Highway 101 at Pulgas Creek.



10. MILLBRAE INTERMODAL STATION

Bay Area Rapid Transit (BART) and Peninsula Corridor Joint Powers Board (PCJPB)

VULNERABILITY SUMMARY

The Millbrae Intermodal Station (Station) is **moderately vulnerable** to sea level rise. The Caltrain and BART tracks are at grade, and exposure to flooding is moderate, with on-going groundwater intrusion into the BART tunnels. Roughly 24 inches of water level increase is needed for water to reach the Station. The Station is extremely sensitive, and trains would not function if power systems or the tracks were flooded. Adaptive capacity is moderate as the asset is an end-of-line stop for BART, and Caltrain could run "bridge" bus service around the Station during repairs to maintain service. Impacts would be high with costly damages, and flooding could affect over 58,000 riders/day.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	*Moderate*	*Moderate*	*High*

ASSET CHARACTERISTICS

200 Rollins Rd | Millbrae

Asset Description and Function:

The Station is a passenger train station for BART and Caltrain, and is served by SamTrans buses as well. It is jointly owned by a Joint Powers Board and BART. All trains on the Caltrain system (Gilroy to San Francisco) must pass through this Station on their way through the peninsula, and it is an end-of-line stop for BART, though an important node for access to San Francisco International Airport. Roughly 11,000 total riders use the station daily. There is also a Historical Train Depot on the property.

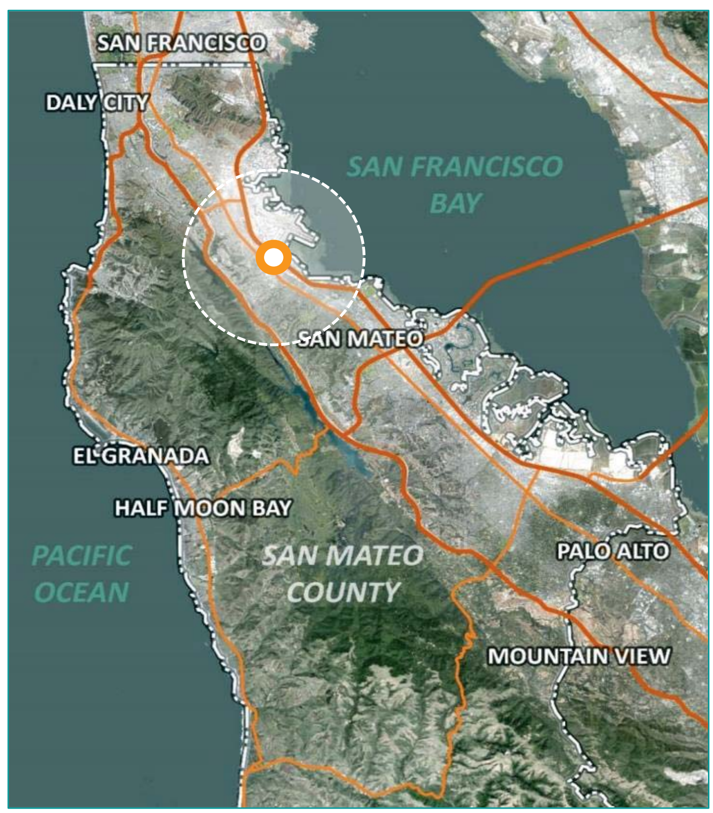
Asset Type	Public Transportation Infrastructure
Asset Risk Class	3
Size	20.7 acres
Year of Construction	2003
Elevation	12 feet, BART datum
Level of Use	11,000 daily riders
Annual O&M cost	Unknown
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	County of San Mateo Transit District

Underground Facilities

BART tracks and third-rail power supply are below grade.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



MILLBRAE INTERMODAL STATION

ASSET SENSITIVITY

Asset sensitivity is high, as flooding of the parking lots and nearby roads (which would be the first components to flood) affects bus drop offs, and station access. BART operations would also be affected if inundated, because the BART train control room, switching station, and substations at the site are sensitive to flooding, and BART service would stop if they were flooded. Both BART and Caltrain tracks are sensitive to flooding, particularly from saltwater due to corrosion. If the tracks were flooded, trains on both systems would stop service.

BART's underground facilities have a sump pump to mitigate groundwater seepage and potential nuisance flooding, however the sump does not have sufficient capacity to address major flooding, as could be caused by a severe coastal storm or overtopping of the nearby Highline Canal, which abuts the tracks (see map below).

Caltrain's power system is located offsite and has not been evaluated as part of this assessment for its vulnerability to flooding. Any Caltrain power sources that are low-lying could be flooded and disabled, potentially affecting Caltrain service at the Station.

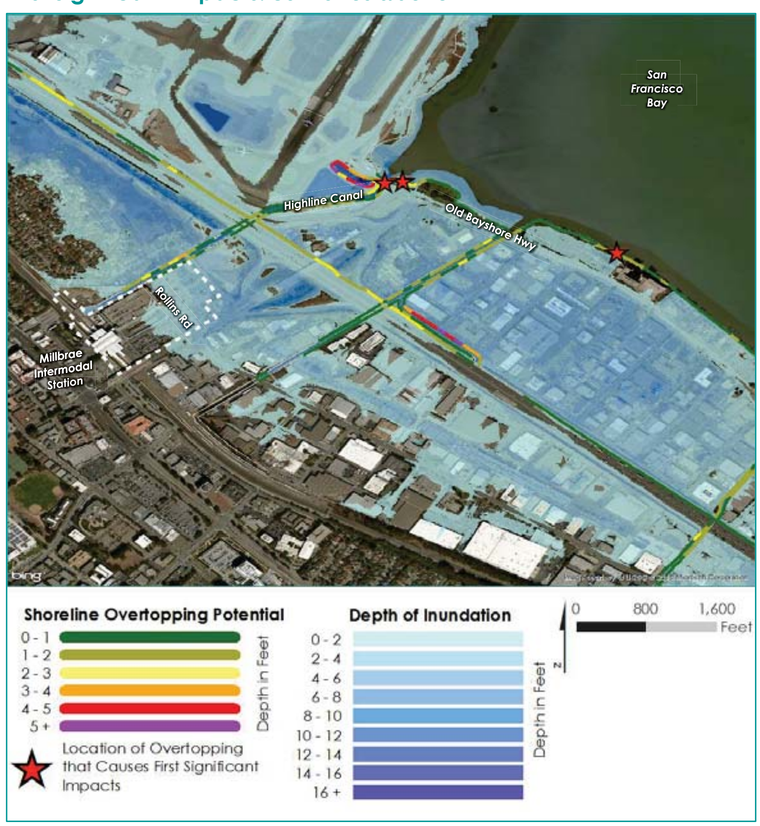
Entrance to BART tunnel at Millbrae Intermodal Station.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

Floodwater from San Francisco Bay (backing up through Highline Canal) is a likely source of flooding at the Station. When water levels reach 0-12 inches above the current mean higher high water (MHHW), water could overtop the shoreline at the Highline Canal Tide Gate (0.5 mile northeast) and Old Bayshore Highway (1 mile east) (red stars on map). With water 24-36 inches above MHHW, Highline Canal would overtop, inundating the parking lot and the area near the BART tunnel entrance.

First Significant Impacts: 36 inches above MHHW.



Cross-Cutting Vulnerabilities

The asset is an end-of-line stop for BART, and could be closed without affecting the rest of the system, though it does provide access to San Francisco International Airport. Caltrain service through the peninsula must pass through this Station. If tracks were damaged or flooded, the sections of the train network running to San Francisco and Gilroy would be severed. Back-up on the Highline Canal is exacerbated by the tide gate, which is not fully functioning, see profile on Highline Canal Tide Gate (AVP #11).

MILLBRAE INTERMODAL STATION

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

Exposure of the Station to the impacts of sea level rise is moderate. The asset has not experienced any surface water flooding; however, groundwater seepage is already apparent in some of the underground BART facilities. Furthermore, the asset could be flooded under 36" of water level rise resulting from sea level change or from an extreme storm.

Because the site is flat and there are currently no barriers to prevent water entry, flooding could affect the BART tracks, substation (power), and train control rooms (at-grade). The Caltrain station platform and the base of the station platform, including the stairways, fare machines, and elevators, are also at grade and could be flooded. This means that other sensitive equipment located on the platform could be exposed to flooding, including the tracks, and critical signal and mechanical systems. BART underground facilities have vent structures along the tracks, and could provide entryway for surface water flooding.

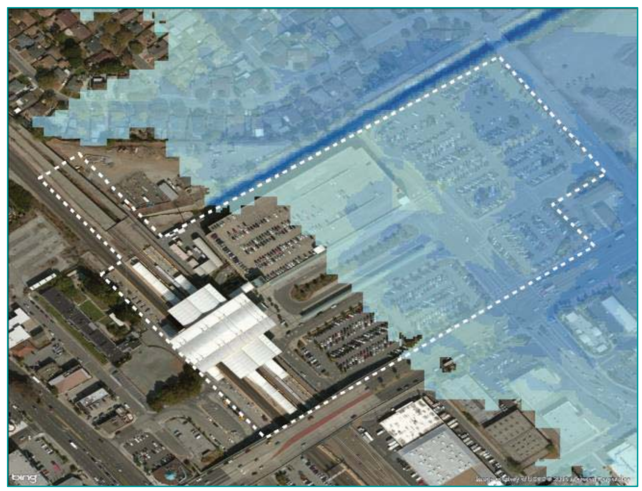
The Caltrain Historical Train Depot is at-grade with no flood barriers and could also be inundated with other at-grade infrastructure. Caltrain has no underground assets onsite, but it relies on underground utility assets, making groundwater seepage a potential concern. Flood depths onsite (near parking lot) could reach up to 11 feet deep in the high-end scenario.

Exposure Analysis Results

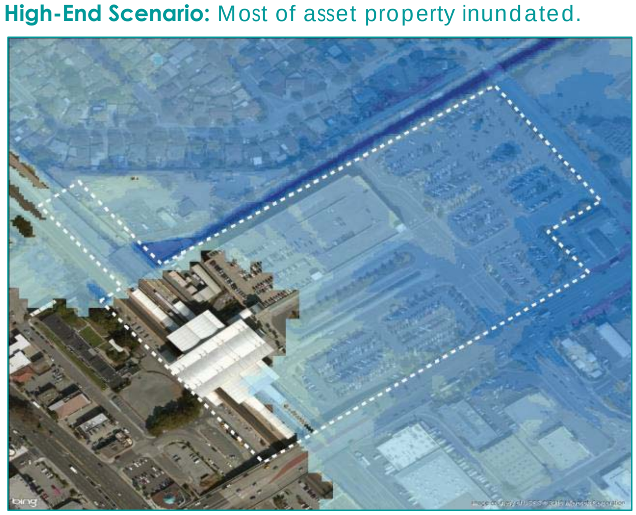
Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(36 inches)*	***0***	***5***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***7***
High-End *1% + 6.6 feet*	***0***	***11***

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Parking lot inundated.



High-End Scenario: Most of asset property inundated.



MILLBRAE INTERMODAL STATION

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the asset is moderate. BART has emergency equipment throughout the system, including sandbags, tarps, and mobile pumps; however, these measures would not be sufficient to maintain BART function for long-duration or permanent flooding. If BART or Caltrain operations at the Station were lost due to flooding, "bridge" service would be made available to pick up and drop off from the adjacent stations using a bus. While, this would cause delays, decreasing level of service, other stations would still maintain their function. Lastly, there is no alternate for the historic train depot from a historic and cultural resources perspective. Often building restrictions (due to historic landmarks) are limiting, which could present additional challenges in near-term protection or long-term adaptation of the depot. Adaptive capacity in the longer-term (or from any potential permanent inundation) is likely to be less effective than it is now, as frequent floods that require frequent use of "bridge" service would likely be too disruptive or costly. This could force a decision to adapt with either an asset-specific or regional approach.

Consequences

Consequences of temporary or permanent flooding of the asset are high, with regional geographic impacts. Flooding could damage both BART and Caltrain infrastructure and would cause a major disruption of service. The asset is a key node in the Caltrain line, so loss of service could affect transit of up to 58,000 commuters and other travelers each day. This in turn has economic impacts associated with delays and the value of commute hours. A loss of this critical service would disproportionately affect those populations who rely heavily on public transportation for getting to work and who do not have a back-up mode for transit. This often includes lower income populations and those with functional and access needs. Shut down of the BART station is likely to have cascading impacts, as often disruption at one station affects the whole system. Repair and replacement would come with steep economic costs as well: damage to the Caltrain system could cost up to $2.2 million for the station and over $6.75 million for tracks; estimates for replacing the BART station are over $85 million. Even if train service were not disrupted, flooding of the parking lot would limit access and the current bus turn-around would be inaccessible, leading to bus detours and time delays.

Additional Important Information

The City of Millbrae plans to convert a portion of the parking lot, a portion of which is vulnerable to sea level rise as shown in the inundation maps, to transit-oriented development. Ongoing BART and Caltrain upgrade and construction projects consider sea level rise, generally through the CEQA process.

Asset Specific Adaptation

Increasing the height and improving the function of the Highline Canal tide gate could limit Bay water travelling up the canal. The facility itself could be adapted to present day rain-driven flooding and future sea level rise by dry floodproofing existing infrastructure, elevating and floodproofing the BART and Caltrain mechanical/electrical systems, and by closing the grates/vents along the tunnel. Future development and roadways to access the development may require elevation or dry floodproofing as well. Green infrastructure could help mitigate some early impacts related to interior (stormwater) flooding.

Vulnerable Rail Stations

This is the only Asset Vulnerability Profile on vulnerable rail stations in the County. The vulnerability assessment analysis shows that there are two vulnerable Caltrain stations (Redwood City and Hayward Park) and one vulnerable BART station (SF International Airport) in the County.

Trains and train platform at Millbrae Station.

11. HIGHLINE CANAL TIDE GATE

City of Millbrae

VULNERABILITY SUMMARY

The vulnerability of the Highline Canal Tide Gate (Gate) to sea level rise is **high**. The Gates were designed to protect Highline Canal from high tides while enabling the canal to discharge water from the Millbrae stormwater system, the Millbrae Intermodal Station, and Lomita Creek. The Gates themselves are not sensitive to sea level rise, but sea level rise reduces the capacity of the canal to convey stormwater. Future conditions will further reduce capacity of the canal when the Gates stick open, as this will allow higher bay water levels into the canal. This could lead to flooding at the Caltrain Millbrae Station, Lomita Creek (home to protected frog and snake species), and local neighborhoods.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	Low	High

ASSET CHARACTERISTICS

349 S McDonnell Rd | Millbrae

Asset Description and Function:

The Gate is a passive flap gate opened and closed by the tides in San Francisco Bay. At high tide, the Gate closes to prevent tidal water from entering Highline Canal, which serves as one of two stormwater outlets for the City of Millbrae. When the Gate operates as designed, the canal is able to release water as designed from the city's stormwater system, drainage at the Millbrae Intermodal Station, and Lomita Creek discharge. However, the Gates are in poor condition and stick open most of the time, allowing water to enter the canal.

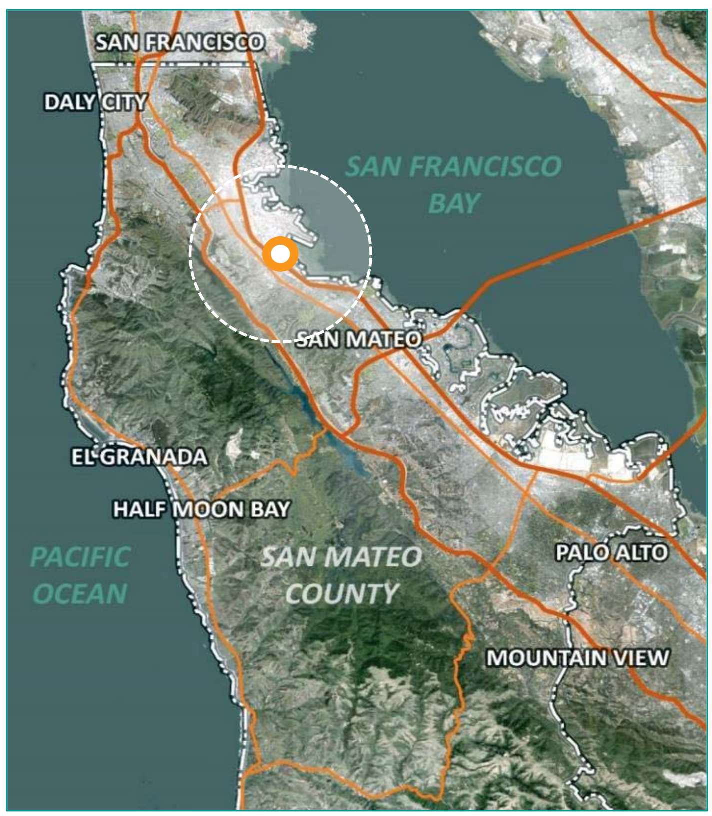
Asset Type	Flood Control Infrastructure
Asset Risk Class	4
Size	2 gates, 15 x 15 feet each
Year of Construction	1965
Elevation	3.2 feet, NAVD88
Level of Use	Serves 15,000 people
Annual O&M Cost	Variable share of $250K
Special Flood Hazard Area	N/A
Physical Condition	Poor
Landowner	City and County of San Francisco

Underground Facilities

No underground facilities were identified.

Environmental Considerations

The Gate receives discharge from Lomita Creek, which is home to protected red-legged frog and garter snake populations. Surrounding areas are potential stopover habitat for migrating avian species.



HIGHLINE CANAL TIDE GATE

ASSET SENSITIVITY

The Gate is passively operated with no underground equipment; therefore, the structure itself is relatively insensitive to sea level rise. However, the Gate currently does not operate as designed and the resulting effects on the Highline Canal and the infrastructure depending on drainage provided by the canal are highly sensitive to sea level rise. When backwater flooding conditions occur, the neighborhoods that drain to Lomita Creek and Highline Canal can be exposed and are sensitive to flooding. Currently, the Gate is in poor condition and does not always close during high tide, allowing high water levels to enter the canal.

Even when the Gate closes, it often leaks water from the San Francisco Bay into the canal. When water levels in the canal are elevated from the San Francisco Bay water, the canal can no longer accommodate the stormwater load from the city, the Millbrae Intermodal Station, and Lomita Creek. This problem would be particularly severe if high water levels (more common with sea level rise) coincided with high rainfall (see Exposure Discussion section).

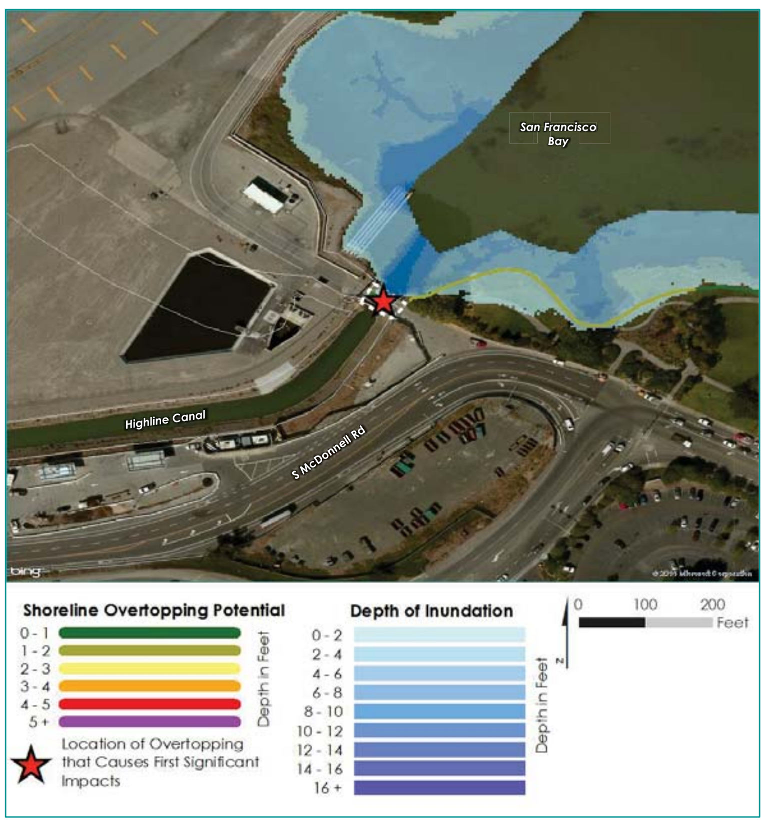
Highline Canal Tide Gates.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

When water surface elevations reach between 12 and 24 inches above the current mean higher high water (MHHW) level, water from San Francisco Bay overtops the Highline Canal Gate, indicated by a red star on the map to the right.

First Significant Impacts: 24 inches above MHHW.



Cross-Cutting Vulnerabilities

Millbrae Intermodal Station drainage system was designed to direct rainfall from a 0.2% annual chance (500-year) storm into the canal, which is only sized for a 4% annual chance (25-year) storm; meanwhile, protected species in Lomita Creek prevent measures to accommodate potential excess flows. Together, these make the system more likely to exceed its capacity and cause backup or flooding. Backup at the Millbrae Intermodal Station (AVP #10) or Lomita Creek (adjacent to Highway 101) (AVP #9) could interrupt train and/or automobile service.

HIGHLINE CANAL TIDE GATE

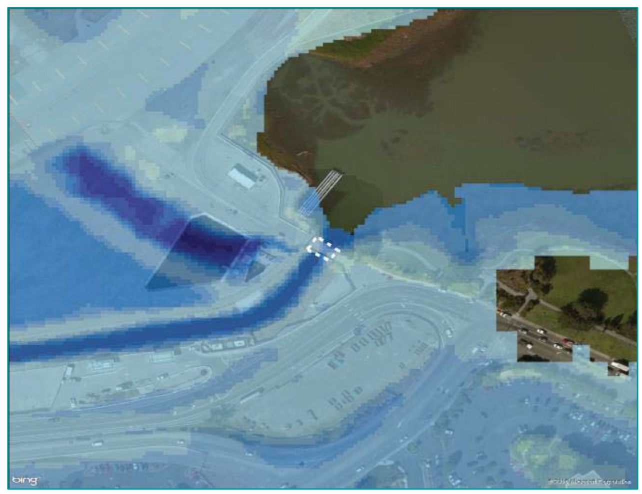
SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

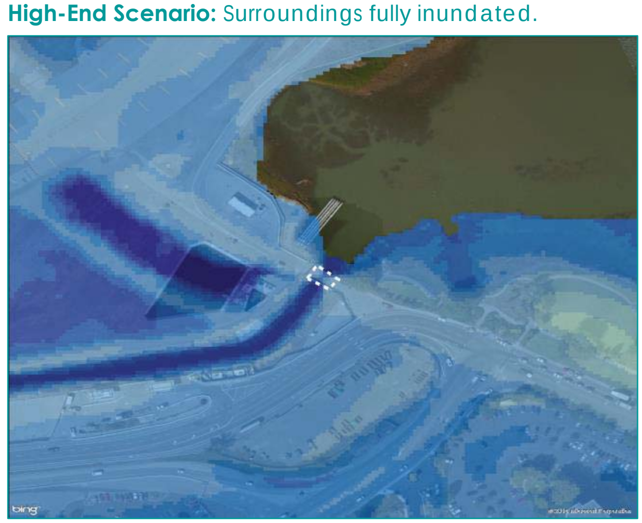
The Gate is moderately exposed to sea level rise. To date, the Gate has not been exposed to surface flooding, and it would take roughly 24 inches of sea level rise to cause overtopping of the gate and fill the Highline Canal (assuming the gate operates as designed). However, when the Gates are stuck open (or if the tide gates were overtopped) then San Francisco Bay water fills the canal, reducing its drainage capacity. When high tides coincide with major rain events, the surrounding areas, such as Lomita Creek and other parts of Millbrae, cannot discharge effectively into the canal (because the canal loses drainage capacity). This causes backup and flooding in the Bayside Manor, Marina Vista, and Landing Lane neighborhoods in Millbrae. If the gate remains unfixed (open), higher water levels from sea level rise will create the backwater flooding conditions more frequently.

Baseline Scenario: Asset is not overtopped.

Mid-Level Scenario: Asset is fully overtopped.



High-End Scenario: Surroundings fully inundated.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(24 inches)*	***0***	***9***
Baseline *1% Flood*	***1***	***8***
Mid-Level *1% + 3.3 feet*	***2***	***12***
High-End *1% + 6.6 feet*	***5***	***15***

HIGHLINE CANAL TIDE GATE

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Gate has low adaptive capacity. It does not rely on electricity so power is not an issue, but there are no alternate or redundant systems to perform the Gate's function. Because it often fails to operate as designed, infrastructure depending on the Gate functions with a variable level of service. Under future conditions, however, the drainage infrastructure that leads to Highline Canal would likely not be able to adapt to continual high water in the canal. Even if the Gate were operational, there is no redundant or alternate system that could relieve stormwater or prevent flooding of the surrounding areas if the Gate were overtopped. Lomita Creek cannot be altered to accommodate more water because it is home to protected frog and snake species.

Consequences

Consequences from damage to the gate or a permanent loss of functionality would be high. The Gate itself is unlikely to fail from flooding, though it could suffer structural damage if overtopped, leading to a direct replacement cost of roughly $1.5 million. More likely, when the canal behind the Gate fills, either due to a broken tide gate or future sea level rise and overtopping, the flooding of surrounding neighborhoods or parts of Highway 101 and San Francisco International Airport could be substantial. This could lead to property damage and major disruptions to traffic for an important expressway (see asset profile for Highway 101 between Pulgas Creek and Whipple Avenue), both of which have economic impacts. Such flooding could also affect up to 15,000 people through property damage in surrounding neighborhoods and exposed areas. This level of flooding in the canal could also cause Millbrae Intermodal Station's drainage system to back up.

Additional Important Information

The Gates currently stick in the mud and stay open during much of the year. In addition, clearing sections of Lomita Creek of vegetation could help alleviate backflooding, but would be difficult due to permitting issues related to protected species. Rehabilitating the Gate could also alleviate the back-flooding issues in the canal. The city is also considering replacing the gates, though this is currently unfunded.

Asset-Specific Adaptation

This asset could be modified by repairing and increasing the height of the Gate. Vulnerability to the area could also be reduced nonstructurally by floodproofing neighboring communities that flood when the canal overflows. Alternatively, the canal could be closed off permanently with a flood wall with the addition of a pump station for drainage during storms. Outside the Gate toward the bay, wetlands could be enhanced to reduce wave and surge impact.

Vulnerable Tide Gates

This is the only Asset Vulnerability Profile on vulnerable tide gates in the County. All tide gates will be vulnerable to sea level rise due to their location on the shoreline. A comprehensive inventory of tide gates in the County was unavailable at the time of this assessment.

Location where vegetation is growing into concrete channel.

Highline Canal.

12. OLD BAYSHORE HIGHWAY AND AIRPORT BOULEVARD

City of Burlingame

VULNERABILITY SUMMARY

Old Bayshore Highway (Bayshore) and Airport Boulevard (Airport) are **moderately** vulnerable to sea level rise. The roads are sensitive to flooding when water is deep enough to limit traffic, restricting the only access to Burlingame's hotel corridor. Exposure is moderate, as high tides prevent rainwater from draining, which creates ponding, isolating parts of the roadway. Adaptive capacity is moderate because there are emergency measures to maintain access and some detours to access businesses; however, none would serve the hotel corridor. Closure of Bayshore could affect Burlingame due to significant revenue loss, and would affect travelers to and from San Francisco International Airport (SFO).

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Moderate	Moderate	High

ASSET CHARACTERISTICS

Old Bayshore Highway and Airport Boulevard | Burlingame

Asset Description and Function:

Bayshore and Airport run parallel to Highway-101, and are primary access routes for much of coastal Burlingame. In particular, they connect travelers from SFO to at least 12 major hotels along Airport, which provide significant income for the city: 35-40% of the annual budget comes from Transient Occupancy Tax from this area. The road also protects underground water mains and utilities that supply the businesses and hotels, and it provides access to a wastewater treatment plant.

Asset Type	Ground transportation (Local Road)
Asset Risk Class	3
Size	4 linear miles
Year of Construction	1960s
Elevation	7 feet (average)
Level of Use	34,100 vehicles/day
Annual O&M Cost	Portion of $2M budget
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	City of Burlingame

Underground Facilities

Water mains, storm drain outlets, utilities for businesses are underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

OLD BAYSHORE HIGHWAY AND AIRPORT BOULEVARD

ASSET SENSITIVITY

The asset is moderately sensitive to inundation. Bayshore and Airport are the main access routes to much of coastal Burlingame. Therefore, if they were inundated, access to most businesses and to other facilities could be impacted; however, a detour may be possible in some locations. Because Airport and Bayshore provide the sole access road to many of the hotels, if it were inundated, businesses along this road would be isolated and inundated. Road access to the Burlingame wastewater treatment plant (WWTP) would be eliminated, and access to other underground utilities would also be affected.

There are different access points for Airport, so inundating different sections would only isolate those sections. A number of the assets in this area that can be accessed by the road are also likely sensitive to inundation; however, the effects on the hotels, parks, and businesses were not evaluated.

Bayshore Highway connects to multiple hotels near the airport.

SHORELINE VULNERABILITY

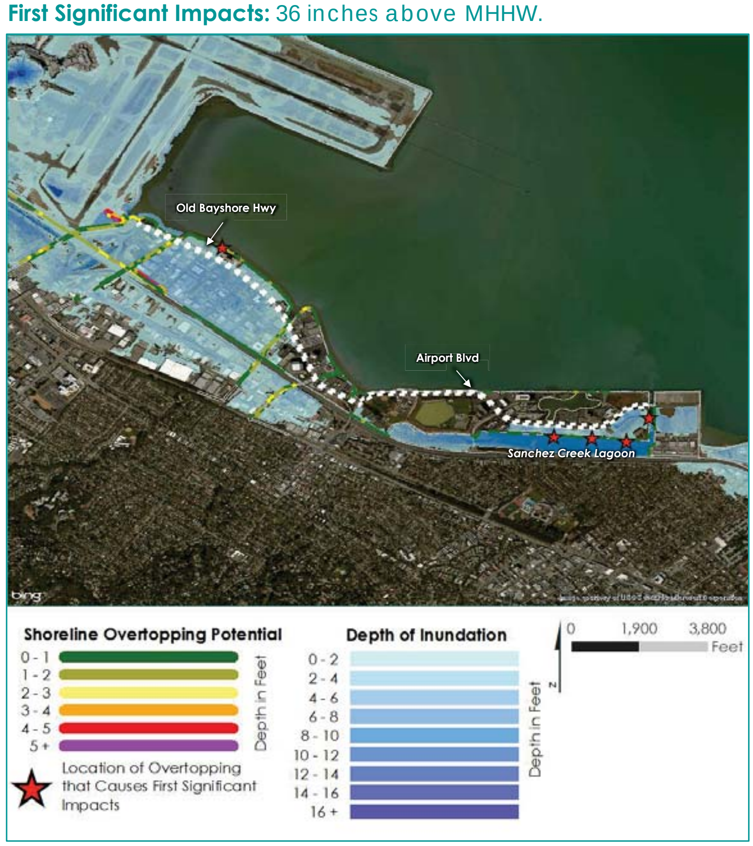
Shoreline Overtopping Analysis

The northwestern portion of the shoreline is first overtopped (red stars on map) when water surface elevations are between the current mean higher high water (MHHW) level and 12 inches above. Meanwhile, the southeastern portion is first overtopped (red stars on map) when water levels reach 12 to 24 inches above MHHW. The first significant impacts occur when water surface elevations are between 24 and 36 inches above the current MHHW level. (Overtopping discussion continues in Exposure Discussion section on next page).

Cross-Cutting Vulnerabilities

Though the creeks were modified and designed to pass 1% annual chance water levels, any storms coincident with high tides would increase the likelihood of flooding on Bayshore. The shoreline that protects the road is mostly in private ownership, and the floodwall is under the jurisdiction of the San Francisco Bay Conservation and Development Commission (BCDC), making Bayshore vulnerable to the decisions and management of many others.

First Significant Impacts: 36 inches above MHHW.



OLD BAYSHORE HIGHWAY AND AIRPORT BOULEVARD

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

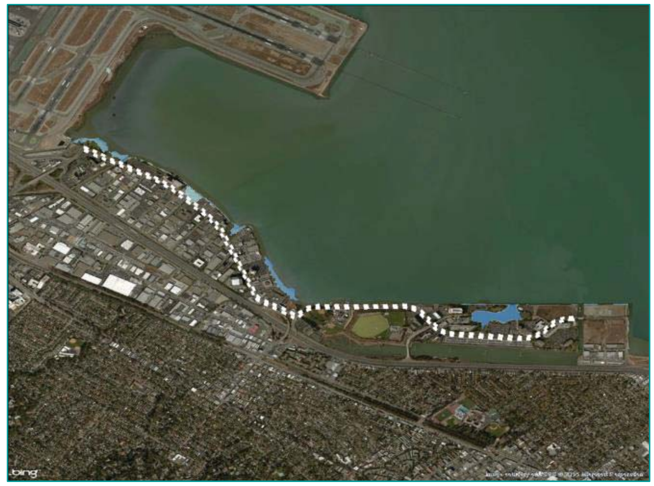
Bayshore is moderately exposed to sea level rise. The roadway has not been fully submerged in the past, though isolated areas have been flooded. This happens when high tides coincide with heavy rains, giving water nowhere to drain. Exposure of the asset to impacts of sea level rise is therefore moderate, despite the fact that even the baseline scenario (to the right) shows minimal flooding of the asset (2 feet deep maximum).

There are two low sections of shoreline that could cause coastal flooding on this segment of Bayshore. The first is a low spot of the shoreline adjacent to San Francisco Bay, roughly 300 feet to the northeast of the northwestern section of the road (northernmost red star on map, previous page). The other low spots are roughly 300 feet west and south of the southeastern segment of the road, where the Sanchez Creek Lagoon (connected tidally to San Francisco Bay) overtops the embankment (southernmost red stars on map, previous page).

Under increased water levels (mid-level and high-end scenarios), the flood depth and extent on those previously affected areas could expand (up to 7 to 10 feet deep), thereby cutting off access to large segments of the road.

Some businesses and hotels have underground facilities (e.g., basements, garages), parking lots, and first floors that could be exposed to higher water levels.

Baseline Scenario: Minimal flooding of the asset.



Mid-Level Scenario: Many areas of the asset affected.

High-End Scenario: Asset flooded at 13 feet deep.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(36 inches)*	***0***	***7***
Baseline *1% Flood*	***0***	***2***
Mid-Level *1% + 3.3 feet*	***0***	***10***
High-End *1% + 6.6 feet*	***0***	***13***

OLD BAYSHORE HIGHWAY AND AIRPORT BOULEVARD

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of Bayshore and Airport is moderate. The road is in good condition (with 40% of the service life remaining), and flood waters are not likely to damage the roadway itself. In addition, there are response plans, including detours and sandbags, to maintain access during a storm. Effectiveness of those measures, however, depends on the extent and location of flooding. They would likely be insufficient to be efffective if the high-end scenario were to occur. If inundation were extensive enough, there would be no detours available to access businesses, hotels, or critical facilities like Burlingame WWTP on Bayshore or Airport.

Consequences

Direct damages to the asset could be high, and the impact from the loss of revenue would be significant. If the road were damaged, it would cost the city approximately $200 per ton of material to repair and rebuild. However, under severe conditions, access to businesses and hotels on Airport could be lost entirely, which could lead to a loss of 35-40% of revenue for the City of Burlingame and disproportionately impact the vulnerable populations in Burlingame. An inundated roadway would also reduce any available evacuation routes for hotel guests and local businesses should an emergency arise. Flooding of the road may also affect or damage the water and utility lines that are protected by the road, each with its own additional repair costs. There are emergency response plans to provide equipment and detours to protect and maintain access to businesses and hotels along Bayshore and Airport during a flood. Engaging these measures would cost the city money and would likely reduce income at the businesses and hotels. Rerouting traffic if this asset were closed also has costs. Loss of access could result in additional damages caused by flooding at the Burlingame WWTP, if staff are unable to access the site.

Additional Important Information

In the event that the asset were to significantly inundate, many businesses and nearby hotels (in lower lying areas)would be flooded. Any future changes to the shore (e.g., riprap, floodwalls) provide jurisdictional challenges for the City of Burlingame because shoreline projects are subject to BCDC management and private ownership. Therefore, the future vulnerability of Bayshore and Airport depends not only on sea level rise, but also upon administrations outside the City of Burlingame. Future plans that affect the asset include flap gates for the nearby lagoon, though it is unclear whether design of flap gates will consider sea level rise.

Asset-Specific Adaptation

Adaptation options may consider raising the shoreline or building protection along the low spots (identified earlier) to prevent inundation of the asset. Because Bayshore is a linear feature, adaptation may require a regional approach that also addresses shoreline vulnerabilities north and south. Adaptation will be challenging because the area traversed by the roadway is managed by the City of Burlingame, meanwhile individual owners and the BCDC are involved in decision-making affecting this land. Coastal green infrastructure (CGI) in front of the road could help reduce the height of flood waters and diminish the need or size of a flood protection feature on land.

Vulnerable Local Roads

There is another Asset Vulnerability Profile on vulnerable roads in the County: Mirada Road (AVP #28). The vulnerability assessment analysis shows that there are 373.8 miles of vulnerable local roads in the project area, and Bayshore and Airport represent 4 miles.

Bayfront Park at north end of Bayshore Highway.

Image from Google Street View

13. SAN MATEO POLICE STATION

City of San Mateo

VULNERABILITY SUMMARY

The San Mateo Police Station (Station) is a critical facility and **moderately vulnerable** to sea level rise. Exposure is low as the Station is currently protected by the Foster City Levee system, which is 1.7 miles away from the Station. Although the Station lies at sea level, it already experiences water intrusion in the underground garage. Any overtopping of the Foster City Levee system could significantly affect the asset. Critical components (some underground) are sensitive to flooding and would be inoperable if power were lost due to flooding. Adaptive capacity is moderate, as the Station can move law enforcement, 911 dispatch, and Emergency Operation Center (EOC) operations temporarily, albeit with a reduced level of service.

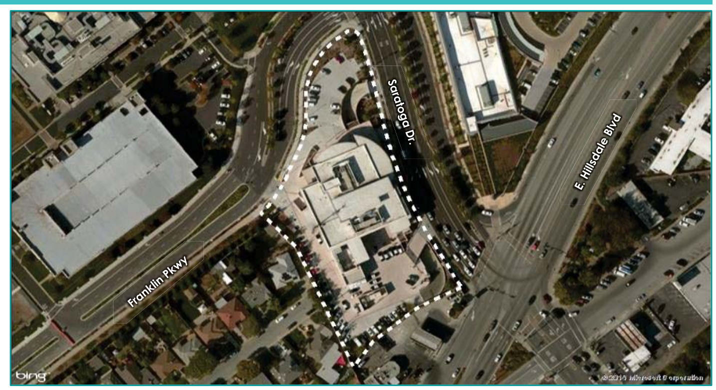
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Low	Moderate	High

ASSET CHARACTERISTICS

200 Franklin Parkway | San Mateo

Asset Description and Function:

The Station serves roughly 105,000 people in the City of San Mateo and Central San Mateo County. The Station houses the City's dispatch center and EOC, if activated, the EOC will support emergencies or planned events. The facility was built in 2006, employs 117 officers, and includes a temporary holding facility and a vehicle fleet garage. It also houses the controls for Caltrans signs for the San Francisco Bay Area.



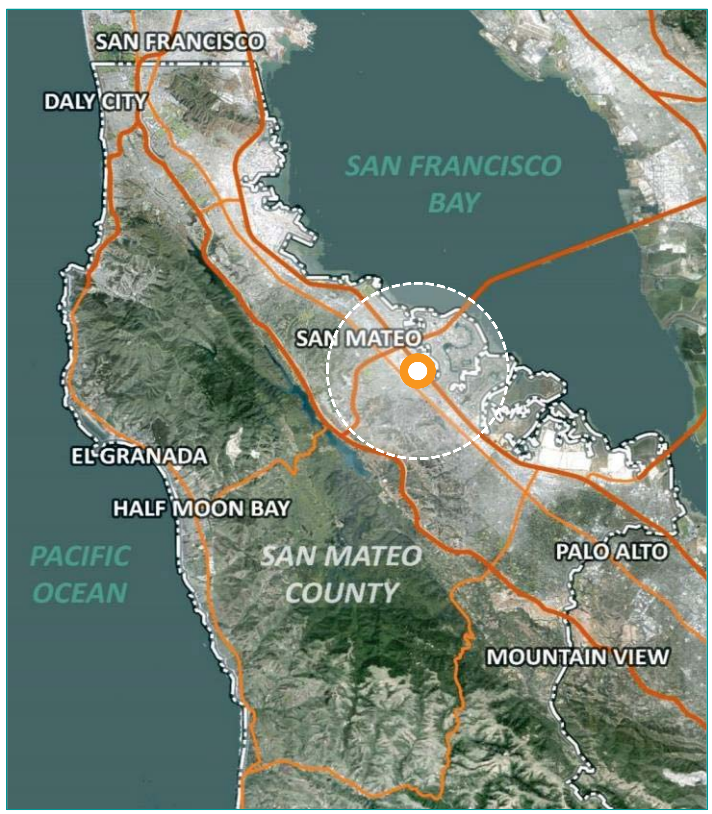
Asset Type	Police Station
Asset Risk Class	4
Size	55,000 square feet
Year of Construction	2006
Elevation	11 feet, mean sea level
Level of Use	Serves 100K+ residents
Annual O&M cost	$85,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Built in 2006
Landowner	City of San Mateo

Underground Facilities

A parking garage, shooting range, armory, storage, fleet vehicles, the main electrical room with dispatch, Uninterruptable Power Supply (UPS), and Caltrans signs controls are underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



SAN MATEO POLICE STATION

ASSET SENSITIVITY

The Station operations and level of service are moderately sensitive to minor flooding, and very sensitive to severe to permanent flooding. The most essential component of the facility is the electricity, without which the Station could not function. The main electrical room and the UPS for dispatch services are located in the basement and could shut down if inundated, despite the five sump pumps, which can generally keep the basement dry during minor flooding. If the Station lost power (main, backup, and/or the distribution system), the emergency 911 dispatch services provided by the department would not be available, and personnel could not respond to calls.

Though the Station has a backup generator with extra fuel on site, power distribution and the circuit board are below grade and could be exposed to deep flood water (though it is designed so minor flooding will drain away); power systems would therefore not function if the site were flooded. The police fleet cars are also stored underground and, if flooded, access and use will not be possible if warning time is insufficient to relocate them. Depending on the warning time and depth of flooding, those in holding cells and other personnel may need to evacuate the facility. The Caltrans controls signs are also sensitive to inundation.

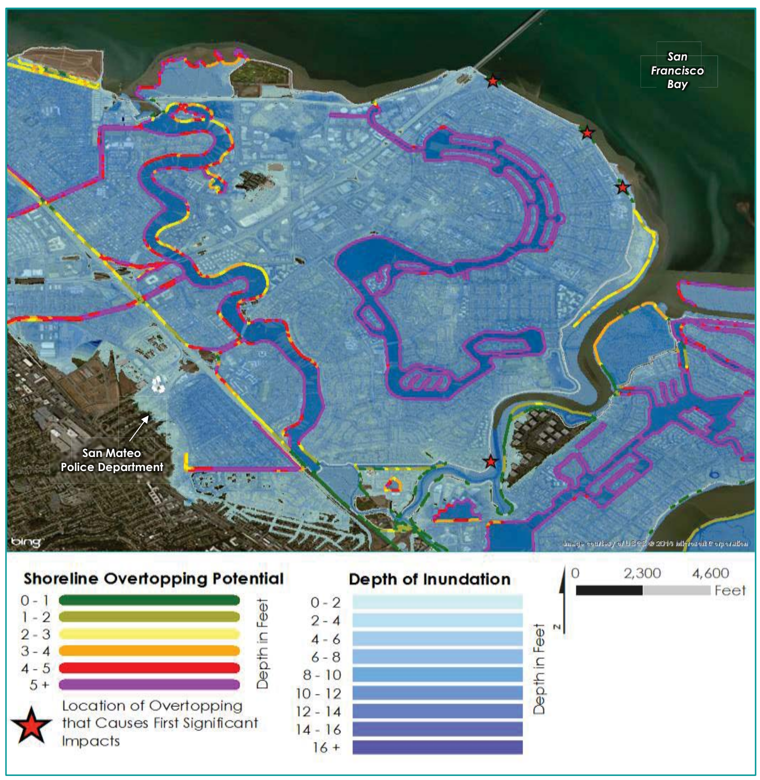
Police department station and specialized vehicles.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

The white arrow shows the location of the Station (see map on the right). The Station is projected to be below sea level when water surface elevations are 0 to 12 inches above current mean higher high water (MHHW). Because the Station is behind a levee, it will likely experience no coastal flooding until that levee overtops or fails. With water 48 to 52 inches above MHHW, water from San Francisco Bay (northeast) and Belmont Slough (southeast) will overtop the Foster City Levee (red stars on map, 2.7 miles from Station) and could reach the Station, assuming no improvements to the levee. However, Foster City is actively working to raise the height of the levee system, which will reduce the exposure of the Station to flooding once completed.

First Significant Impacts: 52 inches of sea level rise.



Cross-Cutting Vulnerabilities

Incoming power, fuel, and road access are critical to the function of the Station and losing these would precipitate a loss of service. This asset serves socially vulnerable populations in the region (many of whom may not have access to a vehicle or may not speak English). They would likely be disproportionately affected if the Station lost the ability to respond in an emergency.

SAN MATEO POLICE STATION

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

Exposure of the Station to the effects of present day coastal flooding and sea level rise is low. The Station is not yet subject to any coastal-influenced flooding because the area is protected by Foster City's levee system (see AVP #24) and the levees on Seal Slough. It will not experience coastal flooding until the levee that protects it is overtopped or fails, at which point the asset could experience significant damage (assuming no action). The facility experiences only temporary flooding (recently in December 2014) from stormwater that flows from street level into the garage entrance ramps. In addition, the Station's underground garage experiences some minor water intrusion through the multiple cracks in the basement wall.

Under future conditions, sea level rise will increase the likelihood of flooding from groundwater intrusion and from San Francisco Bay. The Station is at mean sea level, and with rising sea levels, it will be permanently below sea level, making it dependent on the protection of the Foster City levee. Flooding will not be incremental as the sea level rises, because the asset is protected by a levee. On the contrary, the Station will experience no flooding until the levee overtops, which could occur with water levels between 48-52 inches. Assuming no intervention, this water level could likely flood the Station and any subsurface facilities. It may be possible if this occurred that many other areas in Foster City and the City of San Mateo are flooded as well.

Baseline Scenario: Asset is protected by levees.

Mid-Level Scenario: Asset is fully inundated.

High-End Scenario: Asset flooded 16 feet deep.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(52 inches)*	***0***	***12***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***1***	***13***
High-End *1% + 6.6 feet*	***4***	***16***

SAN MATEO POLICE STATION

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Station has moderate adaptive capacity in a short duration, less severe flood, and moderate adaptive capacity in a severe or permanent flood. Sump pumps in the basement keep the below-ground infrastructure dry during minor flood events, and sandbags are available if needed. The Station has a UPS for dispatch operations and a generator with extra fuel, but these are below and at-grade (respectively) and would not function if inundated. In the case of a severe flood, the vehicle fleet could be moved or relocated at the first signs of flooding. Though unlikely, if not able to be relocated, the Station can rent cars to support basic functions, and the level of service would likely be reduced. If dispatch operations are interrupted due to inundation, staff can forward 911 calls to Burlingame Police Department (elevated, very low vulnerability) and move EOC services to Fire Station 23 in San Mateo to maintain service.

Consequences

Should the Station be flooded from a future storm and lose function, the consequences could be high. However, the County of San Mateo has an emergency operations plan that would be activated if a major flood occurred, which would help minimize impacts to the community from a loss of service of the Station. The Station provides law enforcement services to over 100,000 people, and loss of the ability to respond to calls due to either flooded vehicles or a loss of power at the Station could affect the public health and safety of the entire city. Should a flood occur without time to evacuate, onsite injuries from flooding are possible, although there is not a large staff onsite and there are only a few holding cells. If the police department were permanently damaged, it would cost over $22.5 million to replace.

Additional Important Information

To improve the resilience and preparedness of the citizens in the City of San Mateo in the event of a major emergency (where emergency services are unable to respond), the local fire department provides Community Emergency Response Training. Security threats constrain the location of electrical systems to the basement.

Asset-Specific Adaptation

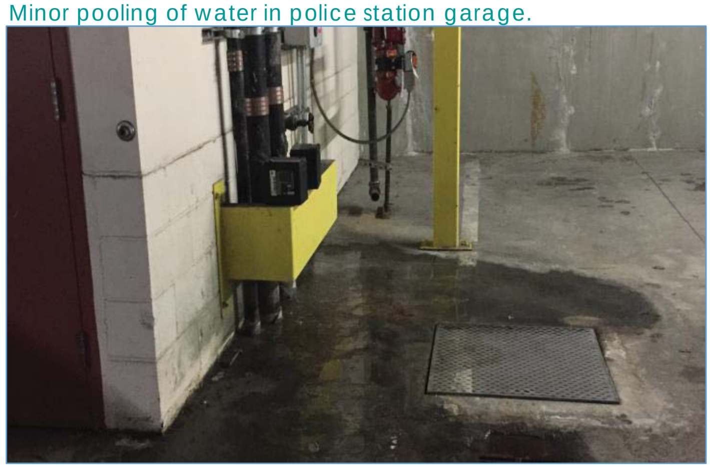
To reduce the likelihood of losing power, the power system and backup could be floodproofed and elevated above grade. In the near-term, additional flood mitigation measures could be implemented, such as floodproofing the entire facility, blocking water access to the basement, and relocating the fleet. Regionally, Foster City has plans to elevate the levee nearby to address sea level rise, which means that the likelihood with which the Station could be exposed to coastal flooding would be further reduced.

Vulnerable Police Stations

This is the only Asset Vulnerability Profile on vulnerable police stations. The vulnerability assessment analysis shows there are three vulnerable police stations in the project area, including those in Foster City, Millbrae, and Half Moon Bay.

Power systems in the basement of the station.

Minor pooling of water in police station garage.



14. SILICON VALLEY CLEAN WATER WASTEWATER TREATMENT PLANT

Silicon Valley Clean Water (Joint Powers of Authority)

VULNERABILITY SUMMARY

The Silicon Valley Clean Water Wastewater Treatment Plant (Plant) is **highly vulnerable** to the impacts of sea level rise. The asset is very sensitive to loss of power, which would result in a complete loss of service of the Plant. Currently, the Plant is not exposed to coastal flooding; however, most of the Plant's critical components are at or below sea level. Shoreline overtopping or failure of the levee system that protects the Plant, therefore, could have catastrophic consequences for the functionality of the Plant. Adaptive capacity onsite is low, and there is no other facility that could treat influent (untreated wastewater) from this service area.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Low	Low	High

ASSET CHARACTERISTICS

1400 Radio Rd | Redwood City

Asset Description and Function:

The Plant treats wastewater for the cities of Belmont, Redwood City, San Carlos, and the West Bay Sanitary District. The West Bay Sanitary District provides services to City of Menlo Park, Atherton, Portola Valley, and areas of East Palo Alto, Woodside and unincorporated San Mateo. Influent is received from five major pump stations in Redwood Shores, Belmont, San Carlos, Redwood City, and Menlo Park. The conveyance system uses a pressurized force main to convey flows to the Plant, which is below sea level. Effluent (treated wastewater) discharges through a pipe with a one-way valve along the bottom of San Francisco Bay near the San Mateo Bridge. The system also includes two volume control equalization ponds located near Bedwell Bayfront Park.

Asset Type	Wastewater treatment plant
Asset Risk Class	3
Size	2,000,000 square feet
Year of Construction	1980
Elevation	Below sea-level to 11 ft.
Level of Use (Dry Weather)	29 million gallons/day
Annual O&M Cost	$23,000,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Good
Landowner	South Bayside System Authority

Underground Facilities

There are pump and piping galleries, mechanical and electrical equipment, and a pump control center below ground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area. A more detailed analysis will be needed before implementing adaptation strategies.

SILICON VALLEY CLEAN WATER

ASSET SENSITIVITY

The Plant is extremely sensitive to coastal flooding and less sensitive to groundwater seepage or saltwater intrusion. The main power feed and distribution system (located at the southwest end of the property) is the Plant's most critical component, and if it were flooded, plant power and service would be lost. The electrical system that controls the effluent pumps is also an essential component of the Plant, and it is located underground. The plant has sump pumps, which are active 24 hours/day to prevent groundwater seepage from affecting plant components; however, a power loss could prevent the pumps from working, at which point water seepage could begin to affect plant components.

The Plant's main power supply comes from PG&E and its own cogeneration system. The cogeneration system consists of internal combustion engines that use digester gas to generate more than half of Plant's power demand. In case of utility power outages, the cogeneration system also shuts down. There are backup diesel generators that provide power in the event of utility power outages; however, they all depend upon the electrical distribution system, which means, if the electrical system is inundated, the generator will not work. The backup generator is also sensitive to flooding because its fuel supply system could be damaged by prolonged flooding.

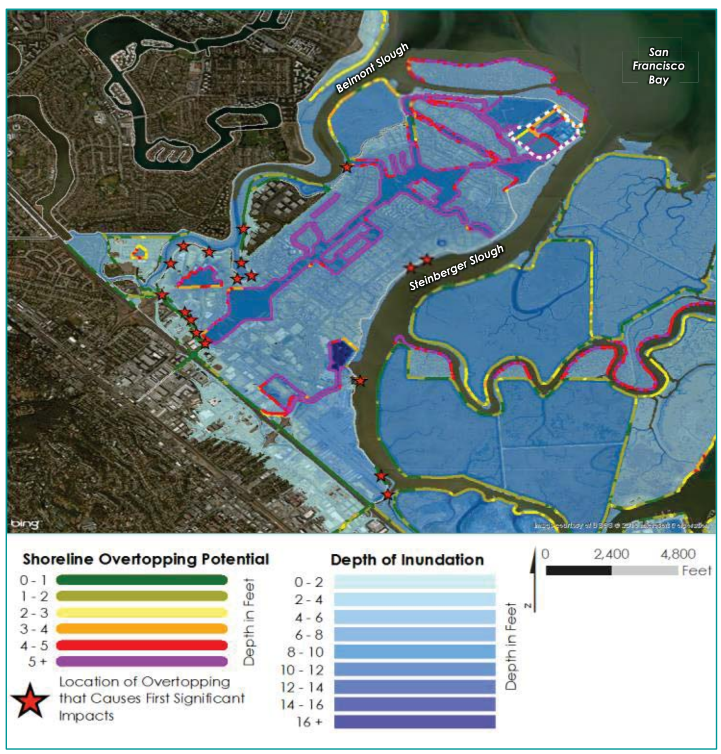
Essential pump control station is underground.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

The Plant is below sea level and protected by the levee system that protects Redwood Shores, which means it will experience no coastal flooding until the levee is overtopped or fails. When water surface elevations reach between 36 and 48 inches above mean higher high water (MHHW), water from Belmont and Steinberger Sloughs overtops the system of levees and berms protecting Redwood Shores (see red stars on map), creating a potential flow path to the asset. The Plant is approximately 1 mile from the nearest overtopped section of levee.

First Significant Impacts: 48 inches of SLR above MHHW.



Cross-Cutting Vulnerabilities

The Plant is wholly dependent upon its five pump stations; if any of the pump stations were affected by flooding, this could disrupt the level of service at the Plant. The Plant is also very sensitive to changes in elevation of any of its components; this is critical for adaptation.

SILICON VALLEY CLEAN WATER

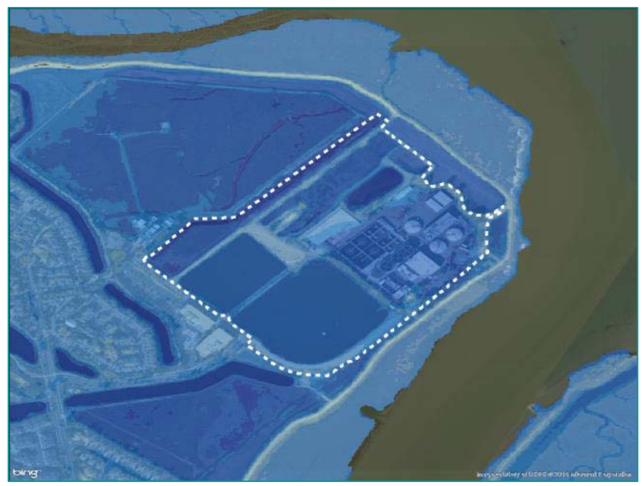
SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

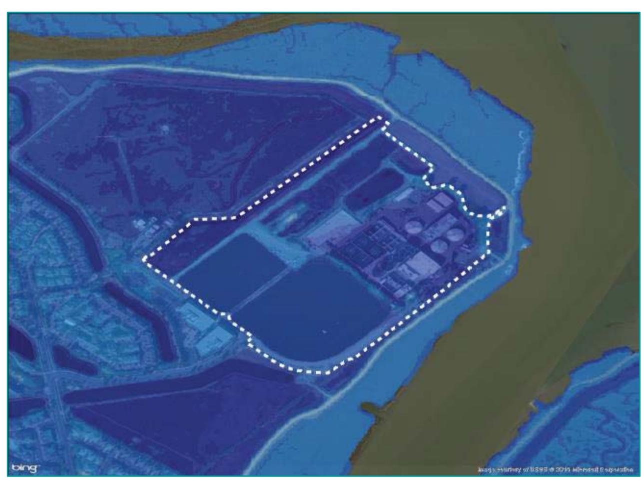
Current exposure is low, as the asset is protected by a levee managed by Redwood City and by a small portion of fiberglass sheets along the northeastern perimeter of the property. To date, the site has not experienced any coastal flooding, but there is evidence on site of water seepage through cracks in gallery floors. As with other assets protected by levees, exposure will remain low until the levee system is overtopped by high water in San Francisco Bay, or until it fails. After this point, flooding would be widespread, inundating the entire area that is protected by levees to water levels consistent with the water level in the Bay. Once overtopped, which could occur between 36 and 48 inches of sea level rise above MHHW (see "Shoreline Overtopping Analysis") or during a severe storm (see "Baseline Condition" on the right), water could flood 13 feet deep. With the high-end sea level rise scenario, flood waters could range from 5-18 feet deep. The Plant's main power feed and distribution system are at street level and would be flooded if the levee overtopped or failed. Many of the Plant's essential components are below ground; minor flooding would likely not be deep enough to reach the entrances because they are elevated roughly 9 feet above grade. However, because deep flooding that results from an overtopping of the levee system could result in water levels higher than the building entrances, these low-lying components are still at risk of flooding in the long-term.

Baseline Scenario: Asset not flooded.

Mid-Level Scenario: Flooding up to 15 feet deep.



High-End Scenario: Asset under 18 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(48 inches)*	***0***	***13***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***2***	***15***
High-End *1% + 6.6 feet*	***5***	***18***

SILICON VALLEY CLEAN WATER

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Near- and long-term adaptive capacity are low as explained; there is no other wastewater treatment plant that could treat waste for this service area, and major improvements would require adaptation. The Plant cogenerates a significant amount of its own power using methane from the digesters onsite; however, policy requires that main power (PG&E feed) operates alongside the cogeneration, meaning if the main power feed is lost, the onsite power generation system (cogeneration) will shut down. The asset also has three backup generators at higher elevations with 5-6 days of diesel fuel to run them, but the fuel system itself is at a lower elevation and is vulnerable to flooding.

Consequences

The impacts of a temporary or permanent loss of the Plant would be high due to the scale of potential economic, environmental, and public health and safety consequences. Coastal flooding could cause direct damages that require repair or full replacement of any of the critical plant components. A loss of the Plant's power may result in sewage overflows onsite, which could threaten the health and safety of plant personnel who come into contact with it. Flooding also poses a health and safety hazard to the roughly 80 staff onsite due to potential electrocution, or due to exposure to floodwaters. Cascading impacts could be created if the plant were shut down; in this case, flooding or sewage overflow is possible at the pump stations offsite. Sewage backup is also possible in any number of manholes in the service area. This could affect businesses and residents who may be forced to evacuate. Up to roughly 200,000 people, including residents and businesses, could be affected. The release of untreated sewage directly into San Francisco Bay would have water quality and environmental impacts and could result in fines.

Additional Important Information

Improving cogeneration system capabilities to generate onsite power in island mode (with PG&E power outage) would greatly improve near-term adaptive capacity of the asset. New buildings onsite will be located where the temporary pond is now. The Plant undergoes regular capital improvement plan cycles, and they will consider sea level rise as new capital assets are built.

Asset-Specific Adaptation

In the near-term, the critical/electrical components could be floodproofed or elevated so the Plant could maintain functionality in the event of overtopping. It may also be possible to send an alarm to customers to reduce water use to minimize sewage backup. In the long-term, it may be necessary (though difficult) to relocate the Plant to higher ground, or raise the structural shoreline protection to reduce the likelihood of exposure. Because the Plant is already below sea level, elevating any of the components onsite affects the flows of all other components onsite.

Vulnerable Wastewater Treatment Plants

There are Asset Vulnerability Profiles on the following vulnerable wastewater treatment plants: SAM Plant (AVP #2) and SSF-SB WQCP (AVP #23). The vulnerability assessment analysis shows that there are seven vulnerable wastewater treatment plants in the project area, including those in the City of Millbrae, City of San Mateo, City of Burlingame and at SF International Airport.

Ongoing upgrades and maintenance of the WWTP.

Sump pumps reduce groundwater seepage impacts.

15. SAMTRANS NORTH BASE FACILITY

San Mateo County Transit District

VULNERABILITY SUMMARY

The San Mateo County Transit District (SamTrans) North Base Facility (Facility) is **moderately vulnerable** to sea level rise. Flooding of the island or access road restricts bus access to the site (including a disaster relief bus), and the Facility would lose most functions (including its emergency relief function), making this asset very sensitive. The access road has not yet flooded, but could be exposed with water levels 24-36 inches above mean higher high water (MHHW). Adaptive capacity is moderate, as most functions could be performed elsewhere. Consequences of a loss of the asset or its functions could be high and would have a regional impact because the Facility serves all of San Mateo County.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*Moderate*	*Moderate*	*High*

ASSET CHARACTERISTICS

301 North Access Rd | South San Francisco

Asset Description and Function:

The Facility is the maintenance and operations facility for SamTrans, and it stores and serves SamTrans' bus and Redi-Wheels paratransit fleets. It also hosts one disaster relief bus that provides a critical service during emergencies. The Facility operates as the bus dispatch center and provides fueling, washing, and heavy-maintenance services. It employs 270 staff and its fleet serves 13.5 million riders per year (as of 2015).

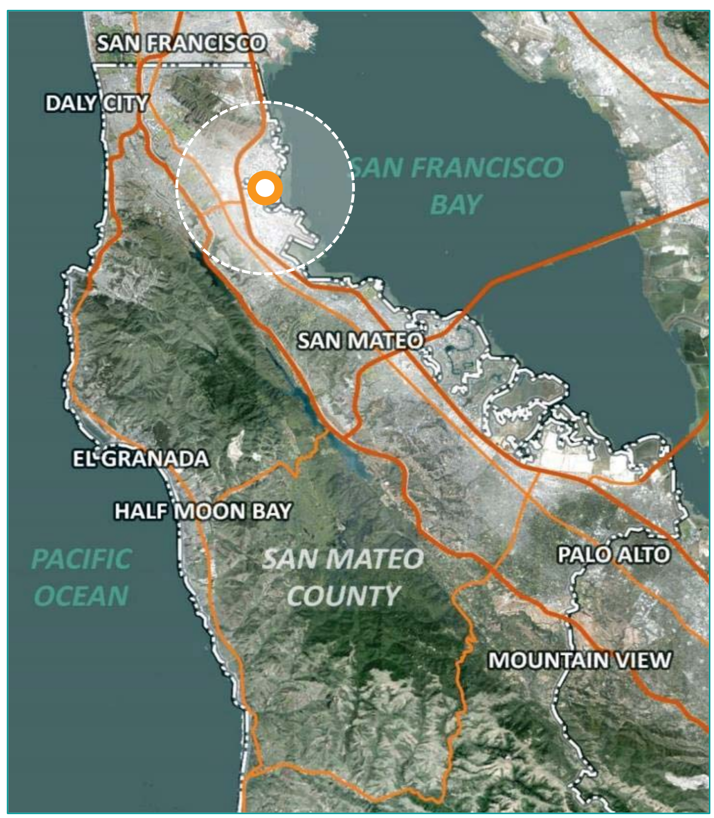
Asset Type	Public Transportation Infrastructure
Asset Risk Class	3
Size	27 acres
Year of Construction	1988
Elevation	-2 to 15 ft, MHHW
Level of Use	165 vehicles
Annual O&M cost	$575,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	San Mateo County Transit District

Underground Facilities

Storm drains and outfalls, fuel tanks, oil-water separators, and electrical infrastructure are underground.

Environmental Considerations

There is a bird sanctuary at the north end of the island. The island and surrounding area provide several "pocket" habitats from the sub-regional habitat corridor, including sand beaches, eel grass, oyster beds, macroalgal beds, mudflats, rocky intertidal areas, and tidal marshes.



SAMTRANS NORTH BASE FACILITY

ASSET SENSITIVITY

The Facility is highly sensitive to flooding. If the yard flooded, buses and other vehicles would no longer be able to access the site, making it impossible to fuel or to be repaired here. If below-grade assets like fuel tanks, electrical conduits, and oil-water separators were inundated, there are no systems in place to remove water from them or maintain their function. While the electrical infrastructure can tolerate moisture, it could not function if flooded, especially by saltwater, which could cause corrosion.

Depending on the severity of temporary flooding, the Facility could be inoperable for seven days or more, potentially leading to a higher rate of bus breakdowns and further disruption to transportation services in the County.

The underground fuel tanks are dual-walled and anchored, with secondary containment piping and monitoring systems, so they are not considered vulnerable to inundation or saltwater intrusion.

One of the oil-water separators is a new, spill-resistant model, but the other is more vulnerable. If the facility were to flood, water could enter the second separator, causing it to overflow and release its contents, onto the site and into San Francisco Bay.

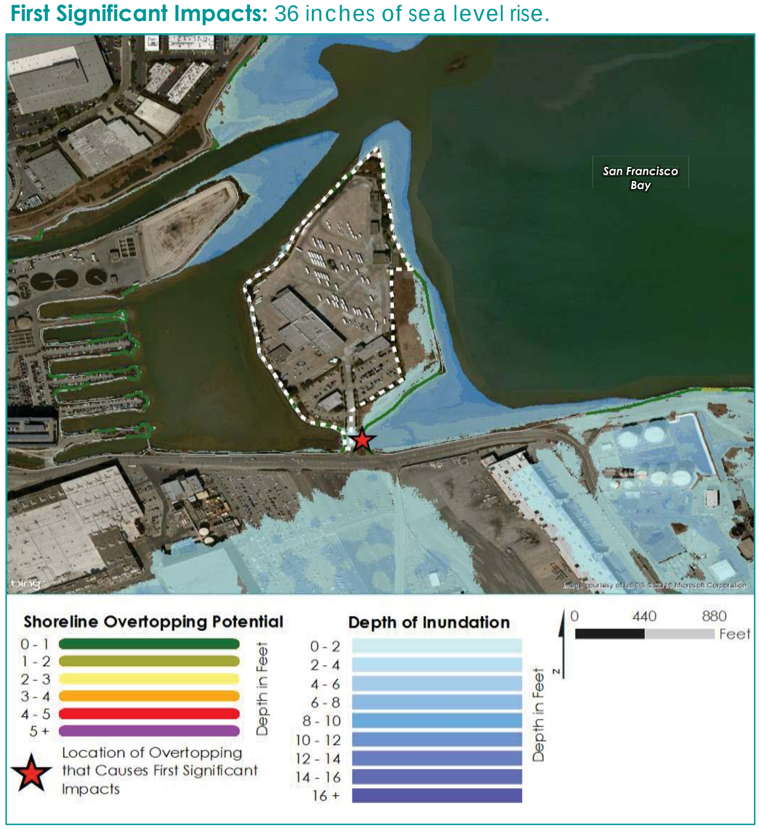
Main yard and buses at SamTrans North Base Facility.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

When water surface elevations reach 12-24 inches above the current MHHW level, San Francisco Bay water could overtop the berm to the east of the entrance road of the Facility (see red star on the map to the right). The first level of inundation that is expected to cause significant impacts to the Facility, however, does not occur until water elevations reach 24-36 inches above MHHW.

First Significant Impacts: 36 inches of sea level rise.



Cross-Cutting Vulnerabilities

The Facility supports public transportation service across the county, and loss of service at the base would make it more difficult for vehicles to refuel or be repaired. This could limit mobility for many in the County, especially in resource-limited communities or those with functional and access needs who rely heavily on public transportation. Furthermore, the asset is home to one of SamTrans' Disaster Relief Buses, which could be trapped at the Facility and unable to assist communities during a disaster.

SAMTRANS NORTH BASE FACILITY

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Facility is moderately exposed to sea level rise. Currently, the west side of the Facility experiences wind and tidal erosion without affecting the entire Facility. The Facility lies far above MHHW that it has not been exposed to inundation from San Francisco Bay to date. The Facility's bus parking lot is 4 feet above MHHW, and the two critical buildings (transportation/operations and maintenance/tires) are 15 feet above MHHW. Below-grade infrastructure experiences groundwater flooding during king tides and heavy rains, seeping through cracks in the concrete of the auto shop brake pits. Higher water levels would lead to more frequent inundation and deeper inundation. The southwestern corner of the Facility is low-lying and particularly vulnerable and could flood during severe storms. If the road connecting the Facility to the mainland were to flood (has not happened to date), access could be eliminated, shutting down the Facility as previously mentioned.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(36 inches)*	***0***	***2***
Baseline *1% Flood*	***0***	***4***
Mid-Level *1% + 3.3 feet*	***0***	***4***
High-End *1% + 6.6 feet*	***1***	***8***

Baseline Scenario: Access road flooded 4 feet deep.

Mid-Level Scenario: SamTrans Island mostly inundated.

High-End Scenario: Asset is fully inundated.

SAMTRANS NORTH BASE FACILITY

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The facility has relatively moderate adaptive capacity. In the case of a loss of complete service, all the facility's functions could be relocated to the SamTrans South Base Facility in San Carlos, assuming this facility (adjacent to San Carlos Airport) was not inundated. SamTrans has a plan in place for an earthquake, but this could also be enacted for severe flooding. The plans assume vehicles could leave the facility, at which point the dispatch, fueling, and repair operations would be transferred to San Carlos; however, if North Access Road were inundated, the vehicles would be isolated (affecting the adaptive capacity of the SamTrans network). The facility has backup generators at grade and subject to future inundation, but an event that flooded the generators would also flood the facility yard and interrupt service with or without backup power. The auto shop brake pits are equipped with sump pumps to mitigate groundwater flooding.

Consequences

Inundation of the asset would have high consequences, with the impacts felt regionally. The Facility has day and night shifts (200 and 15 workers, respectively), so the time of inundation affects both the number of people evacuating and the respective risk of injury. If the Facility were flooded, some or all components would need replacement at a total cost of over $21 million, excluding vehicles. Water quality and resulting environmental and public health impacts are also possible if the oil-water separators spilled into floodwaters. Buses onsite during inundation would be out of service, reducing the level of transportation service county-wide, and adding to the repair/replacement cost. While most functions could be assumed by the SamTrans South Base Facility in San Carlos, buses would be required to travel farther for fuel and repairs, which could reduce service across the County. This disruption would disproportionately affect vulnerable populations such as senior citizens and resource-constrained residents who rely heavily on public transportation. Inundation could also strand the Disaster Relief Bus on site, reducing emergency response capabilities.

Additional Important Information

The northwest side of the island is subject to erosion from wind, waves, and channeled currents. An erosion and mitigation study is underway to investigate and address this issue.

Asset-Specific Adaptation

The Facility could employ non-structural methods like early evacuation plans and floodproofing essential assets. It could also use structural methods like riprap on the eroding west side or raising North Access Road in collaboration with the City of South San Francisco. More conventional solutions could be complemented with green measures. As over the long run, it could be very expensive to maintain and protect the full perimeter of the asset from sea level rise, it may be necessary to identify sites for relocation.

Vulnerable Transit Facilities

This is the only Asset Vulnerability Profile on vulnerable transit facilities in the County. The vulnerability assessment analysis shows that there are two vulnerable bus facilities in the County: the SamTrans North Base Facility in SSF and the SamTrans South Base Facility in San Carlos.

Fueling station at SamTrans North Base Facility.

Auto shop at the SamTrans North Base Facility.

16. SAN CARLOS AIRPORT

Managed by San Mateo County

VULNERABILITY SUMMARY

San Carlos Airport (Airport) is **moderately vulnerable** to sea level rise. All airport components are very sensitive to salt water, and even minor inundation would halt airport operations; flooding would require the replacement of many pieces of saltwater-exposed equipment. Asset exposure is low, though a low section of levee required for takeoff and landing provides a pathway for inundation. Adaptive capacity is moderate, as levees could be raised outside the takeoff and landing zones in the long run. Planes could land and refuel at other nearby airports if the asset were flooded in the near term. Economic losses would be very high, and loss of the asset could have regional implications.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*Low*	*Moderate*	*High*

ASSET CHARACTERISTICS

620 Airport Way | San Carlos

Asset Description and Function:

San Carlos Airport is a reliever airport for the nearby San Francisco International Airport (SFO) and it supports roughly 350 flights per day, hosting private aircraft from several large companies in the County. The asset hosts over 400 aircraft, one airstrip, and an aviation museum that offers special programs for children. The Sheriff's Air Squadron on site stores equipment for the Office of Emergency Services (OES), and manages and fuels airplanes and helicopters during emergency situations.

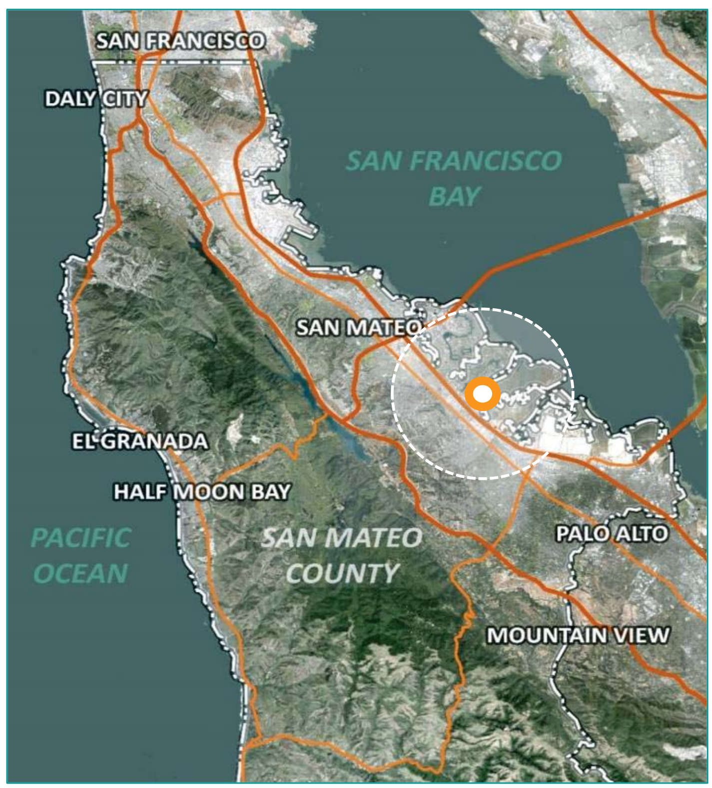
Asset Type	Airport
Asset Risk Class	4
Size	70 acres
Year of Construction	1954
Elevation	4 feet above MSL
Level of Use	135,000 annual flights
Annual O&M cost	$1.5 million
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	County of San Mateo

Underground Facilities

The electrical network for runway lighting is underneath the runway; storm drains are also underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



SAN CARLOS AIRPORT

ASSET SENSITIVITY

The asset, its functions, and its major components are highly sensitive to inundation, particularly salt water. While the runway itself may not be damaged by floodwaters, the site is very flat, so even low levels of flood water would easily cover much of the airport grounds, rendering the facility out of service for over 7 days and requiring the rerouting of 350 flights per day. The airfield lighting system and all other major asset components are very sensitive to salt water. If wheels on any of the more than 400 aircraft stored on site made contact with salt water, they would need to be replaced, and if any part of an aircraft body were submerged, it would be deemed unsafe for flight.

The power system would not function if flooded, and inundation of the runway and other facilities would directly impact (prevent) first responder access during disaster relief efforts, rendering OES personnel unable to respond to disaster situations. While all fuel and hazardous materials are stored above ground, it is assumed that the hazardous materials containment could leak if partially submerged in a flood. If the site were flooded, all education programs that take place at the aviation museum (which include mulitlingual programs designed for non-native English speakers in the community) would be cancelled.

Aircraft at San Carlos Airport.

SHORELINE VULNERABILITY

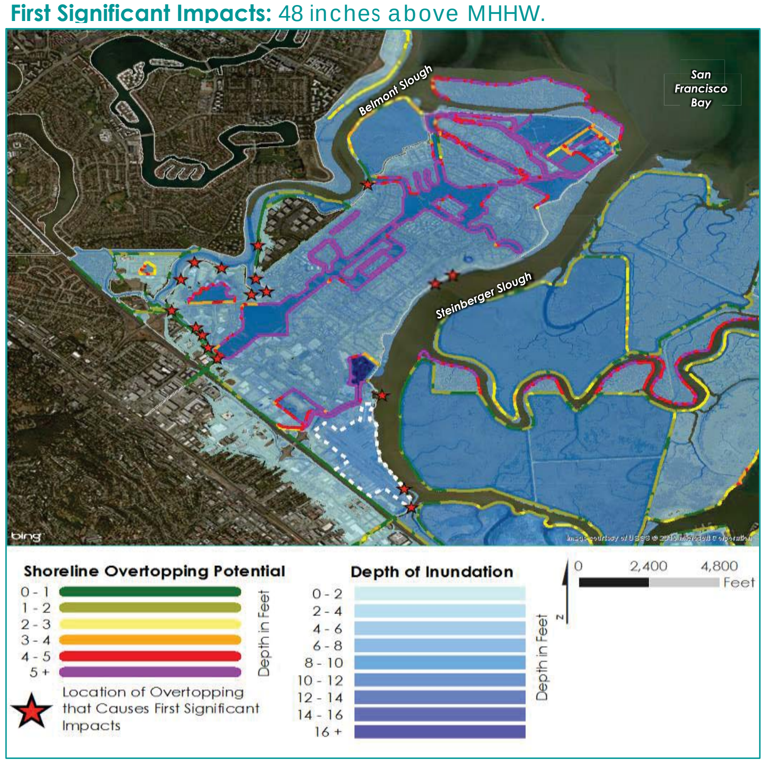
Shoreline Overtopping Analysis

With 0-12 inches of sea level rise above mean higher high water (MHHW), the asset will be below sea level and dependent on levees for 24 hours/day. The asset will experience no coastal flooding until water from Belmont Slough and Steinberger Slough overtops the levee system along the southeastern shoreline (red stars). This is projected to occur between 36 and 48 inches of sea level rise, at which point widespread flooding is likely.

Cross-Cutting Vulnerabilities

The Airport provides emergency response services that would be crippled if it were inundated. The facility houses and maintains the Sheriff's Air Squadron and coordinates emergency response and housing and refueling airplanes and helicopters during an emergency. Cross-jurisdictional responsibilities could present a vulnerability because the asset falls within San Carlos and Redwood City jurisdictions; both cities' Public Works departments coordinate information, funding, and decision-making.

First Significant Impacts: 48 inches above MHHW.



SAN CARLOS AIRPORT

SEA LEVEL RISE EXPOSURE ANALYSIS

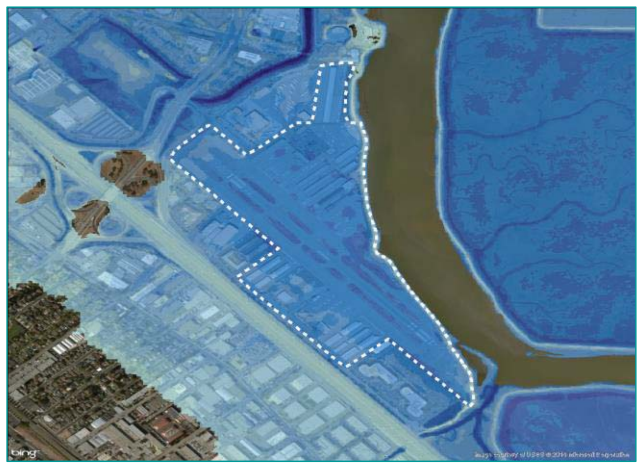
Exposure Discussion

The Airport has relatively low exposure to flooding and inundation from sea level rise. The asset has not been previously inundated from coastal flooding, as it is protected by the levee system connected to the Redwood Shores neighborhood. The levee is owned by Redwood City and was designed to meet federal standards for a 1% flood.

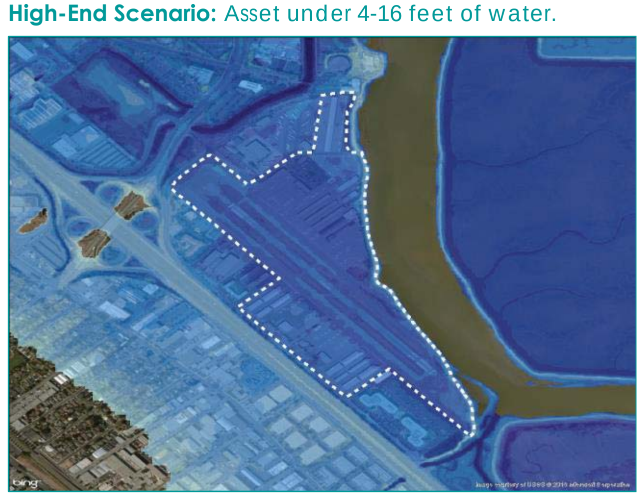
Most of the levee is 12.5 feet above mean sea level, and even during a king tide the crest is several feet above the water. However, there is one 460-foot-wide gap in the southeastern part of the levee to allow planes to take off and land safely without obstructions. Though this section could provide a pathway for overtopping, a temporary barrier is installed during high water events. Under future conditions with higher water levels in the San Francisco Bay, the levee system surrounding the airport would no longer be able to accommodate the same design (1%) flood, and water could overtop the levees, either by wave action or due to water levels exceeding the crest elevation. If the temporary barrier were not installed in time or if there were a failure where it joins the rest of the levee system, this flood could happen quickly and damage large areas of the airport grounds because the site is so flat (see maps on the right). In the baseline scenario, water could flood the site up to 10 feet deep. Under the high-end scenario, water could flood the asset up to 16 feet deep.

Baseline Scenario: Asset not inundated in 1% flood.

Mid-Level Scenario: Flood depths up to 12 feet.



High-End Scenario: Asset under 4-16 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(48 inches)*	***0***	***13***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***1***	***12***
High-End *1% + 6.6 feet*	***4***	***16***

SAN CARLOS AIRPORT

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the asset is moderate. Under high-water conditions, a temporary barrier will be erected to close the 460-foot gap in the levee to prevent coastal flooding. Four stormwater pumps can also reduce the extent of rain flooding on site. However, these pumps are only able to pump freshwater, making them ineffective in removing any salt water that overtops the levee. If the airport were inundated and the pumps were ineffective, 350 flights per day would have to be rerouted to other airports around San Francisco Bay. Provided the generator and power distribution remain dry, generators can power the stormwater pumps and airfield lighting for up to 3-4 days in the event of a power failure.

Consequences

Consequences from a loss of this asset would be extremely high. Airfield lighting and structures like hangars would corrode with saltwater exposure and would need to be replaced. Inundated fuel tanks could leak jet fuel or leaded aviation fuel, releasing hazardous materials into Steinberger Slough. If out of service, the Airport could lose approximately $5,000 per day. Over 400 aircraft owners would lose access to their vehicles and more than 40 businesses based at or dependent upon the Airport would be closed until the facility was rehabilitated. Full replacement of the airport and aviation museum is estimated at $75-$100 million; if all airplanes needed replacement, it could add an additional $100 million in repair costs. Because the asset serves as a reliever airport for SFO, SFO would be required to find another facility to support its overflow. The more than 300 people at the airport during the day, including staff, aircraft pilots and owners, and visitors to the aviation museum would have to be evacuated. This could cause injuries, especially if a levee breach occurred or if people were exposed to hazardous materials like leaded aviation fuel. Employees would also be without work until the airport could be rehabilitated. Lastly, the loss of the aviation museum would result in lost educational opportunities for community members, including non-native English speakers who benefitted from the multi-lingual programming.

Additional Important Information

By 2022, the Airport will begin a process to replace its aging hangars and the old office building. There are also plans to realign the levee due to concerns raised by the Federal Aviation Administration that the current alignment obstructs takeoff and landing operations. It is unclear whether plans consider sea level rise. Adaptation of the facility will require considerable coordination because of jurisdictional issues where Redwood City owns the levee that protects the airport; meanwhile the Airport is in San Carlos and operated by San Mateo County. SFO also has an interest in San Carlos Airport's adaptation because its own assets (flights) also depend on the San Carlos Airport in order to maintain its level of service.

Asset-Specific Adaptation

Five years ago, Redwood City (who owns the levee system) raised the Airport levee to meet FEMA standards. This provides flood protection to the airport but may be insufficient with sea level rise in the mid- to long-term. To protect against sea level rise, the levee may be need to be raised in the future. The Airport has four storm pumps (two each at the south and east pump stations), which can assist with pumping saltwater from the runway. Floodproofing of critical assets or components on site may also be needed. The Airport could also benefit from improvements to nearby wetland habitat, which could limit wave and surge height.

Levee system that reduces flooding at San Carlos Airport.

Vulnerable Airports

This is the only Asset Vulnerability Profile on vulnerable airports. However, there is one other vulnerable airport in the project area: San Francisco International Airport (see Appendix M).

17. PORT OF REDWOOD CITY

Port of Redwood City

VULNERABILITY SUMMARY

The Port of Redwood City (Port) is **moderately vulnerable** to sea level rise. Low-lying infrastructure is already exposed to flooding from king tides and could experience long-term inundation with sea level rise. If inundated, port functions could be maintained with backup power for 2-3 days and ships could still reach the wharves. The Port functions could be moved to other facilities, but at a significant cost in lost revenue, giving it moderate adaptive capacity. The most vulnerable component of the port is Seaport Boulevard, which facilitates truck and rail access to the Port.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
Moderate	*High*	*Moderate*	*High*

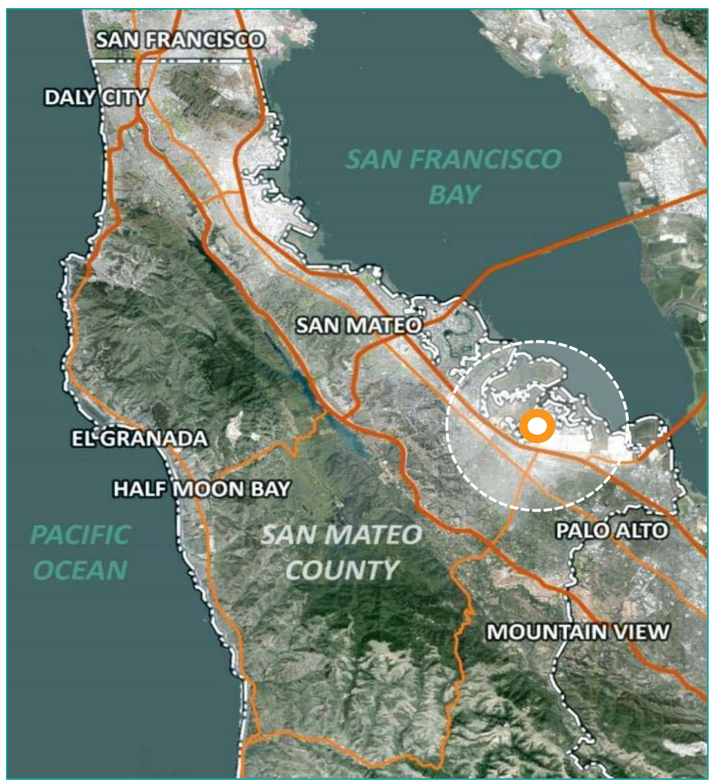
ASSET CHARACTERISTICS

675 Seaport Blvd | Redwood City

Asset Description and Function:

The Port of Redwood City is one of four public ports on the San Francisco Bay. The Port consists of wharves, roads, rail infrastructure, buildings for tenants (e.g., Univar USA--chemical distributors, Cemex) and administration, and a seawall. Seaport Boulevard and the rail line provide essential access to the Port, by means of which trucks and rail cars deliver and transport thousands of tons of goods. Wharves 1 and 2 are newly built and elevated. Wharves 3, 4, and 5 are older.

Asset Type	Port
Asset Risk Class	4
Size	120 acres
Year of Construction	1960
Elevation	14 feet, MLLW
Level of Use	2M tons; $6.9M annually
Annual O&M Cost	Less than $120,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Varies: Fair to Poor
Landowner	City of Redwood City and three private owners



Underground Facilities

There are electrical (power source), water, sewer, and natural gas facilities underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

PORT OF REDWOOD CITY

ASSET SENSITIVITY

The Port operations are moderately sensitive to temporary near-term flooding, as the Port could withstand a short-term disruption (up to 2-3 days) without any major issue. Powerlines run underground and were designed for waterlogged conditions and are not very sensitive to inundation. Even with a power outage, ships could still come in and out (as many have their own power source). However, the distribution of goods would experience delays if Seaport Boulevard or the railway were flooded because trucks and trains would not be able to deliver and pick up cargo. The gasoline on site has secondary containment and is elevated; it is therefore not presently sensitive to temporary flooding.

Long-term (permanent) and widespread inundation that affects Seaport Boulevard or the railway, on the other hand, would permanently affect distribution of goods and shut down Port operations.
In the future, the Port may provide docking and terminal facilities for ferry boats on Seaport Boulevard. While water transit is adaptable to an increase in sea level, the landside facilities serving the ferry boats would be affected by sea level rise.

New seawall at the Port with tenant facilities and new wharf (left).

SHORELINE VULNERABILITY

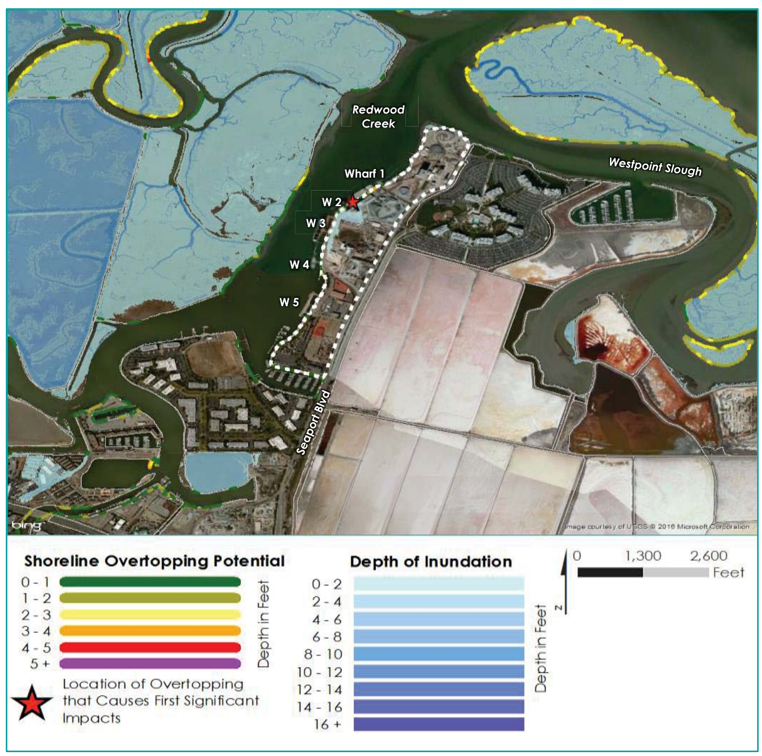
Shoreline Overtopping Analysis

Redwood Creek is a likely source of coastal flooding at the Port. Water 0-12 inches above the current mean higher high water (MHHW), could overtop Redwood Creek along the northwest edge of the site (red star on map), creating a potential flow path to port assets. With water 12-24 inches above MHHW, there is additional inundation at the Port entrance due to overtopping of the berm to the east of Seaport Boulevard, affecting truck and rail access to the Port.

Cross-Cutting Vulnerabilities

Loss of the Port function would increase cargo loads on other regional ports as access roads and railway are essential to port function. Increased loads on other ports, along with increased truck traffic to other ports, could affect local air pollution.

First Significant Impacts: 12 inches above MHHW.



PORT OF REDWOOD CITY

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Port is currently subject to regular nuisance flooding from Redwood Creek during king tides. This occurs at the two low spots in the southwestern recreational end where the marina is located and the northeastern end by the Cemex property, north of Wharves 1 and 2. Port properties also experience occasional flooding from storm drain backup when the tide is high and the flapper gates do not allow stormwater to flow out through the gates. Water generally drains or evaporates from the site due to the elevation and grade of the land.

Sea level rise will likely increase the frequency and severity of both shoreline overtopping from Redwood Creek and storm drain backup flooding. With sea level rise, water will likely not drain from the site naturally and may require pumping. Sea level rise could also cause more widespread inundation of other Port infrastructure (e.g., road, rail, buildings, marina). With 12-24 inches of sea level increase, it may be possible for the sea walls to be overtopped, but more importantly the Port could be exposed to flooding from the salt ponds abutting Seaport Boulevard. The ponds are presently below high tide, but 12-24 inches of sea level rise could overtop and fill the ponds, which could then overtop Seaport Blvd from the east side, affecting ingress and egress at the Port.

Groundwater is not currently a concern at the Port, but more analysis is needed to understand sea level rise impacts to groundwater.

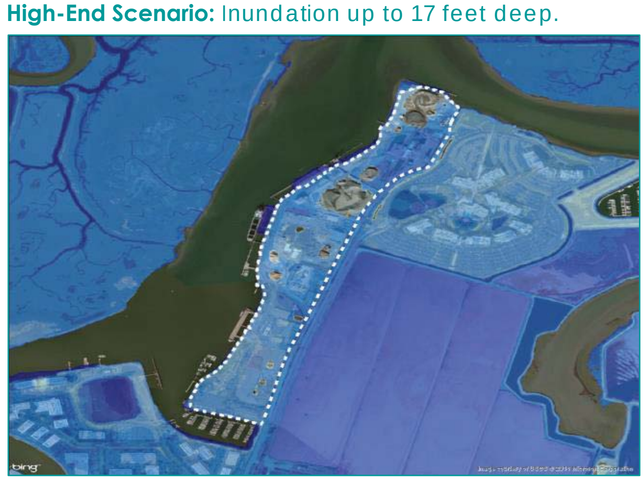
Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(12 inches)*	*0*	*4*
Baseline *1% Flood*	*0*	*9*
Mid-Level *1% + 3.3 feet*	*0*	*13*
High-End *1% + 6.6 feet*	*0*	*17*

Baseline Scenario: Inundation up to 10 feet deep.

Mid-Level Scenario: Inundation up to 13 feet deep.

High-End Scenario: Inundation up to 17 feet deep.



PORT OF REDWOOD CITY

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Port has high adaptive capacity for short-term flooding and moderate capacity for permanent inundation. The Port employees and some tenants have flood mitigation plans, i.e., portable pumps. One area has a two-pump system, but all others rely on gravity to drain water to San Francisco Bay. There is a generator on site to power port administrative buildings, though it is not sufficient to power tenants or industrial operations. For widespread or permanent inundation causing the port to shut down, there is no alternate truck or rail route to access port industrial facilities or transfer goods. However, most port cargo could be shifted to other regional ports (San Francisco or Oakland) with the exception of cement, which would be sent to Stockton. As the Port of Redwood City is more frequently disrupted due to the impacts of sea level rise, the temporary use of barriers, or the use of other ports may prove too cumbersome or costly and will likely require a decision about mitigation or adaptation.

Consequences

Consequences from the loss of the Port or port functions could be high. Direct damage to the Port's and tenants' infrastructure could occur with temporary or permanent inundation, and recreational access to the marina could be lost as well. Employees or other individuals on site could be injured during a large storm, or while driving cargo trucks across flooded roads. Some tenants store hazardous materials (e.g., chlorine, hydrochloric acid) that could have water quality impacts and pose threats to health and safety if released in a flood. The larger, if less direct, impact would be the business interruption and economic impact of delays from disrupted rail and truck operations. If the port were shut down, lost revenue could reach $6.9 million per year ($19K per day) in addition to repair costs of up to $60 million (excluding tenants' infrastructure). If vessels were rerouted to other regional ports, regional truck traffic and cargo transport costs would increase, along with potential air pollution caused by the traffic.

Additional Important Information

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. Flooding on Seaport Boulevard may also affect any businesses that depend on the road. The Redwood City Inner Harbor Specific Plan projects increased development in the region.

Rail and truck access at the Port.

Asset-Specific Adaptation

The third wharf at the Port could be reinforced similar to Wharves 1 and 2, which are less vulnerable following recent reinforcement. Since Seaport Boulevard is an access vulnerability for the Port, it could be raised, and because the road also provides access to neighboring businesses, co-funding is a viable option.

Ponding near Cemex Aggregates facilities.

Vulnerable Ports

This is the only Asset Vulnerability Profile on vulnerable ports in the County. There are no other ports in the County, but there are four in the San Francisco Bay Area. These include the ports of Oakland, San Francisco, Stockton, and Richmond. All of them would be vulnerable to sea level rise because they are located on the water.

18. KAISER PERMANENTE REDWOOD CITY MEDICAL CENTER

Kaiser Foundation Hospital

VULNERABILITY SUMMARY

Vulnerability of Redwood City Medical Center to sea level rise is **moderate.** This new facility has an emergency department (ED) and has never been flooded, but could be exposed to flooding from Redwood Creek. Sensitivity to flooding is moderate, as most of the essential components are unlikely to be exposed, with the exception of the ED, the ED entrance, and the supply dock. Adaptive capacity is high as ED patients can be evacuated to a higher floor or to nearby hospitals, and backup power and supplies are on site. Consequences of a loss of the asset would be high because evacuation could create additional stress for patients and increase loads on other hospitals.

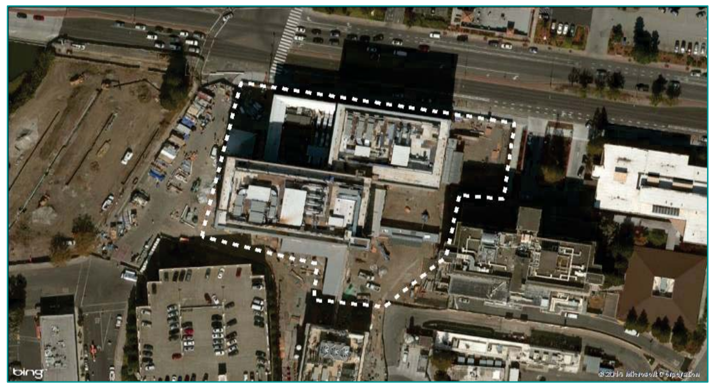
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Moderate	High	High

ASSET CHARACTERISTICS

1100 Veterans Way | Redwood City

Asset Description and Function:

The Redwood City Medical Center ED is part of the larger campus, which is about 18 acres. The facility's primary components include parking lots, entryways to the facilities, clinics, a pharmacy, and an ED. The building also houses a Neuroscience Center of Excellence. There are 149 licensed beds with capacity for 175. It serves primarily Kaiser Permanente members, but also San Mateo County residents and nearby hospitals. The ED is on the ground floor with 25 beds; all other departments are on floors 2-7.



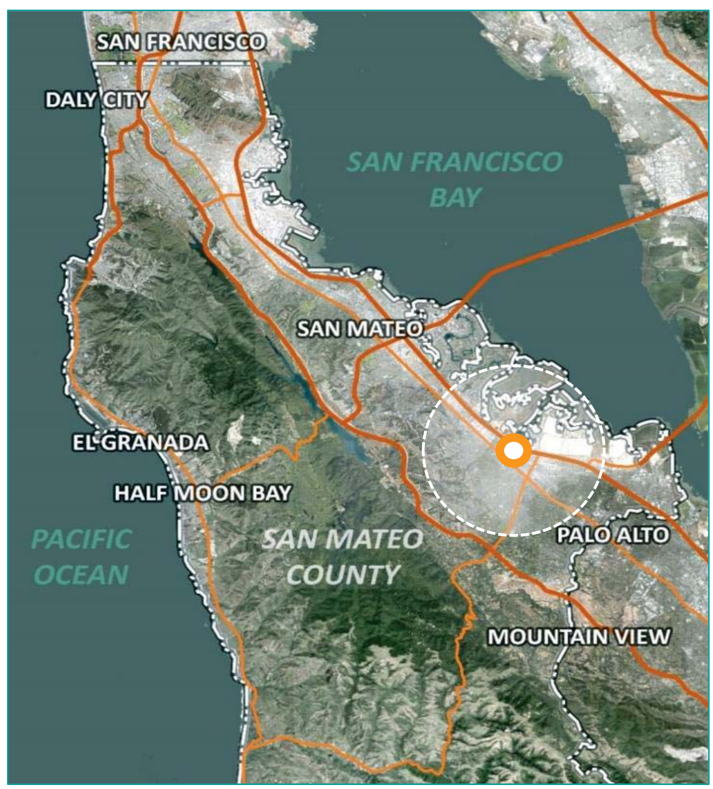
Asset Type	Hospital with Emergency Department
Asset Risk Class	4
Size	2.2 acres
Year of Construction	2015
Elevation	8-9 feet
Level of Use	149 beds
Annual O&M Cost	Unknown
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Newly Constructed
Landowner	Kaiser Foundation Hospitals

Underground Facilities

Electrical lines built for water-logged conditions. There are no conduits or entryways for water.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



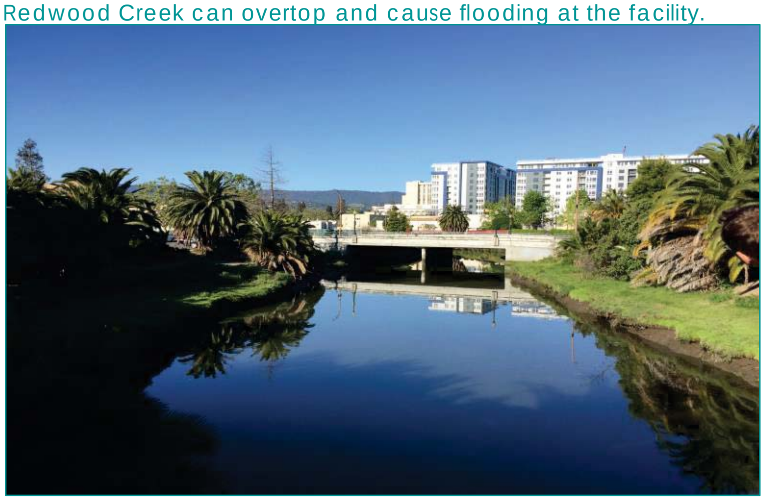
KAISER PERMANENTE REDWOOD CITY MEDICAL CENTER

ASSET SENSITIVITY

The new medical facility is moderately sensitive to flooding. The electrical (power), mechanical, and plumbing systems (including potable water), which directly affect level of service, are not sensitive to inundation as they are all located on the second floor of a Central Utilities Plant, which makes inundation of those systems very unlikely if not impossible. The electrical conduits that go into the ground and connect to the hospital are also designed with water in mind, so they should not be vulnerable to flood waters.

The underground storage tanks that store diesel fuel are sealed and regularly monitored. However, if the ground floor of the ED flooded, the ED would close and patients would need to be evacuated. Inundation of the driveway to the hospital, especially to the ED, would make it difficult to get patients in and out: a delay that could affect a patient's well-being. The extent of damage to the facility is likely to be low because the building was built with flood considerations in mind. Also, the only facility that is sensitive to flooding is the ED on the ground floor. So long as the hospital had power, clinics and other sections of the hospital serving non-emergency functions could remain in operation because they are all on the second and higher floors.

Redwood Creek can overtop and cause flooding at the facility.



SHORELINE VULNERABILITY

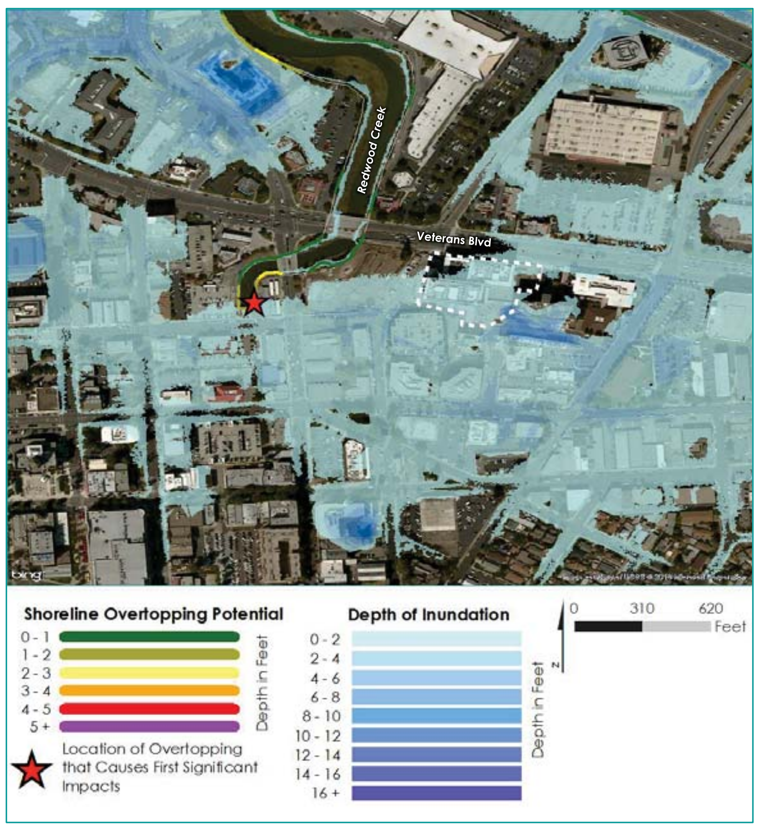
Shoreline Overtopping Analysis

High water on Redwood Creek would be the source of flooding nearest to the asset. When water surface elevations increase around 12 inches above mean higher high water (MHHW), Redwood Creek would overflow the bank about 600 feet west of the asset (see red star to the right). The first level of inundation that would cause significant disruption to the asset, however, does not occur until water levels reach between 24 and 36 inches above MHHW. This water level affects facility access roads, parking lots, and the entrance ways to the ED, as well as the supply chain loading dock.

Cross-Cutting Vulnerabilities

In the past, stormwater overflow has affected roads and parking lots on the Kaiser campus when Redwood City's storm pump station on the corner of Maple Street and Veteran's Boulevard stopped working.

First Significant Disruption: 36 inches above MHHW.



KAISER PERMANENTE REDWOOD CITY MEDICAL CENTER

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

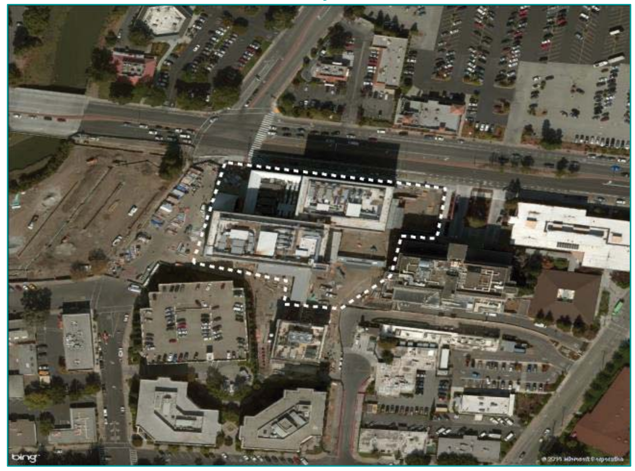
Exposure of the Kaiser Medical facility is moderate. While the asset has not previously experienced flooding or groundwater impacts, the site is vulnerable to flooding from the nearby Redwood Creek. Under a condition with heavy rain and a high tide, the creek may not discharge to San Francisco Bay, causing backup and overtopping near the asset. Historically, Redwood Creek overtopped and caused flooding in the nearby parking lot.

Flooding from the combination of rain and higher tides will likely occur more frequently in the future due to sea level rise. If water were on site, the lower-lying areas of the facility would flood first, including the parking lot, the loading dock, the entrance to the ED, and the ED itself. At 10 and 13 feet deep (the depth of flooding in the mid-level and high-end scenarios), the ED would be flooded, but the second floor - and therefore additional hospital clinics and the backup power system - would not be flooded. All access roads in the area would be underwater, however, thereby preventing intake and discharge (or evacuation) of patients.

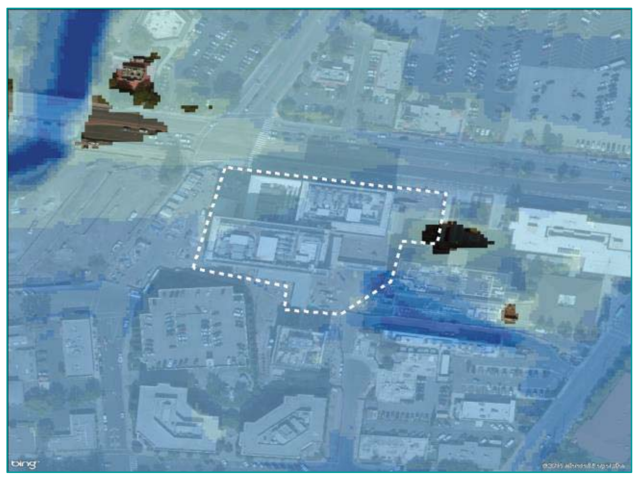
Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(36 inches)*	***0***	***7***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***10***
High-End *1% + 6.6 feet*	***2***	***13***

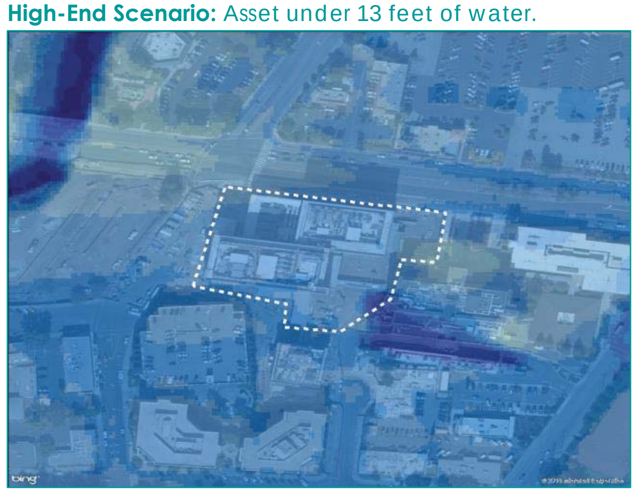
Baseline Scenario: Asset not yet inundated.



Mid-Level Scenario: Flooding up to 10 feet deep.



High-End Scenario: Asset under 13 feet of water.



KAISER PERMANENTE REDWOOD CITY MEDICAL CENTER

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

In the near-term, the hospital has a relatively high adaptive capacity, as it is a new facility and its design incorporates lessons learned from the impacts of Hurricane Sandy on healthcare facilities in 2012. Each Kaiser building on the campus has a business continuity plan that includes backup supplies, power, and alternate staging areas or other medical facilities in the event of evacuation. Specifically, the medical facility has two diesel generators with 3 MW capacity and enough fuel to operate for 96 hours. Both generators are elevated, and the storage tank that provides the diesel fuel is located underground, sealed to prevent water intrusion, and regularly monitored. There is an automatic transfer switch (on the second floor) that allows for uninterrupted transition from regular power to emergency power. If power and backup power were lost and elevators became inoperable, special chairs are available to evacuate patients down stairs. The hospital also has additional food to last 96 hours, and additional medical supplies to last 72 hours; there is also a 35,000-gallon sealed underground potable water tank.

If the ED were flooded, some patients in less critical condition could be taken to a higher floor out of harm's way, as the hospital has additional capacity (175 beds in total). ED patients or would-be patients that could not access the ED entrance could also be evacuated and taken to nearby Kaiser hospitals or other county hospitals if necessary. If the entire hospital were shut down, patients would be evacuated to any number of Kaiser hospitals in nearby Santa Clara, San Jose, Oakland, etc. Kaiser has a memorandum of understanding with nearby hospitals to accept additional patients. Because the hospital was built with flood considerations in mind, materials were used so that damage to the facility itself would be low or unlikely. Though the hospital has a high present-day adaptive capacity, more frequent flooding expected with sea level rise may reduce the effectiveness of current measures and a new broader adaptation strategy will need to be developed.

Consequences

Consequences of loss of service of the medical facility would be high, and the scale of impact would be regional. Flooding could cause direct damages to the facility and its major components; however, because of measures in place and the design of the facility, it is unlikely that damages would be significant.
If the site were inundated long enough (beyond 96 hours), the hospital would likely shut down until the site could be drained and the building cleaned out for reoccupancy; this would force an evacuation of all hospital patients (and staff) and relocation of some patients to nearby Kaiser facilities in South San Francisco, San Francisco, Santa Clara, or Oakland. Evacuation could create additional stress on already vulnerable patients and possibly compound health concerns or injuries. Increasing the load on other hospitals could create additional stress, though most hospitals in the area have additional surge capacity. A permanent loss of this facility would result in a loss of the Neuroscience Center of Excellence, which is unique in the region.

Additional Important Information

The hospital facility hosts evacuation drills to ensure they are prepared for a real emergency. This increases their adaptive capacity even more and may reduce impacts to hospital facilities and patients.

Asset-Specific Adaptation

Adaptation of the hospital may include elevating or floodproofing access roads to the entryways to the ED and supply center. It could also involve dry floodproofing the facility to prevent any flooding of the ED so overnight patients could shelter in place and not have to evacuate.

Vulnerable Hospitals with EDs

This is the only Asset Vulnerability Profile on vulnerable hospitals in the County. The vulnerability assessment analysis shows that this asset is the only medical facility with a vulnerable ED in the County.

ED entranceway for ambulance is a critical component of asset.

19. STATE ROUTE 84 - HIGHWAY 101 INTERCHANGE

California Department of Transportation (Caltrans)

VULNERABILITY SUMMARY

The State Route (SR) 84 / Highway (Hwy) 101 interchange is **highly vulnerable** to sea level rise. It is already exposed to flooding from the Bayfront Canal (Canal) and Atherton Channel (Channel) when high rainfall coincides with high tides and the canals cannot discharge. Although not as common, overtopping of the San Francisquito Creek has also flooded the area. The interchange must close if inundated, making it highly sensitive. Closure would affect thousands of travelers, creating regional impacts. It is already at, or above capacity during peak hours, and detours lack the capacity to support the usual level of service, giving the interchange no redundancy and low adaptive capacity.

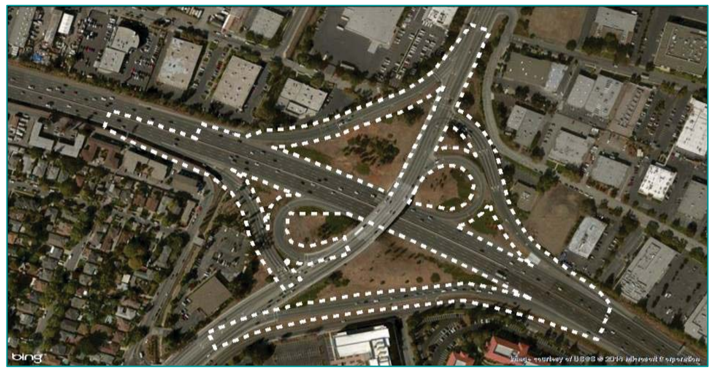
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	High	Low	High

ASSET CHARACTERISTICS

State Route-84 / Highway 101 | Menlo Park

Asset Description and Function:

The interchange at SR 84 (Marsh Road) and Hwy 101 is a regional transportation node for local, regional, and interregional travel. The interchange is in the City of Menlo Park and consists of a freeway interchange with on/off ramps, ramp meters, and vehicle loop detectors. SR 84 connects to Alameda County and carries 45,500 vehicles daily; Hwy 101 connects peninsula communities, linking San Francisco, San Mateo County, and Silicon Valley, and carries 217,000 vehicles daily.



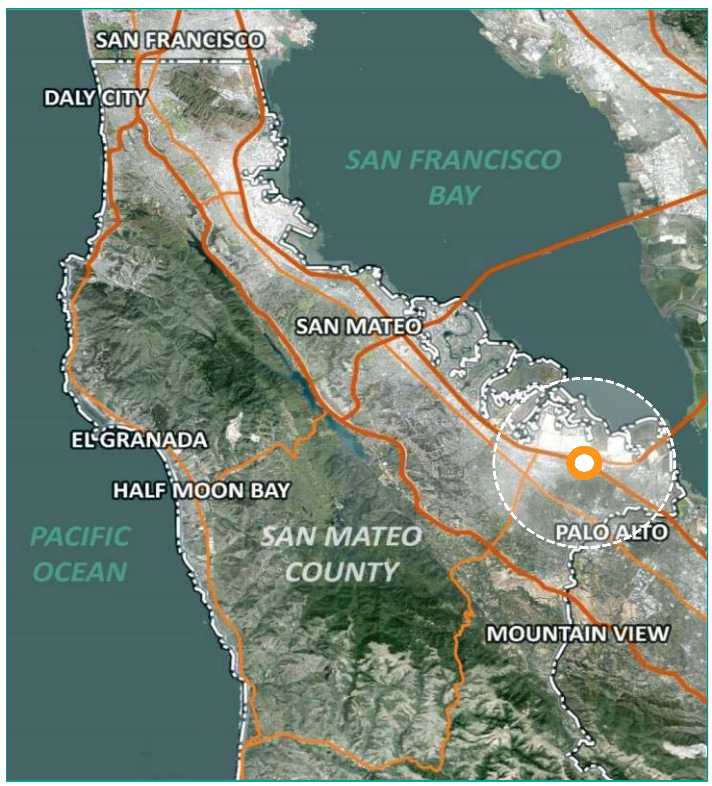
Asset Type	Transportation Infrastructure
Asset Risk Class	4
Size	23 acres
Year of Construction	1964, 1984
Elevation	Ramps 13.32 feet, NAVD88
Level of Use	260K vehicles per day
Annual O&M Cost	$1,150,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Good
Landowner	State of California

Underground Facilities

Sanitary sewers, water mains, storm drains, electrical conduits, lighting, transponders, ramp meters, gas lines, and fiber optics are underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



STATE ROUTE 84 - HIGHWAY 101 INTERCHANGE

ASSET SENSITIVITY

The sensitivity of the interchange directly depends on the severity and extent of inundation, but in general it is highly sensitive to severe flooding. If severely flooded, the highway cannot function. The highway is already at capacity, and with a loss of any lanes of Hwy 101 or the lanes of SR 84, levels of service would be severely decreased. If any of the underground infrastructure (metering and detection equipment) were exposed to salt water, their functions would likely be affected.

To date, ponding under the interchange has not caused a disruption, but future sea level rise could cause deeper or more frequent ponding, disrupting ramp access. While the interchange itself would remain dry because it is elevated, a water level increase of 36 inches is expected to cause flooding on the north side of the interchange, rendering it inaccessible.

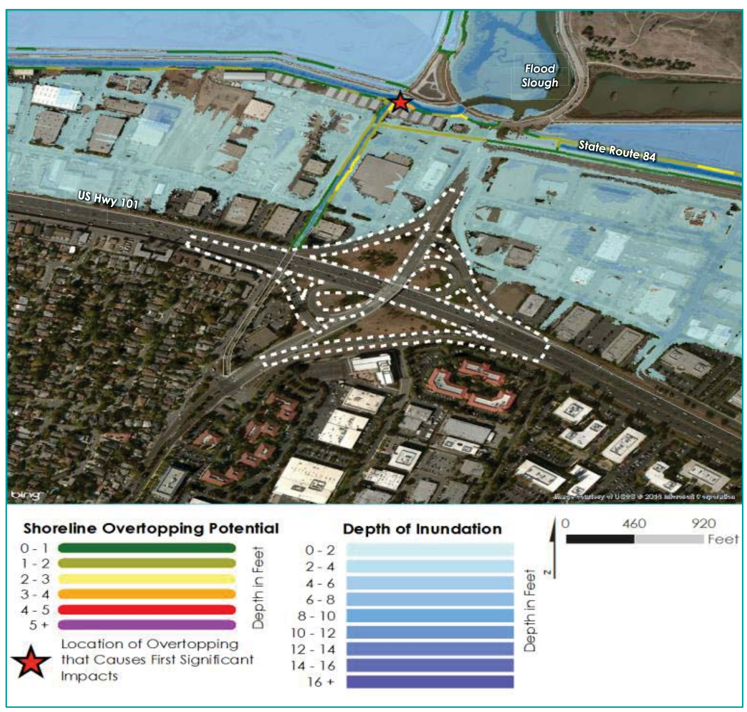
Street view of Marsh Road overpass heading south on Highway 101.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

The primary source of flooding is from the Canal and Channel. When the tides are high and the Flood Slough tide gates are closed, the Canal cannot drain, causing flooding of the Haven Avenue area. When water surface elevations reach between 12 and 24 inches above the current mean higher high water (MHHW) level, the slough overtops the embankment roughly 720 feet north of the interchange, indicated by a red star on the map to the right, creating a potential flow path. The first damaging inundation to the site, however, does not occur until water elevations reach between 24 and 36 inches above MHHW.

First Significant Impacts: 36 inches above MHHW.



Cross-Cutting Vulnerabilities

This section could create significant geographical cross-cutting issues, as it joins the North, South, and East Bay to San Mateo County and to each other.

STATE ROUTE 84 - HIGHWAY 101 INTERCHANGE

SEA LEVEL RISE EXPOSURE ANALYSIS

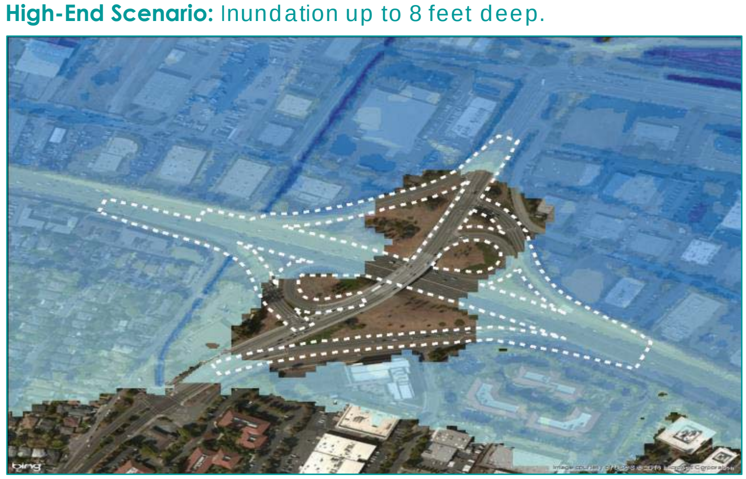
Exposure Discussion

Exposure of the asset to surface water flooding and sea level rise is high. Other than nearby standing water, most flooding near the interchange to date has been caused by overflow of the Canal and Channel. Both the Canal and Channel have caused flooding during high tides and rain events. Less frequently, flooding also occurs from San Francisquito Creek. With high tide and heavy rainstorms, the creek overflows the banks and runs along the southbound lanes of Hwy 101 toward the SR 84 Interchange. This does not appear in the Baseline Scenario figure (right) because it is driven by the creek, not sea level rise. The Bay side of the interchange sits at 17 feet (NAVD, 1988), 4 feet above the Federal Emergency Management Agency projected 1% base flood elevation at 13 feet (NAVD, 1988), so it is unlikely to flood under current conditions. With no action, sea level rise will likely result in more frequent canal and creek overflows and could also cause inundation of the interchange from the Bay side. Modeling suggests that 3 feet of sea level rise would begin to affect the interchange. There are drainage pipes and electrical conduits that run parallel to Hwy 101 underneath the pavement. They were not built for waterlogged environments and there is no underground system to pump flood waters away from the infrastructure. Water entry at any point in either utility system (even outside this asset boundary) could affect the infrastructure.

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Inundation up to 5 feet deep.

High-End Scenario: Inundation up to 8 feet deep.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(36 inches)*	***0***	***3***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***5***
High-End *1% + 6.6 feet*	***0***	***8***

STATE ROUTE 84 - HIGHWAY 101 INTERCHANGE

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity at the interchange is low, as there is limited ability to remove water in near-term floods, and the Canal and Channel have limited additional capacity in high tide and rain events. Caltrans generally allows the road to drain naturally after a heavy rain event, utilizing the sound wall and barrier to direct water across the highway and into the Bay. If the road flooded, Caltrans pump stations could be used to pump water out. This would happen only after the rain event, as they are not sized to address anything more than storm flows up to a 50-year event. Temporary flooding would require detours, such as using Willow Road and University Avenue, neither of which can accommodate the volume of traffic from the interchange. If the facility became permanently inundated and closed, use of these streets would not be a viable permanent solution to maintain the level of service provided by Hwy 101 and SR 84.

Consequences

Impacts from the loss or disruption of this asset are high and far-reaching. Floodwater would not likely cause direct damage to roadways; however, continual exposure to salt water could reduce the service life. Salt water would more immediately affect infrastructure near/under the interchange (e.g., electrical cabinets, loop detectors). Damaging the utility network here could disable the system more broadly. With enough structural or foundation damage, ramps could need replacing, costing up to $63 million. Likely, the impacts of temporary or permanent closure due to flooding would be more significant. Prior to complete closure of this section of highway, hazardous conditions could lead to accidents (e.g., hydroplaning). Closure would create delays for more than 260,000 travelers who use these routes daily (especially commuter traffic to job centers) and increased traffic volumes would impact the level of service and service life of detours. Loss of service at this interchange would make it particularly difficult to travel to or from the east bay, since bridge access could be blocked, and travel north to the San Mateo Bridge would require detours.

Additional Important Information

The SAFER Bay project led by the San Francisquito Creek Joint Powers of Authority (SFCJPA), is ongoing and plans to reduce flood exposure to the highway (and by default, SR 84-Hwy 101 interchange and adjacent communities) by building levees along the Bay shoreline. The San Francisco Bay-Hwy 101 project also led by the SFCJPA is also working to reduce highway and residential flooding exposure in East Palo Alto from the San Francisquito Creek. Plans consider sea level rise and aim to provide ecological and recreational benefits as well.

Asset-Specific Adaptation

The underground infrastructure could be protected by barriers to prevent saltwater intrusion; however, salt water could still enter at other vulnerable spots and disable the network, so system-wide (not local) adaptation is recommended. In the near-term, pump stations could be built or relocated nearby to alleviate flooding and maintain service. Long-term region-wide adaptation will be required and is already underway, including the two projects listed above and possible restoration of the Ravenswood Ponds complex.

Vulnerable Highways

There are Asset Vulnerability Profiles on the following vulnerable highways: SR 1 (AVP #3) and HWY 101 (AVP #9). The vulnerability assessment analysis shows that there are 99.6 miles of vulnerable highways in the project area, including SR 54, 92, and 114.

Aerial view of the interchange at State Route 84 and Highway 101.

20. EAST PALO ALTO

City of East Palo Alto

COMMUNITY VULNERABILITY SUMMARY

East Palo Alto (EPA) is **highly vulnerable** to the impacts of sea level rise. Infrastructure and communities are highly sensitive to flooding as most assets were not built to withstand it, and many residents are resource-constrained due to factors explained below. This city is situated adjacent to the San Francisco Bay and San Francisquito Creek, making it subject to frequent surface flooding and storm drain or sewer backup, both of which cause significant disruption. Adaptive capacity is low in the near and long term. Pumping infrastructure is insufficient, and as explained below, some residents are less able to respond to or recover from flooding. Finally, relocating both infrastructure and people would be difficult.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*High*	*Low*	*High*

COMMUNITY CHARACTERISTICS

Community Description

EPA is situated adjacent to the San Francisco Bay and San Francisquito Creek. The low-lying levee-protected community is ethnically, age, and economically diverse, and many are resource-constrained as explained below. While most of the city is urban, 20% of land area is composed of natural areas, including wetlands, which are a valued ecological and recreational resource. Early inhabitants of EPA were members of the Ohlone tribe.

Population	28,114
Size	2.6 sq. miles
Elevation	18 feet (varies)
Year of Incorporation	1983
Special Flood Hazard Area	25% area is in SFHA.
Area in SLR impact zone	Over 50%
Most recent flood	2012
Renter occupied housing	57%
Population density	10,777/sq. mile

Underground Facilities

Storm and sewer systems, electrical utilities, basements.

Environmental Considerations

Natural areas within EPA include northern coastal salt marsh, non-tidal salt marsh, brackish marsh, freshwater marsh, open water, non-native grasslands, and riparian woodlands. The area also has potential for waterbird habitat.

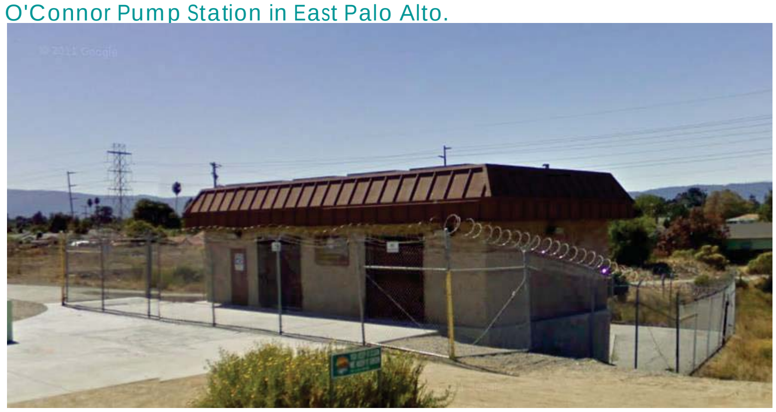
EAST PALO ALTO

COMMUNITY SENSITIVITY

EPA infrastructure and some of its residents would be highly affected by the impacts of present day flooding and future sea level rise, making them highly sensitive. These sensitivities are due to land uses that are incompatible with flooding, infrastructure and buildings that are not flood-tolerant, and residents who may be resource-contrained in some way; for example, residents without sufficient financial resources, a vehicle, a connection to a strong social network, employment, housing, or some other resource. These factors can make it more difficult for some to respond to and recover from flooding than others.

Because most land use in the city is not compatible with flooding, inundation would cause considerable disruption or damage to the many houses, community centers, businesses, roadways, transportation hubs, and critical infrastructure in the area. Floods could affect any of the 10 schools, the police station, or the corporation yard. Flooding or a rise in the groundwater table could also mobilize contaminated soil at the two Superfund sites and at any number of the 31 cleanup sites located in East Palo Alto. Future drinking water wells may also be sensitive to saltwater intrusion. Most housing is not flood-damage resistant or elevated; over 7% of units are mobile homes, and a lack of affordable housing has forced the conversion of numerous garages to dwelling units. (Continued on page 5.)

O'Connor Pump Station in East Palo Alto.



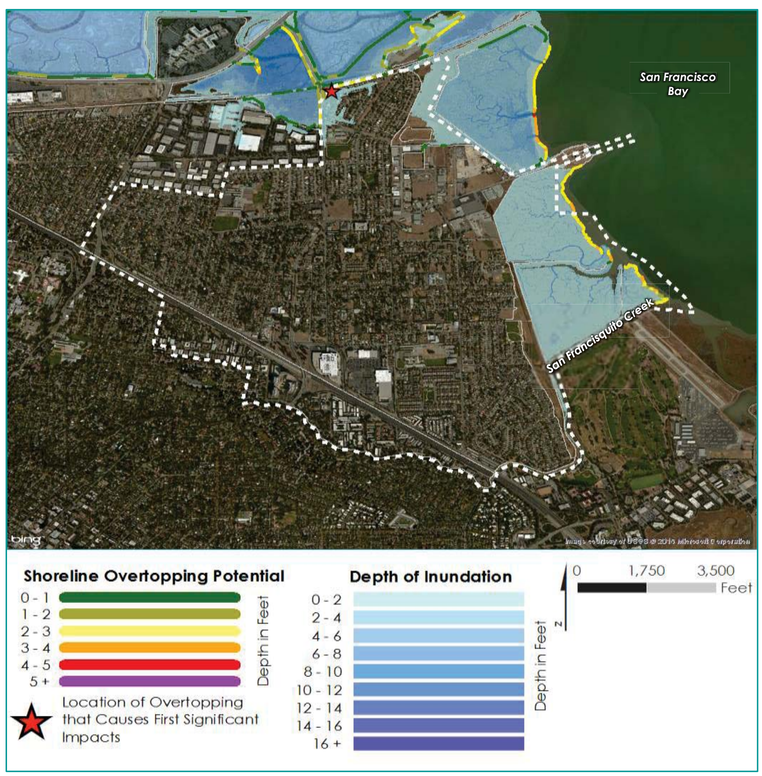
SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

Parts of EPA are already below sea level, and when water levels reach between 12 and 24 inches above current mean higher high water (MHHW), San Francisco Bay water could fill the salt ponds immediately north of the city and overtop the embankment that protects this northernmost area (see red star to the right), creating a potential flow path to nearby neighborhoods in EPA.

*This map does not account for flooding related to San Francisquito Creek.

First Significant Impacts: 24 inches of sea level rise.



Cross-Cutting Vulnerabilities

EPA is subject to the actions or inactions of others; for example, when Caltrans put in the sound wall on Highway 101, it cut off the drainage system, resulting in inadequate drainage in this area. The outcomes of the SAFER Bay and other local projects, as well as any restoration or management of wetlands in front of EPA. will reduce the city's exposure to current flooding and may reduce future flooding and wave action.

EAST PALO ALTO

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

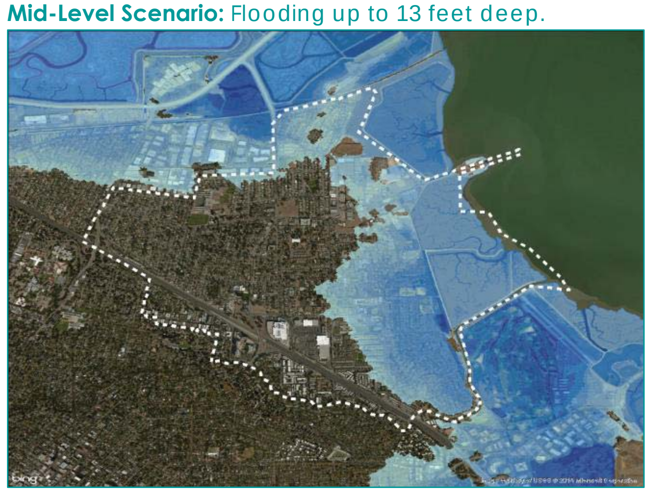
Present-day and future exposure to flooding and sea level rise in EPA is high; the community has historically experienced some type of flood-related disruption at least once every 5 years. Because much of EPA is low-lying, it does not drain naturally--especially during high tides. In the near-term, these conditions often lead to storm drain backups, ponding, and disruption in the area, and require pumping to remove excess water. In the long-term, these conditions could increase the frequency, duration, and potential disruption of any flood-related event because water cannot drain.

EPA could be subject to four major impacts from sea level rise: i) high water from San Francisco Bay (the shoreline could overtop); ii) ponding and storm-water or sewage backup tied to very high tides and exacerbated by rain storms; iii) high water from San Francisquito Creek, which could overtop the levee as occurred in 2012; and iv) groundwater table increase, which could mobilize contaminants, enable saltwater intrusion, or lead to flooding or seepage in underground structures. Each of these conditions are likely to occur more frequently with sea level rise. For example, because San Franciscquito Creek drains to San Francisco Bay, high tides (and future high water levels) raise the water surface elevation in San Francisquito Creek, making it possible for the creek to overtop the levees and more frequently flood the adjacent Gardens and Woodland neighborhoods.

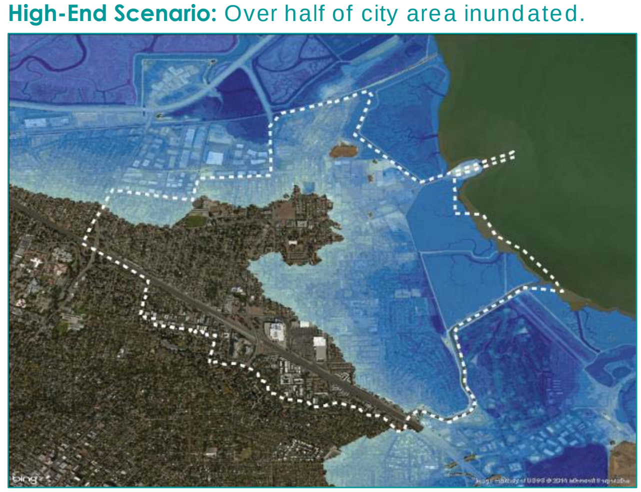
*Maps on the right only show flooding from San Francisco Bay.

Baseline Scenario: Natural and built assets flooded.

Mid-Level Scenario: Flooding up to 13 feet deep.



High-End Scenario: Over half of city area inundated.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(48 inches)*	*0*	*9*
Baseline *1% Flood*	*0*	*9*
Mid-Level *1% + 3.3 feet*	*0*	*13*
High-End *1% + 6.6 feet*	*0*	*16*

EAST PALO ALTO

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

EPA's adaptive capacity is low. Specifically, the ability of the city and its communities to respond to and recover from near-term temporary flooding is very limited. The community also has limited ability to adapt in the long term to more frequent and severe flooding that may result from future sea level rise as explained below. The O'Connor Pump Station currently pumps excess surface water from the city to minimize the extent of flooding. However, pumping capacity is insufficient to accommodate additional flood water that would be expected with any amount of surge or sea level rise, as it currently reaches maximum pumping capacity during king tides. Temporarily inundated roadways may drain and be used again. However, permanently inundated roadways will require permanent alternate routes or relocation. Responding to and recovering from temporary (or permanent) flooding would be very challenging if not impossible for some residents as they may not have access to vehicles and alternate housing, or to the support services and strong social networks that are key to recovery. (Continued on page 5.)

Consequences

Consequences of inaction in the near-term and with sea level rise could be high, with wide ranging impacts. Deep flooding could cause considerable property and infrastructure damage in a large part of the city, posing long duration disruptions to public health and safety, and to the community. As a proxy for potential direct damages, the total assessed value of parcels at risk in EPA under the baseline scenario is over $170 million. In the high-end scenario, the assessed value of exposed property is over $970 million.

Housing and community centers could be flooded, forcing evacuation. Some people may be unable to evacuate due to limited resources, access and functional needs, or language barriers. Those who do evacuate face additional threats to life safety caused by evacuation, and mental stress from the disruption. If evacuees do not have any place to go, they may be in a temporary shelter, making it difficult to continue working or to continue with other daily norms. Near-term flooding can also result in injury or death, especially for people with access and functional needs. Surface flooding or groundwater table increases that mobilize otherwise stationary contaminants can expose people and wildlife to hazardous materials. Flooding of wastewater infrastructure, or other potentially hazardous sites poses a major public health and environmental concern. In general, all of these consequences are exacerbated for vulnerable populations. (Continued on page 5.)

Additional Important Information

The ABAG Stronger Housing, Safer Communities Program identified EPA as a Community of Concern based on 10 indicators that affect individuals' abilities to prepare for, respond to, and recover from disasters (and climate change). Proposed developments in EPA, including the Ravenswood Four Corners Transportation Oriented Development Specific Plan could be exposed to impacts of sea level rise. The Specific Plan includes opportunities for new development and revitalization, and recently the City has seen an increase in new development plans for this area.

Asset-Specific Adaptation

Adaptation strategies are available to address each of sensitivity, exposure, and adaptive capacity of EPA. Overall adaptation should prioritize the public health and safety of all the city's residents, and likely the preservation of its essential facilities upon which these residents depend. Both adaptation and near-term flood risk reduction may require special consideration for the needs of the city's most vulnerable populations. For example, as evacuation may not be possible for the 9% of households without personal vehicles, or for mobility-limited people, buses could be organized to complete evacuation for everyone. Similarly, any warnings that go out to the public should consider distribution in multiple languages. (Continued on page 5.)

Sandbags placement at levee near Verbena.


Photo courtesy of City of East Palo Alto

EAST PALO ALTO

VULNERABILITY & ADAPTATION (CONTINUED)

Sensitivity (continued from second page)

Some of the city's most sensitive residents include i) a number of undocumented people; ii) homeless individuals living in the wetlands area and near the abandoned railroads; iii) seniors, and iv) non-native English speakers. All four groups would have limited means of accessing information necessary to prepare for a flood, and likely limited resources or ability to evacuate somewhere safe. In fact, 25% of the city does not speak English at home, making it less likely that they have the information they need to make decisions to prepare. In general, even if they have information, socially vulnerable populations have many daily pressing needs that take precedence over things like flood safety and sea level rise exposure.

Renters comprise more than 50% of households (HH) and likely cannot adapt a unit for flooding because they do not own the property. Most HH lack the financial means to do so. Nine percent of HH do not own a car, meaning that flooding of roadways or transit infrastructure disproportionately affects their ability to get to work, home, or to higher ground during a flood.

Adaptive Capacity (continued from previous page)

The Office of Emergency Operations distributes sandbags prior to flood events so property owners can minimize damage in the near-term. It is currently unknown how many HH have flood insurance (and could therefore afford repairs after a flood); however, through participation in FEMA's Community Rating System (CRS) program, the city works to raise community awareness about flooding and to encourage people to mitigate their property. The city also has a Hazard Mitigation Plan to reduce potential damages from disasters, and to make the city eligible to receive recovery funding following a disaster declaration. Some local organizations work directly with the city's vulnerable populations to support near-term adaptive capacity through disaster prevention and preparedness, flood survival, and recovery. However, over time, and without action, flooding frequency will likely increase and the extent of the flooded area will likely expand, decreasing the amount of livable space for EPA's people and infrastructure (which would be incapacitated). It may be difficult to relocate roadways, schools, and numerous other infrastructure to higher ground given the density in the Bay Area and limited availability of high ground. EPA's many resource-constrained inhabitants will also have a difficult time relocating to safer areas.

Consequences (continued from previous page)

If severe flooding occurred, important infrastructure (including transportation, medical, or other essential facilities) could be damaged and out of service, which could create cascading impacts. Flooded roadways, for example, make it difficult to get to work or to access basic needs like food and medical care. In addition, a loss of individual commercial assets, roadways, and transportation would create a significant disruption to businesses when employees cannot get to work. This can result in lost productivity and revenue, unemployment, and a potential increase in the number of people needing financial and human services. Long-term consequences from sea level rise could result in a decrease in the number of people living in EPA population due to forced evacuation from a permanent inundation of over 50% of the land area.

Asset-Specific Adaptation (continued from previous page)

To reduce **sensitivity**, the city may consider floodproofing its most essential assets (including infrastructure and housing) such that risks to life safety and property will be reduced and so that basic community services could be met during a flood. Future land use policy, building codes, and other related decisions should consider sea level rise impacts and incorporate flood-compatible land uses. For example, preventing new development in low-lying areas, preserving open space, or requiring greater freeboard in the city's flood damage ordinance will reduce the losses and disruption from future floods. To reduce **exposure,** the city is engaged in work to raise the levees on San Francisquito Creek and along the Bay Shoreline. Wetlands in front of the shoreline could be incorporated into any strategy that seeks to maintain and preserve the ecological, recreational, and storm wave reduction benefits. The O' Connor Pump Station should be replaced with one (or many) that can accommodate considerably more water. Additional improvements should be made to other drainage infrastructure to reduce the extent of interior drainage. Near-term **adaptive capacity** could be improved with outreach efforts that target vulnerable or disconnected populations to increase the likelihood that they will prepare for, survive, and be able to recover from future flood impacts. The city could partner with some of its local organizations that already have relationships with these communities to begin achieving this goal.

21. LIFE MOVES MAPLE STREET SHELTER

San Mateo County
Department of Public Works

VULNERABILITY SUMMARY

The Life Moves Maple Street Shelter (Shelter) is **moderately** vulnerable to the effects of sea level rise. The Shelter has relatively low exposure to flooding and sea level rise, but its services are moderately sensitive to flooding and its clients are a particularly vulnerable population. Flooding would require evacuation of the Shelter, further stressing already disadvantaged individuals. The asset has a low adaptive capacity as there are limited options for relocating clients in the near-term. Furthermore, permanent relocation of the facility will likely be required in order to continue to support San Mateo County's homeless populations, yet options to do so are limited.

SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
Moderate	*Low*	*Low*	*High*

ASSET CHARACTERISTICS

1580 Maple St | Redwood City

Asset Description and Function:

The Life Moves Maple Street Shelter is a homeless shelter serving 1,240 single adults in San Mateo County (San Mateo County Homeless Census and Survey, 2015). It is the only one of its type in the County, providing services to some of the County's most vulnerable populations. The Shelter takes referrals from across the County, which leaves it consistently at capacity (75 beds). The Shelter is currently undergoing a large remodel to double capacity and improve service.

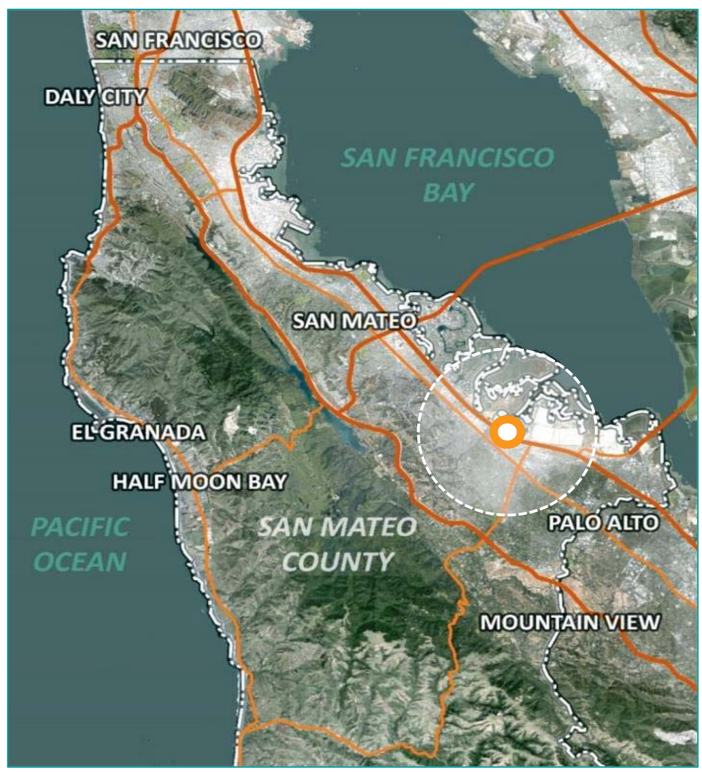
Asset Type	Homeless Shelter
Asset Risk Class	3
Size	37,000 square feet
Year of Construction	1962
Elevation	10 feet, MSL
Level of Use	75 clients/night
Annual O&M Cost	$127,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Fair
Landowner	County of San Mateo

Underground Facilities

No underground facilities were identified.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



LIFE MOVES
MAPLE STREET SHELTER

ASSET SENSITIVITY

The Shelter is moderately sensitive to flooding and the impacts of sea level rise. It has no underground facilities and can operate without electricity in the event of power outages. However, the level of service would decrease as heat and hot water would be unavailable to occupants and staff. During previous flood events, the road has flooded and shelter staff were able to bring in supplies and shuttle clients in vans. If the Shelter were flooded, it would likely be unsafe for occupancy and the level of service would be significantly reduced. Clients would have to be relocated temporarily to motels or another shelter if available as they likely have no other housing alternative.

For this reason, the clients are highly sensitive to flooding and sea level rise, as other shelters may not be available, and motels are not a viable long-term solution.

Maple Street entrance to the shelter.

SHORELINE VULNERABILITY

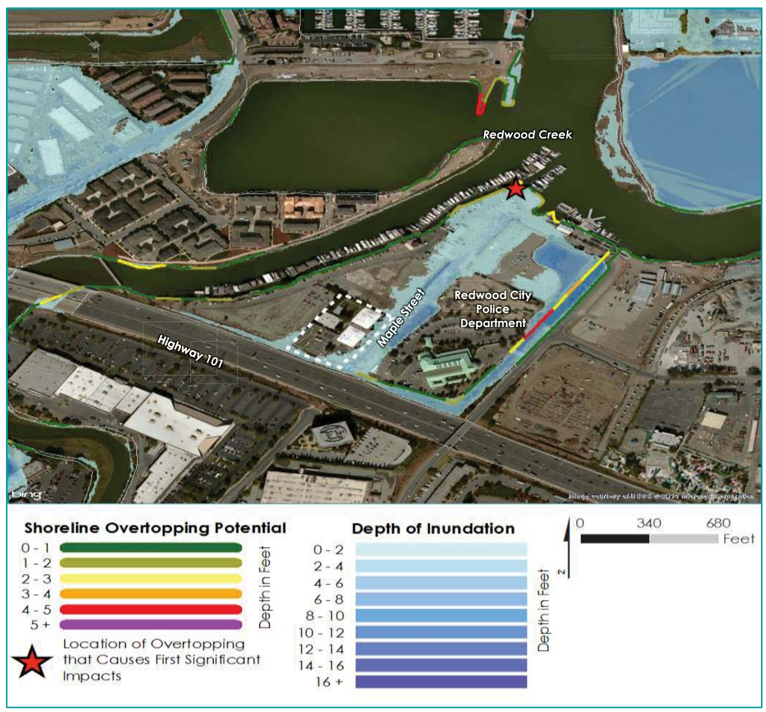
Shoreline Overtopping Analysis

Redwood Creek is a likely source of coastal flooding at the Shelter. When water surface elevations reach 0-12 inches above the current mean higher high water (MHHW) level, the creek overtops the embankment roughly 900 feet northeast of the Shelter (red star on map), creating a potential flow path to the asset. The first damaging inundation is likely to occur when water reaches 12-24 inches above MHHW.

Cross-Cutting Vulnerabilities

The access road (Maple Street) floods before the Shelter is impacted. This can limit ingress and egress for supplies (food or fuel) and for clients who need to travel to commute to jobs. This could lead to these clients missing work and being laid off, worsening their prospects in an already disadvantaged community. Additionally, the drainage ditch in front of the Redwood City Police Department, which serves stormwater and road runoff, can also overflow and flood the Shelter.

First Significant Impacts: 24 inches above MHHW.



LIFE MOVES MAPLE STREET SHELTER

SEA LEVEL RISE EXPOSURE ANALYSIS

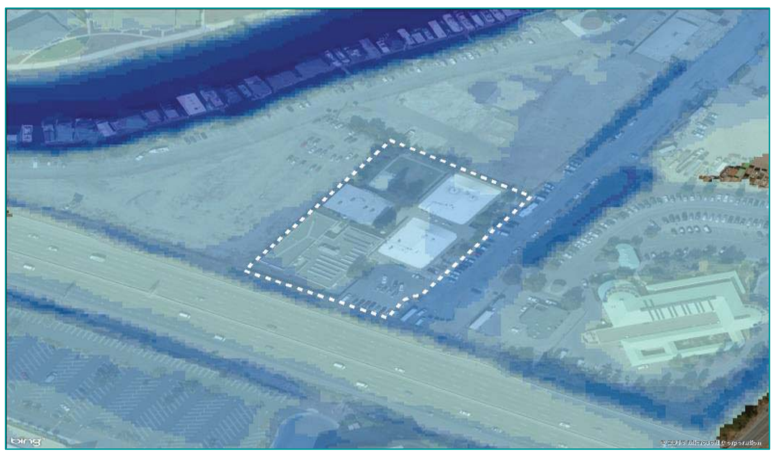
Exposure Discussion

The Shelter has a low level of exposure to present-day coastal flooding and sea level rise. It has not experienced flooding in recent years, though flooding of Maple Street used to reach up to the door of the Shelter, most recently in 1986.

The Shelter is at grade, and it is exposed to flooding when high water levels in San Francisco Bay prevent stormwater from discharging to the bay, and instead force it to back up on site. Following days of rain, saturated soils prevent the low-lying site from draining and cause ponding on site. With rising sea levels, these two events are likely to coincide more often, leading to more frequent floods at the Shelter. If floodwater did submerge the site, water could enter the Shelter through doors on the perimeter.

Baseline Scenario: Asset not yet inundated.

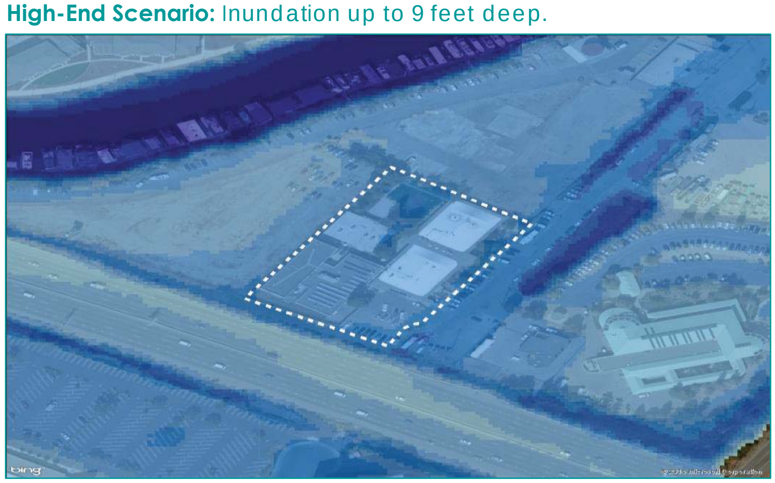
Mid-Level Scenario: Inundation up to 6 feet deep.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(24 inches)*	***0***	***2***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***3***	***6***
High-End *1% + 6.6 feet*	***6***	***9***

High-End Scenario: Inundation up to 9 feet deep.



LIFE MOVES
MAPLE STREET SHELTER

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the facility is low, as there are no pumps or barriers on site to minimize or prevent flooding. Flooding would require clients to evacuate, and the County of San Mateo has an agreement with the Redwood City Police Department to allow evacuation through the station parking lot in emergency situations. Relocating the Shelter's clients would be difficult, as many shelters in the area are already at capacity. If the Shelter were forced to temporarily close, the County would finance temporary housing solutions such as motels or apartments. If the Shelter were permanently closed, however, an alternate location for the Shelter would be required, and there are likely limited options available.

Consequences

Flooding at the facility would cause damage to furniture and other office items. The Shelter's 75 clients could also be subject to injury, and would likely need to be evacuated and housed elsewhere until the facility could be drained and repaired for re-occupancy, absent mold and other hazards that can be caused by flooding. These potential impacts could be experienced more frequently with sea level rise. Evacuating already vulnerable clients adds stress and disruption to their lives—stresses unique to homelessness that are likely not experienced by the general public. For example, the clients likely do not have access to a vehicle, alternate places to stay, means of replacing damaged personal property, or social support networks critical to response during and recovery after disasters. Relocating clients could create overcrowding at other facilities or incur high rental costs for the Shelter. If the facility were permanently damaged, replacement costs have been estimated at nearly $5.5 million (as of 2000).

Additional Important Information

Adaptation poses a particular challenge to this facility. Elevating the facility could be cost-prohibitive, and there are limited options for relocation. There is also often a public stigma attached to homeless and other vulnerable populations, which makes finding a location (on high ground) difficult because other neighborhoods would prefer it be located elsewhere. Overall, the County is committed to working with Redwood City on strategies to protect its assets within the tidal floodplain.

Asset-Specific Adaptation

Vulnerability of the road and shelter could be reduced using nonstructural measures including elevation and dry floodproofing. This would enable clients to safely shelter in place or get to and from work. Improvements to the adjacent wetlands could reduce wave action along the shoreline and alleviate some flood risk.

Vulnerable Homeless Shelters

This is the only Asset Vulnerability Profile on vulnerable homeless shelters in the County. An inventory of vulnerable homeless shelters in the project area was not available at the time of this assessment.

Parking and rear of shelter; Planned site for expansion.

View of water entry point at dorm room door to garden.

22. RAVENSWOOD PONDS

US Fish and Wildlife Service (FWS)

VULNERABILITY SUMMARY

The Ravenswood Pond Complex is **moderately vulnerable** to sea level rise. If inundated, snowy plover habitat could be lost, and rising sea levels could reduce the flood reduction benefits provided. Adaptive capacity is high, as despite the potential loss of snowy plover habitat, other habitat benefits would remain, and the flood reduction and recreational uses on site could be adapted as well. Consequences of the loss of the pond complex could impact the region, with potential for permanent loss of wetlands and heavy costs to improve local protection of heavily used roads and other adjacent assets.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	High	High

ASSET CHARACTERISTICS

Marsh Road | Menlo Park

Asset Description and Function:

The Ravenswood Pond Complex contains four managed seasonal ponds, earthen berms, the All American Canal, and fringe marshes outside of the berms. The former salt ponds now in the Don Edwards San Francisco Bay National Wildlife Refuge provide three benefits: habitat, recreation, and flood risk reduction. Ponds are normally dry except during rain, or when deliberately filled with water to control vegetation. The South Bay Salt Pond (SBSP) Phase 2 Restoration Project will restore tidal marsh in the outer pond and build up interior berms to protect snowy plover habitat. Adjacent to the Ravenswood Ponds is the Bedwell Bayfront Park, which is a closed landfill with a leachate and methane collection system, including a flare that burns the gas. The area also includes wastewater equalization basins owned by the West Bay Sanitary District. These are considered critical assets and impacts to these should be clarified in the future.

Asset Type	Wetlands (Managed ponds)
Asset Risk Class	N-Wetlands
Size	685 acres
Year of Construction	2003 (Purchased)
Elevation	5 feet
Level of Use	Typically filled during winter months
Annual O&M Cost	\$20,000 - \$50,000
Special Flood Hazard Area	N/A
Physical Condition	N/A
Landowner	US FWS

Underground Facilities

There are pipes underneath the ponds running parallel to the road, but the pipes are not associated with this asset.

Environmental Considerations

The ponds provide important nesting and foraging habitat for the endangered western snowy plover and other waterbirds; planned restoration actions will restore tidal marsh habitat and enhance remaining ponds to support a diversity of wildlife.

RAVENSWOOD PONDS

ASSET SENSITIVITY

The sensitivity of the asset to inundation is high, as two feet of water level rise will flood all four ponds. Temporary flooding that occurs during snowy plover nesting season (April through August) would prevent them from nesting, as they depend on dry soils. Permanent flooding would therefore eradicate nesting sites. The fringe marshes can also be sensitive to high water, and if permanently overwhelmed, could be converted to tidal mud flat. The loss of wetland and marsh functions could affect the other benefits provided by wetlands, including water quality, and the flood risk reduction benefits of the ponds would be reduced, and the Bayshore Expressway and assets behind it have no other line of defense from high water on San Francisco Bay.

If all the berms in the complex were overtopped, the road could be inundated, affecting traffic in both directions. Recreational uses at the Ravenswood Complex have moderate sensitivity to temporary or permanent flooding, as flooding could reduce the abundance or diversity of waterfowl and shorebird species that has historically attracted birdwatchers, or it could reduce trail access. The future sensitivity of the site (given restoration) is moderate and will depend on the ability of sediment and tidal marsh accretion to keep up with sea level rise. Snowy plover nesting habitat will remain sensitive to future flooding, though other species and habitats may be less sensitive.

Aerial view of Ravenswood Ponds

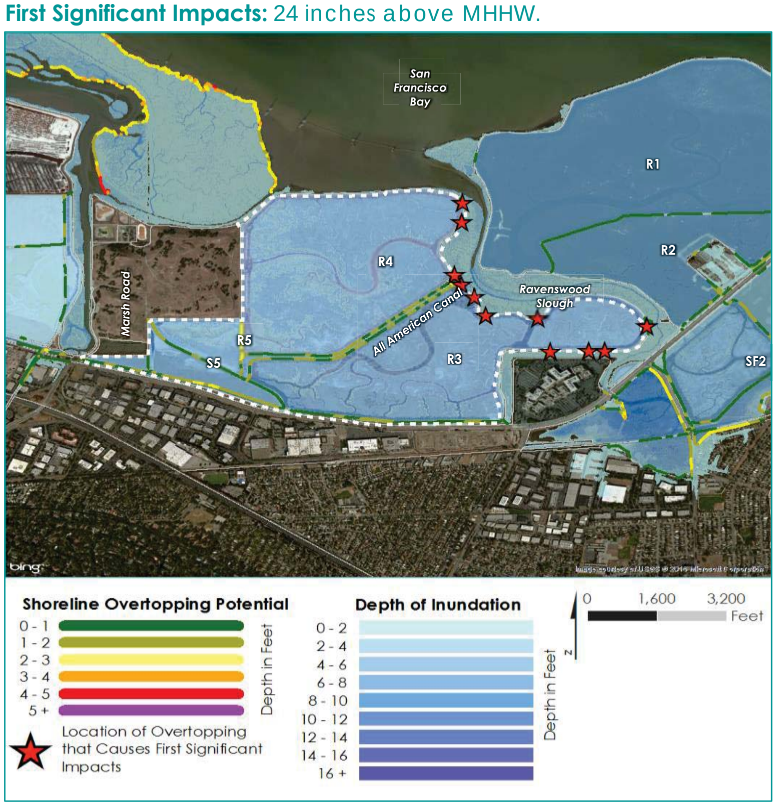

Photo: John Bourgeois

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

Ravenswood Slough, connected to San Francisco Bay, is the source of coastal flooding at the Ravenswood Ponds. When water surface elevations reach between 12 and 24 inches above the current mean higher high water (MHHW) level, the slough overtops the embankment at many low spots along the eastern portion of the site, indicated by the red stars on the map to the right, potentially creating a flow path through the asset and widespread flooding. No overtopping analysis has been performed on the existing berms or future levees to understand how they would perform during a storm.

First Significant Impacts: 24 inches above MHHW.



Cross-Cutting Vulnerabilities

The ability of the existing fringe marshes and future restored tidal marshes to keep up with sea level rise will depend largely on the Bay sediment supply, which is affected by many additional factors.

All activities in this location depend on permits from multiple agencies (sometimes with competing objectives), which can make adaptation and restoration of the ponds' many functions and varied habitats challenging.

RAVENSWOOD PONDS

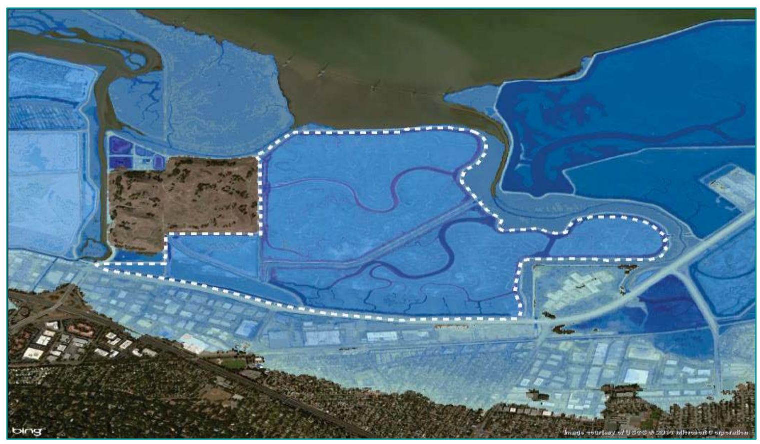
SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

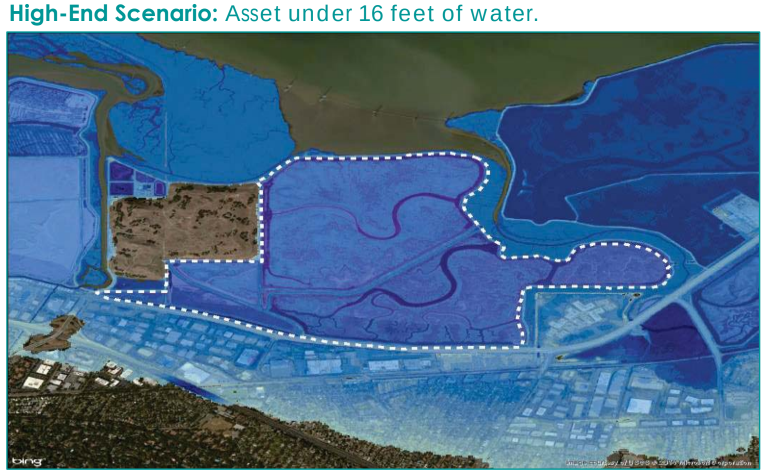
Exposure of the asset in its current state is moderate as it has never been overtopped, but it is subject to waves during high tides (and to potential breaches of the earthen berms) and is fully inundated under all three sea level rise scenarios (see maps on right). Once inundated, ponds would not drain because there is no natural drainage or any pumping. High groundwater tables may contribute to poor drainage on site, but there are no known instances to date of groundwater being the sole source of standing water. The outboard earthen berms along Pond R3 and R4 are higher than the land, and therefore prevent inland flooding of State Route 84 and the section of Bayshore (and everything behind it) between Marsh Road and State Route 84. Future inundation at the site could lead to exposure of the highway as well. Future restoration plans will restore Pond R4 to tidal marsh (the outermost pond) and raise the levee along the All American Canal, reducing tidal and wave action on Pond 3. It is expected that increased sediment will allow the marsh to accrete at pace to match sea level and the marsh will be successfully established. It is expected that the SBSP Phase 2 Restoration Project will raise levees to protect the snowy plover habitat in Pond R3 from flooding. The SAFER Bay project anticipates raising levees/berms along the Bayshore highway, which will reduce exposure of the highway and associated infrastructure to inundation.

Baseline Scenario: Asset inundated by 9 feet.

Mid-Level Scenario: 13 feet of water inundates asset.



High-End Scenario: Asset under 16 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(24 inches)*	*0*	*9*
Baseline *1% Flood*	*0*	*9*
Mid-Level *1% + 3.3 feet*	*0*	*13*
High-End *1% + 6.6 feet*	*3*	*16*

RAVENSWOOD PONDS

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the asset's many functions varies and is high overall. There are additional options for western snowy plover nesting in the region, even if the local population could not nest here. Furthermore, the area can provide habitat benefits for a greater diversity of species, particularly as it converts to tidal marsh. To increase the ability of tidal marsh to adapt with sea level rise, the SBSP Phase 2 Restoration Project includes a proposal to build an artificial upland transition zone (30:1 slopes). It may be possible for the tidal fringe marshes, and tidal marsh created when the pond complex is breached, to accrete at a pace commensurate with sea level rise due to the expected sufficient sediment supply. This also enhances the adaptive capacity of the flood risk reduction benefits provided by the complex because marsh in front of the levees provides an additional line of defense from wave action and erosion of berms. Even with the loss of these, the Bayshore Expressway could also be protected with a flood wall or levee in the long-term. Recreational uses of the site are highly adaptive, as trails are easy to relocate and bird viewing options would likely remain.

Consequences

Environmental impacts to the asset would be high, given the potential for a loss of many functions provided by wetlands in general, including biodiversity and water quality benefits, and given local agencies' goals to restore significant tidal marsh in the San Francisco Bay. Wetland and marsh habitat is already limited in San Francisco Bay, and, if they do not accrete at a pace commensurate with sea level rise, it could be a major loss of an important habitat in the region. Direct economic impacts from damage to the site itself would be low, although if the berms were overtopped in a major storm and assets behind the pond complex (i.e., highway, bridge access, or businesses) flooded, this could cause considerable economic damages that have not yet been quantified. If the asset were permanently inundated, it would also be costly to build levees or other flood protection for the Bayshore Expressway and nearby assets behind the complex; levee construction costs millions of dollars per mile. If the site were lost, some public access and recreational uses could be lost as well, though the adjacent Bedwell Bayfront Park could absorb some of those and may still provide options for wildlife viewing from the property.

Additional Important Information

Nearby Bedwell Bayfront Park is regularly used for recreation due in large part to the bird viewing opportunities at the Ravenswood ponds. It may be possible for sea level rise to affect the landfill at Bedwell Bayfront Park either from the rising groundwater table, or by eroding and exposing part of the landfill, which could release waste materials into nearby waters. As part of the SBSP Phase 2 Restoration Project, future plans aim to improve the adaptive capacity of the Ravenswood Pond Complex to sea level rise. 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 be improved to enhance flood protection and the remaining three ponds will continue to be managed for habitat—water birds and western snowy plover. Upland transition zones to buffer wave action and provide wetland migration space are also a part of the restoration project.

Asset-Specific Adaptation

Successfully preparing the SBSP for sea level rise is a complex task, and will include different approaches for different habitat types, such as snowy plover nesting habitat, duck pond habitat, and tidal marsh. To ensure a successful approach, the restoration project is designed to allow tidal marsh habitats to shift over time, and also incorporates an adaptive management approach, which allows for changes as needed based on detailed, science-based monitoring data.

Vulnerable Wetlands

This is the only Asset Vulnerability Profile on vulnerable wetlands in the County. The vulnerability assessment analysis shows that there are 7,242.9 acres of vulnerable wetlands in the project area.

Trail along the pond complex on a rainy day.

23. SOUTH SAN FRANCISCO - SAN BRUNO WATER QUALITY CONTROL PLANT

City of South San Francisco
City of San Bruno

VULNERABILITY SUMMARY

The South San Francisco San Bruno Water Quality Control Plant (WQCP) is a critical asset that is **highly vulnerable** to sea level rise. The site is vulnerable (exposed) at three spots along the shoreline, which could cause flooding of the Plant's power distribution, its most essential and sensitive component. A loss of power would cause the plant to shut down completely, and saltwater intrusion could result in unsanitary discharges. Adaptive capacity is low; there is no other plant to treat the wastewater in this area, and backup power is vulnerable to flooding. Total loss of service would damage the plant, and result in sewage backups or overflow.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	High	Low	High

ASSET CHARACTERISTICS

195 Belle Aire Rd | South San Francisco

Asset Description and Function:

The WQCP treats wastewater (influent) for approximately 100,000 people in South San Francisco, San Bruno, Colma, and part of Daly City. The plant also dechlorinates treated effluent for Millbrae, Burlingame, and San Francisco International Airport. The major treatment processes include screening, grit removal, primary and secondary treatment, and dechlorination. Treated water (effluent) is conveyed to San Francisco Bay via a deepwater outfall.

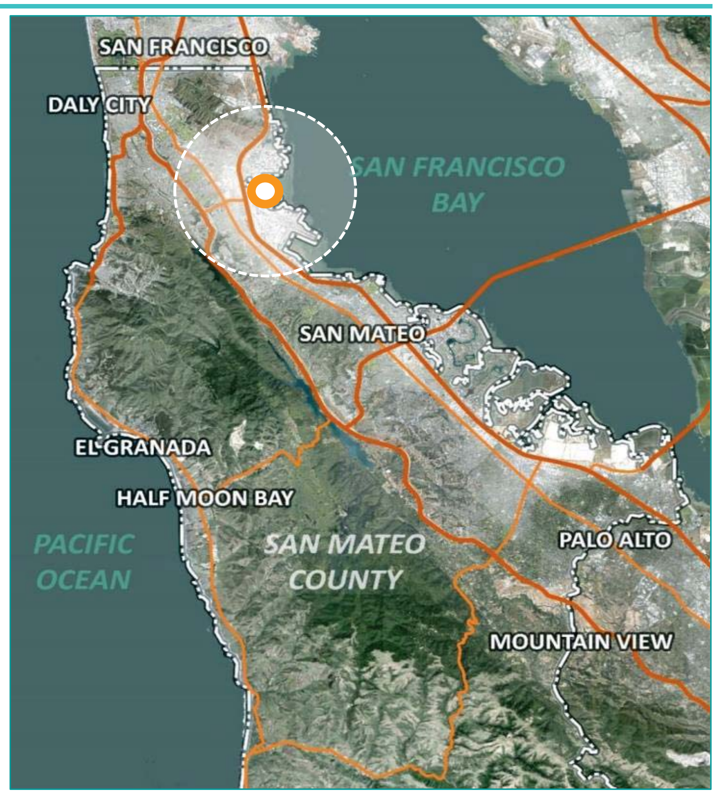
Asset Type	Wastewater Treatment Plant
Asset Risk Class	3
Size	21 acres
Year of Construction	1950
Elevation	11 feet
Level of Use (Dry Weather)	7.5 million gallons/day
Annual O&M Cost	$20,500,000
Special Flood Hazard Area	Asset is in SFHA
Physical Condition	Fair
Landowner	City of South San Francisco

Underground Facilities

Power conduits, portions of grit removal, sump pump, power transmission system (wire and cables rated for waterlogged conditions).

Environmental Considerations

The area near the site provides a habitat corridor that includes sand beaches, eelgrass, oyster beds, macroalgal beds, mudflats, rocky intertidal areas, and tidal marsh. The area is also an important avian stopover site as well as a spawning site for Pacific herring.



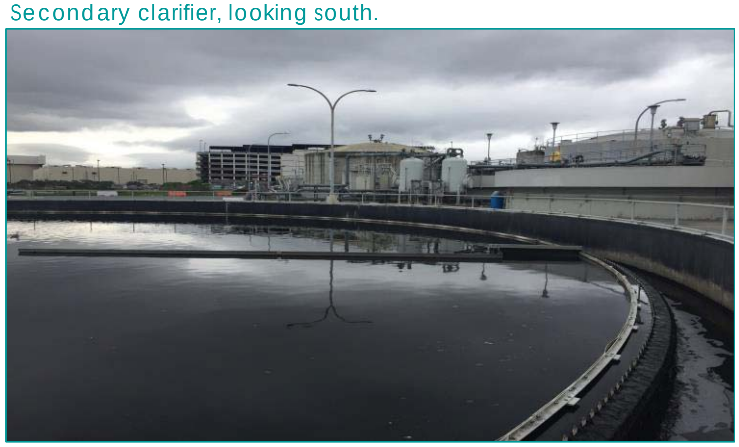
SOUTH SAN FRANCISCO - SAN BRUNO WATER QUALITY CONTROL PLANT

ASSET SENSITIVITY

The WQCP is very sensitive to inundation and high water. The power distribution system is the WQCP's most critical component. If flooded, the WQCP's main and backup power would be lost. A loss of power would cause the plant to shut down completely. Other sensitive components include the pumps, which are subterranean by design and would not work if inundated. Because off-site sanitary sewer pump stations (pump stations), which are part of the collection system, will still pump and convey water to the WQCP, both of these outages would result in on-site flooding or wastewater backup, which would lead to a spillover at the main control building and a loss of service.

In addition, a nearshore bypass line that can be used during extreme storm events to discharge fully treated effluent to Colma Creek is very sensitive to high water. If water levels become higher than the weir, creek water can cause backflow into the WQCP, affecting the usability of the nearshore bypass line. The weir was elevated 18 inches, but permanent high creek levels may decrease the level of service, preventing discharge during extreme storms. The WQCP is also very sensitive to salt water that could intrude from off-site pump stations or through the plant's underground discharge conduit. On-site fuel tanks have secondary containment and are not sensitive to flooding. The WQCP's effluent storage basin will not be affected by sea level rise.

Secondary clarifier, looking south.



SHORELINE VULNERABILITY

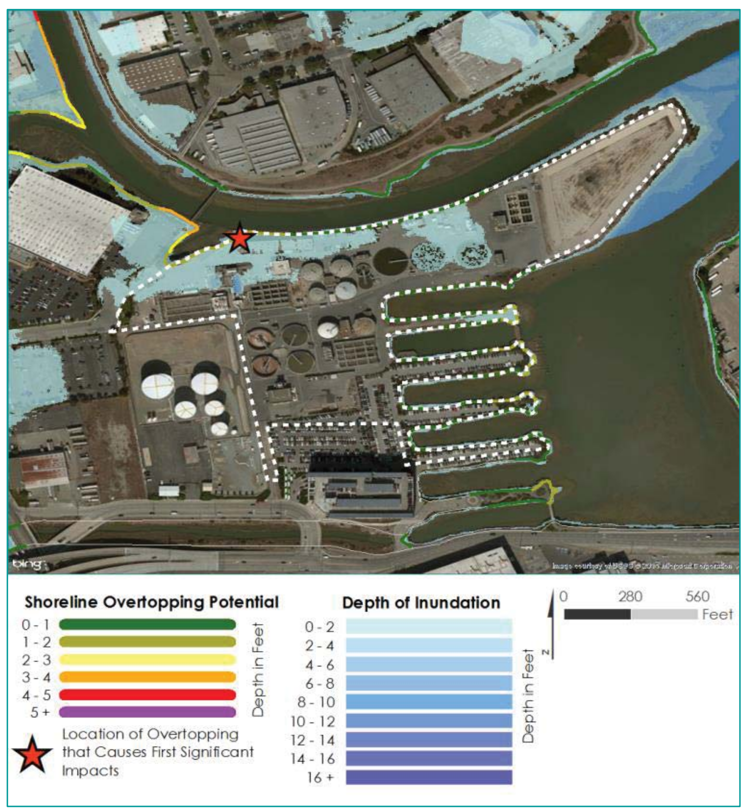
Shoreline Overtopping Analysis

When water surface elevations in San Francisco Bay reach between 0 and 12 inches above the current mean higher high water (MHHW) level, Colma Creek would overtop the embankment at the northwestern edge of the property (red star), creating a potential flow path to the critical features of the asset. The first level of inundation with significant impacts to the asset does not occur until water elevations reach between 36 and 48 inches above MHHW.

Cross-Cutting Vulnerabilities

The WQCP is vulnerable to collection system saltwater intrusion. If any of its off-site (low-lying) pump stations were exposed to salt water, the salt water would enter into the conveyance system. Excessive saltwater intrusion can affect the plant's biological treatment processes, and can lead to exceedance of effluent limitations. A loss of any pump station could affect the level of service of the collection and conveyance system. For more information see profile on Pump Station Number 4 (see AVP #8). Flooded access roads would inhibit the delivery of fuel and chemicals needed for operation and treatment.

First Significant Impacts: 48 inches above MHHW.



SOUTH SAN FRANCISCO - SAN BRUNO WATER QUALITY CONTROL PLANT

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

Though it has never flooded, the WQCP is currently exposed to high flows at three main locations on Colma Creek due to rainstorms combined with high tides and surges. Plant staff observed a 1997 high-water event on Colma Creek, which eroded 6 feet of shoreline just behind the administration building on the northwestern corner of the property. This part has since been reinforced with riprap (large, loose rock), but another low-lying spot in the northeastern part of the site just north of the secondary clarifiers enables a pathway for water to reach the transformer and power distribution system. Once on site, water could also enter the underground components of the asset. Finally, the nearshore bypass line that can be used during extreme storms to discharge fully treated effluent to Colma Creek is very sensitive to high water. If water levels become higher than the weir, creek water can flow up the line and the plant, impacting the usability of the nearshore bypass line.

Because it is tidally influenced, sea level rise will increase the frequency of high water in Colma Creek, thus increasing the potential to overtop low spots and potentially inundate part or all of the asset. Sea level rise also increases the frequency with which salt water could intrude over the discharge weir (which was recently elevated). More frequent higher water levels combined with major storm events will likely overwhelm the system more frequently because stormwater makes its way into the sewage treatment process, using up some of the pumping capacity.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(48 inches)*	***0***	***7***
Baseline *1% Flood*	***0***	***6***
Mid-Level *1% + 3.3 feet*	***0***	***15***
High-End *1% + 6.6 feet*	***0***	***19***

Baseline Scenario: Asset is not yet inundated.

Mid-Level Scenario: Asset inundation up to 15 feet.

High-End Scenario: Asset inundation of 0 to 19 feet.

SOUTH SAN FRANCISCO - SAN BRUNO WATER QUALITY CONTROL PLANT

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity to both near-term flooding and long-term sea level rise is low. The plant has some built-in redundancies and enough diesel to operate the plant using generators for up to 48 hours. There are also staff on site 24 hours/day to respond to complications. However, there are not any flood mitigation measures in place for the WQCP's most vulnerable component (the power distribution system) and no way for the plant or its backup generators to function if power were lost. In addition, there is no other plant that can treat wastewater from this service area in the near term. Finally, the WQCP has no means of adapting should seawater enter the plant either from the collection system or from Colma Creek. Minor interventions may be possible to address near-term flooding, but long-term adaptation to sea level rise will require a major infrastructure upgrade both to the plant and to Colma Creek.

Consequences

Consequences of flooding are high. Flooding the WQCP would result in direct damages to any number of plant components, which would have to be torn down and rebuilt. If the headworks were to flood, overflow would damage the grit processing room and it would have to be replaced. The loss of function would mean that overflow could discharge directly into Colma Creek without receiving treatment. If the plant lost power altogether, it is also possible for wastewater to back up in manholes and impact city streets. In addition, the plant could affect up to 100,000 customers in the service area. While few injuries would be expected from flooding, there would be a danger of electrocution for any on-site staff. Economic impacts based on the most recent valuation could range up to $282 million, though current direct replacement costs are unknown. EPA fines for discharging untreated effluent could add an additional $60 million or more.

Additional Important Information

Plant expansion projects and additional construction has occurred in the following years: 1964, 1977, 1980, 1992, 1999, 2005 and 2015. Current capital improvements include plans to treat up to 40 million gallons per day of secondary effluent and replacing existing transformers. Sea level rise was not identified as a risk at the time of the design of these projects.

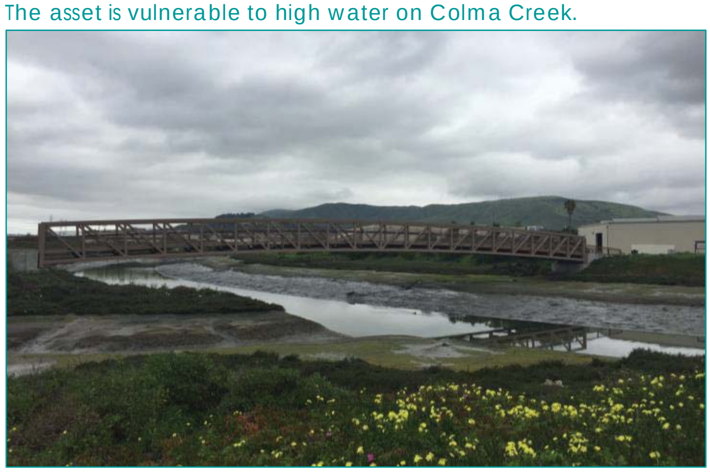
Adaptation

On-site adaptation measures include nonstructural measures such as elevating or floodproofing water- or salt-sensitive equipment such as the power/electrical systems or the L-shaped weir, or potentially floodproofing any number of individual critical structures. It may be possible to build a seawall around the perimeter. Elevating the treated effluent discharge location (and associated infrastructure) may be required as more frequent high water levels on Colma Creek could prevent discharge, necessitating the use of the effluent storage much more frequently. Treating stormwater upstream through green or traditional stormwater infrastructure can also reduce high flows on Colma Creek.

Vulnerable Wastewater Treatment Plants

There are Asset Vulnerability Profiles on the following vulnerable wastewater treatment plants: SAM Plant (AVP #2) and Silicon Valley Clean Water (AVP #14). The vulnerability assessment analysis shows that there are seven vulnerable wastewater treatment plants in the project area, including those in the City of Millbrae, City of San Mateo, City of Burlingame and at SF International Airport.

The asset is vulnerable to high water on Colma Creek.



Part of low-lying power and electrical system.

24. FOSTER CITY LEVEE

The City of Foster City

VULNERABILITY SUMMARY

The vulnerability of the Foster City Levee system (Levee) is **moderate.** If overtopped, the levee would not provide its primary function; however, it was designed not to fail, making it moderately sensitive to coastal flooding. Exposure of the asset is low; it is tall enough to accommodate the baseline scenario. Adaptive capacity of the asset is high, as the lagoon pump system located just behind the levee will reduce the extent of interior flooding if the levee is overtopped. If the levee failed or lost function completely, the scale of the impact would be very high, as the 40,000 residents of Foster City and San Mateo, along with the cities' infrastructure and property, could be exposed to deep flood water.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Low	High	High

ASSET CHARACTERISTICS

Address: Entire perimeter of Foster City

Asset Description and Function:

The Levee protects 40,000 people in Foster City and San Mateo from coastal flooding. The Bay Trail on top of the levee provides a popular recreational asset to the region. The asset, which consists of an earthen berm, floodwall, and intake and discharge tide gates, does not meet federal accreditation standards for elevation. It is undergoing an improvement process and there are plans to raise the levee to meet accreditation standards and adapt to sea level rise. This asset profile pertains to the existing levee.

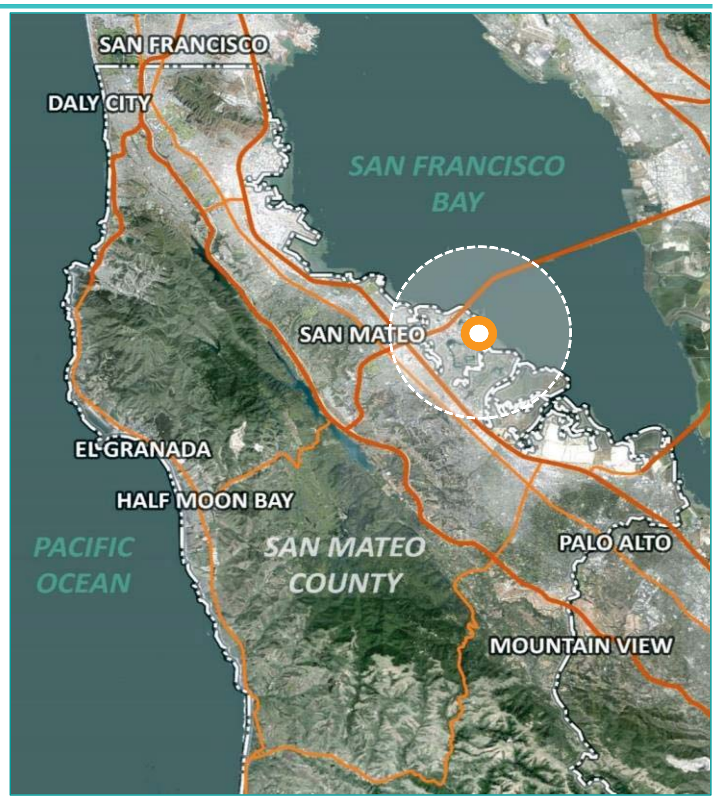
Asset Type	Flood Control Infrastructure
Asset Risk Class	4
Size (Length)	8 miles
Year of Construction	1960 (Improved in 1994)
Elevation (average)	12 feet NAVD
Protection Provided	17,000 properties
Annual O&M Cost	$20,000
Special Flood Hazard Area	N/A
Physical Condition	Excellent
Landowner	State of CA, Estero Municipal Improvement District, and City of Foster City

Underground Facilities

The stormwater pump station discharges stormwater water collected in the lagoon to the bay. The floor elevation of the facility is at the same level as the levee. All other utilities including water, sanitary sewer, electricity and telephone services are underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



FOSTER CITY LEVEE

ASSET SENSITIVITY

The Levee itself is moderately sensitive to high water; it was designed to withstand overtopping from coastal inundation. While the Levee would likely not fail catastrophically if overtopped by floodwater, the asset would not perform its primary function (flood protection), and it would require the use of backup or redundant measures to reduce flooding. The trail on top of the Levee is sensitive to high water and would not be accessible if it were inundated.

However, while the Levee is only moderately sensitive, there are thousands of assets protected by the Levee system, including infrastructure, houses, and businesses, that are likely very sensitive to coastal flooding and especially sensitive to levee overtopping because they were likely not designed with flooding in mind.

Bike path along Foster City Levee.

SHORELINE VULNERABILITY

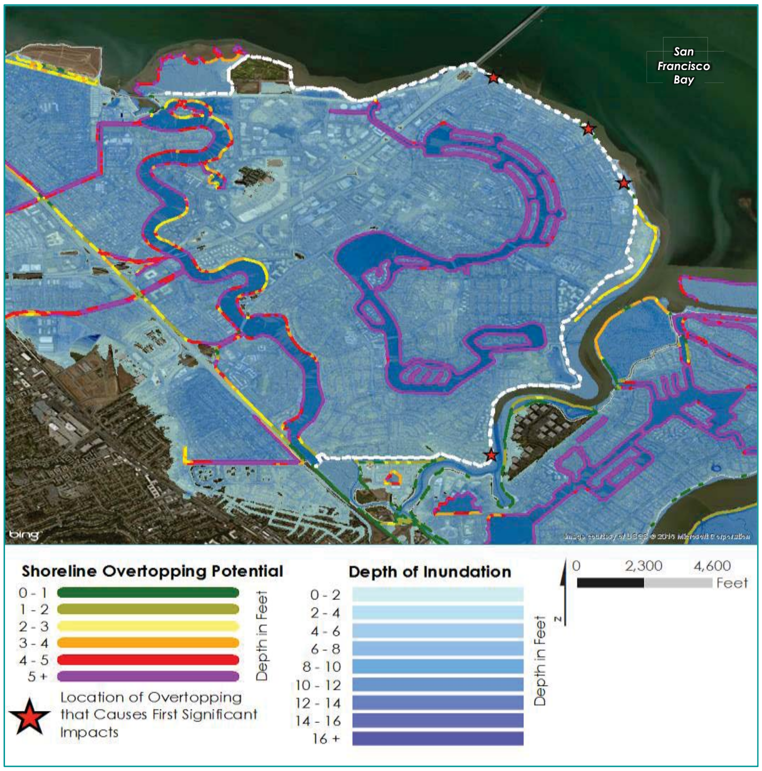
Shoreline Overtopping Analysis

When water surface elevations reach between 48 and 52 inches above the current mean higher high water (MHHW) level, water from San Francisco Bay (in the northeast) and Belmont Slough (in the southeast) overtops the Levee, which could create widespread inundation in Foster City (assuming no intervention). These overtopping locations are indicated by the red stars on the map to the right.

Cross-Cutting Vulnerabilities

Because the Levee and the Foster City Lagoon Pump System protect thousands of assets (including houses, businesses, and infrastructure), failure or overtopping of the levee and failure of the pump system could suddenly expose many assets and people to deep flood waters.

First Significant Impacts: 52 inches above MHHW.



FOSTER CITY LEVEE

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Levee is continuously exposed to daily tidal, wind, wave erosion, and scour, and to the occasional king tide or storm event. Though the asset has not been overtopped by coastal flooding so far, sea level rise will increase the frequency with which the Levee experiences high water, and thus the potential for overtopping. Roughly 12 inches of sea level rise will raise water levels enough so that there is water against the levee 24 hours a day (as opposed to just during high tides).

With no action, the Levee could be overtopped by significant storm surge or wave action today (between 48-52 inches high as noted in the previous map), causing flooding in Foster City in the interior of the levee. In contrast to areas not protected by a levee system, which will experience incremental flood exposure due to sea level rise, assets that are below sea level and protected by levees will experience no coastal flooding until the levee that protects them is overtopped or fails, at which point flood waters in the interior could be very sudden or deep. The depth and extent of flooding will depend on the high water conditions and the effectiveness of the lagoon pump system.

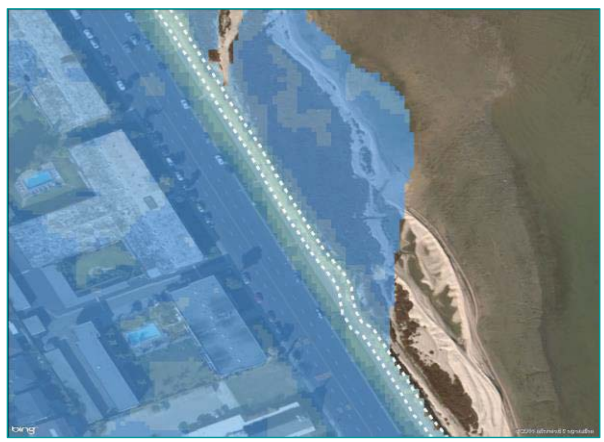
With no action, future coastal storm surge could overtop the lowest segment of the levee by up to 6 feet. However, Foster City plans to elevate the Levee, making this an unlikely scenario. The maps at the right show one of the vulnerable segments of the asset, and the table below reflects the maximum potential for overtopping at this specific segment of the Levee.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(52 inches)*	***0***	***1***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***3***
High-End *1% + 6.6 feet*	***5***	***6***

Baseline Scenario: Levee segment is not overtopped.

Mid-Level Scenario: Segment overtopped by 3 feet.



High-End Scenario: Levee overtopped by 6 feet.

FOSTER CITY LEVEE

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Levee, when combined with Foster City's interior storm drain and pump system, has a high adaptive capacity to maintain the flood risk reduction function. Foster City operates a pump system (from the Corporation Yard) to reduce the depth and extent of interior, rain-driven flooding. The pump system capacity is up to 250,000 gallons per minute, which is roughly sufficient to pump water from the 1% annual chance rain event or from expected amounts of levee overtopping. Adaptive capacity will decrease in the future if no actions are taken, as pumping capacity will be insufficient to handle increased amounts of overtopping that could occur with sea level rise. The pumps can operate while inundated because they were designed to do so using diesel fuel instead of electrical power. There is also emergency equipment in the pump house at the Foster City Corporation Yard to support flood fighting, including 5,000 sandbags. There are additional stockpiles and boulders available if needed. The Foster City drainage and pump system can also drain the lagoon in advance of a storm or should the levee be overtopped for a short duration to accommodate floodwaters and prevent flooding of Foster City's streets, infrastructure, and property.

Consequences

Consequences from the complete loss or failure of the Levee could be very high. Levee failure during a large storm with high water levels could result in catastrophic damages to property, infrastructure, and life safety. The Foster City Levee protects assets in Foster City, as well as some areas of San Mateo and Belmont. Flooding could damage up to 17,000 properties in the flooded area, estimated at up to $75 million in replacement costs. Pending successful evacuation, damages and the life safety hazard could be reduced. If the asset were lost, Foster City's key services could be lost, including damages to the stormwater and wastewater systems, which could pose additional safety hazard and water quality impacts if untreated wastewater were released. Thousands of people would require shelters, and resources from other cities or counties might be required to help. Costs to repair damage to a breached levee vary but are expensive. See the Asset Profiles for the following assets in this inundation zone: San Mateo Police Department; Foster City Corporation Yard; and the Bayside STEM Academy.

Additional Important Information

Because much of San Mateo County is low-lying along San Francisco Bay, a vulnerability in one part of the shoreline could affect many cities and assets nearby. Foster City is in the planning stages of raising the levee, but could still be exposed to sea level rise if neighboring cities do not also adapt to sea level rise. Adaptation requires a coordinated plan.

Other Vulnerable Levees

This is the only Asset Vulnerability Profile on vulnerable levees in the County. The vulnerability assessment analysis shows that there are an estimated 25.9 miles of vulnerable levees and floodwalls in the project area.

Asset-Specific Adaptation

Foster City is currently undergoing a re-accreditation process for the levee, and plans to raise it to meet sea level rise projections up to 2050. Depending on the pace of sea level rise, the Levee may need to be raised again in the future to accommodate additional sea level rise. Adapting some of the protected assets may also be beneficial should the levee ever lose function.

Bay Trail on top of levee system is a recreational asset.

25. FOSTER CITY CORPORATION YARD

Owned by the City of Foster City

VULNERABILITY SUMMARY

Vulnerability of the Foster City Corporation Yard (Yard) is **low**. The critical stormwater and wastewater systems were designed to tolerate flooding, making the Yard's functions relatively insensitive to flooding. Present exposure of the Yard is low, as it is protected from high water on San Francisco Bay by the Foster City levee. Finally, the pumping infrastructure system in the Yard itself was built to minimize the depth and extent of flooding, reducing potential damages to facilities and reducing the likelihood for a loss of service, giving the pump station a moderate adaptive capacity. The scale of consequences should the Yard lose service are very high.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Low	Low	Moderate	High

ASSET CHARACTERISTICS

100 Lincoln Centre Dr | Foster City

Asset Description and Function:

The Yard serves around 31,000 people, and it houses all critical infrastructure for Foster City's main utilities, including stormwater and wastewater pumping systems, potable water tanks, and a communication tower that supports emergency broadcasting. The Foster City Lagoon (just south of the corp yard) acts as the storm drain system for the City and controls runoff or storm flows on the interior side of the levee. The lagoon is also a valuable recreational asset for Foster City.

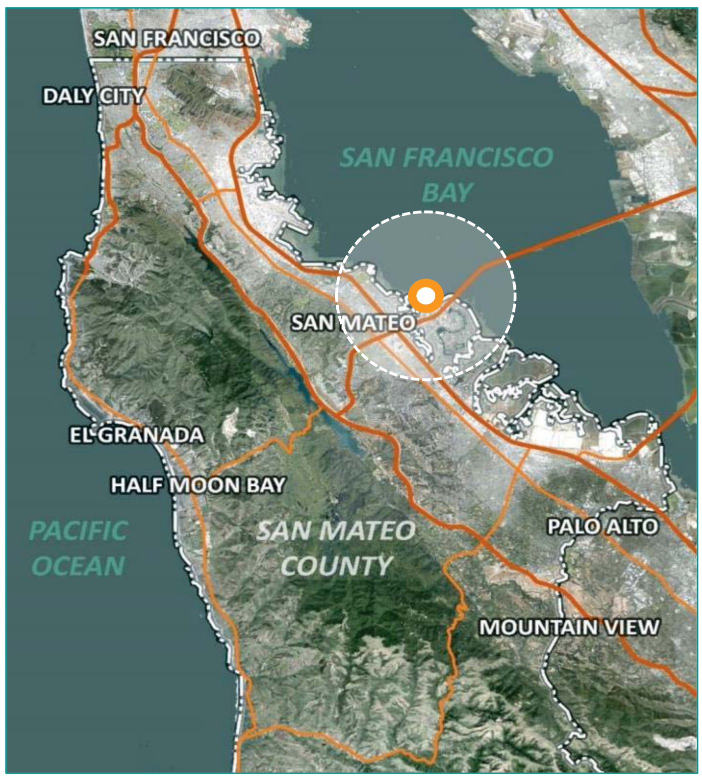
Asset Type	Corporation Yard
Asset Risk Class	4
Size	9.1 acres
Year of Construction	1960s
Elevation	5 feet NAVD
Level of Use	24 hours per day
Annual O&M Cost	$50,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Good
Landowner	City of Foster City, Estero Municipal Improvement District

Underground Facilities

Utility and electrical lines, sewer and wastewater pipes are underground.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



FOSTER CITY CORPORATION YARD

ASSET SENSITIVITY

Most services provided by the Yard are not very sensitive to a moderate level of coastal inundation. Most importantly, for stormwater and wastewater, the two 750-horsepower pumps (with a combined capacity of 250,000 gallons per minute) are both elevated and operate on diesel fuel, not electricity, meaning their operation is not sensitive to inundation. A loss of the pumps would require inundation to be so severe that all access to the pumps or fuel is eliminated. While drinking water would be sensitive to saltwater intrusion, the potable water tanks are sealed and the only inlet for salt water would be through vents in the top, making it insensitive to minor inundation.

The communication tower is sensitive to flooding because the lagoon pump house on which the tower sits contains the essential components for the communication tower. If flooded, the loss of those components would likely cause the communication tower to lose service. While it is unlikely the tower itself would be exposed to flood water, long-term exposure could cause corrosion and structural damage to the tower. Lastly, if the Yard and vicinity were flooded, recreational use of the lagoon would be eliminated until floodwater were pumped out, any damage to relevant infrastructure repaired, and until any water quality concerns were addressed.

Communication tower with emergency broadcast function.

SHORELINE VULNERABILITY

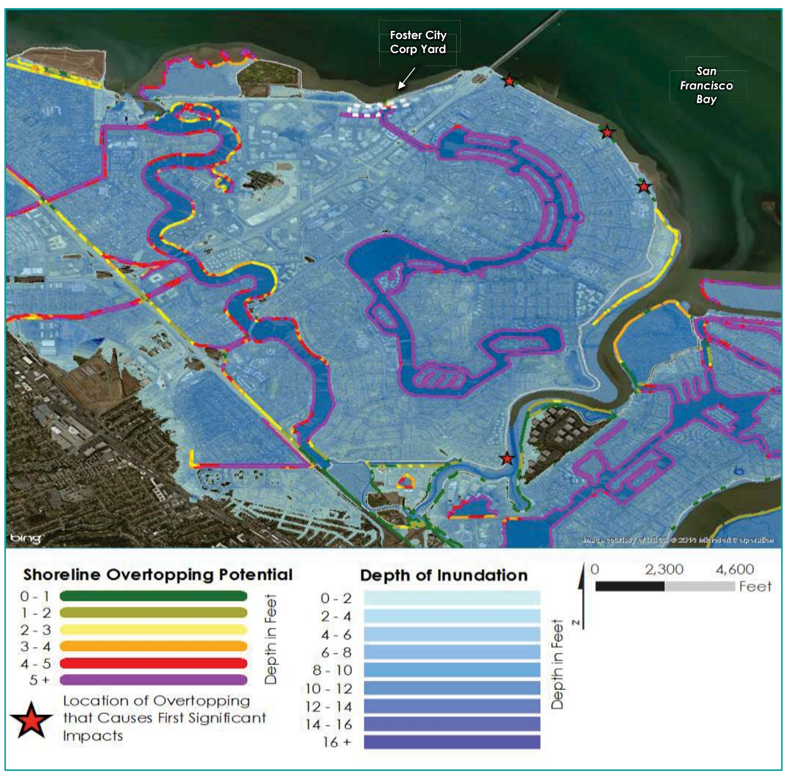
Shoreline Overtopping Analysis

When water surface elevations reach between 48 and 52 inches above current mean higher high water (MHHW), water from San Francisco Bay (in the northeast) and Belmont Slough (in the southeast) can overtop the Foster City levee (red stars in map), causing widespread inundation and creating a potential flow path to the asset. The nearest overtopped section of the Foster City levee is roughly half a mile from the Yard.

Cross-Cutting Vulnerabilities

The exposure of the Yard depends on the Foster City levee system and the shoreline that connects to the Foster City levee system (including neighboring communities). This means that even as Foster City may improve its levee to adapt to sea level rise, areas protected by the Foster City levee (including the Yard) could be exposed to flooding due to overtopping of other sections of the shoreline that are lower than the Foster City levee.

First Significant Impacts: 52 inches above MHHW.



FOSTER CITY CORPORATION YARD

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

Exposure to coastal inundation is low because this area is protected by the Foster City levee system, and therefore the corp yard and its critical infrastructure systems have not experienced any coastal flooding. Because the Yard and Foster City were built on bay mud, groundwater tables are high and the ground is saturated most of the time, which makes the area vulnerable to any type of flooding. This necessitates the frequent use of the lagoon pump system.

Modeling suggests that the corp yard will be below sea level with between 0 and 12 inches of sea level rise. However, it will not experience coastal flooding until the levee that protects it is overtopped or fails, at which point the asset could experience significant damage (assuming no action), and water levels could flood the Yard up to 16 feet deep, depending on the scenario (see table below).

Many of the Yard's components are elevated, including the pumps, the communications tower, the water tanks, and the diesel tanks (used to operate the pumps), reducing the likelihood of exposure even if flooding occurred on the interior of the levee. The lagoon system would likely fill up as well.

**Note: Maps to the right assume no intervention (i.e., interior pumping and drainage system).*

Baseline Scenario: Corp yard not flooded.

Mid-Level Scenario: Corp yard under 2-13 feet of water.

High-End Scenario: Corp yard under 6-16 feet of water.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(52")*	***0***	***11***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***2***	***13***
High-End *1% + 6.6 feet*	***6***	***16***

FOSTER CITY CORPORATION YARD

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the Yard is moderate. There are no other locations that can provide the same functions; however, the existing infrastructure systems were designed to tolerate and minimize the extent and depth of flooding on site (and in Foster City) or have backup systems to do this. For example, with advance notice, Foster City will release water from the lagoon to San Francisco Bay in order to create space to accommode flood flows that may come from coastal flooding or a rain event. The pumps, which operate even while inundated, will continue to remove floodwater and have enough backup fuel to function for roughly one month. There are sandbags on site and response plans in place. There are also 18 emergency generators throughout Foster City to support the other key lift stations in maintaining the stormwater and wastewater functions, minimizing damage in Foster City. If the communication tower lost broadcast function, there are a number of other towers in the County that could compensate, rebroadcasting for the Yard tower such that only a small portion of the county would lose its signal altogether.

Consequences

The consequences of near-term and minor flooding are low; however, the impacts caused by a total loss of this asset would be high and could affect the entire area protected by the levee-pump system. The pumps and other buildings on site could incur direct damages, requiring repair or replacement, but the loss of service of critical infrastructure could contribute to greater and more significant impacts. It is possible that an event that causes a loss of this asset would be large enough to affect the region already, making the incremental impacts from the loss of the Yard small in comparison. However, the loss of these critical functions is worth noting, as they will need to be immediately restored following the receding (or pumping) of floodwaters. For example, a loss of potable water supply poses an immediate threat to fire-fighting operations, and lack of clean drinking water could be hazardous to Foster City's residents. A loss of sewer system function could result in sewer overflows, creating a public health hazard and property damage for the residents and businesses in Foster City and San Mateo (City of); this could affect up to 31,000 people. Total damages to the Yard are estimated at roughly $75 million.

Additional Important Information

The Foster City Levee may be raised to adapt to sea level rise, which means that the likelihood with which the Yard could be exposed to coastal flooding would be further reduced.

The pumps in the Yard combined with the levee system also protect communities identified as socially vulnerable (primarily due to their age and status as renters). This means they could face greater challenges, relative to other communities, in responding and adapting to any flooding.

Asset-Specific Adaptation

Adaptation needs at the site may be accommodated if the Foster City Levee is raised for sea level rise. However, the pump station could be floodproofed to maintain access (thus ensuring operation) even in a severe flood event, and to preserve the essential components of the communication tower.

Vulnerable Corporation Yards

There is another Asset Vulnerability Profile on vulnerable corporation yards: Belmont Corporation Yard (AVP #29). At the time of this assessment, an exhaustive dataset on corporation yards in San Mateo County is unavailable.

Foster City Lagoon as it enters pump house.

The levee in Foster City protects potable water tanks (white) in the corp yard (left).

26. BAYSIDE STEM ACADEMY

San Mateo - Foster City School District

VULNERABILITY SUMMARY

The Bayside Science, Technology, Engineering, and Mathematics (STEM) Academy (Academy) is **moderately vulnerable** to impacts of sea level rise. The Academy has a performance theater and soccer fields on the property that are used by numerous public and non-profit organizations. The asset is highly sensitive to inundation, as flooded buildings could force closure and evacuation. Exposure to coastal flooding is low due to the benefits provided by the Foster City Levee and Lagoon Pumping System; however, the Academy has already experienced groundwater seepage, making exposure overall moderate. Adaptive capacity is high, as students could be distributed to other schools in the district.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Moderate	High	High

ASSET CHARACTERISTICS

2025 Kehoe Avenue | San Mateo

Asset Description and Function:

The Academy is a public middle school serving the City of San Mateo within the Foster City and San Mateo School District. The school has an administrative building, a gym, 30 classrooms, five portable classrooms, a library, and a theater. The performance theater is also used by the greater community, and San Mateo Parks and Recreation uses the school yard field during soccer season (non-school hours). Like all other schools in the district, the Academy may be used as an emergency shelter if needed, though it has not been identified by the City of San Mateo or by the American Red Cross as a primary shelter site.

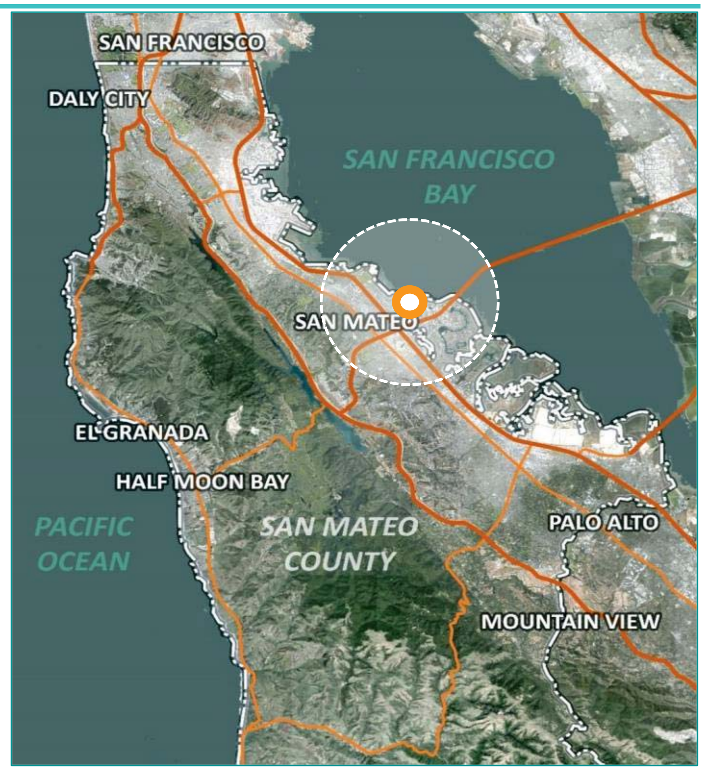
Asset Type	School
Asset Risk Class	3
Size	12 acres
Year of Construction	1959
Elevation	5 feet (one building below grade)
Level of Use	680 students 180 days/year
Annual O&M Cost	Unknown
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Good
Landowner	San Mateo - Foster City School District

Underground Facilities

The orchestra pit (performance theater) is below grade.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



BAYSIDE STEM ACADEMY

ASSET SENSITIVITY

The Academy's primary function is very sensitive to inundation, but the school's other functions are moderately sensitive. Specifically, the Academy is only moderately sensitive to a power loss, but could be very sensitive to inundation, depending on the extent and duration of the flood. While the school's transformer (power system) is at grade, the school can operate without power and has done so previously. However, if water inundated the classroom and other buildings that normally contain students, the Academy would likely close and students would need to be evacuated.

If the Academy were closed, it could no longer provide the emergency shelter service. The Academy and its buildings on site are fairly insensitive to groundwater table increase and saltwater intrusion. The theater was closed for repairs to fix a seepage problem, but the theater was able to reopen; the extent of groundwater seepage has not yet caused a disruption to any other services the Academy provides. Because there are no other below-grade essential facilities on the property, it is unlikely that future groundwater seepage driven by sea level rise would noticeably affect levels of service of buildings at the school.

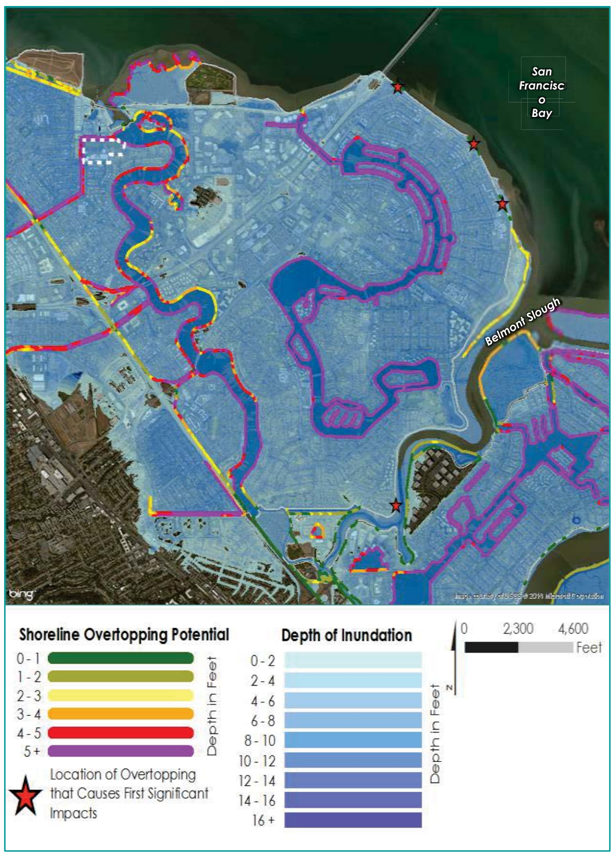
Entrance to Bayside STEM Academy.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

The Academy is in white-dashed lines. When water surface elevations reach between 48 and 52 inches above MHHW (6-10 inches above the 1% flood level), water from San Francisco Bay (in the northeast) and Belmont Slough (in the southeast) overtops the Foster City levee system, causing widespread inundation, and creating a potential flow path to the asset, if no action is taken. These areas are indicated by red stars on the map to the right. However, there is a proposal to raise the height of the levee system, reducing the exposure to flooding. Because the Academy is protected by levees, it will experience no coastal flooding until the levee system that protects it is overtopped or fails, at which point the asset could experience significant damage. The nearest overtopped section of the Foster City levee is roughly 1.8 miles northeast of the school.

First Significant Impacts: 52 inches above MHHW.



Cross-Cutting Vulnerabilities

The exposure of the Academy depends almost wholly on the Foster City levee system (see AVP #24), the lagoon pump system at the Foster City Corporation Yard (see AVP #25), and the City of San Mateo levee and pump system. If any of those assets were compromised, exposure of the school is almost certain.

BAYSIDE STEM ACADEMY

SEA LEVEL RISE EXPOSURE ANALYSIS

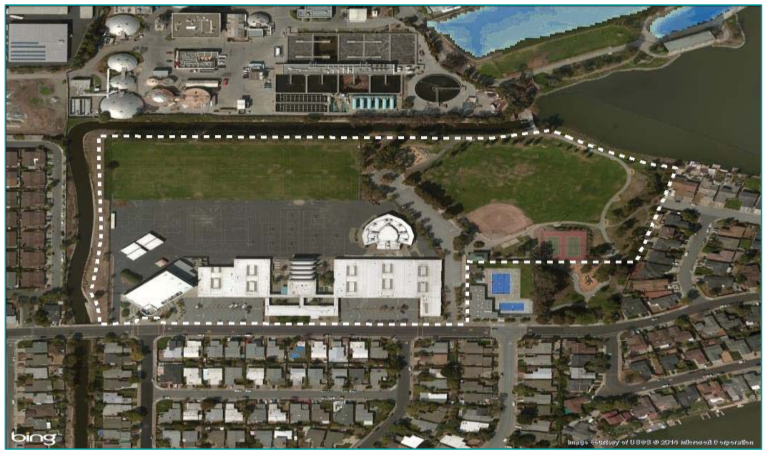
Exposure Discussion

Exposure of the asset is moderate. The Academy has never experienced flooding from San Francisco Bay or the adjacent Leslie Creek Canal, and this is largely due to combined flood protection benefits offered by the Foster City levee system and the Foster City lagoon pump system at the Foster City Corporation Yard. Because the asset was built on Bay mud, the groundwater table is high; however, and groundwater seepage and saltwater intrusion are already apparent on the southeastern corner of the property in the theater adjacent to Crestview and Kehoe Avenues. Part of the theater is built below grade and possibly below sea level.

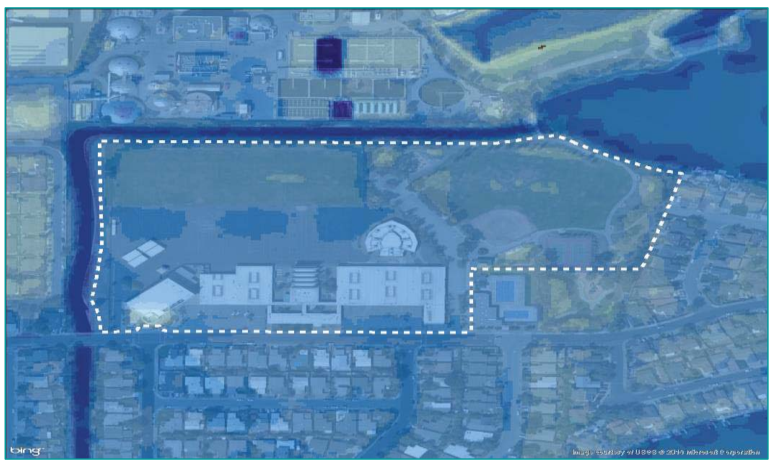
When sea level rises between 0 and 12 inches above MHHW, the Academy property will be below sea level. With sea level rise, saltwater intrusion and groundwater seepage are likely to increase as the groundwater table rises, and likely to pose challenges to interior drainage during storms.

Because the asset is protected by a levee, flooding will not be incremental as the sea level rises. On the contrary, the Academy will experience no flooding until the levee overtops (between 48-52 inches). At that point, assuming no action (such as Foster City Lagoon pumping) the entire school and property including sports fields, parts of the theater, classrooms, and gym could be inundated up to 6 or 13 feet deep, depending on the sea level rise scenario.

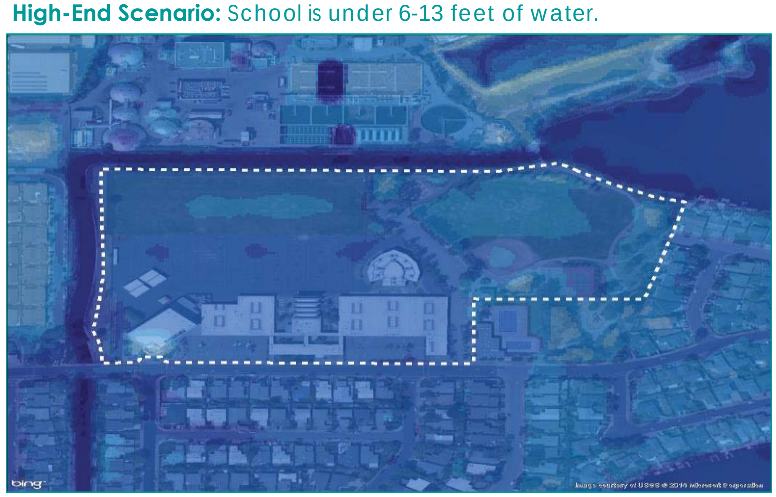
Baseline Scenario: School is not flooded.



Mid-Level Scenario: School is under 2-10 feet of water.



High-End Scenario: School is under 6-13 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts *(52")*	***0***	***8***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 ft.*	***2***	***10***

BAYSIDE STEM ACADEMY

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

While the Academy may be vulnerable to flooding, the educational service it provides has a high adaptive capacity, albeit with a decreased level of service. If flooded for any length of time, the Academy has an evacuation and emergency plan (such as additional food and supplies) in place to mitigate damage and injuries during the event. Additionally, the Academy district could redistribute its students to other schools within the district in order to ensure the educational function is maintained. However, many schools in the district are already at capacity and level of service could decline with more students. In the event of a catastrophic disaster, the school could be used as an emergency shelter. Given its location, if the school were to flood, many adjacent assets in the area could be flooded as well. It is likely that the recreational uses of the school (soccer) could be relocated to other soccer fields, even if one season were lost. The performance theater function may be able to transfer to San Mateo High School's theater.

Consequences

Groundwater and saltwater seepage to date has forced the repair of the theater including carpet replacement. The particular issue was mitigated, but future groundwater seepage could damage the foundation or below-grade components of the theater and cause repeated damages that needed repair. Inundation of the school due to a flood event would cause direct damages to the school and buildings on site, and would force immediate closure of the buildings for an extended period of time. If the school were closed short-term, students may simply stay home; if the school were closed in the long term, students would likely be relocated to other schools. The Academy also serves many low income families who may face additional hardship posed by temporary or extended flood related to sea level rise that forces students to stay home for extended periods of time or to relocate to other schools.

Additional Important Information

Despite evacuation and emergency preparedness, it may also be possible that the adjacent San Mateo Waste Water Treatment Plant is flooded during the same event, which could expose people to hazardous waste. Young people are more vulnerable than others in their ability to respond to and recover from disasters. Special care and concern must be taken in management and adaptation decisions.

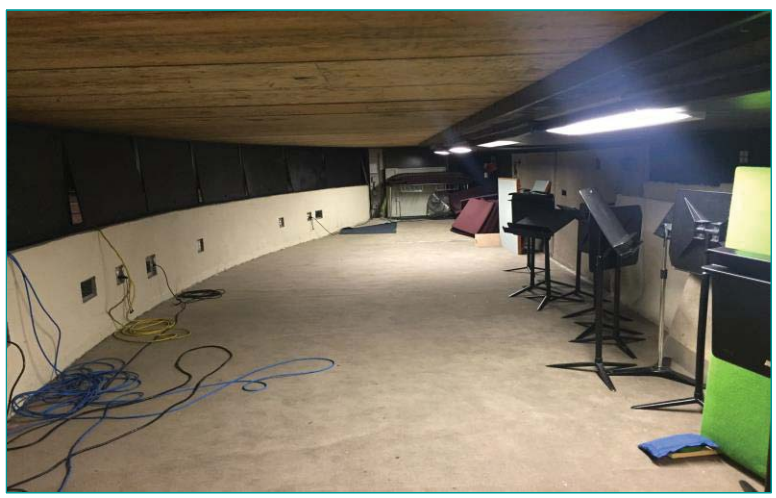
Asset-Specific Adaptation

Potential sea level rise adaptation measures for the Academy include raising the Foster City and City of San Mateo levee systems. Other adaptation measures on site include floodproofing or elevating facilities and access roads to ensure that essential school facilities are at least safe and at best usable to provide minimal disruption when the area is inundated. On-site green infrastructure improvements could also help minimize initial impacts by helping retain water rather than let it run off.

Vulnerable Schools

This is the only Asset Vulnerability Profile on vulnerable schools in the County. The vulnerability assessment analysis shows that there are 45 vulnerable schools in the project area, including those in Belmont, Burlingame, East Palo Alto, Foster City, Menlo Park, Pacifica, Redwood City, San Bruno, and San Mateo.

Orchestra pit is below grade, experienced saltwater intrusion.



27. BEACH BOULEVARD SEAWALL

City of Pacifica

VULNERABILITY SUMMARY

The Beach Boulevard seawall (Seawall) is **highly vulnerable** to the impacts of sea level rise. Exposure of both northern and southern sections of the Seawall is high. The northern section is more vulnerable and currently undergoing repairs from a recent breach. The functions it protects (recreation, including the CCT, transportation, utilities, and housing) are highly sensitive to a breach as none can tolerate flooding or erosion. There are no redundant measures or alternatives to provide the same levels of service, making near- and long-term adaptive capacity low. Consequences from the loss of the asset would likely be locally focused in Pacifica, and could be high.

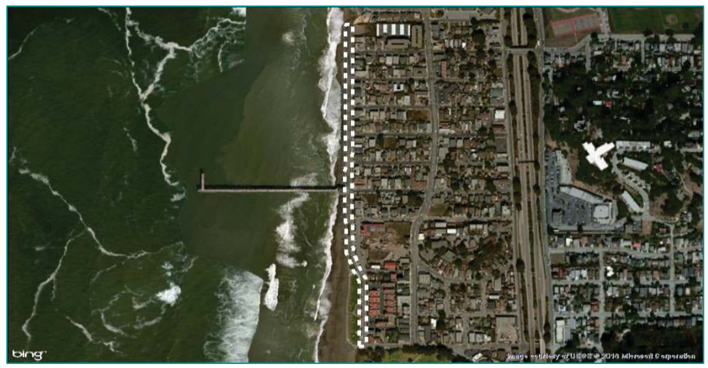
SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*High*	*Low*	*High*

ASSET CHARACTERISTICS

2100 Beach Blvd | Pacifica

Asset Description and Function:

The Seawall runs along Beach Boulevard from Paloma Avenue to Clarendon Road in Pacifica. It protects the boulevard and the roughly 2,000 people who live in the West Sharp Park District, which includes Pacifica City Hall, Council Chambers, a wastewater pump station, and other community assets. A popular promenade on top of the Seawall provides access to the beach and Pacifica Pier. The Seawall protects various utilities located under the boulevard, including sewer, stormwater, water, gas and electrical service.



Asset Type	Flood Control Infrastructure
Asset Risk Class	4
Size	2,500 linear feet
Year of Construction	1984 (N), 1987(S)
Elevation	18-22 feet, MLLW
Protection Provided	2,000 residents
Annual O&M Cost	Unknown
Special Flood Hazard Area	N/A
Physical Condition	Poor to Fair
Landowner	City of Pacifica

Underground Facilities

Sewer, water, gas, and electrical lines and conduits are below the adjacent street, not directly associated with this asset.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

BEACH BOULEVARD SEAWALL

ASSET SENSITIVITY

The Seawall functions, particularly the northern section, are very sensitive to seawall breaching, as the Seawall is the only line of defense for this area. The northern section was built in 1984 as a retaining wall rather than an engineered seawall. It is built on loose fill and is particularly vulnerable to wave action and erosion. In 2016, a breach caused a portion of northern Beach Boulevard and the pedestrian promenade to be closed for roughly six months. The southern section, built in 1987 using a more robust method, has never experienced a breach.

Under high water conditions, access to the site would be restricted. If high water occurred during or after a breach, it could flood the houses and other structures behind it. The utilities under the adjacent road could be exposed and are highly sensitive to the seawall breaching as well as overtopping; for example, if waves overtopped the Seawall, water could flow into the storm drains.
In the West Sharp Park neighborhood behind the Seawall, many houses are sensitive as they are low lying and built at-grade. Note: The Seawall was constructed in two phases—Phase I, north of Pier was built in 1984 ("tile"), and Phase 2, south of Pier was built in 1987 ("concrete panel").

Beach Boulevard seawall from the beach, looking north.

SHORELINE VULNERABILITY

Erosion Analysis

The Seawall is located within the area identified in the Pacific Institute study (2012) as susceptible to erosion (eastern extent by 2100 in yellow). The area of erosion concern, as illustrated, could occur by 2100 if the Seawall were breached, if the northern section is not upgraded, and if all shore line protections were not adequately maintained. The City of Pacifica is repairing the recent damage and pursuing grant opportunities to replace the entire northern section of the Seawall.

Erosion Analysis: Site is entirely in future erosion area.

Cross-Cutting Vulnerabilities

If the Seawall were to breach and expose utility lines under Beach Boulevard, these could be damaged by high water and could interrupt service in surrounding communities. Due to the uncertainty of future erosion events, a geophysical survey would be useful to better understand the full extent of the risk.

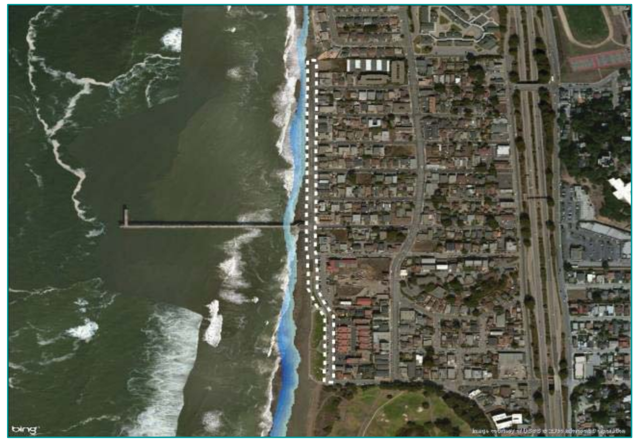
BEACH BOULEVARD SEAWALL

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The Seawall is highly exposed and is regularly subject to high tides and wave action under current conditions. The northern section of the Seawall has experienced breaches in 2002, 2006, and 2016 when exceptionally high tides combined with high swells and waves crashed into and over the Seawall. The rock revetment adjacent to the northern Seawall also regularly loses rocks due to wave action. The southern section has sustained no damage since construction in 1987. Sea level rise will increase the exposure of both Seawall sections, as higher mean water levels will lead to more frequent overflow, and deeper water will allow larger waves to reach and damage the Seawall. This combination will put the Seawall further at risk of overtopping and erosion damage and endanger city infrastructure, utilities, houses, and other properties it protects. Historical erosion data and projected future erosion (USGS, Pacific Institute) indicate that this asset, and the surrounding area, are particularly likely to experience severe erosion by 2100. For more detail on the Seawall construction and an overtopping analysis of the southern Seawall, refer to the *Coastal Hazards Study 2212 Beach Boulevard, Pacifica: Technical Report with Executive Summary* (City of Pacifica 2016).

Baseline Scenario: Asset not yet inundated.



Mid-Level Scenario: Asset under 0 to 5 feet of water.

High-End Scenario: Extensive flooding behind asset.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	*Minimum*	*Maximum*
First Significant Impacts	***Area Not Included in Overtopping Analysis***	
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***5***
High-End *1% + 6.6 feet*	***0***	***6***

BEACH BOULEVARD SEAWALL

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The adaptive capacity of the Seawall itself is low; however, regular monitoring, maintenance, and repairs such as slurry walls can prevent a near-term breach of the full Seawall, which the city is currently doing. Wave overtopping can create flooding if backup measures are not in place. At this time, there are no redundant protections for the utilities, the road, or the properties. To minimize the impacts of flooding, the City of Pacifica is working to upgrade the northern Seawall to "concrete panels" to match the the southern section. The city also engages in flood preparedness activities with residents in the West Sharp Park neighborhood, and some may have flood insurance. There is access to Sharp Park Beach by other means.

Consequences

A breach of the Seawall would directly affect recreational use of the area by preventing beach access and prohibiting use of the heavily used pedestrian promenade. Traffic would be rerouted until the Seawall could be repaired. Under a severe storm, there could be direct flood damages to the houses behind the Seawall, to the wastewater pump station, and to the utilities under the boulevard (if the wall were breached). Disruption of utilities, gas lines, sewer lines, and water lines could create contaminated or hazardous conditions for residents, rendering homes uninhabitable. Injuries or casualties are also possible with a Seawall breach. The area behind the Seawall is low-lying, so a flood could force up to 2,000 people out of their homes, creating a demand for temporary shelters in addition to utility repairs. Repair of the Seawall in 2016 is estimated to cost $450,000 for 40 feet. This could mean up to $28 million to replace the full 2,500 feet of the Seawall. The economic damage potential for property losses has not yet been quantified.

Additional Important Information

There is planned development in this area, which could increase the consequences of a breach. Raising the Seawall may be needed to reduce flood risk and prevent shoreline erosion. As mentioned above, the City of Pacifica has plans to upgrade the northern section of the Seawall.

Asset-Specific Adaptation

In the near-term, the Seawall height can be increased; houses may need to be elevated or floodproofed to provide a second line of defense. In the long-term, relocating the adjacent utilities to higher ground may be necessary.

Vulnerable Seawalls

This is the only Asset Vulnerability Profile on vulnerable seawalls in the County. The vulnerability assessment analysis shows that the Seawall (also called a floodwall in other locations) is part of the 25.9 total miles of levees and floodwalls in the project area.

Beach Boulevard Seawall, looking south.

Repairs being performed on the Seawall after the 2016 breach.

28. MIRADA ROAD

County of San Mateo

VULNERABILITY SUMMARY

Mirada Road (Road) is **highly vulnerable** to sea level rise. It is exposed to high water levels and waves and has experienced erosion failures under current conditions. For instance, the north and south segments of this location have been converted to trails and informal beach access after severe erosion eliminated vehicle access. Bluff erosion rapidly undercuts the road, making it very sensitive to storm conditions. The Road provides sole access to residences and businesses on the waterfront, which would need an alternative route if the road were damaged, though the scale of impact is local.

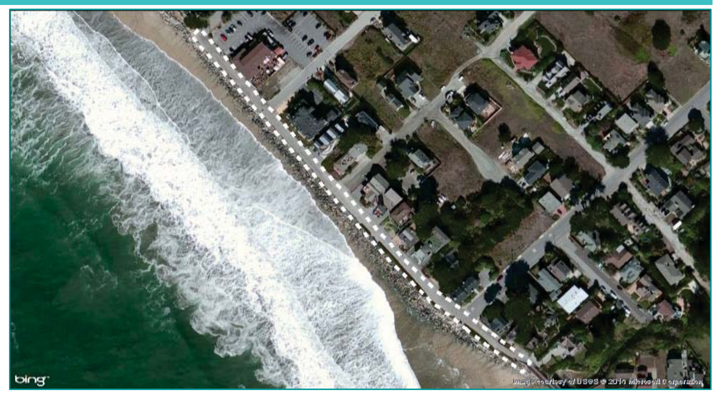
SENSITIVITY	*EXPOSURE*	*ADAPTIVE CAPACITY*	*CONSEQUENCES*
High	*High*	*Low*	*High*

ASSET CHARACTERISTICS

Mirada Road | Half Moon Bay

Asset Description and Function:

The Road between Magellan Avenue and the Pedestrian Bridge south of Medio Avenue is a two-lane asphalt road lying along the California Coastal Trail (CCT) in Half Moon Bay, directly adjacent to an eroding bluff. The Road is managed by the County and provides pedestrian, bicycle, and vehicle access to the beach, the bluffs, and local shorefront dining, residences, and businesses. Water and sewer lines serving these properties are located beneath the Road. Specifically, water and sewer lines are approximately 6 and 10 feet from the bluff, respectively.



Asset Type	Transportation Infrastructure
Asset Risk Class	3
Size	1000 linear feet
Year of Construction	Early 1900s
Elevation	30 feet, NGVD29
Level of Use	500 ppl/day (weekend)
Annual O&M Cost	$400,000 (varies)
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Poor
Landowner	County of San Mateo

Underground Facilities

There are underground water and sewer lines at this site.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

MIRADA ROAD

ASSET SENSITIVITY

The Road is in poor condition, and is extremely sensitive to erosion and wave impacts. If erosion were to cause a section of the Road to collapse (see photographs on following pages), the level of service of the Road, including access to bluffs, beaches, residences, and connection to the CCT, would be lost.

This damage could reach utility lines underneath the road, which are as little as 6 feet from the current bluff, and if exposed, the underground utility lines could also lose service. If erosion caused this section of the Road to collapse, the use of the Road could be permanently lost. This is clear from the north and south segments of the area, which collapsed in the past and were converted to trail segments instead of being rehabilitated. If exposed, underground utilities would be very sensitive to collapse of the road infrastructure or waves and salt water.

Google Street View showing poor but functional maintenance.

SHORELINE VULNERABILITY

Erosion Analysis

This segment of the Road is located within the area identified by the Pacific Institute study (2012) as susceptible to erosion (eastern extent by 2100 in yellow). The Coastal Sediment Management Workgroup (CSMW) has specifically identified the coastline near this asset as an erosion concern area, due to expected damages to nearby assets, including the Road and nearby sewer lines. See the “Exposure Discussion” section for more details.

Cross-Cutting Vulnerabilities

This is the only access road for properties with frontage along the Road.

Erosion Analysis: Site is entirely in future erosion area.

MIRADA ROAD

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The site is currently highly exposed to coastal hazards, particularly erosion from wave action. Waves routinely overtop the bluff and throw water across the full width of the Road during storm events. Large storms in the winter of 1997/98 caused significant damages to this section of the Road and adjacent properties. Even when the Road is not flooded by wave overtopping, wave-driven erosion of the bluff has led to displacement of the rock slope protection there, and severe erosion has caused the edge of the road to collapse. There is currently ongoing repair from recent bank failures adjacent to the Road. Higher water levels will likely increase the frequency with which the Road and its adjacent properties are exposed to wave impacts, and will increase erosion impacts on this section of the Road. Currently, the Road protects underground water and sewer utility lines: under future conditions, wave erosion could expose the underground utility lines.

Baseline Scenario: Asset under 0 to 2 feet of water.

Mid-Level Scenario: Asset under 0 to 3 feet of water.

High-End Scenario: Asset under 0 to 4 feet of water.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts	***Area Not Included in Overtopping Analysis***	
Baseline *1% Flood*	***0***	***2***
Mid-Level *1% + 3.3 feet*	***0***	***3***
High-End *1% + 6.6 feet*	***0***	***4***

MIRADA ROAD

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

This segment of Road is the only access to the coastal properties here, giving it very low adaptive capacity in the near-term. In the long-term, it may be possible to extend roads perpendicular to the beach or behind properties to provide improved access. However, absent the acquisition of separate access easements, additional roads would not provide direct access for several properties that lack frontage on these "back roads", nor would they address the delivery of utilities that Mirada Road properties will require. Further evaluation is needed to understand the feasibility of this option, and solutions will need to be developed in partnership with property owners and community members. While small interventions, like reinforcing the Road with riprap, could slow the erosive impacts of sea level rise, additional solutions such as an inboard sheet pile wall that would support a one way road and multiuse path, as is currently being considered, would have to be a part of a long-term solution. Past events indicate that a failure could lead to a loss of service lasting over 7 days, and with no alternative access, local residents and businesses would suffer. As an extreme example, the north and south segments of the Road have failed in the past (in the 1960s) and are no longer suitable for motor vehicles. Instead of being rehabilitated for vehicle traffic, the former roadway serves pedestrian beach access to the north and south.

Consequences

Damage at the Road could have high consequences. Direct damage to the Road could cost up to $1.5-2.5 million in repairs, depending on the extent of damages. Indirect damages are also possible if the Road were damaged by wave erosion at the bluff, because vehicle access to the businesses and residences on the coast here could be eliminated. Access to the CCT is less likely to be eliminated. Furthermore, water and sewer utility lines under the Road could be damaged if the bluff eroded and the road collapsed, which could pose health and safety hazards to nearby properties as well as interruption of service. The Road has suffered erosion damage in the past and is likely to suffer more severe damage in the future. Impacts from future severe storms could permanently damage the Road and adjacent properties, which would likely drive loss of business, loss of homes, and loss of recreational opportunities (CCT). The scale of the impacts would be local as the Road is not a major thoroughfare, but the area draws thousands of tourists during the summer and loss of access could lead them to visit other coastal areas or cities.

Additional Important Information

Repair and improvement of the Road is challenging given the multiple jurisdictions and permitting agencies involved. For example, protecting the Road (County jurisdiction) is likely to impact beach habitat (City of Half Moon Bay jurisdiction).

Asset-Specific Adaptation

In the short-term, the bluff could be reinforced to protect the Road. In the long-term, structures could be elevated to mitigate wave damage, but the erosion hazard would remain. Following erosion damage to the Road, properties would need alternative access, and eventually a phased relocation could be necessary.

Vulnerable Roads

There is another Assest Vulnerability Profile on vulnerable roads in the County: Old Bayshore Highway and Airport Blvd (AVP #12). The vulnerability assessment analysis shows that there are 373.8 miles of vulnerable local roads in the project area.

Warning sign and barricades at eroded segment of Mirada Rd.

Eroded segment of Mirada Rd with temporary riprap protection.

29. BELMONT CORPORATION YARD

City of Belmont

VULNERABILITY SUMMARY

Belmont's Corporation Yard (Yard) is **moderately vulnerable** to sea level rise. It is moderately exposed to flooding from heavy rainfall events that coincide with high water levels on San Francisco Bay, causing water from Belmont Slough to back up on site. This condition is expected to increase with sea level rise. The Yard's many functions are moderately sensitive to flooding, although there are backup power supplies, and most functions could be performed at other locations during severe inundation. This would be a difficult and expensive shift as the city keeps all of its equipment here, and work done elsewhere would have to be done by other entities.

SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	Moderate	Moderate	High

ASSET CHARACTERISTICS

110 Sem Lane | Belmont

Asset Description and Function:

The Yard is the base of operations for the Belmont's Public Works and Parks Department operations, including street maintenance, traffic and electrical operations, sewer, drainage and pollution control, and vehicle fleet management. Vehicles, tools, and supplies for these operations are stored at the Yard. It also contains a sign shop, an auto repair shop, a vehicle canopy, a fuel tank and pump, and two oil-water separators. The Yard is the primary fueling location for Belmont's police and fire departments.

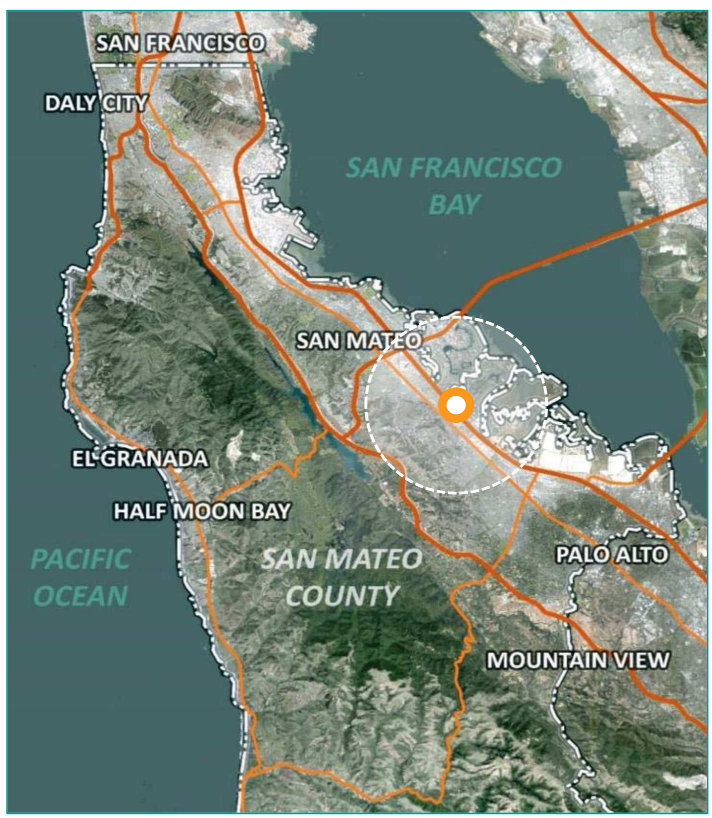
Asset Type	Corporation Yard
Asset Risk Class	4
Size	2.1 acres
Year of Construction	1950
Elevation	8 feet, MSL
Level of Use	Continuous, annual
Annual O&M Cost	$120,000
Special Flood Hazard Area	Asset is not in SFHA
Physical Condition	Fair
Landowner	City of Belmont

Underground Facilities

There is one underground fuel tank on site.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.



BELMONT CORPORATION YARD

ASSET SENSITIVITY

This asset is moderately sensitive to inundation, as all Public Works operation activities mentioned previously would be affected to some degree; the level of service, however, will be fully dependent on the depth, extent, and duration of floodwaters. When Sem Lane only is flooded, access to the yard is limited. In the near-term, the Yard itself could still operate internally if Sem Lane were flooded, despite the access challenges posed to fire, police, and other vehicles entering the Yard. Low clearance cars (such as police cars) would not be able to safely enter or exit the Yard, and so could not be fueled or repaired.

Any power loss could also cause the Yard to lose maintenance and fueling functionality after 2 to 3 days (limit of generator fuel). If the Yard itself were flooded, infrastructure subject to saltwater exposure would likely be non-functional and require replacement. It is likely that damaged equipment would include vehicles, such as the fire and police fleets, which could be unable to perform critical emergency services.

Stored fuel for the vehicle fleet could last roughly 3 weeks, maintaining this service provided that vehicles could still access the Yard. If water got into the oil-water separator, however, it could cause a hazardous spill.

Facilities at the Belmont Corporation Yard.

SHORELINE VULNERABILITY

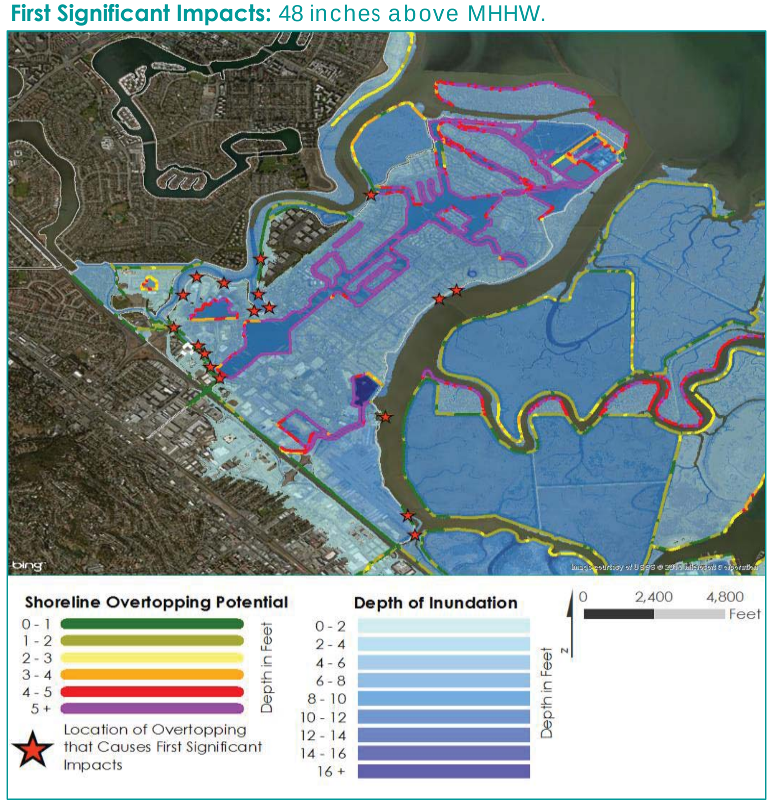
Shoreline Overtopping Analysis

The Yard will be below sea level with water levels 24-36 inches above the current mean higher high water (MHHW) level. With water 36-48 inches above MHHW, water from Belmont Slough (Northwest peninsula) and Steinberger Slough (Southeast peninsula) will overtop the Redwood Shores levee system (red stars on map) and could then reach the Yard.

Cross-Cutting Vulnerabilities

Belmont Slough has lost capacity to convey flood flows in part due to sediment; this increases the water levels in the slough and the frequency with which the slough could overtop and flood Sem Lane. Unlike Redwood Shores, the west side of Belmont Slough was not built with a well-designed levee or flood control system, which leaves it more exposed to overtopping during high tides and heavy rains. The levee protecting nearby Redwood Shores could also be a source of coastal flooding if not maintained or if overtopped, but it is managed by other jurisdictions.

First Significant Impacts: 48 inches above MHHW.



BELMONT CORPORATION YARD

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

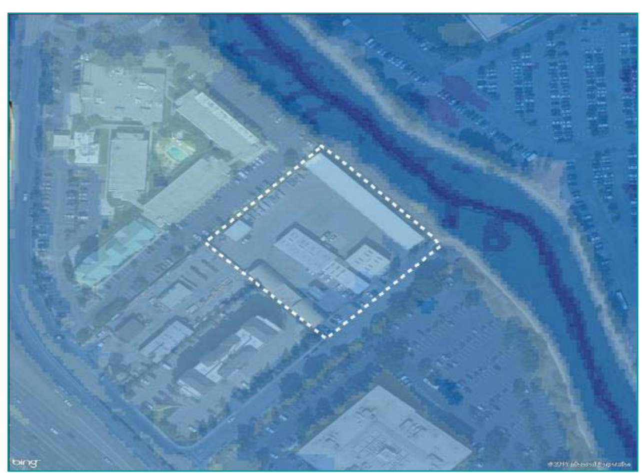
Exposure of the asset is moderate. The Yard is currently vulnerable to heavy rainfall events coinciding with high water levels in San Francisco Bay, whereby the Belmont Slough cannot drain to San Francisco Bay, and backs up onto Sem Lane. In 2010, 2011, and 2014, flooding from Belmont Slough inundated parts of Sem Lane roughly 18 inches and reaching as far as the door to the auto shop. Water will only drain naturally into Belmont Slough if the slough level drops, but if it is high, then standing water remains on site. Groundwater is present on site but has not yet caused any impacts to site facilities or functions.

Sea level rise will increase the frequency with which a high tide coincides with high water on Belmont Slough. In addition, the Yard could be vulnerable to coastal flooding with an increase of 48 inches of water level above MHHW. In this case, water could flood much of the site to a depth of 7.5 feet, including buildings through the doorways, any on-site vehicles, the fuel island, and the auto repair shop. Water could also enter the site through the manhole covers which are at grade. It may also be possible for the adjacent Redwood Shores Lagoon to overtop and cause flooding at the Yard.

Baseline Scenario: Asset not yet inundated.

Mid-Level Scenario: Asset under 0 to 5 feet of water.

High-End Scenario: Asset under 4 to 8 feet of water.



Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts *(48 inches)*	***0***	***3***
Baseline *1% Flood*	***0***	***0***
Mid-Level *1% + 3.3 feet*	***0***	***5***
High-End *1% + 6.6 feet*	***4***	***8***

BELMONT CORPORATION YARD

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The Yard has moderate near-term adaptive capacity relative to other assets in the project area. In the near-term, the Yard can use a pump to mitigate minor flooding of Sem Lane, given electrical power. There is also an elevated generator to support Yard function with fuel to last roughly 3 days. However, use of backup power depends upon the switch gear and power distribution system remaining dry. If these or the generator were flooded, all power would be lost, causing the loss of most services. Police and fire vehicles can fuel at other locations, and police cars could use alternative auto-mechanics if the Yard's auto repair were unavailable; however, the City of Belmont would need to hire others to perform these services, likely involving higher costs and delays. There is currently no other city-owned repair facility for unique fleets like fire engines. Over the long-term, water 48 inches over MHHW on San Francisco Bay would flood the Yard and render it inoperable.

Consequences

Flooding could cause direct damages to buildings and vehicles on site, valued at roughly $2 million each, for a total of approximately $4 million. It may also be possible for the underground fuel tanks or oil-water separators to spill, creating hazardous conditions and negative water quality impacts in Belmont Slough or for personnel on site. More importantly, loss of the Yard would affect all Public Works operations, including emergency services associated with the use and maintenance of police and fire vehicles, as well as traffic and electrical operations, street maintenance, sewer utility, drainage, and water pollution services. Loss of this facility could leave the City of Belmont unable to repair major thoroughfares if damaged. Loss of emergency services would have cascading impacts on the public health and safety of Belmont residents.

Additional Important Information

Because the Yard accommodates many operations and houses associated equipment and materials, it is subject to strict permitting guidelines for human health, air quality, building codes, and fire codes. That also makes temporary or permanent relocation difficult due to the lack of available space and the cost of doing so. This affects both near- and long-term adaptive capacity.

Finally, local drainage depends on discharge to Belmont Slough, which is impeded by high water levels, and a Caltrans stormwater pipe whose outfall is buried in sediment. This means that, like other assets in the project area, flood exposure of one asset can be affected inadvertently by management actions of other stakeholders.

Asset-Specific Adaptation

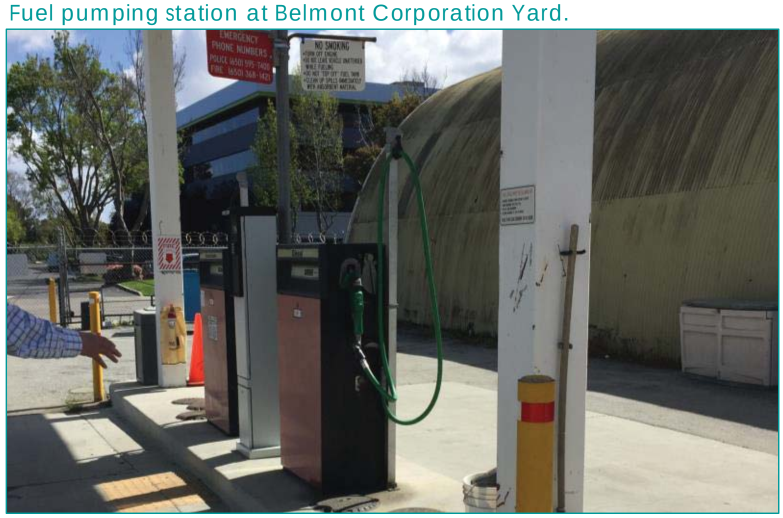
In the near-term, pumping may be a practical nonstructural option to remove water from Sem Lane and other nearby components. Floodproofing the power supply or directing flow off Sem Lane could enable car access. It may also be possible to relocate the facility to higher ground west of Highway 101, or to enhance the shoreline protection in collaboration with other stakeholders.

Vulnerable Corporation Yards

There is another Asset Vulnerability Profile on vulnerable corporation yards: Foster City Corporation Yard (AVP #25). At the time of this assessment, an exhaustive dataset on corporation yards in San Mateo County is unavailable.

Belmont Slough adjacent to Belmont Corporation Yard.

Fuel pumping station at Belmont Corporation Yard.



30. PACIFICA NURSING AND REHAB CENTER

Pacifica Care Center Inc.

VULNERABILITY SUMMARY

The Pacifica Nursing and Rehab Center (Center) is **moderately** vulnerable to sea level rise. The Center is very sensitive to erosion, as erosion would force evacuation and closure of the facility; however, the site is not likely to be exposed to erosion until some point in the future, as it is set back from the cliff and protected by Esplanade Avenue and an apartment complex (undergoing cliff repairs). The Center's adaptive capacity is moderate, as there is an emergency evacuation plan and patients could be relocated to other facilities. Despite this, evacuation poses additional stress and safety concerns on already vulnerable patients in the near-term, making the consequences of closure high.

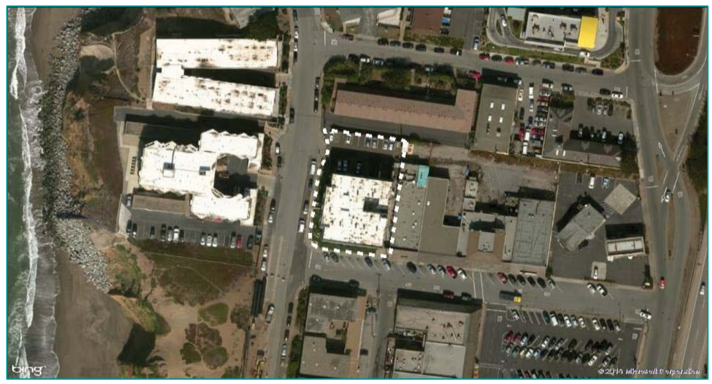
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
High	Low	Moderate	High

ASSET CHARACTERISTICS

385 Esplanade Avenue | Pacifica

Asset Description and Function:

The Center is a skilled nursing facility focused on post-acute care. The facility employs 12 physicians as independent contractors and receives primarily elderly patients with limited mobility from area hospitals in San Francisco and San Mateo Counties. Patients stay for 21 days on average, though there are a few long-term care beds for those staying an extended duration. The asset is nearly at capacity (92%) most of the time.



Asset Type	Healthcare Facility (Skilled Nursing)
Asset Risk Class	3
Size	0.6 acres
Year of Construction	1969
Elevation	75 feet
Level of Use	68 beds
Annual O&M cost	$8.5 million
Special Flood Hazard Area	Asset not in SFHA
Physical Condition	Excellent
Landowner	Vajs Pacifica LLC

Underground Facilities

No underground facilities were identified.

Environmental Considerations

Special status plants, animals, and natural communities may be present in the project area; a more detailed analysis will be needed before implementing adaptation strategies.

PACIFICA NURSING AND REHAB CENTER

ASSET SENSITIVITY

The asset is very sensitive to erosion; the length of time before the level of service will be disrupted depends on the eastern extent of erosion. For example, erosion today does not affect the asset; however, if the erosion extent reached Esplanade Avenue, then patient or personnel access, as well as delivery of food and medical supplies, would be affected. If erosion continued east toward the asset, the asset's foundation and structural integrity would likely be compromised, making it unsafe for occupancy. This would require evacuation and result in a complete loss of service at this facility.

SHORELINE VULNERABILITY

Erosion Extent and Exposure

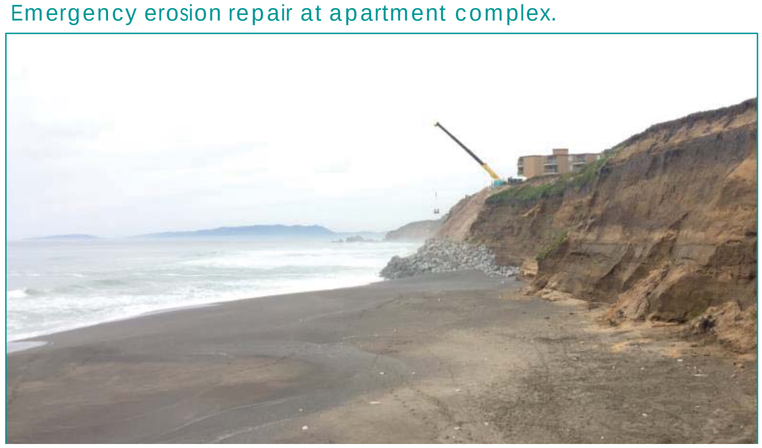
Historical and future projected erosion data indicate that this asset and the surrounding area (in yellow band on the right) are particularly at risk from erosion. At present, however, exposure to erosion is currently low as the asset is set back from the cliff and therefore not subject to wave action, or scour. In response to severe erosion at the apartment complex located on the cliff just west of the asset (see photo below), the apartment complex is currently building a protective seawall, which also minimizes the exposure at this facility.

Asset expected to be exposed to erosion by 2100.

Cross-Cutting Vulnerabilities

In the long-term, the Center may be fully dependent on management and erosion mitigation actions of others (including those entities responsible for the apartment complex and Esplanade Avenue) to minimize its likelihood of erosion exposure. Patients, food, and medical supplies depend on the presence and good condition of Esplanade Avenue, making exposure and proctection of the road critical to the function of the Center.

Emergency erosion repair at apartment complex.



PACIFICA NURSING AND REHAB CENTER

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

Adaptive capacity of the asset is moderate in the near-term and depends on the extent of erosion. For example, if erosion reached Esplanade Avenue and the road were to lose some level of service such that contracted food supplies could not be brought in, personnel would purchase food from a local grocery store to ensure patients had food. If erosion affected the power system (but somehow not the facility itself), there is a diesel-powered generator that can provide power for up to 96 hours to keep the building open, assuming the generator and power distribution are not exposed to erosion. Severe erosion that reaches the asset, however, will likely force the patients and facility staff to evacuate the hospital and be distributed to other facilities. The asset maintains an Emergency Evacuation Plan for this reason, and it is inspected annually and updated if necessary. Given that there is a shortage of nursing beds in San Francisco and San Mateo Counties, the relocation and distribution option is possible, though less viable, and may reduce the level of service at other nursing facilities due to overcrowding.

Consequences

A loss of the Center would have high near-term consequences and more moderate long-term consequences. In the near-term, if the asset were unusable, it would require that the roughly 65-80 elderly, already vulnerable patients (most with limited mobility) evacuate to other facilities or return home, which could place patients under additional stress, causing further injury or delaying rehabilitation. The cost of healthcare for these patients could also increase due to the loss of the asset. If a patient were transferred to an acute hospital, he or she could pay more than 10 times the cost at the Center for the same care. Additional challenges are posed when patients are required to travel longer distances to other facilities. Patient load on other facilities (up to 85 patients per month) would increase in both the near-term from evacuations, and in the long term because other hospitals would no longer be able to discharge patients to this facility. Depending on the capacity of nearby skilled nursing facilities, additional patients may cause overcrowding and reduce care quality at those facilities. The value of the facility is estimated at $35-40 million. This facility is one of the biggest employers in Pacifica, apart from the school district. A loss of the facility could mean the loss of 185 jobs.

Additional Important Information

In addition to any Coastal Development Permits issued by the California Coastal Commission in areas of retained jurisdiction for mitigating erosion, any actions taken to mitigate vulnerability of this facility must be approved/permitted by the City of Pacifica and the Office of Statewide Health Planning and Development.

Asset-Specific Adaptation

Near-term mitigation strategies include sand placement and offshore reefs on this section of vulnerable coastline, additional coastal armoring along the cliff, and, in the longer term, eventual managed retreat (relocation) to mitigate the impacts of erosion. Though the asset may not be exposed for some time into the future, it may be in its interest to get involved in these mitigation measures in the near term, particularly at the apartment complex and at the road as needed. Investing in this now may reduce exposure in the future.

Vulnerable Healthcare Facilities

This is the only Asset Vulnerability Profile on vulnerable healthcare facilities in the County. There are no additional vulnerable inpatient healthcare facilities without emergency rooms in San Mateo County.

Entrance to facility.

APPENDIX E

Appendix E: Data Sources

Dataset or Asset Type	Description	Data Source	Date	Notes
Airports		County of San Mateo	2015	
Beaches		California Coastal Trail Association, San Mateo County Parks Department	2008, 2015	
Boat Launches		California Department of Fish and Wildlife, Marine Region GIS Unit	2012	
Buildings with Affordable Rental Units	Buildings with rental units for extremely low-income families or families with incomes below the poverty line in San Mateo County.	County of San Mateo Department of Housing	2015	
Caltrans Maintenance Facilities		California Department of Transportation, via David Ford Consulting Engineers	2013	Report from David Ford Consulting Engineers completed in 2013.
Coastal Erosion	Erosion hazard under a 1.4-meter sea level rise scenario (predicted for year 2100).	Phil Williams & Associates, LTD	2009	Developed and used in the Pacific Institute study (2012).
Communication Towers	Consists of cell phone, land mobile, paging, radio, and television towers.	Federal Communications Commission, Wireless Telecommunications Bureau	2010	
Eelgrass Habitat		California Department of Fish and Wildlife, Marine Region GIS Unit	2014	
Electric Substations		California Energy Commission	2014	
Emergency Operations Centers		California Department of Water Resources, Risk Characterization Study	N/A	Source date unavailable at time of publication.

Dataset or Asset Type	Description	Data Source	Date	Notes
Emergency Shelter Sites	Includes a general shelter inventory and any Human Services Agency offices or partner locations designated as emergency shelters.	County of San Mateo	2015	
Fire Stations		County of San Mateo	2015	
Fishing Piers		California Department of Fish and Wildlife, Marine Region GIS Unit	2012	
Hazardous Material Sites	Includes 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.	California Water Board; United States Environmental Protection Agency, via David Ford Consulting Engineers; California Department of Water Resources, Risk Characterization Study	2015, 2013	Data from San Mateo County provided in 2015; Report from David Ford Consulting Engineers completed in 2013; Source date for the Risk Characterization Study is unavailable at the time of publication.
Healthcare Facilities (emergency)	Healthcare facilities with emergency rooms and inpatient accommodations; includes public and private hospitals.	California Office of Statewide Health Planning and Development	2012	
Healthcare Facilities (inpatient)	Healthcare facilities without emergency rooms but with inpatient accommodations; includes hospitals and long-term care facilities.	California Office of Statewide Health Planning and Development	2012	
Healthcare Facilities (outpatient)	Healthcare facilities without emergency rooms or inpatient accommodations; includes clinics, hospice, and home health agencies.	California Office of Statewide Health Planning and Development	2012	

Dataset or Asset Type	Description	Data Source	Date	Notes
Highway and Railway Bridges		California Department of Water Resources, Risk Characterization Study	N/A	Source date unavailable at time of publication.
Highways	Federal and State Highways.	United States Census Bureau	2015	
Human Services Agency Facilities	Locations of Human Service Agency offices and partner agencies that are not also potential emergency shelter sites.	County of San Mateo Human Services Agency	2015	
Jails		County of San Mateo	2015	
Kelp Habitat		California Department of Fish and Wildlife, Marine Region GIS Unit	2009	
Lakes		County of San Mateo	2015	
Levees and Floodwalls	Includes bayside levees and floodwalls and coastal floodwalls.	San Francisco Estuary Institute, National Oceanic and Atmospheric Administration	2016, 2013	
Marinas		California Department of Fish and Wildlife, Marine Region GIS Unit	2012	
Mobile Home Parks		County of San Mateo Office of Sustainability	2015	
Natural Gas Pipelines		National Pipeline Mapping System, California Energy Commission	2015, 2015	NPMS data requested in October 2015; said to be updated every 12 months.
Natural Gas Storage	Includes natural gas stations and breakout tanks.	National Pipeline Mapping System, California Energy Commission	2015, 2014, 2015	NPMS data requested in October 2015; said to be updated every 12 months.
Oil, Gas, & Geothermal Wells		California Energy Commission	2015	

Dataset or Asset Type	Description	Data Source	Date	Notes
Other Built Shorelines	Includes bayside berms, embankments, shoreline protection structures, transportation structures, and water control structures, as well as coastal revetments and breakwaters.	San Francisco Estuary Institute, Coastal Commission, National Oceanic and Atmospheric Administration	2016, 2012, 2013	
Outfalls		City/County Association of Governments of San Mateo County	2015	
Parcels	Assessed value and type of parcels in the hazard zone of the project area.	County of San Mateo	2015	
Parks		County of San Mateo Parks Department	2015	Park footprints were converted to points in order to count discrete parks. A park that overlaps jurisdictional boundaries will be counted for each city or town it is in.
Police Stations		County of San Mateo	2015	
Population	Number of people potentially exposed to inundation or erosion.	United States Census Bureau	2010	Counted 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.
Population in Vulnerable Communities	Number of people living in communities that are less able to prepare, respond and recover from natural hazards.	Association of Bay Area Governments, Resilience Program (Communities at Risk)	2014	Counted 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.
Ports		California Department of Fish and Wildlife, Marine Region GIS Unit	2012	
Power Plants		California Energy Commission	2015	

Dataset or Asset Type	Description	Data Source	Date	Notes
Priority Development Areas		Association of Bay Area Governments	2016	
Rail	Centerlines of BART, Caltrain, and freight railroad tracks.	San Mateo County Transit District	2015	
Rail Stations	BART and Caltrain Railroad stations.	San Mateo County Transit District	2015	
Refined Products Terminals		California Energy Commission	2015	
Roads (local)	Roads not classified as Federal or State Highways.	United States Census Bureau	2015	
Salt Ponds and Crystallizers		San Francisco Estuary Institute	2001	
Satellite Imagery	Satellite background for maps in the report.	Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, Harris Corp, 2016 Microsoft Corporation	2016	Asset Exposure maps use the Esri World Imagery basemap; all other maps use Bing Aerial Imagery.
Schools	Public, private, and charter schools.	County of San Mateo Office of Education	2015	
Sea Level Rise Scenarios	Baseline (0 cm), mid-level (100 cm), and high-end (200 cm) sea level rise scenarios.	United States Geological Survey (Our Coast, Our Future)	2016	
Senior Centers	Facilities that provide multiple services to older adults in San Mateo County.	County of San Mateo Health System	2015	
Solid Waste Facilities		County of San Mateo	2015	

Dataset or Asset Type	Description	Data Source	Date	Notes
Storm Drains		City/County Association of Governments of San Mateo County	2015	
Stormwater Pump Stations		City/County Association of Governments of San Mateo County	2015	
Streams		County of San Mateo	2015	
Surfgrass Habitat		California Department of Fish and Wildlife, Marine Region GIS Unit	2005	
Trails	Trails in San Mateo County.	San Mateo County Parks Department; National Park Service, California Department of Parks and Recreation, California Coastal Commission, California Coastal Trail Association	2015, 2012	
Transmission Lines		California Energy Commission	2015	
Transmission Towers		County of San Mateo	2015	
Underground Chemical Storage Tanks	Permitted Underground Storage Tanks containing hazardous material.	State Water Quality Control Board (Geotracker)	2015	
Urban, Agricultural, Industrial, and Natural Land		California Department of Water Resources, Risk Characterization Study	2012	
Wastewater Pump Stations		County of San Mateo	2016	
Wastewater Treatment Plants		County of San Mateo	2015	

Dataset or Asset Type	Description	Data Source	Date	Notes
Wetlands		California Department of Fish and Wildlife, Marine Region GIS Unit, San Francisco Estuary Institute	2006, 2001	The inventory counts the area of wetlands exposed to the sea level rise 'footprint.' This does not take into consideration sediment or wetland accretion rates.

APPENDIX F

Infrastructure · Water · Environment · Buildings

Imagine the result

San Mateo County Vulnerability Assessment

Appendix F: Report on Asset Categorization and Classification

September 22, 2015

Tables

Figures

1. Introduction

A critical part of a comprehensive sea level rise (SLR) vulnerability assessment (VA) is categorizing and classifying the built and natural assets that will be exposed to present and future inundation in San Mateo County. Because there are so many different assets and asset types in urban areas like San Mateo County, it could be overwhelming for decision makers to understand what is and will be exposed to inundation, what it could mean if assets were inundated, and whether the vulnerability of some assets warrants action. Asset categories and classes enable us to think about this issue differently and provides a framework to focus on the most critical issues first.

The approach taken in this SLR VA has two parts and is complimentary to (the) regional Adapting to Rising Tides SLR VA methodology.[1] In addition to categorizing assets by their similar function or sector (part I), this method also integrates a risk component whereby prior to any evaluation of an asset, the asset will be assigned to a risk class (1, 2, 3, or 4) according to the severity or magnitude of the consequences if it were to flood (part 2). In the end, this additional step in the methodology will provide a high-level understanding of what kinds of assets are at risk in the County, and where those assets are located. The risk-based criteria described below provide a sense of the criticality in terms of public health, safety, and welfare. It further provides preliminary insight into cross-cutting vulnerabilities, and into the Adapting to Rising Tides (ART) guiding question: *If exposed to climate impacts, what is the expected magnitude of the consequences?*[2]

The approach used in this assessment accounts for all of the built and natural assets within the project boundary, including attention to human assets, and provides a framework for future risk analyses and a flood risk management/sea level rise adaptation strategy. As described below, the overall methodology including the asset classification component was developed to better prepare San Mateo County and its cities to apply for federal funding to reduce flood risk.

[1] San Francisco Bay Conservation Development Commission (BCDC). (2012). Adapting to Rising Tides project. Accessible: http://www.adaptingtorisingtides.org/

[2] BCDC. (2012). Adapting to Rising Tides: Chapter 1, page 10.

1.1 Purpose

The purpose of this document is to describe the previously defined categories and classes into which San Mateo County assets will be organized, and to explain the rationale and criteria used to classify the assets. This document also provides a preliminary list of San Mateo County's assets, assigned to the appropriate asset class.

1.2 Definitions and Background

To support a better understanding of this document, this section discusses some key terms and background.

Flood risk is the product of the likelihood of inundation and the potential for adverse consequences when inundation occurs. For purposes of this project, the terms *inundation* and *flood* are used interchangeably.

Risk-based criteria means that the consequences to public health and safety of inundation are a determining factor in assigning built assets to classifications.

A *flood risk management strategy* (Figure 1 below) is an overall strategy aimed at reducing flood risk; it is developed based on a clear understanding of risk, and incorporates stakeholder preferences and economic efficiency.

A *flood risk assessment* (Step 1 in Figure 1 below) provides a clear understanding of risk, and involves identifying the likelihood of inundation and the potential consequences of inundation. The consequences are determined by who and what lie in harm's way, and how vulnerable they are to inundation (vulnerability assessment, Figure 1 below).

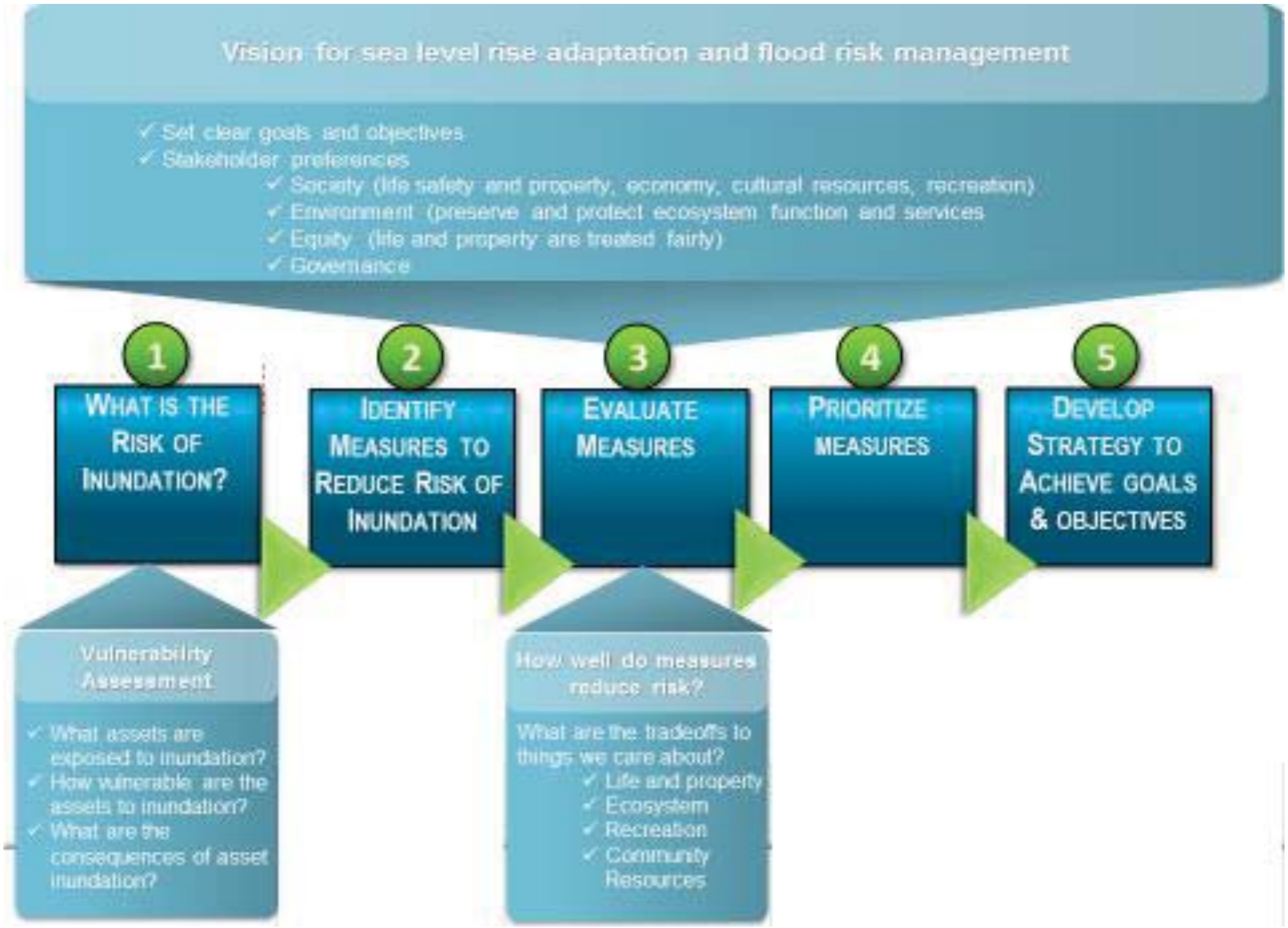
An *asset category* refers to a group of assets that are similar in function or service; for example, energy infrastructure and pipelines, ground transportation, hazardous materials, and natural areas.

An *asset class* refers to a group of assets that are organized based on risk and criticality for built assets, and based on habitat type or species for natural assets. Classifying assets is a critical part of understanding risk (part of Step 1 in Figure 1 below).

It is important to distinguish asset *classification* from asset *prioritization.* Asset classification is objective and transparent; it organizes built assets such as housing, transportation infrastructure, energy infrastructure, and critical infrastructure, according to their function and criticality as it relates to public health, safety, and welfare. Asset classification also objectively captures natural and human assets without a weight or preference that could influence investment decisions or the outcomes of future assessments; it is part of the Vulnerability Assessment in Step 1 of Figure 1 below.

Asset *prioritization,* on the other hand, is subjective; it comes later in the flood risk management process (Step 4 in Figure 1 below), and is part of an overall flood risk management and sea level rise adaptation strategy. Such a strategy would be developed based on the results of a full risk assessment (Step 1), the effectiveness of risk-reduction measures (Steps 2 and 3) including cost, and an overall vision with specific goals and objectives that incorporate stakeholder preferences.

Figure 1 Components of a flood risk management and adaptation strategy



2. Approach to Asset Categorization and Classification

For a vulnerability assessment to be useful regionally, the method should support, align with, or compliment other regional best practices. For a vulnerability assessment method to be credible, it should be transparent, defendable, and based on the best available science.

To that end, the San Francisco Bay Conservation Development Commission (BCDC) developed a methodology in the *Adapting to Rising Tides* (ART) project to guide vulnerability assessments in the San Francisco Bay area. This method is being adopted and used by many local jurisdictions as they begin to address SLR adaptation. The ART project specifically identifies and describes 12 asset categories into which assets should be organized for analysis[3]. This enables communities to assess vulnerabilities and risk to entire sectors. Therefore, to align with regional efforts, all natural and built assets in San Mateo County will be categorized in to the same 12 categories identified in the report and listed below.

Meanwhile, flood risk management under federal guidance (US Army Corps of Engineers) identifies life safety as paramount; federal funding for flood risk reduction and hazard mitigation is almost exclusively allocated to projects that reduce risk to life and property.[4] California state guidance on sea level rise preparedness[5] (Safeguarding California, California Coastal Commission Sea Level Rise Guidance) places an emphasis on nature-based solutions and protection of vulnerable populations. In addition, this project is funded through California State Coastal Conservancy Climate Ready grant funds, which require a focus on protection of natural resources. Therefore, it is critical to incorporate these elements into a vulnerability assessment since the vulnerability assessment is one of the first steps to developing a flood risk management and sea level rise adaptation strategy.

2.1 Built Assets

The American Society of Civil Engineers (ASCE) developed guidance on building standards in order to protect public health, safety, and welfare in the event of a hazard. In the guidance, titled *ASCE 24-14 Flood Resistant Design and Construction*[6] and *ASCE 7-10 Minimum Design*

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[3] San Francisco Bay Conservation Development Commission (BCDC). (2012). Adapting to Rising Tides: Existing Conditions and Stressors

[4] California Department of Water Resources (DWR). (2013). Floodsafe California: California's Flood Future: Recommendations for Management the State's Flood Risk.

[6] American Society of Civil Engineers (ASCE). (2015). 24-14 Flood Resistant Design and Construction

Loads for Buildings and Other Structures[7], built assets are assigned a risk classification according to the assets' function or occupancy type, and the classes range from class 1—no or low risk to public safety and society (including economic disruption)—to class 4—highest risk to public safety and society. The guidance documents then provide construction and design guidelines for assets in each class in order to minimize risk to public safety, and society. The ASCE built asset classes are used by FEMA in its Hazard Mitigation Assistance programs[8], whereby flood mitigation measures must be designed for a flood elevation that is associated with each asset class. The ASCE asset classes have also been adopted by the International Building Code Council[9]and by the California Building Codes[10]; it is therefore appropriate to use them in this vulnerability assessment. This approach of asset classification is also consistent with the State of Florida Department of Emergency Managements' Public Facilities Flood Mitigation Initiative[11]

In addition to assigning each asset type to one of the 12 *Adapting to Rising Tides* (2012) categories referenced above, all built assets in San Mateo County will be herein classified according to the same criteria used to classify assets in *ASCE 24-14*. This approach is transparent and defendable; it also enables consideration of societal disruption, as well as issues of equity because all assets are classified objectively using the same criteria.

2.2 Natural Assets

To date, no guidance exists to assign *natural assets* to a risk class (low to high) as in the built asset method, and there is currently not consensus among the scientific community on which ecosystem types are more critical or valuable than others in a way that would support a risk classification for natural assets. If natural assets were assigned to the classes under *ASCE 24-14*, they would in most cases be assigned to the lowest risk class because inundation would not necessarily pose a threat to public health, safety, and welfare. As a result, a decision maker, unless he or she has time to do a detailed investigation into each of the classified assets, would

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[7] ASCE (2013). 7-10 Minimum Design Loads for Buildings and Other Structures

[8] FEMA (2015). Hazard Mitigation Assistance Guidance Addendum. Available from: http://ecodes.biz/ecodes_support/free_resources/2013California/13Building/PDFs/Chapter%2016%20-%20Structural%20Design.pdf

[9] International Code Council, see table 1604.5 Available from: http://publicecodes.cyberregs.com/icod/ibc/2012/icod_ibc_2012_16_par023.htm

[10] California Building Codes, 2013, see table 1604.5, available from http://ecodes.biz/ecodes_support/free_resources/2013California/13Building/PDFs/Chapter%2016%20-%20Structural%20Design.pdf

[11] Florida Division of Emergency Management (2015). Public Facilities Flood Hazard Mitigation Assessment Manual. Accessible: http://www.floridadisaster.org/Mitigation/SMF/Index.htm

not be aware of potentially critical habitat or natural asset. Therefore, it would be inappropriate to assign natural assets a risk-based classification.

However, natural assets such as wetlands, marshes, beaches, and endangered species are of great importance to San Mateo County, the State of California, and the federal government (see applicable State of California Coastal Act policies[12], Executive Order 11990 on the protection wetlands, Executive Orders 11988 and 13690 on the wise use of floodplains, and the Federal Endangered Species Act,). Not only do natural assets provide intrinsic value to San Mateo County and its residents, but natural assets are also recognized for the services they may provide, including biodiversity, flood and erosion control, water quality improvement, and carbon sequestration.[13] Therefore natural assets will be included in this vulnerability assessment. Natural assets will be classified as simply N, 'Natural,' with a descriptor partially based on the habitat types assessed in the *Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean*[14], such as *N-beach*, or *N-wetlands*, *N-rocky intertidal,* or *N-species of concern* (Table 2). This provides an inventory of natural assets to support future flood risk analyses, and 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 assets.

2.3 Human Assets

The protection of human health and safety is often the priority of a flood risk management strategy, therefore the vulnerability assessment offers an opportunity to identify the number of people that are exposed to a flood hazard or will be exposed in the future (Methodology report, steps five, six, and seven). Further, some individuals and communities are less able to respond and adapt to natural hazards like flooding (and the risks posed by sea level rise); instead, they are more vulnerable than the general population at large and may experience disproportionate impacts from flooding. Strategies to reduce the risks from flooding to vulnerable populations may need to be considered explicitly. The factors that could affect an individual's or community's ability to respond include (but are not limited to), things like age, income, education, and mobility. It is therefore imperative in SLR planning that the County understand

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[12] California Coastal Act Sections: 30230, 30231, 30240, and 30253

[13] BCDC. (2012). *Adapting to Rising Tides.* Chapter 4

[14] Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. (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.

where socially vulnerable or disadvantaged communities are, and consider this in the risk reduction strategies.

Similar to natural assets, human assets will not be classified according to risk. Instead, human assets will be classified as an "H", *followed by a descriptor,* meaning *human asset.* The vulnerability assessment will inventory both the population at risk (*H-Population*), and in the identification of socially disadvantaged or vulnerable populations (*H-Disadvantaged Community*). The assessment may also identify the location of affordable housing units (*H-Affordable Housing Unit*).

3. Asset Categories and Classes

All assets in San Mateo County will be assigned to one of the following 12 categories:

- Airport
- Community land use, services, and facilities
- Contaminated lands
- Energy infrastructure and pipelines
- Ground transportation
- Hazardous materials
- Natural areas
- Parks and recreation areas
- Seaport
- Structural shorelines
- Storm water
- Wastewater

For a detailed description of each category, please refer to *Adapting to Rising Tides: Existing Conditions and Stressors* (2012).

Table 1 below, is adapted from *ASCE 24-14* and describes each asset *class* according to the function of the asset or the occupancy of the building. The description includes examples of asset types that belong to each asset class. There are a number of asset types present in San Mateo County that were not explicitly listed in ASCE's table; therefore, these asset types are identified in the far right column and are organized according to asset class based on the description provided. In the far right column, where an asset has a number with parentheses, e.g., (4.*X*), the *X* refers to the number in the column to the left, as justification for why an asset was placed in that class.

Table 1 Classification for built assets in San Mateo County (Adapted from ASCE 24-14, Table 1-1)

Risk Classification	Description of Category	Asset type or function
1	Buildings and structures that normally are unoccupied and pose minimal risk to the public or minimal disruption to the community should they be damaged or fail due to flooding.	(1) temporary structures that are in place for less than 180 (2) accessory storage buildings and minor storage facilities (3) small structures used for parking of vehicles (4) certain agricultural structures.
2	Buildings and structures that pose a moderate risk to the public or moderate disruption to the community should they be damaged or fail due to flooding, except those listed as Flood Design Classes 1, 3, and 4.	The vast majority of buildings and structures that are not s industrial buildings.
3	Buildings and structures that pose a high risk to the public or significant disruption to the community should they be damaged, be unable to perform their intended functions after flooding, or fail due to flooding.	(1) buildings and structures in which a large number of pe religious institutions with large areas used for worship (2) museums (3) community centers and other recreational facilities (4) athletic facilities with seating for spectators (5) elementary schools, secondary schools, and buildings (6) jails, correctional facilities, and detention facilities (7) healthcare facilities not having surgery or emergency t (8) care facilities where residents have limited mobility or persons (9) preschool and child care facilities not located in one- a (10) buildings and structures associated with power gene other utilities which, if their operations were interrupted b losses in a community (11) buildings and other structures not included in Flood D handle, store, use, or dispose of such substances as hazar explosive substances where the quantity of the material e sufficient to pose a threat to the public if released.
4	Buildings and structures that contain essential facilities and services necessary for emergency response and recovery, or that pose a substantial risk to the community at large in the event of failure, disruption of function, or damage by flooding.	(1) hospitals and health care facilities having surgery or en (2) fire, rescue, ambulance, and police stations and emerg (3) designated emergency shelters (4) designated emergency preparedness, communication, (5) power generating stations and other public utility facili (6) critical aviation facilities such as control towers, air traf (7) ancillary structures such as communication towers, ele continued functioning of a Flood Design Class 4 facility du (8) buildings and other structures (including, but not limit substances as hazardous fuels, hazardous chemicals, or h quantity of the material exceeds a threshold quantity esta public if released.

Table 2 below identifies the classes that will be used to account for natural assets in San Mateo County. To date, they account for all natural assets in the dataset. Developing risk classes for natural assets may be a useful exercise in the future so that flood risk reduction measures can be evaluated for their effectiveness at reducing risk to critical ecosystems (as in Figure 1 above), or to those ecosystems and habitats most important to the region; however, this would require considerable scientific input, debate, and consensus. In the interim, as previously mentioned, existing legislation discourages building in floodplains, wetlands, or environmentally sensitive habitat areas, and the take of threatened species[15], so the suggested classification scheme for natural assets in San Mateo County should be appropriate. Details on the vulnerability of these natural assets and the services they provide will be assessed in the Asset Vulnerability Profiles if a natural asset is selected for a profile.

Table 2 Classification for natural assets in San Mateo County

Class	Natural Asset Descriptor	Natural asset type and examples
N-W	Natural Assets – Wetlands/ Estuaries	Wetlands, marshes, etc.
N-B	Natural Assets – Beaches/ Dunes	Beaches
N- R	Natural Assets – Rocky Intertidal	Rocky intertidal
N-S	Natural Assets – Species of concern	Federally or State-listed, threatened, or endangered species, or other species of concern, including those identified in the Climate Change Vulnerability Assessment for the North-central California Coast and Ocean, or elsewhere.
N-G	Natural Assets – Groundwater	Groundwater basin or source
N-O	Natural Assets – Other	Natural assets not listed in any other category

As mentioned, human assets will be accounted for and organized/classified in terms of the sheer number of the persons that are or could be exposed to current and future flooding posed by sea level rise, and in terms of communities that have been identified as socially vulnerable or disadvantaged.

[15] Coastal Act Sections: 30230, 30231, 30240, and 30253

3.1.1.1 Table 3 Classification of human assets

Class	Human Asset Description
H-P	Population exposed to current or future flooding (in number of individuals)
H-DC	Disadvantaged community
H-H	Affordable housing unit

4. Next steps: inundation mapping and asset inventory

As described in the Methodology report, after all assets for which data are available have been both categorized and classified, those assets that are exposed to current flooding or future sea level rise (step four in the methodology) will be displayed on a map according to asset class (steps five and six). This will provide county, city, and asset managers a clear sense of what types of assets are at risk, and where they are located. Asset inventories and spreadsheets (step seven) that correspond with the assets on the inundation maps will then be developed. The inventories will identify the number and types of assets at risk in each area according to asset category and asset class. A sample asset inventory spreadsheet is included in the Methodology report.

APPENDIX G

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

MEMO

To:
Hilary Papendick
Kelly Malinowski

Copies:
Michael Barber
Dave Pine

ARCADIS U.S., Inc.
100 Montgomery Street
Suite 300
San Francisco
California 94104
Tel 415 432 6909

From:
Peter Wijsman

Date:
September 15, 2015

ARCADIS Project No.:
LA00SCC.0000

Subject:
Memo Regarding the Selection of Inundation Scenarios for San Mateo County Sea Level Rise Vulnerability Assessment

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Introduction

This memo describes the selection of three inundation scenarios that will be used to carry out the sea level rise risk and vulnerability assessment. These three inundation scenarios are based on the guidance in the California Coastal Commission's August 2015 Sea Level Rise Guidance Document Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits, which is consistent with many of the local sea level rise planning efforts in California. With the selection of inundation scenarios, the Project Management Team (PMT) aims to provide an understanding of today's flood risk as well as realistic future scenarios that account for sea level rise.

Why Scenarios

The use of scenarios is important to better understand the impact of flooding on local San Mateo County communities under different circumstances. While higher sea level rise scenarios are less likely to occur or will happen later in time, looking at these scenarios provides valuable input for zoning and risk reduction decisions. For example, flood protection features along the shoreline could be designed in such a way that they can be adapted later to withstand higher flood levels as there is more confidence in the rate of sea level rise, land use could shift over time to those that are more compatible with temporary or permanent inundation or, with capital improvements decisions on critical infrastructure taking a 100-year planning horizon into account might lead to a different designs or locations of assets.

Another important aspect of the selection of these scenarios is to understand the relationship between current day flood risk and future flood risk. The past few decades have shown that large parts of San Mateo County are vulnerable to flooding and erosion even today. Both on the bayshore and Pacific Ocean side, storm events have led to flooding and loss of assets in storm events well below the 1%-annual chance flood (also called the 1% chance flood, 1% annual exceedance probability), the event most commonly referenced storm event in FEMA flood hazard maps. The challenge and disruption posed by flooding will be exacerbated by sea level rise and future development, and risks of inundation will increase. Rather than presenting sea level rise as solely a problem of the future, tying flood risk to present the day will allow for near term action to reduce inundation risks to San Mateo County communities.

Coastal Commission and Other State Guidance

The Coastal Commission Sea Level Rise Guidance document Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits (2015) uses the 2012 National Research Council's (NRC) report *'Sea-Level Rise in California, Oregon and Washington that released the report, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future'* as the most up to date and best available science for the California coast regarding sea level rise projection. This report provides an examination of global and regional sea level rise trends and projections of future sea level. The table below is an interpretation of this guidance used by the City of San Francisco for the San Francisco shoreline. This table provides an overview of potential sea level rise projections and ranges:

Year	Projections	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

Table 1: Sea Level Rise Projection for San Francisco (based on NRC 2012 from guidance for incorporating sea level rise into capital planning in San Francisco: assessing vulnerability and risk to support adaptation (September 2014))

The table presents the local projections which represent the *likely* sea level rise values (11 inches for 2050 and 36 inches for 2100) based on a moderate level of greenhouse gas emissions and extrapolation of continued accelerating land ice melt patterns with a certain deviation. The extreme limits of the ranges (17 and 66 inches for 2100 as an example) represent unlikely but possible levels of sea level rise utilizing both very low and very high emissions scenarios.

Furthermore, the Coastal Commission poses two key questions to help in establishing scenarios:

- What are the impacts from the worst-case scenario of the highest possible sea level rise plus elevated water levels from high tide, El Nino, and a 100-year storm (described in this study as the 1% annual event)?

- What is the minimum amount of sea level rise that causes inundation, flooding, or erosion concerns?

Other state guidance that is used to determine appropriate sea level rise scenarios comes from former Governor Schwarzenegger's Executive Order S-13-08 and the California Ocean and Climate Action Team (CO-CAT). This includes the following, partially overlapping recommendations:

- Executive Order S-13-08 details that planning should consider a range of sea level rise scenarios for the years 2050 and 2100 and sites the NRC 2012 scenarios.
- CO-CAT March 2013 Sea Level Rise Guidance Document recommends:
    1. Use of NRC 2012 ranges as a starting point and select sea level rise values based on agency and context-specific considerations of risk tolerance and adaptive capacity.
    2. Consider timeframes, adaptive capacity, risk tolerance when selecting estimates of sea level rise.
    3. Consider storms and other extreme events, including giving consideration to scenarios that combine extreme oceanographic conditions on top of the highest water levels projected to result from sea level rise over the expected life of a project.
    4. Coordinate with other state agencies when selecting values of sea level rise and, where appropriate and feasible, use the same projections of sea level rise.
    5. Future SLR projections should not be based on linear extrapolation of historic SLR observations.
    6. Consider changing shorelines as California has a very dynamic coast which will evolve under rising sea level. Assessments of impacts from sea level rise to shoreline projects must address local shoreline changes.
    7. Consider predictions in tectonic activity (not applicable for San Mateo County).
    8. Consider trends in relative local mean sea level. Predictions of future sea levels at specific locations will be improved if relative trends in sea level from changes in land elevation are factored into the analysis.

Our Coast Our Future Tool

The sea level rise vulnerability assessment will rely on the Our Coast Our Future (OCOF) tool. This is an online tool developed by National Oceanic and Atmospheric Administration (NOAA) and others, and fueled by the United States Geological Survey (USGS) hydrodynamic model called CoSMoS (Coastal Storm Modeling System) (http://data.prbo.org/apps/ocof/). The tool allows users to view different inundation scenarios for San Francisco Bay and parts of the Pacific Coast. In total, a combination of 41 different sea level rise and storm scenarios, including a King Tide scenario, can be selected. The output of the model is an interactive flood map in which flood extent, depth, duration, and minimum and maximum flood potential, wave height, and current velocity can be displayed. As this is a relatively new tool, there are some portions of the OCOF tool in San Mateo County that may not accurately reflect the shoreline elevation and could over or underestimate the risk from sea level rise.

Since the project is relying on an existing tool with existing data, there are limitations in terms of which storm and which sea level rise scenario is selected for further analysis. The storm scenarios available in the tool are: none, annual, 20-year and 100-year storms. There are 10 sea level rise scenarios available for analysis. These are summarized in the table below, in centimeters and inches above Mean Higher High Water (MHHW).

OCOF Tool Available Scenarios					
Sea Level Rise				Storms	
No.	Cm	Inches		No.	
1	0	0		1	None
2	25	9.8		2	Annual
3	50	19.7		3	20-year
4	75	29.5		4	100-year
5	100	39.4			
6	125	49.2			
7	150	59.1			
8	175	68.9			
9	200	78.7			
10	500	196.9			

Table 2: OCOF Tool Available Scenarios

Considering combinations that can be made from ten sea level rise scenarios and four storm scenarios, there are 40 possible alternative scenarios. Separately there is also one King Tide scenario (based on January 2014 King Tide) available, leading to 41 scenarios that are available to choose from for this study.

Peer Comparison

Appendix A provides an overview of San Mateo County, San Francisco Bay Area and other California sea level rise vulnerability studies that are currently underway and the inundation scenarios that are being used in those studies. From this overview, it is clear that there is a wide variety in approaches as to which scenarios could be used, however most of these studies are following the state's guidance and using the NRC best available science, yet they have not examined a common set of scenarios when comparing one to another. It should also be noted that while scenarios are presented for many different time horizons and different storm scenarios, the vulnerability and risk assessments themselves often use a subset of scenarios to describe the vulnerabilities in detail.

Proposed Inundation Scenarios

The table below presents the three proposed inundation scenarios for the vulnerability assessment and a rationale why these 3 scenarios were selected. These scenarios provide a broad range of water levels using approximately 0, 3 and 6 feet of sea level rise scenario (0, 100, 200 cm), plus the 1% annual chance storm. The 1% annual chance or 100-year storm is added as this is commonly used as input for the design height of a shoreline protection feature.

No.	Proposed Short Name	Water Level Input	Rationale
1	Present Day Flood Risk	MHHW + 1%-annual chance storm	The 100–year storm (1% annual chance) provides insight in present day flood risk without sea level rise. This is a water level that is high enough, compared to the other nearest lower OCOF flood levels (King Tide and 20-year storm), to show significant inundation in the county.
2	2100 Scenario (or 3 feet scenario + 100 year storm)	MHHW + 39 inches SLR + 1%-annual chance storm	Sea level rise scenario available in OCOF closest to NRC 'likely' 2100 scenario (36 inches), plus 1% annual chance storm. This is significantly different from water level from present day flood risk compared to a 2050 11 inch most likely scenario. Also used in Half Moon Bay, Marin County and San Francisco.
3	Extreme Scenario (or 6 feet scenario + 100 year storm)	MHHW + 79 inches SLR + 1%-annual chance storm	In line with Coastal Commission's Guidance Document recommendation to use an extreme scenario that presents a potential 'worst case', plus 1% annual chance storm. Also used in Marin.

Table 3: Recommended Inundation Scenarios for San Mateo County

ARCADIS

Appendix A: Sea Level Rise Scenarios Used in San Mateo County Projects and Other California Sea Level Rise Vulnerability Assessments

City of Foster City Levee Protection Planning Study

- Based on CCAMP and NRC Report
- 2030: 0.5 feet
- 2050: 1 foot
- 2100: 2 feet

San Francisco International Airport Shoreline Protection Feasibility Study Evaluation and Recommendations Report

- Based on NRC Report
- 2050: Max SLR of 2 feet
- Two SLR scenarios
    - 2 feet
    - Greater than 2 feet

Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean

- Based on NRC Report and Climate Change Impact Report from Cordell Bank and Gulf of the Farallons National Marine Sanctuary Advisory Councils
- 2050: 5 to 24 inches
- 2100: 17 to 66 inches

San Mateo County Climate Action Plan

- Based on NRC Report
- 2030: 7 inches
- 2050: 14 inches
- 2100 Low GHG: 40 inches
- 2100 High GHG: 55 inches

San Mateo County General Plan: Energy and Climate Change Element

- Based on NRC
- 2050: 5 to 24 inches
- 2100: 17 to 66 inches

SAFER Bay Project

- Based on FEMA preliminary FIRM, LIDAR, and parcel data
- 3 feet

San Bruno and Colma Creek Resilience Study

- Based on NRC Report
- Between 2030 and 2080: 1 foot
- Between 2050 and 2125: 2 feet
- Between 2065 and 2155: 3 feet

City of Half Moon Bay Local Coastal Program Update

- Scenarios include conditions in the near-term (next decade), General Plan/LCP horizon (2040-2050), as well as a longer view (approaching 2100)
- 0 centimeters with King Tide
- 25 centimeters with 100-yr storm event
- 50 centimeters with 100-yr storm event
- 3 feet with 100-yr storm event

Humboldt County

- Relative sea level rise rates, the high projections (due to tectonic subsidence)
- Based on NRC
- 2015, 2030, 2050 and 2011
- *for some critical assets, looking at 2070 too

Marin County

- Annual storm + 25 cm (0.82 ft)
- 5% annual chance (20-year) storm + 25 cm (0.82 ft)
- 5% annual chance storm + 50 cm (1.64 ft)
- 1%-annual chance (100 year) storm + 100 cm (3.28 ft)
- 1%-annual chance storm + 200 cm (6.56 ft)

City of Benicia

- 12 inches (1 foot)
- 24 inches (2 feet)
- 60 inches (5 feet)
- *also took into account the effect on storms

City of Oakland Oakland/Alameda County Adapting to Rising Tides Study

- *SLR projections range from 12-96 inches. Range selected based on:
  - Best available science (based on CO-CAT March 2013 report, which presents ranges in 3 time periods, based on the NRC 2012 report:
    - 2030: 2 inches (low), 12 inches (high)
    - 2050: 5 inches (low), 24 inches (high)
    - 2100: 17 inches (low), 66 inches (high)
  - Range of elevations of the Alameda County shoreline
  - Water levels that are most likely to overtop the current shoreline

- *Total of 6 future climate scenarios; based on 2 SLR projections + 3 bay water levels
    - 16 inches + MHHW
    - 16 inches + 1%-annual chance Stillwater (SWEL)
    - 16 inches + 1%-annual chance Stillwater (SWEL) + wind driven waves
    - 55 inches + MHHW
    - 55 inches + 1%-annual chance Stillwater (SWEL)
    - 55 inches + 1%-annual chance Stillwater (SWEL) + wind driven waves
- **uses "one map, many futures" approach that shows, for example that a future bay water level of 36 inches above MHHW can represent:*
    - the new "daily" high tide with 36 inches of SLR,
    - and can also represent the existing 2% annual chance high tide level with no SLR,
    - An annual high tide level (e.g. King tide) with 24 in SLR, and
    - Or a 2 year tide level with 18 inches SLR.

City of San Francisco Mission Creek Adaptation Study

- Uses maps derived from San Francisco Public Utilities Commission Sewer System Improvement Program. Similar approach to Alameda County ART study
- Uses 2 scenarios for 2050 and 2100 based on NRC 'most likely' scenarios
    - 2050: 11 inches of SLR + 1%-annual chance -year storm
    - 2100: 36 inches of SLR + 1%-annual chance storm

APPENDIX H

INTRODUCTION

Sea level rise inundation and extreme high tide[1] (a.k.a., storm tide) flooding maps for the San Francisco Bay Area are available from mu most prominent sources are the Adapting to Rising Tides (ART) and Our Coast, Our Future (OCOF) projects. While the mapping product similar, there are several underlying differences in the methods and data used to develop each product. This document highlights som technical differences between the ART and OCOF analysis methods and mapping products:

- 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 100-year storm is defined); and
- A brief overview of the **inundation mapping** approach.

PURPOSE

Adapting to Rising Tides

The Adapting to Rising Tides (ART) Program, led by the San Francisco Bay Conservation and Development Commission (BCDC), provides support, guidance, tools, and information to help agencies and organizations understand, communicate, and begin to address complex climate change issues. The ART sea level rise and storm surge flooding maps use a "one map equals many futures" approach, which allows each map to represent multiple potential future combinations of sea level rise and extreme water levels. The maps show the inland areas that are at risk of inundation or flooding, and the companion products -- the shoreline delineation, shoreline type, and overtopping potential maps -- identify the pathways of inundation

Our Coast, Our Future

Our Coast, Our Future (OCOF) is a collaborative, user- on providing San Francisco Bay Area coastal resource locally-relevant, online maps and tools to help them and anticipate vulnerabilities to sea level rise, storm s

The project included a collaborative product-develop designed to: meet stakeholders' information needs; r ecosystem vulnerabilities at scales relevant to planni

[1] Extreme tides (a.k.a., storm tides) are relatively infrequent water level events that are a result of relatively high astronomical tides coupled with a stor elevations reached during these events are due to short-term meteorological processes (such as low atmospheric pressure due to storms) and large-s conditions (such as King Tides or El Niño conditions).

or flooding from the Bay. Together, the products support robust, local scale vulnerability assessments and the development of both near-term and long-term adaptation strategies.

Through a collaborative effort with local and state agencies, the ART mapping is currently available for Alameda, Contra Costa, San Francisco, and San Mateo Counties. With funding from the Bay Area Toll Authority and the Metropolitan Transportation Commission, the ART maps will be completed for all nine Bay Area counties by early 2017. Technical reports, maps, case studies, and additional information, including ART Program staff Help Desk support, are available at: www.adaptingtorisingtides.org.

develop products in accessible, user-friendly formats
and technical assistance on the use of the products a

The OCOF maps are available for all nine Bay Area co
additional areas along the open Pacific coast. The ma
an online viewer, and the data can also be download
depending on the project need. The online viewer an
on the OCOF project are available at: www.ourcoastc

An additional online viewer that translates the flood e
exposure is available at https://www.usgs.gov/apps/l

SCENARIOS

Adapting to Rising Tides

The ART maps depict the inland extent of inundation or flooding associated with ten scenarios ranging from 12 inches to 108 inches above mean higher high water (MHHW). Using the one map equals many futures approach, the ten scenarios can represent over 50 combinations of sea level rise (i.e., from 0 to 66 inches) and extreme water level (i.e., from 1- to 100-year tide) scenarios. The scenarios range from an existing conditions King Tide (i.e., MHHW + 12 inches) to a 100-year storm surge condition coupled with 66 inches of sea level rise (equivalent to MHHW + 108 inches). The ten mapped scenarios are intended to be used in tandem with a county-specific matrix (i.e., reference table) of sea level rise and extreme water level elevations that identify the equivalent scenarios that can be represented by each of the ten maps.

Our Coast Our Future

The OCOF maps depict inland extents of flooding ass
tides in combination with a range of sea level rise val
storms that are user-selected within the online viewe
amount of sea level rise from 0 to 200 cm (in 25 cm in
cm. These scenarios correspond approximately to 0-,
69-, 79-, and 197-inches of sea level rise. The user can
level rise scenario with a King or spring tide and every
conditions, or spring tides in conjunction with a 1-yea
coastal storm event. This range of scenarios represen
combinations of sea level rise and extreme storm-driv
Francisco Bay.

TERRAIN

Adapting to Rising Tides

The ART maps use a 1-meter digital elevation model (DEM) developed from the 2010/2011 LiDAR collected by the USGS and NOAA as part of the

Our Coast Our Future

The OCOF maps use a 2-meter bare-earth DEM devel
LiDAR collected by USGS and NOAA as the base topo
DEM is of sufficient resolution and detail to capture th

California Coastal Mapping Program[2]. The DEM is of sufficient resolution and detail to capture the majority of shoreline levees and flood protection assets, but structures narrower than the 1-meter LiDAR resolution may not be adequately represented in the LiDAR or the resulting DEM.

The ART approach relied on stakeholder review and feedback to verify if features such as flood walls and tide gates were accurately captured in the DEM. If areas are shown as inundated with less than 24 inches of sea level rise above MHHW, and these areas have never been inundated during a King Tide condition or storm event, the local topography is reviewed. Stakeholders submit as-built drawings or infrastructure, or higher-resolution survey data, to improve the DEM. Potential levee or shoreline improvement projects (i.e., projects that are not yet constructed) are not incorporated within the DEM. Future shoreline erosion and geomorphic change are not considered, and the base DEM does not change over time.

levees and flood protection assets, but structures nar
LiDAR point spacing or the 2-meter DEM resolution m
represented in the DEM.

As part of the DEM development process, levees were
needed to better represent these features. However,
not be adequately represented. The OCOF team main
database to capture areas where the DEM may need
represent local flood protection structures or other fe

Future shoreline erosion and geomorphic change are
base DEM does not change over time for areas inside

MODEL COMPONENTS

Adapting to Rising Tides

The ART maps use water level output from the Federal Emergency Management Agency (FEMA) San Francisco Bay Area Coastal (SFBAC) Study[3]. The FEMA modeling relied on regional hydrodynamic and wave modeling using MIKE21 developed by DHI. The following sections describe the model simulation timeframe, general model setup, and input and boundary conditions.

Our Coast Our Future

The OCOF maps are created using the Coastal Storm
(CoSMoS) developed by the USGS. A coupled 2-way D
and wave model is primarily used within the CoSMoS
flow and flooding projections within the San Francisc
sections describe the model simulation timeframe, g
input and boundary conditions.

[2] http://www.opc.ca.gov/2010/01/mapping-californias-coastal-areas/
[3] http://www.r9map.org/Pages/San-Francisco-Coastal-Bay-Study.aspx

Model Simulation Timeframe

The FEMA MIKE21 model is calibrated and validated for existing conditions. In the Central and North Bay, the hindcast[4] period spans January 1973 through December 2003[5]. In the South Bay, the hindcast period spans January 1956 thru December 2009[6]. The models were calibrated to two storm events (January and December 1983), and validated against 11 large storm events that occurred during the model hindcast period. Although the model is well calibrated to water levels, limited wave data was available for model calibration and validation, therefore a higher uncertainty is associated with the modeled wave conditions. Model output is saved at 15-minute time steps for water levels, and 1-hour time steps for waves, over the entire 31- or 54-year hindcast period. The model is driven by observed data (e.g., water levels, winds, atmospheric pressure) and modeled data (e.g., Delta inflows, offshore waves, and tributary discharges).

Model Domain

The MIKE21 model uses a rectangular grid with 100-meter grid cell sizing for the entire model domain. The model domain spans the entire San Francisco Bay and into the Delta, with an eastern boundary just upstream of the City of Antioch. The western model boundary lies outside of the Golden Gate to capture the penetration of ocean-driven swell through the Golden Gate and into the Central Bay.

Model Simulation Timeframe

CoSMoS simulates potential future conditions during
events. Storm events (1-year, 20-year, 100-year, and a
associated atmospheric/environmental conditions w
derived from one CMIP5 (Coupled Model Intercompa
Global Circulation Model (GCM): the Geophysical Flui
(GFDL) Earth System Model (ESM2M). For each discre
CoSMoS' Delft3D models were driven by projections
ocean swell, winds, atmospheric pressure, and riverin
storm's conditions. Models were run for more than 1
include the higher-high tide); time-steps varied on lo
the particular model (see 'Model Domain').

Model Domain

The Delft3D model uses a grid with ~100 meter grid c
resolution of 10 to 20 meters in select focus areas inc
Creek/Alviso, Foster City, Corte Madera, Highway 37,
River estuary, Richardson Bay, Oakland Airport, Emba
Bay), and East Palo Alto, among others. Focus areas w
locations where hydrologic and shoreline complexity
resolution, and with further input from the OCOF Adv
model domain spans the entire San Francisco Bay ar
eastern boundary just upstream of the City of Antioch
lies outside of the Golden Gate and offshore of the co
capture the penetration of ocean-driven swell throug
into the Central Bay.

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[4] A hindcast is a simulation of historical conditions using a model driven by historical observations of certain environmental parameters such as wind

[5] Regional Coastal Hazard Modeling Study for North and Central San Francisco Bay, 2011. Prepared by DHI Water and Environment for FEMA Region IX

[6] Regional Coastal Hazard Modeling Study for South San Francisco Bay, 2013. Prepared by DHI Water and Environment for FEMA Region IX.

Offshore Water Levels

The offshore open boundary was driven by water levels recorded by the National Oceanic and Atmospheric Administration (NOAA) at the San Francisco Presidio (Presidio) tide station. The observed sea level rise trend was removed from the recorded water levels to raise the historical water levels to present day (i.e., 2009 for Central and North Bay; 2011 for South Bay) mean sea level conditions.

Offshore Water Levels

Offshore and regional water levels rely on tidal consti State University TOPEX/Poseidon model. Modeled wa Francisco Bay are highly correlated ($r^2 > 0.97$)[7] with ob most water level stations inside San Francisco Bay.

Offshore Ocean Swell

The offshore ocean swell boundary condition relies on a 31-year hindcast of 3-hourly deep ocean wave conditions produced by Oceanweather, Inc. (OWI). OWI developed the hindcast using their Global Reanalysis of Waves (GROW) model which relies on deep water and nearshore wave measurements from the National Data Buoy Center and the Coastal Data Information Program for model calibration and validation.

Offshore Ocean Swell

Offshore ocean swell conditions were modeled using global and nested Eastern North Pacific grids of the N (WWIII) model. Swell conditions were originally mode projections for the outer coast[8]. To capture the variab projections for the 21st century, the WWIII model was generated from two different climate scenarios (Repr Pathways (RCP) 4.5 and 8.5) and four CMIP5 GCMs. Oc the RCP4.5 scenario and winds from NOAA's GFDL-ES as boundary conditions to the Bay's coupled Delft3D Nearshore (SWAN) models. The RCP4.5 scenario was analysis of the WWIII results which show higher storm Central California coast compared to the RCP8.5 scen GCM was selected because the resulting wave time-se the observed wave climatology spanning 1976-2005 f buoy network (i.e., from the National Data Buoy Cent Information Program), and additionally, spatially dov wind data through the year 2100 available for the San the time of the modeling effort (see section on winds below).

[7] r^2 (r-squared) is a statistical measure of the goodness-of-fit of model data to observed data. A higher r^2 value (closest to 1), usually indicates a better f

River Discharge

The open Delta riverine boundary condition is represented by discharge from the Sacramento River (just upstream of the City of Antioch). Delta inflows are based on daily mean streamflow throughout the model hindcast period. Daily mean streamflow was generated using the California's Interagency Ecological Program (IEP) Dayflow daily discharge model. Smaller freshwater tributary inflows are input at a constant rate, represented by mean annual discharge.

River Discharge

River discharge rates for principal tributaries in the B
Petaluma, San Francisquito, Guadalupe, Coyote, Old
and the Delta) were included in the CoSMoS framewo
precipitation patterns depicted in the GCM (GFDL-ES
patterns from the GFDL-ESM2M-derived Delta discha
project (Computational Assessments of Scenarios of
Ecosystem), appropriate Delta discharges were ident
events. Historical relationships between the tributari
then used to calculate river discharge rates for each 2
event.

Winds and Wind-Driven Waves

Wind-driven waves are not considered in the ART mapping because increases in wave heights do not scale linearly with increases in mean sea level due to sea level rise. The ART mapping process only incorporates processes that can scale linearly with sea level rise (e.g., MHHW). However, wind-driven wave information is available from the FEMA SFBAC study. The wind fields for the SFBAC study were developed from hourly observations of wind speed and direction from the San Francisco International Airport, the Oakland International Airport, and the Travis Airforce Base. The wind fields were used as forcing for MIKE21 simulations to appropriately simulate waves and surge. Wind-driven waves were modeled using the MIKE21 SW (Spectral Wave) model.

Winds and Wind-Driven Waves

Wind fields were derived from a downscaled version
The downscaled wind projections come from the Un
Multivariate Adaptive Constructed Analogs[9] (MACA) s
GCM data. The MACA method downscales GCM outpu
spatial resolution at a daily time step. The temporal r
fields were increased to 3-hour time steps to support
modeling within Delft3D using the coupled SWAN (i.e
fields for identified storm events were used as forcing
to appropriately simulate waves and surge. Data fron
used due to time constraints and to maintain consist
GCM-derived storm conditions (i.e. river discharge an

STORM DEFINITION

Adapting to Rising Tides

Our Coast Our Future

[8] Barnard, P. L., O. van Maarten, L.H. Erikson, J. Eshleman, C. Hapke, P. Ruggiero, P. Adams, and A. Foxgrover (2014), Development of the Coastal Storm
for predicting the impact of storms on high-energy, active-margin coasts, Nat. Hazards, 74(2), 1095-1125, doi:/10.1007/s11069-014-1236-y.
[6] Abatzoglou J. T. and Brown T.J. 2011. A comparison of statistical downscaling methods suited for wildfire applications. International Journal of Clim
[9] Abatzoglou J. T. and Brown T.J. 2011. A comparison of statistical downscaling methods suited for wildfire applications. International Journal of Clim

The ART maps use a response-based[10] statistical approach to define local extreme tide recurrence intervals (e.g., 1-year, 10-year, 100-year, etc.) based on historical conditions at 900 points along the Bay shoreline[11]. This approach assumes that no single storm "event" will simultaneously produce the 100-year (or other recurrence internal) flood extent along the entire Bay shoreline. Instead, multiple storm events with varying storm directions and intensities are analyzed to produce a composite map that represents the 100-year flood hazard[12] (the extent and depth of inland inundation that has a 1-percent-annual-chance of occurring at any given location along the shoreline). This approach is consistent with the FEMA guidelines for analyzing and mapping coastal hazards along the Pacific coast[13]. The 100-year extreme high tide levels are consistent with the values used for the FEMA SFBAC study; however, these values do not include the addition of waves or wave runup at the shoreline.

The OCOF maps rely on an event-based approach, w discrete storm events (i.e., 1-year, 20-year, and 100-y analysis of the storm climatology from the downscal output over the 21st century. The analysis considers s orientation, as well as the geometry and orientation define a storm event that has a 1-percent-annual-cha interval) of occurring in any given year. As the comple affects exposure to storms and wind direction, and in waves and related flooding, multiple events for majo 100-year) were identified and simulated. Storm even predominant wave and wind directions in each regio resultant hazard projections are a composite of all co simulations for the event. Orientation differences bet yield flood extents that are larger for less-intense sto year) in some locations.

FLOOD MAPPING

Adapting to Rising Tides

The ART inundation mapping uses an approach developed by the NOAA Coastal Services Center[14]. San Francisco Bay water levels are projected landward on a 1-meter DEM to assess the inland extent and depth of flooding, and low-lying areas that are protected from flooding by levees or other topographic features are removed from the direct flood zone and highlighted

Our Coast Our Future

For each storm event (1-year, 20-year, 100-year), a co wave) Delft3D model with inclusive storm conditions atmospheric pressure) is run over more than 1 tide cy higher-high tide). Resulting water levels are projected create OCOF flooding maps and corresponding dept

[10] Response-based analysis refers to a coastal analysis technique in which long time series of environmental parameters, such as astronomical tides, a winds, are combined and simulated to derive an estimate of storm water level conditions at the shoreline. This is in contrast to an event-based analys time period considered to be representative of a desired storm magnitude (such as a 100-year event) is simulated. The response-based analysis is con than an event-based analysis, especially in the Bay where extreme tide levels can be realized through many different combinations of astronomical tid conditions.

[11] San Francisco Bay Tidal Datums and Extreme Tides Study, 2016. Produced by AECOM for FEMA.

[12] Extreme Storms in San Francisco Bay – Past to Present. 2016. Produced by AECOM for FEMA.

[13] Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States. 2005. FEMA.

[14] Marcy, D., B. William, K. Dragonoz, B. Hadley, C. Haynes, N. Herold, J. McCombs, M. Pendleton, S. Ryan, K. Schmid, M. Sutherland, and K. Waters. 2011 Techniques for Visualizing Sea Level Rise and Coastal Flooding Impacts." In: *Proceedings of the 2011 Solutions to Coastal Disasters Conference*. June

in green. The extent and depth of flooding is controlled by the difference between the water and ground surface elevations.

The flood mapping uses a base water level of existing MHHW, which is spatially variable along the San Francisco Bay shoreline. Discrete amounts of sea level rise are added to MHHW to create the ten mapped scenarios. This approach does not account for the complex physics of overland flow, dissipation, levee wave overtopping, storm duration, or the potential for shoreline erosion and levee failure that can occur during storm events. To account for these processes, a more sophisticated modeling effort would be required. However, given the uncertainties associated with climate change and sea level rise, as well as potential future land use changes, development, and geomorphic changes that will occur throughout the 21st century, a more sophisticated approach may not necessarily provide more accurate results.

The ART maps include an analysis of the type and elevation of the shoreline that produces an overtopping potential map that illustrates not only where overtopping may occur, but how deep the water may be, on average, over the shoreline. Overtopping potential maps help identify locations that pose the largest risk to shoreline communities and infrastructure. This is a powerful tool that is unique to the ART maps. Coupled with the inundation and storm surge maps, the overtopping potential maps help users quickly and efficiently identify the shoreline locations and flowpaths that could lead to inland flooding so that additional investigation (e.g., field verification or more sophisticated modeling) can be targeted at these locations.

approach and inclusion of overland high-resolution g
physics of overland flow; therefore the inland extent
the volume of Bay water available during the simulat
overtop the shoreline and flood low-lying areas durin
Each storm simulation is repeated for the range of se
considered and the resulting depth and extent of floo

Acknowledgements

Prepared by: Kris May, Michael Mak, Justin Vandever (AECOM), Patrick Barnard, Andy O'Neill, Li Erikson (USGS), Wendy Goodfriend (BCD

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APPENDIX I

Appendix I: Groundwater Resources Evaluation

Groundwater in San Mateo County is present in alluvial groundwater basins. These include the more populated Westside and San Mateo Plain Basins on the San Francisco Bay side of San Mateo County and San Pedro Valley (Pacifica), Half Moon Bay Terrace, San Gregorio Valley, and Pescadero Valley on the less populated Pacific Ocean side of San Mateo County. The beneficial uses of groundwater is summarized below.

San Mateo County Groundwater Uses

The Westside Groundwater Basin is approximately two miles wide by 11 miles long, ranging in depth from approximately 500 feet in Golden Gate Park to about 3,500 feet near Daly City (San Francisco Bay Regional Water Quality Control Board, 1996). The Basin is bounded to the north by a northwest trending bedrock ridge northeast of Golden Gate Park in San Francisco, to the east by a bedrock ridge that includes San Bruno Mountain, and to the west by the San Andreas Fault. The southern boundary is estimated to end south of the City of San Bruno. The water bearing zones in this Basin include the Merced and Colma formations. Groundwater is unconfined in the shallow Colma Formation and confined in the Merced formation. The deeper Merced formation is used for municipal groundwater supply because groundwater in the shallower Colma formation is inferior and subject to points of contamination from anthropogenic sources.

As of 2013, groundwater pumping in the Westside Basin was primarily for municipal water supply to Daly City, San Bruno, and South San Francisco, as well as for irrigation and other non-potable uses by the San Francisco Zoo, Golden Gate Park, golf courses, and cemeteries (San Francisco Public Utilities Commission 2014). Production wells in the San Mateo County portion of the Westside Basin are present near the Lake Merced Golf Club, the California Golf Club, and Cal Water wells near San Bruno and South San Francisco. In the Town of Colma, groundwater is primarily used for irrigation at the cemeteries. No municipal pumping is currently ongoing within the Town of Colma. Other groundwater pumping within the Westside Basin (e.g., private homeowner wells, groundwater remediation extraction wells, and construction dewatering wells) is estimated to be negligible compared to the municipal and large-scale irrigation uses.

The San Mateo Plain Basin begins south of the West Side Basin and extends approximately from the city of San Mateo south to the Santa Clara County line. Groundwater is used for irrigation, public drinking water, and private drinking water (San Francisco Bay Regional Water Quality Control Board, 2007). The San Mateo Plain is a northern extension of the Santa Clara Basin located to the south. The majority of pumping for irrigation occurs in the South San Mateo Plain Sub-basin, where approximately 90% of the irrigation wells are located. Of the wells in the South San Mateo Plain Sub-basin, approximately 65% are located in Atherton. The majority of the wells in Atherton and Menlo Park are screened in the deeper aquifer making them unlikely to be affected by sea level rise, while the majority of the irrigation wells in other cities in the South San Mateo Plain Sub-basin are screened in the shallower aquifer making them potentially vulnerable to sea level rise.

Public drinking water wells in the San Mateo Plain Basin are located in East Palo Alto (Palo Alto Park Mutual Water Company), Menlo Park (O'Connor Tract Corporation and Menlo College), and in the City of San Mateo (San Mateo High School). While Menlo College and San Mateo High School are small water systems that provide water for their campuses, O'Connor Tract Corporation and Palo Alto Park Mutual Water Company provide drinking water for the population of East Palo Alto and to the East Menlo neighborhood in Menlo Park. All public drinking water wells are screened in the deeper aquifer. Public drinking water wells are discussed in more detail in the following section.

A few private drinking water wells are located in East Palo Alto. These wells were installed in the 1980s when Palo Alto Park Mutual Water Company had a moratorium in place on new water connections. Most of the houses developed in the 1980s have since been connected to public drinking water, and their wells have either been destroyed or are currently used for irrigation only. These drinking water wells are screened in the shallow water-bearing zone, making them potentially vulnerable to sea level rise, however there are not estimated to be many private drinking water wells currently in use. Of the known wells in the San Mateo Plain, 74% are monitoring wells related to current site remediation activities. The majority of the monitoring wells, about 72%, are located in the South San Mateo Plain Sub-basin. There are no known plans for significantly expanding groundwater uses in the San Mateo Plain (California Regional Water Quality Control Board San Francisco Bay Region, 2003).

Assessment of Municipal Groundwater Use in San Mateo County

An evaluation of the primary sources of potable municipal water supply in each of the following Water Districts of San Mateo County was performed to assess potential vulnerability to current potable water resources from sea level rise: Brisbane, Burlingame, Daly City/Colma, East Palo Alto, Hillsborough, Millbrae, Redwood City, San Bruno, Coastside County Water District (Half Moon Bay), Estero Municipal Improvement District (Foster City), Guadalupe Valley Municipal Improvement District (Brisbane), Mid-Peninsula Water District (Atherton, Belmont, Hillsborough, Portola Valley, Woodside), North Coast County Water District (Pacifica), Westborough Water District (South San Francisco), California Water Service Company (Cal Water) (Los Altos, Menlo Park, San Mateo, and San Carlos).

Information was obtained from the following sources:

- The Bay Area Water Supply and Conservation Agency http://bawsca.org/members/map
- Annual Consumer Confidence Reports for each of the water districts: http://www.greenenvironmentnews.com/State/California/WaterQualityReports

As reported by the sources above, the San Francisco Regional Water System provides water to San Francisco, Santa Clara, Alameda and San Mateo counties. Approximately 85% of the water provided to these counties comes from Sierra Nevada snowmelt stored in the Hetch Hetchy reservoir situated on the Tuolumne River in Yosemite National Park. Hetch Hetchy water flows 160 miles from Yosemite to the San Francisco Bay Area. The remaining water comes from runoff in the Alameda and Peninsula watersheds and is captured in reservoirs located in San Mateo and Alameda counties. Groundwater is not a resource for the majority of the Water Districts in San Mateo County, and where it is used it represents a small portion of current water supply. Districts in San Mateo County where groundwater is a reported resource include San Bruno, South San Francisco, Daly City, East Palo Alto, the Coastside County Water District, and less populated areas on the Pacific Ocean side of San Mateo County (e.g., Pescadero and San Gregorio). The potential vulnerability of these potable groundwater resources to sea level rise is discussed below.

Estimated Vulnerability of Groundwater to Sea Level Rise

Municipal groundwater extraction wells are reported to be in use in the cities of San Bruno, South San Francisco, and Daly City. All wells are reported to be screened in the deeper, confined Merced aquifer where the water quality is better than shallow groundwater. In March 2003, a drinking water source assessment was completed for the Daly City supply wells, and the assessment showed that five of Daly City's six municipal production wells are highly protected from potential pathways of contamination with one well identified as moderately protected. The moderately protected well was scheduled for replacement in 2015 (City of Burlingame, 2011).

An aquifer susceptibility assessment for the Santa Clara and San Mateo County groundwater basins was performed by Lawrence Livermore National Laboratory in (LLNL, 2004) and included collection of tritium samples to estimate groundwater age. In two areas of San Mateo County on the western side of the San Francisco Bay, the Westside Basin (includes the northern portion of San Mateo County) and San Mateo Plain (includes the southern portion San Mateo County) many of the public supply wells produce old, entirely pre-modern groundwater, indicating that recharge has not occurred for the last 50 years or more. Groundwater that is this old is unlikely to be adversely affected by sea level rise in the near-term.

A relatively large number (8 of 14) of Westside Basin wells do not contain detectable tritium (less than 1 picocuries per liter [pCi/L]), and another two Daly City wells have tritium values between 1 and 2 pCi/L, for a total of 10 wells with groundwater ages that indicate that the groundwater recharge occurred more than 50 years ago. Three wells in

South San Francisco and two in Daly City also produce water that is also largely greater than 50 years old. Supply wells with deeper screens (greater than 200 feet below ground surface) draw an older groundwater component and are free of volatile organic compounds (VOCs) (sourced from modern anthropogenic activities). In this basin, supply wells that tap deeper aquifers appear to be protected from the widespread contamination present at the surface. The age and low detections of VOCs in the supply wells of the Westside Basin suggests that that these wells would likely be protected from future sea level rise.

In East Palo Alto, groundwater is also identified as a potable water resource. The City of East Palo Alto overlies a portion of the San Francisquito Cone Sub-basin, an area that overlaps the San Mateo Plain and Santa Clara sub-basins of the Santa Clara Valley Groundwater Basin (City of East Palo Alto, 2015). The principal groundwater aquifers of the basin and sub-basins are composed of interbedded coarse- and fine-grained alluvial fan deposits of San Francisquito Creek, extending from the Santa Cruz Mountains north and under San Francisco Bay, and distal alluvial fan deposits of the Niles Cone, extending from the Diablo Range. Overlying most of the alluvial sediments beneath the City are thick, laterally-extensive fine-grained materials, deposited when the area was below sea level. These Bay Mud sediments form a continuous aquitard or confining layer. The USGS characterized the groundwater aquifers and aquitards as a generalized three-layer system: an upper unconfined to a confined shallow aquifer zone, a fine-grained Bay Mud unit near the Bay, and a deep principal aquifer beneath the confining layer (Metzger 2002). Most large production wells in East Palo Alto derive their water from the deep aquifer zone, at depths ranging from 200 to over 800 feet below ground surface (ft-bgs). Nine wells in Palo Alto and East Palo Alto, considered to be part of the San Mateo Plain Basin, produce mostly pre-modern groundwater (older than 50 years). In general, the groundwater produced from deep-screened wells in this part of the basin is tens to hundreds of thousands of years old, and likely has a very deep source (LLNL 2004). Therefore, the potential for an adverse impact by sea level rise is estimated to be very limited.

The Coast Side Water District derives approximately 28% of the its water supply from local wells and surface water, the remaining 72% is from the San Francisco Regional Water System with water derived from Hetch Hetchy (Coastside County Water District, 2016). The Pilarcitos Well Field and the Denniston Project supply ground water. Water from the Pilarcitos Well Field is limited to pumping between November and March. In the California aquifer susceptibility assessment for the Santa Clara and San Mateo County groundwater basins performed by LLNL (LLNL, 2004), it was noted that on the Pacific Coast in San Mateo County, a small number of wells provide the sole source of drinking water for coastal communities. Many of these supply wells are estimated to draw groundwater from a shallow, unconfined aquifer in the Coastside Basin and have a mean groundwater age of only 4 years (based on tritium age dating data). The young age of the water pumped from these wells indicates that there is rapid recharge of surface water into the aquifer. This shall0ow, rapid recharge makes these wells highly vulnerable to near-surface contamination sources, and these wells may also be susceptible to impairment from sea level rise.

Bay Mud Aquitard Influence on Potable Groundwater Protection

The Bay Mud aquitard occurs beneath San Francisco Bay and extends south-southwest under the entirety of East Palo Alto. There is a clear increase in aquitard thickness (up to 300 ft-bgs) in the northeast closer to the San Francisco Bay. The unit does not extend to the foothills in the southwest resulting in an unconfined aquifer system. The southwestern extent of the Bay Mud aquitard has been mapped by USGS and others, and demarcates the unconfined and confined aquifer zones. In the vicinity of East Palo Alto (El Camino Real and Sand Hill Road) the Bay Mud is generally present four or more miles from the San Francisco Bay forming a confining unit. This would presumably prevent sea level rise from the San Francisco Bay from impairing the unconfined aquifer generally east of El Camino Real in the future. A more detailed evaluation of the western San Francisco Bay groundwater elevations in comparison to groundwater levels at the estimated western limits of the Bay Mud aquitard would provide more information to estimate how high sea level rise would need to occur to potentially migrate beneath the Bay Mud Aquitard and affect high quality deep aquifer groundwater.

Groundwater Susceptibility to Impacts from Hazardous Materials Sites

As previously described, the presence of land or facilities containing hazardous materials in areas at risk of inundation increases the risk of exposure to toxic chemicals for nearby residents and ecosystems.

Summary of Findings

Reported information suggests that there is generally a limited risk posed by sea level rise to municipal supply wells due to the great depths that they are screened across, the presence of shallow confining layers such as the Bay Mud above these deep supply wells, and the distances of supply wells from the San Francisco Bay on the eastern portion of San Mateo County. In addition, most of the population of San Mateo County receives potable water from the State Water Project (Hetch Hetchy), so groundwater is not a primary resource for potable water supply. A potential exception that warrants further review pertains to any municipal supply wells adjacent to the Pacific Ocean, which are reported to be screened much shallower and contain much younger groundwater indicating a higher potential for adverse impacts from sea level rise. In addition, some private domestic drinking water wells are reported to be in use in southern San Mateo County that 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 that is much more vulnerable to anthropogenic contaminants, flooding, and potentially sea level rise.

APPENDIX J

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

This section was written by Pacific Gas and Electric.

Company Overview

PG&E is one of the largest combined natural gas and electric utilities in the United States. Based in San Francisco, with more than 23,000 employees, the company delivers some of the nation's cleanest energy to nearly 16 million people throughout a 70,000-square-mile service area in Northern and Central California.

PG&E's Approach to Climate Change Resilience

PG&E understands that there is no single approach to building climate change resilience. It involves taking a holistic approach to better understand, plan for and respond to climate change risks—and doing so in partnership with others.

There are four key aspects to PG&E's approach to addressing changing climate conditions:

Near-term planning: Robust emergency response plans and procedures to address near-term risks, including extreme storms, heat waves and wildfires.

Risk assessment and operational planning: A multi-year, comprehensive risk assessment process to prioritize infrastructure investments for longer-term risks associated with climate change.

Staying abreast of the latest science: An in-house science team that regularly reviews the most relevant climate-change science and integrates that research into PG&E's risk assessment process.

External engagement: Active engagement and partnerships at the federal, state and local level on climate change adaptation and resilience.

PG&E's *Climate Change Vulnerability Assessment* highlights many of the physical risks the company faces from climate change and PG&E's progress in understanding and addressing them on behalf of its customers. The report is available at http://www.pgecurrents.com/wpcontent/uploads/2016/02/PGE_climate_resilience.pdf.

PG&E's Risk Assessment and Operational Planning

PG&E has undertaken a multi-year, comprehensive risk assessment to gain a better understanding of how the company's critical assets would perform under different natural hazard scenarios. The overarching goal of the assessment, known as PG&E's Natural Hazard Asset Performance (NHAP) initiative, is to identify potential risks resulting from natural hazards and enable PG&E's business units to evaluate those risks and develop response plans.

The assessment, which covers PG&E's electric and gas infrastructure, includes scenarios for both flooding and sea level rise. The flooding scenario assesses PG&E's assets against Federal Emergency Management Agency (FEMA) 100- and 500-year flood zones. The sea level rise scenario assesses the potential impact on PG&E's assets of 24 inches—or two feet—of sea level rise above the Mean Higher High Water by 2050, per California Coastal Commission Sea Level Rise Guidance issued in August 2015.

PG&E is conducting the NHAP process in several phases. To date, PG&E has completed an assessment and identified the risk exposure of the company's assets, calculated as the percentage of assets in the hazard zone. As a next step, PG&E is assessing the ability of those assets to withstand the natural hazards.

The results of the NHAP assessment will be integrated into PG&E's enterprise-wide integrated planning process. The results will also inform PG&E's emergency planning and response activities so the company can continuously improve and make its system more resilient to catastrophic events. PG&E is also piloting a more robust coastal flood risk analysis of at-risk assets using additional scenarios of sea level rise.

Potential Risk Exposure to PG&E's Substations and Gas Infrastructure

As part of the NHAP assessment, PG&E found that two of its substations in San Mateo County are located within areas modeled for two feet of sea level rise and six are located in FEMA's 100-year flood zones. PG&E also found that about 3% of its gas transmission pipelines in San Mateo County are located within areas modeled for two feet of sea level rise and about 14% are located in FEMA's 100-year flood zones.

Compared to 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, it is not expected that all of the FEMA flood zones would be affected by a flooding incident at the same time.

Actions Taken

Substations and Electric Infrastructure

When making repairs or modifications to facilities, PG&E takes into account any additional modifications necessary to protect structures within the 100- and 500-year flood zones. For example, PG&E has elevated structures at several of its substations to reduce the risk of flooding, including the San Mateo 115kV GIS Building. In some cases, the company also looks to reinforce identified substations; in other cases, in the event of a flood, the reliability of the electric grid can allow the flexibility to serve customer load through other parts of the system.

PG&E also uses a model developed by PG&E meteorologists to predict the number and timing of sustained power outages each PG&E geographic region can expect during adverse weather conditions. The model is run on a daily basis, with more frequent updates issued as storms approach. The model outage forecast information is a key tool that PG&E uses to determine the number and type of resources needed to restore operations and power delivery back to normal.

Gas Infrastructure

From a planning perspective, PG&E's Gas Emergency Response Plan prescribes immediate actions to be taken to ensure safety and reliability in major flooding events. PG&E has prioritized areas of exposed pipeline and pipeline spans in flood zones and coordinated on response plans for assets with higher-risk exposure to flood zones. PG&E is also developing long-term plans to address areas of gas transmission pipeline at risk of erosion and landslides.

From an operational perspective, PG&E continues to identify and mitigate potential impacts from flooding through scheduled air and ground patrols, leak surveys and routine maintenance. PG&E has also automated notifications for areas at risk of landslides due to heavy rain events. In addition, PG&E has identified and is monitoring pre-determined gas transmission pipeline locations susceptible to erosion and landslides through use of Light Detection and Ranging (LiDAR) to monitor and track potential land movement, accompanied by field verification.

Additionally, PG&E's meteorological department forecasts where and when storms are likely to arrive and progress through PG&E's service area, including identifying potential areas of greatest rainfall intensity. A PG&E-developed model enables the company's gas operations to identify high risk areas susceptible to rainfall-induced landslides. Together, the rainfall forecasts and associated models help PG&E to better understand the potential impact to its gas system infrastructure from storms.

APPENDIX K

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

This section was written by Kelly Malinowski from the California State Coastal Conservancy and explains how the Goals Project (Conservancy 2015) applies in San Mateo County.

Introduction

Baylands Ecosystem Habitat Goals Science Update 2015: The Baylands and Climate Change: What We Can Do (Conservancy 2015) is an update to the 1999 Baylands Ecosystem Habitat Goals, which for the first time set comprehensive restoration goals for the San Francisco Bay estuary, produced by a collaborative of 21 management agencies working with a multi-disciplinary team of over 100 scientists. The 2015 science update synthesizes the latest science, and incorporates an understanding of climate change and sediment supply, and projected change through 2100 to generate new recommendations in achieving healthy baylands ecosystems. Recommended actions offer opportunities for multi-benefit projects to enhance ecological function, which can also provide benefits to the built and human communities and help enhance resilience to sea level rise. Summaries of segments are included below. For a full list of the opportunities, segment features and setting, implications of drivers of change, recommended actions and considerations for implementation of the actions, and challenges, please visit: http://baylandsgoals.org/

Segment J

Overview

Segment J covers the section of bayshore in San Mateo County north of Coyote Point to the northern boundary of San Mateo County.

Opportunities

Opportunities for this segment include restoration of tidal wetlands, beaches, sand dunes, intertidal rocky areas, subtidal habitats, and demonstration projects to educate the public and raise awareness about climate change impacts, and promote solutions. Ongoing creek work in the segment could be leveraged to integrate climate-change-adaptation techniques. Though highly urbanized, Segment J offers the opportunity for multi-benefit projects that incorporate small-scale restoration and the protection of existing infrastructure, shorelines, and baylands. This segment also presents the opportunities for innovative and experimental approaches, such as sediment placement, the use of uncontaminated on-site fill-in restorations, and integrated multi-habitat designs.

Sea Level Rise Adaptation Recommendations

Near-Term (Now to midcentury, prior to sea level rise curve acceleration)

Near-term actions to enhance the existing baylands and provide immediate ecological benefits will maximize shoreline resilience. One action to preserve and enhance native eelgrass and oyster beds is to create living breakwaters around fringing marshes and partner with industrial and shoreline communities to create habitat bayward of flood protection levees. For infrastructure remaining in current configurations, living seawalls could enhance habitat value, and improving tide gate management can also enhance habitats. Additional habitat can also be created along flood-control channels.

Long-Term (Letter half of the century, after sea level rise curve acceleration)

In the long-term, it is likely sea-level rates will outpace vertical accretion rates for marshes in this segment. Prior to this, plans for restoring or relocating functions within existing tidal marshes should be implemented. The creation of wetlands bayward of flood protection levees could provide this landward migration space. If managed retreat opportunities become available, options to restore areas to baylands or to connect bay habitats should be pursued.

Segment M

Overview

Segment M covers the San Mateo County bayshore between Coyote Point and Steinberger Slough.

Opportunities

Opportunities in Segment M are limited, but include opportunities to protect and enhance remaining tidal marshes and other wetlands, subtidal habitat, creating breakwaters to protect fringing marshes or artificial rock groins to form small beaches. Horizontal levees can be built along the shoreline as residential communities invest in flood protection against sea level rise.

Sea Level Rise Adaptation Recommendations

Near-Term

Near term actions to enhance the baylands will provide immediate ecological benefits and maximize their resilience. Breakwaters around fringing marshes can be used to preserve shell mounds, and marsh recharge can increase vertical accretion rates for marshes. Native oyster and eelgrass beds can also be restored in this segment, and there are opportunities for horizontal levees bayward of flood protection levees. There is also a unique opportunity to restore the transition zone along the Foster City shoreline at the mouth of Belmont Slough.

Long-Term

Since sea level rise rates will likely outpace vertical accretion rates, a plan for restoring or relocating functions of existing marshes should be implemented prior to sea level rise acceleration. Creating wetlands bayward of the flood-protection levees could provide this landward migration space. If managed retreat opportunities arise, there will be opportunity for restored marshes along this segment.

Segment N

Overview

Segment N covers the San Mateo County bayshore from Steinberger Slough to the Dumbarton Bridge and includes both the Bair Island restoration and Ravenswood pond complex.

Opportunities

There are opportunities in Segment N for tidal marsh restoration and the enhancement of seasonal wetlands and ponds, Bedwell Bayfront Park allows for some marsh migration as sea levels rise, and local sediment and water supplies could be used for habitat creation.

Sea Level Rise Adaptation Recommendations

Near-Term

In this segment, near-term opportunities are significant in restoring tidal marsh in managed ponds. Other measures, such as levees, may be needed in protecting Highway 101 on the western side of Inner Bair and to prevent flooding of Highway 84 next to the Ravenswood pond complex.

Long-Term

If sea level rise accelerates and sediment supply decreases in the long-term, marsh plains could become fringing marshes and tidal marshes may be unable to keep up with sea level rise. Gently sloping levees bayward of existing levees would facilitate anticipated landward migration of marshes.

Segment O

Overview

Segment O covers the San Mateo County bayshore from the Dumbarton Bridge to the southern boundary of San Mateo County.

Opportunities

Segment O provides opportunities to enlarge existing marshes and to link the eastern and western parts of the South Bay for tidal-marsh-dependent species. There are also opportunities to enhance tributary streams such as San Francisquito Creek and the Guadalupe River.

Sea Level Rise Adaptation Recommendations

Near-Term

In the near-term, restoring tidal marsh in managed ponds can help create a continuous corridor of tidal marsh, and managed ponds could continue to be managed for shorebirds and waterfowl while rates of sea-level rise are low.

Long-Term

As sea level rise accelerates, marsh plains will convert to narrower fringing marshes and tidal marshes may be unable to keep up with rising seas. A gently sloping transition zone bayward of the levee would facilitate marsh migration in the long-term.

APPENDIX L

Appendix L: Stakeholder Group List

The project team engaged local experts through public meetings, workshops, guided discussions, personal interviews, and site visits. The team also worked with asset managers, civic leaders, elected officials, and representatives from agencies and special interest groups to collect information and feedback. This information augmented scientific and archival information to provide a more comprehensive perspective on sea level rise vulnerability in San Mateo County. The stakeholders involved to-date are in the following list.

Stakeholder Group List
Alain Pinel Realtors
Association of Bay Area Governments (ABAG)
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 Gordon
California State Office of Assemblyman Mullin
California State Office of Congresswoman Speier
California State Office of Senator 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
County of San Mateo Office of Education
County of San Mateo Office of Emergency Services
County of San Mateo Office of Supervisor Horsley
County of San Mateo Office of Supervisor Pine
County of San Mateo Office of Sustainability
County of San Mateo Office of the County Counsel
County of San Mateo Parks Department
County of San Mateo Public Works Department
County of San Mateo Resource Conservation District
County Santa Clara Office of Sustainability
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 Area Planning and Urban Research Association (SPUR)
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 Transit (SamTrans)
San Mateo County Transportation Authority (SMCTA)
San Mateo County Union Community Alliance
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
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)

APPENDIX M

APPENDIX N

Appendix N: Recommendations for Next Steps from Stakeholders

This list is based on feedback from 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.

- Prioritize assets. Prioritize assets that are at risk now and with future sea level rise based on the most critical to the least critical.
- Develop Countywide sea level rise standards. Establish Countywide standards for sea level rise science, sources, scenarios, and assessment methodology and produce guidance on how to consistently address sea level rise in General Plans and Local Coastal Programs. This process includes identifying the key components of a rigorous sea level rise analysis and developing a standardization of information, assessments, and approach to limit a piecemeal or inconsistent way of looking at the problem. The guidance should be a two- to nine-page document tailored for San Mateo County city staff and elected officials.
- Understand adaptation options. Conduct a more detailed shoreline analysis to understand where levees are needed and what shoreline adaptation options would work in specific locations and incorporate flooding from the upper watershed. Evaluate ways to reduce greenhouse gas emissions during adaptation, prioritize green infrastructure options, and better understand the regulatory constraints and legal liability moving forward.
- Collaborate across sectors. Integrate adaptation into the Climate Action Plan process and work to collaborate between planning efforts, emergency preparedness efforts, and facility operations efforts. Use the Local Hazard Mitigation Plan as an avenue to accomplish this goal.
- Provide mapping products and accessible data. Provide a map viewer that all stakeholders could use. Cities, CalTrans, and wetland managers requested data in multiple formats: GIS files, PDFs, and online interactive viewers. Each of these would serve a different purpose. Google Earth/KMZ files would also be useful. Develop a system for sharing data across entities.
- Refine sea level rise modeling. Develop local wave run-up models. Understand watershed-scale flooding impacts, including combination of riverine and bay flooding.
- Evaluate governance options. Evaluate governance options, including formation of a Countywide joint powers authority. Consider establishing a Countywide independent review committee that would complete review of projects to ensure they adequately prepare for sea level rise. It may be helpful to consider different governance models.
- Investigate funding opportunities. Understand how to approach coordinated funding across cities.
- Raise public awareness of sea level rise. Understand what the current level of public understanding of sea level rise is, and develop a targeted outreach program to raise awareness of the issue among community members.

APPENDIX O

Appendix O: Additional Resource

The following reports can be found on the Sea Change SMC website and are relevant to the issues discussed in this report. Please refer to them for more information.

BCDC. 2012. Addressing Social Vulnerability and Equity in Climate Change Adaptation Planning. Prepared by the Baldwin Group. Accessible from: http://www.adaptingtorisingtides.org/wp-content/uploads/2015/04/ART_Equity_WhitePaper.pdf

PG&E's *Climate Change Vulnerability Assessment* (2016) is available from: http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf

San Francisco International Airport. (2015). San Bruno Creek/Colma Creek Resiliency Study Final Report. Prepared by Moffat and Nichol and AGS. Accessible from: http://seachangesmc.com/wp-content/uploads/2015/08/SanBruno_Colma-Resiliency-FINAL_Rpt_150820.pdf

San Mateo County, BCDC, the Conservancy, and AECOM. 2016. *Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore.* Accessible from: http://seachangesmc.com/wp-content/uploads/2015/08/SanMateoCo_Bayshore_Final_Report_w_Appendices.20160523_web.pdf.

APPENDIX P

Appendix P: Glossary

Glossary

Adaptation - The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. [7]

Adaptation strategies - A general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the country's vulnerability. [9,10]

Adaptive capacity - The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences. [3]

Artificial reef - manmade structure that may mimic some of the characteristics of a natural reef. [13]

Asset - a resource that provides an economic, social, or environmental functions or services.

Asset sensitivity (also sensitivity) - Degree to which a resource, asset, or process is or could be affected, either adversely or beneficially, by climate variability or change. [2]

Beach nourishment - Placement of sand and/or sediment (e.g., beneficial re-use of dredged sediment) on a beach to provide protection from storms and erosion, to create or maintain a wide(r) beach, and/or to aid shoreline dynamics throughout the littoral cell. The project may include dunes and/or hard structures as part of the design. [3]

Berm - A commonly occurring, low, impermanent, nearly horizontal ledge or narrow terrace on the backshore of a beach, formed of material thrown up and deposited by storm waves. [5]

Bluff - A high bank or bold headland with a broad, precipitous, sometimes rounded cliff face overlooking a plain or body of water. [5]

Climate Change - Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. [1]

Effluent - Treated or partially treated wastewater that is discharged into the environment from a treatment plant, sewer, or industrial facility. [15]

Embankment - An artificial BANK, mound, DIKE, or the like, built to hold back water or to carry a roadway. [20]

Erosion - The wearing a way of land by natural forces; on a beach, the carrying away of beach material by wave action, currents, or the wind. Development and other non-natural forces (e.g., water leaking from pipes or scour caused by wave action against a seawall) may create or worse erosion problems. [3]

Exposure - The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and setting that could be adversely affected. [7]

Flap gates - a flow control device that, in principle, functions as a check valve, allowing water to flow through it in only one direction. [21]

Flood - A condition of partial or complete inundation of normally dry land areas from: (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) Mudslides. [6]

Flood proof - Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents. [6]

Force Main - A pressurized pipe installed to accommodate the pump discharge from a wastewater pumping station. [17]

Green infrastructure - Refers to the use of vegetative planting, dune management, beach nourishment or other methods that mimic natural systems to capitalize on the ability of these systems to provide flood and erosion protection, stormwater management, and other ecosystem services while also contributing to the enhancement or creation of natural habitat areas. [3]

Groundwater recharge (groundwater seepage) - Inflow of water to a ground-water reservoir from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. [5]

Hazard - The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts. [7]

Horizontal levee (also hybrid levee) - a type of natural infrastructure (also known as green infrastructure) restoration strategy to help reduce shoreline flooding caused by sea level rise [19]

Influent - the flow of untreated wastewater into a treatment process [16]

Inundation - The process of dry land becoming permanently drowned or submerged, such as from dam construction or from sea level rise. [3]

King tides - The highest predicted high tide of the year at a coastal location. [4]

Levee - A man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding. While levees can help reduce the risk of flooding, they do not eliminate the risk. [6]

Living reef (also coral reefs) - a wave-resistant structure resulting from cementation processes and the skeletal construction of hermatypic corals, calcareous algae, and other calcium carbonate-secreting organisms [12]

Managed realignment (also managed retreat) - Reduces coastal flooding and erosion by setting back the flood defenses to allow flooding of a presently defended area [11]

Mean higher high water (MHHW) - The average of the higher high water height of each tidal day observed over the national tidal datum epoch [5]

Mitigation - Human intervention to reduce the human impact on the climate system [3]

Nature Based Solutions- features that mimic characteristics of natural features but are created by human design, engineering, and construction to provide specific se vices such as coastal risk reduction [2]

North American Vertical Datum 88 (NAVD 88) - The vertical control datum established in 1991 by the minimum-constraint adjustment of the Canadian-Mexican United States leveling observations [14]

Overtop - Water carried over the top of a coastal defense due to wave run-up or surge action exceeding the crest height. [20]

Resilience - The capacity of social, economic, and environmental 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. [7]

Revetments - A sloped retaining wall; a facing of stone, concrete, blocks, rip-rap, etc. built to protect an embankment, bluff, or development against erosion by wave action and currents. [3]

Riprap - Loose boulders placed on or along the shoreline as a form of armoring. [5]

Risk - The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (see Figure SPM.1). In this report, the term risk is used primarily to refer to the risks of climate-change impacts. [7]

Saltwater intrusion - Displacement of fresh or ground water by the advance of salt water due to its greater density, usually in coastal and estuarine areas. [5]

Sea level rise - Changes in the shape of the ocean basins, changes in the total mass of water and changes in water density. Factors leading to sea level rise under global warming include both increases in the total mass of water from the melting of land-based snow and ice, and changes in water density from an increase in ocean water temperatures and salinity changes. [3]

Seawall (also floodwall) - structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. It is usually a vertical wood or concrete wall as opposed to a sloped revetment. [3]

Sensitivity - The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors). [7]

Slurry walls - a technique used to build reinforced concrete walls in areas of soft earth close to open water or with a high groundwater table. [8]

Storm surge - A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in water level due to atmospheric pressure reduction as well as that due to wind stress [3]

Tidal barrier- A large dam, gate, or lock — or a series of them — that manages tidal flows. [18]

Tidal floodplain - Any land area susceptible to being inundated by water from a tide event. [6]

Vulnerability - The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity. [3]

Water Table (groundwater table) - The depth at which the ground is saturated with water. [5]

Weir - A wall or plate placed in an open channel and used to measure the flow of water. The depth of the flow over the weir can be used to calculate the flow rate. [5]

Wetland - Areas that are frequently inundated or saturated with water for periods of time long enough to support vegetation suited for survival in saturated soils. Wetlands may include bogs, swamps, marshes, etc. [15]

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