



CITY AND COUNTY
OF SAN FRANCISCO



SAN FRANCISCO

SEA LEVEL RISE

ACTION PLAN

WORKING TOGETHER TO BUILD SAN FRANCISCO'S RESILIENCE TO SEA LEVEL RISE | MAR 2016



CITY AND COUNTY
OF SAN FRANCISCO

LETTER FROM

MAYOR EDWIN M. LEE



The shoreline of the San Francisco Bay comprises approximately one third of the total California coastline. The wonder and beauty of our Bayshore and Pacific Coast waterfronts are major contributory factors to making this a vibrant and extraordinary city and region in which to live.

Sea level rise may be a slow moving threat to our city but it demands our action now. Climate change is accelerating the rate at which oceans are rising and our lower-lying shoreline areas are increasingly exposed to flood waters. Over the next several decades, these hazards will increase in frequency and extent. In March of 2015, I convened an

interagency task force of twelve City departments to work together to develop this thoughtful and collaborative **Sea Level Rise Action Plan** for San Francisco.

My charge for this plan was three fold. First, to explain what is at risk. A high-level analysis was completed to identify our exposed risk for both public and private assets. Second, to review the complex regulatory environment that governs coastal planning and development activities. Finally, to identify actions that San Francisco can take now and in the near future to meet the challenge of rising seas, in partnership with its neighbors and regional leaders.

This **Sea Level Rise Action Plan** gives us a critical path forward to further understand and address the threat of sea level rise and what it means for our waterfront, economy, residents, and visitors. It provides clear direction to our City departments to be flexible and adaptive as they continue to plan for uncertainty. Proactive and thoughtful adaptation planning will continue the innovation, creativity, and inclusivity that have always inspired growth, development, and jobs in San Francisco. The significant changes expected along the entire length of our coastline demand our attention now.

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INTRODUCTION





San Francisco's Pacific Coast as it meets the Bay, at the north end of Ocean Beach

INTRODUCTION

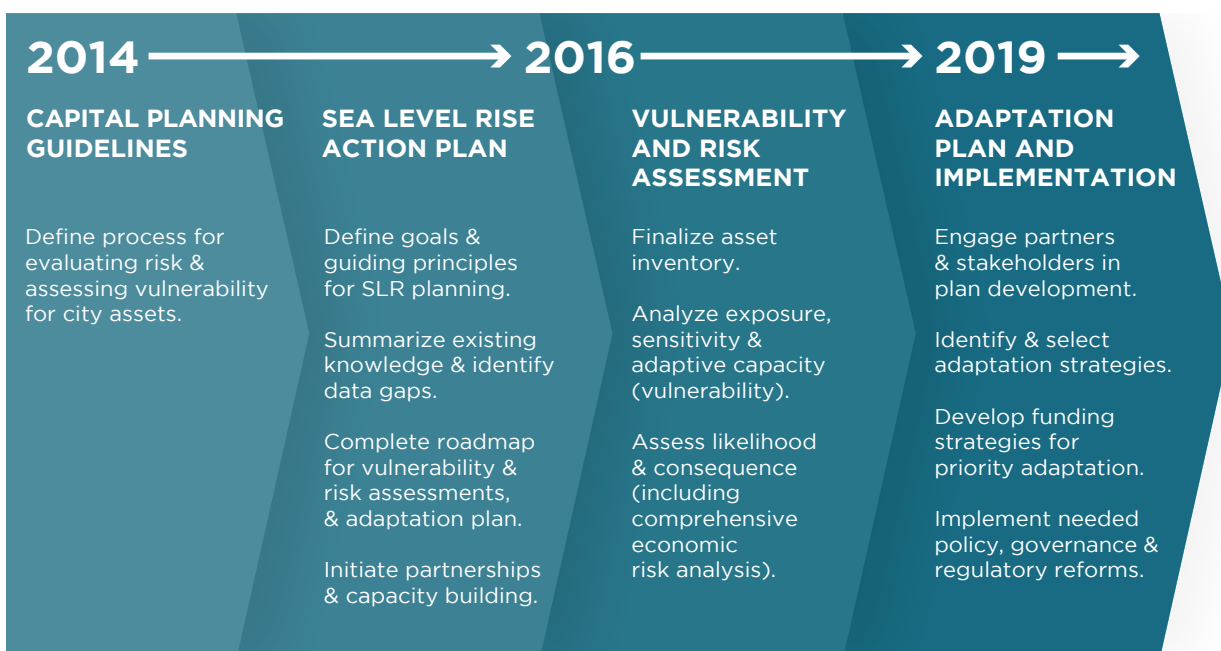
San Francisco is committed to planning for and adapting to the anticipated and unavoidable effects of climate change. Its innovative and aggressive climate change policies have helped boost the local economy and advance environmental goals to reduce greenhouse gas emissions. San Francisco's efforts exceeded emissions reduction targets of 20 percent below 1990 levels by the end of 2012 and are on track to reduce emissions by 25, 40, and 80 percent by 2017, 2025, and 2050 respectively.

San Francisco is also continuing its leadership on climate change by placing a strategic focus on the immediate and long-term threats of sea level rise (SLR) and associated coastal flooding. In accordance with Mayor Ed Lee's direction, a Sea Level Rise Technical Committee was appointed in 2013 to begin to address SLR vulnerability with a focus on City-owned assets contained in the City's 10 Year Capital Plan. That committee developed the "Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco" (CPC Guidance), which was adopted by the Capital Planning Committee

in 2014. The guidance, one of the first of its kind in the nation, was informed by the groundbreaking work initiated by several San Francisco departments to incorporate SLR into their plans and policies, particularly the San Francisco Public Utilities Commission (SFPUC), the San Francisco Planning Department (SF Planning), the Port of San Francisco (Port of SF), and the San Francisco International Airport (SFO). San Francisco has also partnered with the private sector and other stakeholders to co-develop innovative adaptation plans, such as the recent Ocean Beach Master Plan and Mission Creek Study.

San Francisco's comprehensive Resiliency Program builds on these important efforts. In 2015, as a next step, Mayor Lee established the SLR Coordinating Committee with representatives from major San Francisco departments whose responsibilities and assets will likely be impacted by SLR. This **Sea Level Rise Action Plan** (Action Plan) is the Committee's first task. This Action Plan is based on the latest climate science presented in the CPC Guidance and sets an aggressive agenda for further analysis, adaptation planning, and implementation.

SAN FRANCISCO SEA LEVEL RISE RESILIENCY PROGRAM



ACTION PLAN PURPOSE

This San Francisco SLR Action Plan aims to:

- Establish an overarching vision, goals, and a set of guiding principles for SLR planning
- Summarize current climate science, relevant policies and regulations, and vulnerability and risk assessments conducted to date
- Identify data gaps and establish a framework for further assessment, adaptation planning, and implementation
- Provide the foundation and guidance to develop a citywide SLR Adaptation Plan

Instrumental to the success of the overall SLR Resiliency Program will be the formation of strategic partnerships with local and regional stakeholders as collaborators in plan development and execution. Adaptation planning will be iterative to protect San Francisco's most vulnerable assets as conditions change.

The future Citywide SLR Adaptation Plan process (to be completed by summer 2018) will include adaptation strategy development and selection, and set a planning framework

that helps prioritize investments to best improve climate resilience while protecting economic and environmental values. The SLR Adaptation Plan will also identify potential funding sources, governance structures, and timelines.

This SLR Action Plan provides the foundation and guidance to develop a citywide SLR Adaptation Plan. Proactive, thoughtful adaptation planning will allow San Francisco to minimize risks and meet the challenges posed by rising seas. The innovation, creativity, and inclusivity that have always inspired growth and development in San Francisco will support both SLR adaptation and continued growth as a leading global city.

VISION

Make San Francisco a more resilient city in the face of immediate and long-term threats of sea level rise, by taking measures to protect and enhance public and private assets, natural resources, and quality of life for all.



AT&T Park, where Mission Creek enters the Bay

GOALS

This SLR Action Plan lays the groundwork for:

- A resilient city that is adaptable to the impacts of SLR, and recognizes and protects physical, economic, and social value
- Communities that understand and are reassured by a comprehensive response to SLR, and are mobilized and empowered to support efforts over the long term
- Interagency and regional collaboration and partnerships that are coordinated, transparent, and focused on delivering implementable and innovative solutions for a resilient future for San Francisco and the Bay Area region
- Capacity building that enables leadership and staff to implement good solutions
- A Citywide SLR Adaptation Plan that can serve as a local and global model



Bayshore Central Waterfront, in between Pier 70's future Crane Cove Park and The Ramp

Image ©Shae Rocco

GUIDING PRINCIPLES

The planning and implementation of SLR adaptation and action in San Francisco will:

- Engage partners and stakeholders as owners and collaborators using an inclusive, equitable, and community-based planning process
- Provide dependable and actionable information to foster transparency and openness
- Promote an increased understanding of the shared responsibilities between public, private, and community interests in adapting to SLR
- Recognize regional interdependencies and promote regional collaboration
- Foster innovative, inter-disciplinary design approaches and solutions that increase resilience to SLR while enhancing San Francisco's treasured shoreline qualities
- Closely monitor evolving climate science and adapt approaches accordingly, as consistent with the CPC Guidance
- Develop and apply rigorous metrics to track progress for reducing vulnerabilities, risk, and impacts



Embarcadero promenade at Folsom Street from the Bay

SIMILARITIES BETWEEN EARTHQUAKE PLANNING AND SLR PLANNING

The challenge of planning around uncertain, imprecise science is not unique to climate issues. In fact, it is very familiar in California, and specifically in San Francisco. For more than a century, San Francisco has been planning for, and adapting to, the risk of large earthquakes.

Sea level rise and earthquakes have important similarities when it comes to planning. Both are certain to occur in California, both have the potential for devastating consequences, and the specific timing and magnitude of impacts are currently very difficult to predict. However, since the devastation from San Francisco's 1906 earthquake, California (and San Francisco itself) has established and continually improved earthquake-related building standards, zoning, and emergency planning. This adaptation planning has dramatically improved public safety and the ability of communities to withstand and recover from large earthquakes. Continued advances in both science and planning have increased California's earthquake resilience to a degree not possible even half a century ago. These measures instill confidence in residents and investors alike: California has earthquakes, but remains a safe and attractive place to raise a family, grow a business, and invest for the long term.

With proactive and thoughtful adaptation, San Francisco will provide that same confidence around the issue of rising seas.

ADAPTATION FRAMEWORK

Adaptation planning and implementation typically follows a cyclical, six-step process. To date, various efforts and projects in San Francisco have touched on all stages of this cycle. Acknowledging work to date, this Action Plan sets forth San Francisco's SLR priority actions for 2016–2019 (see *Section 7: Next Steps*), following each step of the comprehensive adaptation framework.

STEP 1: REVIEW SCIENCE

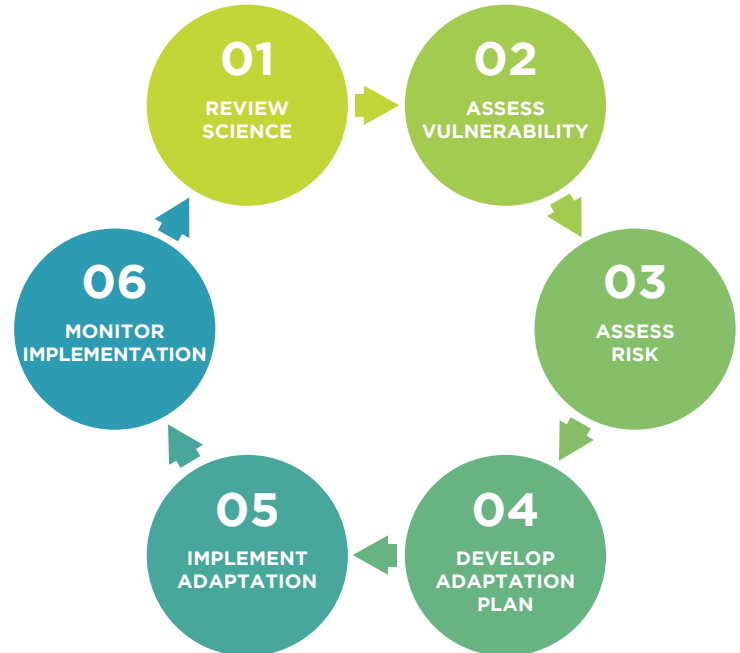
Selecting the most reliable climate information to plan around requires drawing on local, regional, and national scientific expertise. *Section 2: Sea Level Rise Science* of this Action Plan describes the most appropriate projections currently identified for San Francisco. Over time, adaptation efforts will be fine-tuned to accommodate new science, information, and conditions.

STEPS 2 & 3: ASSESS VULNERABILITY AND RISK

Vulnerability and risk assessments identify the potential physical damage an asset may incur when exposed to a hazard (e.g., flooding), as well as the consequences and likelihood of said damage. These findings then help inform the prioritization of assets for adaptation planning. Assessments carried out to date in San Francisco are outlined in *Section 6: Vulnerability and Risk Assessment*.

STEP 4: DEVELOP ADAPTATION PLAN

Once assets have been prioritized for adaptation, comprehensive planning evaluates the best strategies to reduce vulnerability and risk. Good planning will engage those who may be affected by or responsible for the impacts of SLR. The process will encourage and integrate innovative, interdisciplinary design thinking and solutions for adaptation. The *Regulatory Framework*, *Engagement and Coordination*, and *Next Steps* sections document these aspects of planning for SLR in San Francisco.



STEP 5: IMPLEMENT ADAPTATION

Implementation of adaptation strategies has already started in San Francisco and will continue in the near term to address imminent risk as necessary information, funding, and/or partnerships become available. Larger scale interventions identified, prioritized, and designed as part of the Adaptation Plan will be phased in over longer time frames.

STEP 6: MONITOR IMPLEMENTATION

Monitoring is a critical and ongoing component of any successful adaptation effort. Monitoring informs an understanding of which actions are most effective, highlights unintended consequences, and identifies new data, which may indicate a need to change direction or implement additional strategies. Effective adaptation plans will include the types and timeframe of monitoring to be conducted, any thresholds that would trigger new actions, reporting requirements, and responsible parties.

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SCIENCE OF

SEA LEVEL RISE

In the last century, sea levels have risen eight inches around the San Francisco Bay and Pacific Coast. By the end of this century, they are most likely to rise an additional 36 inches. Keeping up to date with advances in sea level rise (SLR) science is vital to developing appropriate adaptation strategies that prove implementable over time. This section describes the state of SLR science today and current end-of-century projections, as well as other factors (e.g., El Niño, King Tides, large storms, et al) that periodically raise waters during temporary coastal floods.

The science of SLR is being continuously revised, as climate models are improved and updated with new data and observations. These revisions improve our understanding of both natural climate variability and the global oceanic response to atmospheric greenhouse gases, and suggest adjustable solutions.

EXISTING IMPACTS

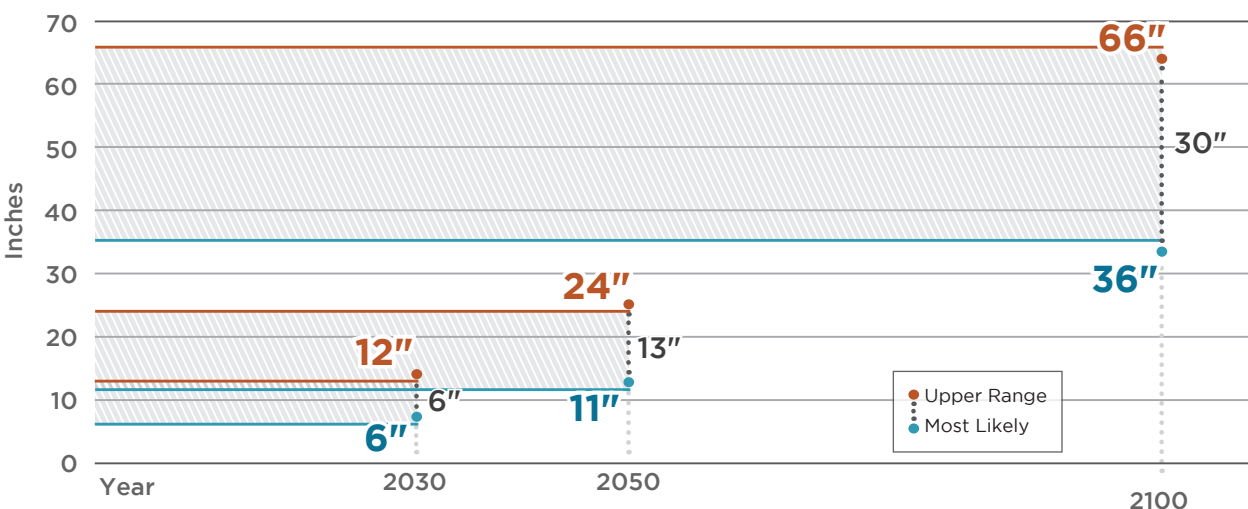
Rising Bay and coastal water levels are already affecting San Francisco with periodic coastal flooding of low-lying shorelines, increased shoreline erosion, and salt water impacts to San Francisco's wastewater treatment systems. When rain falls during higher-than-normal tides, tide levels can also slow the drainage of rainfall run-off into San Francisco Bay, increasing the potential for urban stormwater flooding.

FUTURE IMPACTS

Over the coming decades, SLR-related impacts will increase in frequency and extent, and additional areas will begin to experience periodic coastal and/or urban flooding. Where shorelines are built on Bayfill, subsidence may further intensify flooding risks, and higher groundwater levels may increase liquefaction and seismic risks during earthquakes.

The most *likely* projections for San Francisco are based on a moderate level of global greenhouse gas (GHG) emissions and continued accelerating land ice melt patterns.¹ The upper range estimates represent *unlikely, but possible* levels of SLR using very high greenhouse gas emissions scenarios with significant land ice melt.

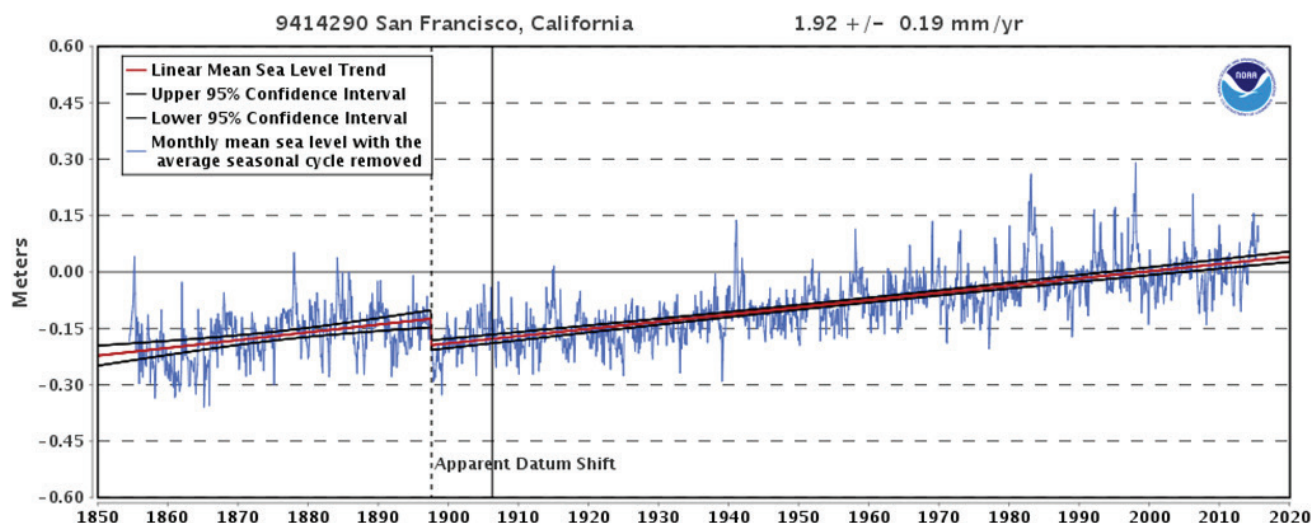
SEA LEVEL RISE PROJECTIONS FOR SAN FRANCISCO RELATIVE TO THE YEAR 2000



Source: NRC (2012). Lower range projections are excluded as they are not recommended for planning purposes.

NOTE: These SLR projections do not include extreme tides or coastal storms, which could add up to 42 inches of temporary flooding on top of rising sea levels, for a total of up to 108 inches above today's average high tide (*unlikely, but possible upper-range scenario*).

MEAN SEA LEVEL TREND. PRESIDIO TIDE GAUGE, SAN FRANCISCO, CA

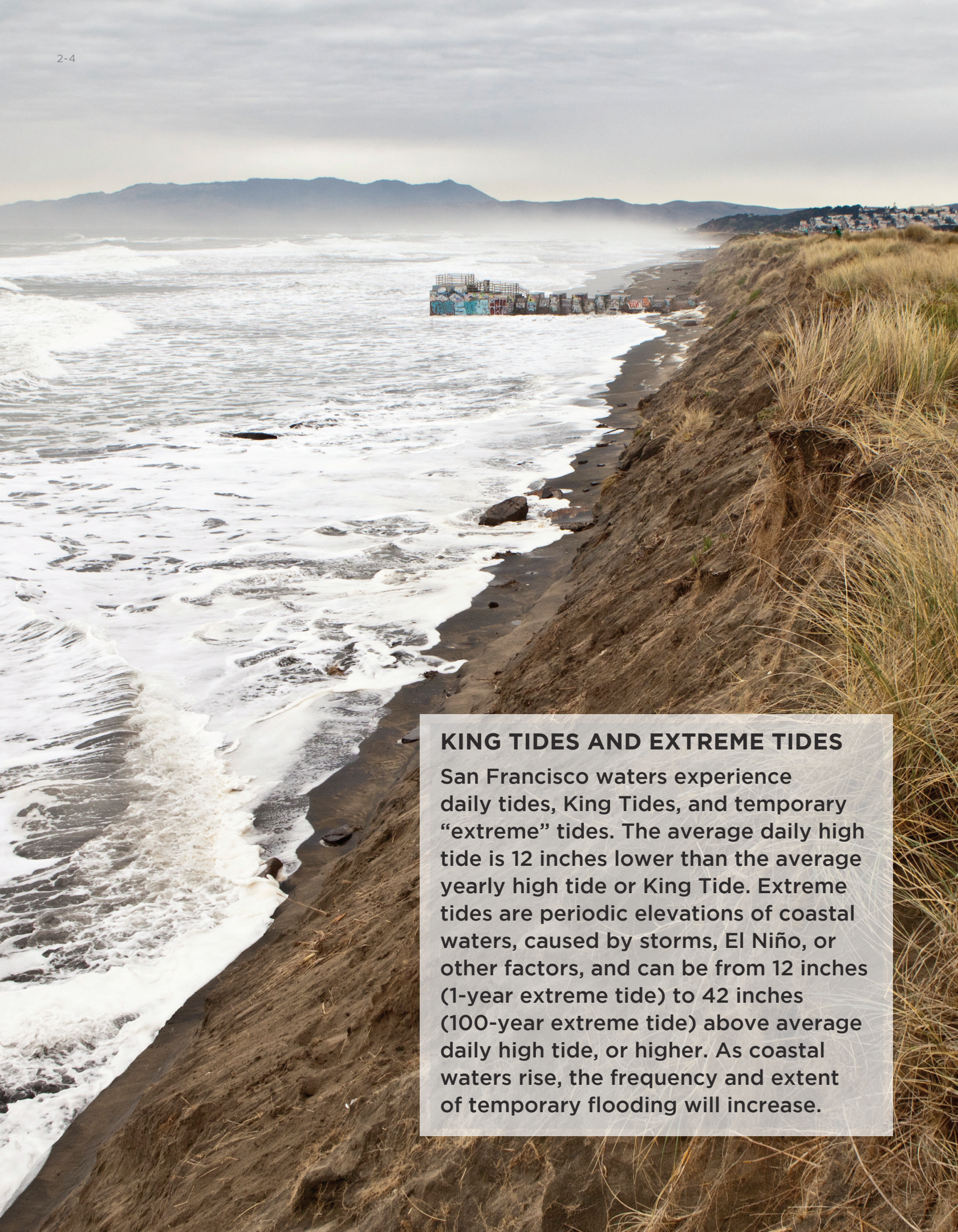


Source: National Oceanic and Atmospheric Administration (NOAA) Sea Levels Online.

Note: The solid black vertical line shows the earthquake of 1906. NOAA researchers fit separate trend lines before and after an apparent vertical datum shift that occurred in 1897, disrupting consistent measurement.

Without action, a variety of coastal hazards will increase as seas rise, including:

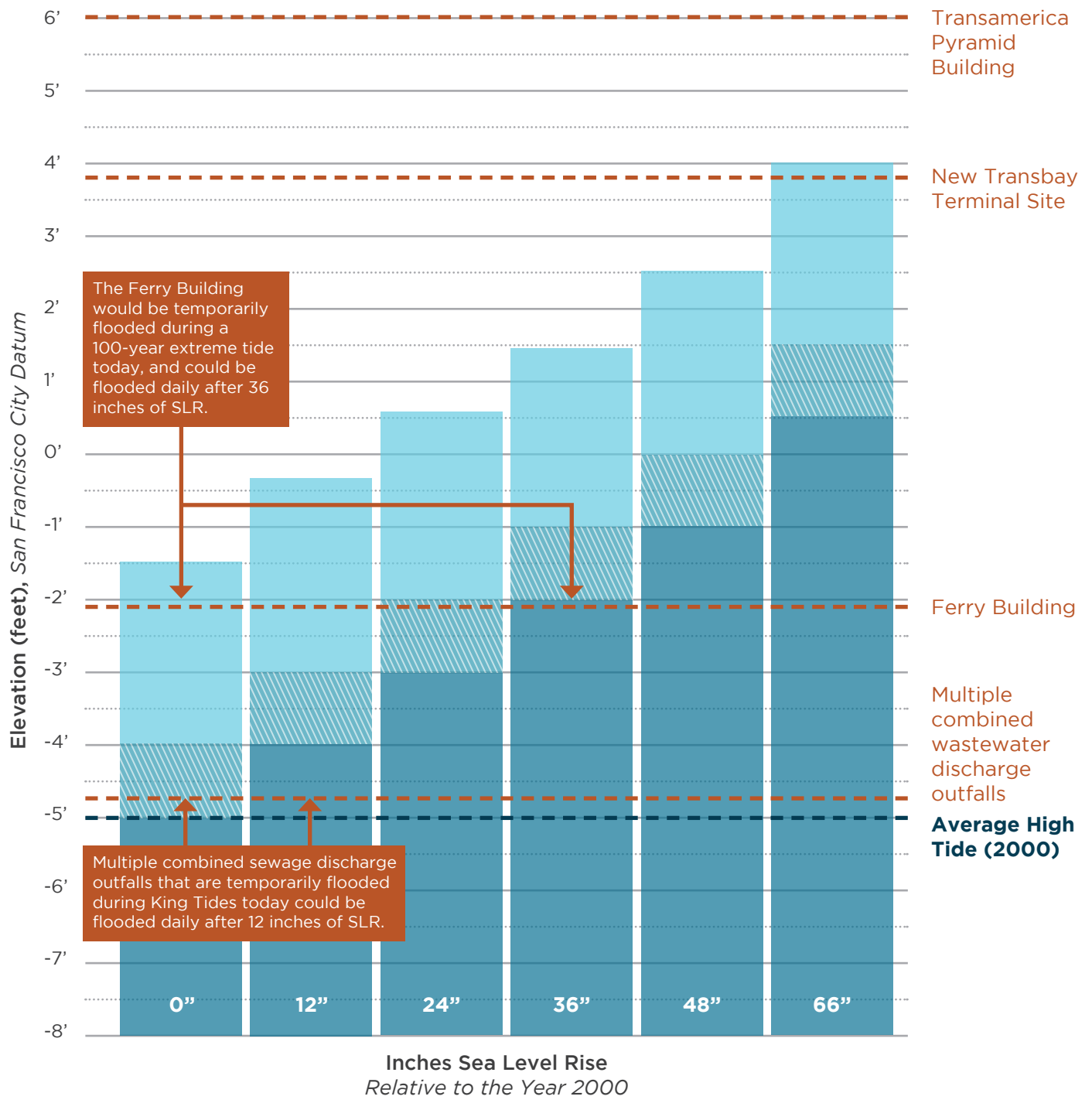
- **Temporary coastal flooding from extreme tides.** San Francisco's current coastal flooding issues, including damaged infrastructure, impacted sewage system, and road closures will increase in frequency and extent.
- **Urban flooding.** Unlike coastal flooding, urban flooding is caused by rainfall runoff. As the sewage and stormwater system storage capacity is maximized, Bay discharges occur. When the Bay is high enough to slow discharges, drainage of storm water runoff from San Francisco to the Bay can be impeded, resulting in inland urban flooding during storms.
- **Shoreline erosion.** The Pacific coastline and some Bay shoreline areas, such as Crissy Field, are susceptible to increased erosion associated with extreme tides and increased wave action. Without protective action, rising seas will increase erosion hazards.
- **Regular King Tide flooding.** The Embarcadero waterfront (Pier 14) and the Marina neighborhood area can experience flooding under current annual highest tides in the absence of storms. Without protective action, this regular, predictable flooding will occur more frequently and affect larger areas as seas rise.
- **Daily tidal inundation.** As sea level rises, the elevation of average daily high tides will continue to increase. Without action, up to six percent of San Francisco's current land could be permanently inundated by daily tides by the end of the century.
- **Weather and weather cycles.** Climate change may affect the frequency and intensity of coastal storms, El Niño cycles, and related processes. A clear consensus has not fully emerged on these changes, but a commonly identified trend is a tendency toward increased wind speed and wave height along northern California.² This may increase both erosion rates along the Ocean Beach coast and extreme tide frequency within the Bay.



KING TIDES AND EXTREME TIDES

San Francisco waters experience daily tides, King Tides, and temporary “extreme” tides. The average daily high tide is 12 inches lower than the average yearly high tide or King Tide. Extreme tides are periodic elevations of coastal waters, caused by storms, El Niño, or other factors, and can be from 12 inches (1-year extreme tide) to 42 inches (100-year extreme tide) above average daily high tide, or higher. As coastal waters rise, the frequency and extent of temporary flooding will increase.

COMBINED IMPACTS OF SEA LEVEL RISE AND TEMPORARY COASTAL FLOODS





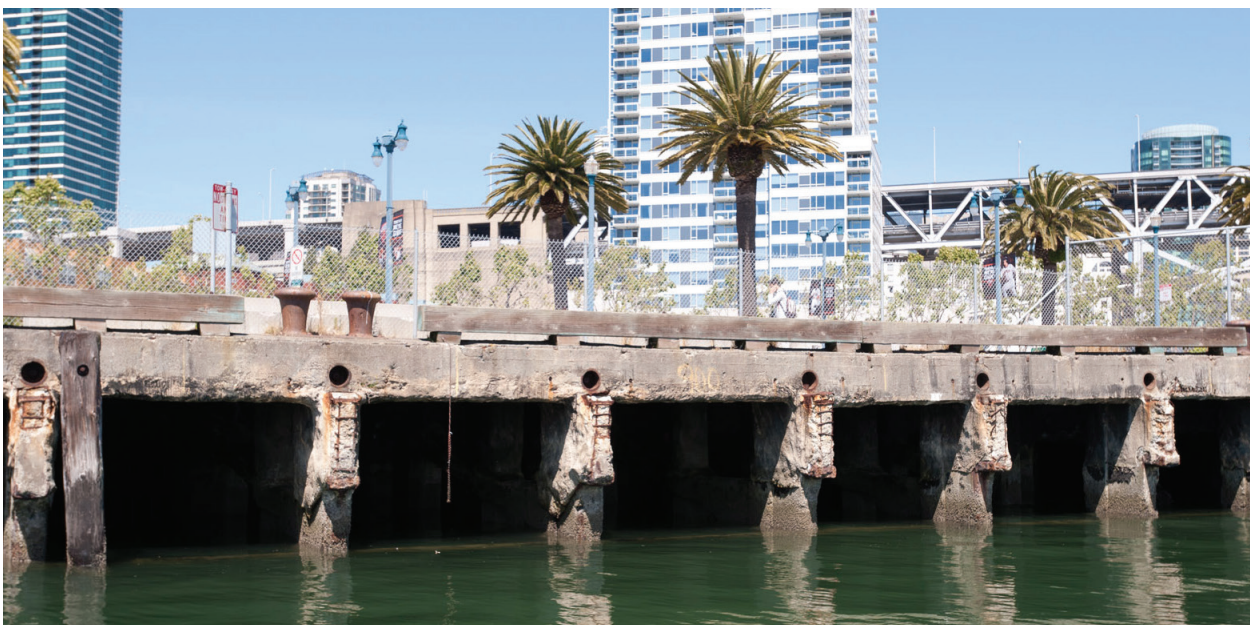
King Tide on the Embarcadero
Image Courtesy of Flickr CC User "Tom Hilton"



SLR VULNERABILITY ZONE

For long-range planning, CPC Guidance defines a SLR Vulnerability Zone based on the National Research Council's (NRC) upper range (*unlikely, but possible*), end-of-century SLR estimate, in the event that future GHG emissions and land ice melting accelerates beyond current predictions. The Zone (see map on page 2-7) therefore includes shoreline areas that could be exposed to 66 inches of permanent SLR inundation with temporary flooding from a 100-year (1% annual chance) extreme tide IF no adaptation measures or actions are taken. The 100-year extreme tide is consistent with Preliminary Flood Insurance Rate Maps (FIRMs) released by the Federal Emergency Management Agency (FEMA) in November 2015 and with FEMA's West Coast SLR Pilot Study (2015).

For ongoing planning and development purposes related to environmental review and project approvals, the City uses the NRC's most likely SLR projection of 36 inches.



Crissy Field's restored tidal lagoon (image courtesy of California Beach Blog), Ocean Beach (image courtesy of SPUR), and eroding piers on the Embarcadero at Brannan Street



Legend

— Sea Level Rise Vulnerability Zone

0 3,400 6,800
Feet



NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's average high tide.

Map Disclaimer: The inundation maps and the associated analyses are intended as planning level tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The maps do not represent the exact location of flooding. The maps relied on a 1-m digital elevation model created from LiDAR data collected in 2010 and 2011. Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures narrower than the 1-m horizontal map scale may not be fully represented. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or Open Coast. For more context about the maps and analyses, including a description of the data and methods used, please see the Climate Stressors and Impacts Report: Bayside Sea Level Rise Inundation Mapping Technical Memorandum, March 2014 and FEMA Open California Coast Sea Level Rise Pilot Study, San Francisco County, 2015.

Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.



Dolphin Swim and Boat Club, Aquatic Park

BAYSIDE POTENTIAL IMPACTS

The SFPUC analyzed 10 SLR “scenarios,” or future tide levels, with varying levels of permanent SLR inundation and temporary flooding from extreme storms equating between 12 and 108 inches above today’s average daily high tide (MHHW).³⁻¹⁰ Without adaptation measures, the frequency of temporary flooding will increase with rising seas in low-lying Bayshore areas, until permanent inundation is reached. The shoreline has several low points and in some cases, larger inland areas may experience flooding through a relatively small shoreline access point. As shown on page 9, these maps help identify priority locations for flood-protection strategies. *See Chapter 3 for adaptation planning efforts already underway along the San Francisco Bayshore.*



Ferry Building and Ghirardelli Square from the Bay, and King Tide flooding on the Embarcadero near the Ferry Building Image Courtesy of Flickr CC User “Dave R”

**SLR VULNERABILITY ZONE—DOWNTOWN TO CENTRAL BAYSHORE DETAIL
THROUGH END-OF-CENTURY WITHOUT ANY ADAPTATION MEASURES OR ACTIONS**



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's MHHW. See Appendix for complete set of San Francisco SLR Vulnerability Zone maps and public land ownership information.

SAN FRANCISCO SEA LEVEL RISE ACTION PLAN



Mel Leong Wastewater Treatment Plant, SFO shoreline

SFO POTENTIAL IMPACTS

With ground elevations ranging from approximately 2.5 to 12.5 feet NAVD (North American Vertical Datum), and MHHW of 6.83 feet NAVD along the Airport's shoreline, SFO's assets, including runways, taxiways, terminal buildings, emergency facilities, and tenant operation centers, are currently vulnerable to flooding from extreme storm events. SLR will increase the frequency of these events and intensify the severity of potential flooding at SFO. Direct and indirect economic losses from interrupted air operations to the region can be enormous. SFO is proactively engaged in adaptation planning and actions; *see Chapter 3 and 7 for more information on these measures.*



U.S. Coast Guard boat access ramp



Low-lying runways and other facilities at SFO, *image courtesy of GeoTRavelPhoto.com*

SLR VULNERABILITY ZONE—SAN FRANCISCO AIRPORT SHORELINE
THROUGH END-OF-CENTURY WITHOUT ANY ADAPTATION MEASURES OR ACTIONS



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's MHHW.



Ocean Beach (O'Shaughnessy) Seawall today: sand accretion covered the steps in 2011



Ocean Beach (O'Shaughnessy) Seawall as built in 1922 and with the steps still visible through the mid 1970s

PACIFIC COAST POTENTIAL IMPACTS

Unlike the sheltered shoreline within the San Francisco Bay, impacts along the Pacific coast are dominated by waves,^{2, 3, 4, 14, 15, 16, 17}

The Federal Emergency Management Agency (FEMA) examined the combined effect of increased 100-year extreme tide plus 12, 24, 36, and 66 inches of SLR on flooding, erosion, and shoreline retreat on the Pacific coast. The Ocean Beach Master Plan and San Francisco General Plan's Local Coastal Program Amendment both incorporate this range of levels. *See Chapter 3 for more information on adaptation planning efforts already underway along the Pacific Coast.*



Ocean Beach King Tide, north end

SLR VULNERABILITY ZONE—SOUTHERN PACIFIC COAST
THROUGH END-OF-CENTURY WITHOUT ANY ADAPTATION MEASURES OR ACTIONS



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's MHHW.

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3

DESIGNING FOR RISING SEAS

SLR ADAPTATION BY DESIGN

The complex and evolving nature of climate change-related impacts demand innovative, iterative, and implementable solutions created collaboratively with interdisciplinary teams of designers, engineers, economists, scientists, community leaders, government entities, and more. Adaptation strategies and actions need to be robust yet flexible, with short- and long-term approaches to resilience.

Creative responses to SLR are already being planned throughout San Francisco's major waterfront development projects, as illustrated in this section. But, much of the existing built environment along the Bayshore and Pacific Coast remains vulnerable, both within the city and throughout the Bay Area.

DESIGN THINKING APPLIED TO SLR CHALLENGES

In 2017, San Francisco and partner groups will launch the Bay Area Resiliency Design Challenge. It will bring together government representatives, community leaders and stakeholders, and world-class professionals to create design-driven approaches for addressing the resilience of local neighborhoods, public infrastructure, and the environment.

The Design Challenge is inspired by New York's Rebuild by Design, a multi-stage planning and design competition launched in 2013 in response to the physical and structural

damage caused by Superstorm Sandy. Rebuild by Design reviewed 148 entries from around the globe and selected 10 talented teams to take on specific projects throughout the New York region. This innovative process engaged 535 organizations, 141 neighborhoods and cities, 181 government agencies, and 64 community events. Rebuild by Design is a model for robust inclusivity that has inspired new collaborative methods for disaster planning and responses.



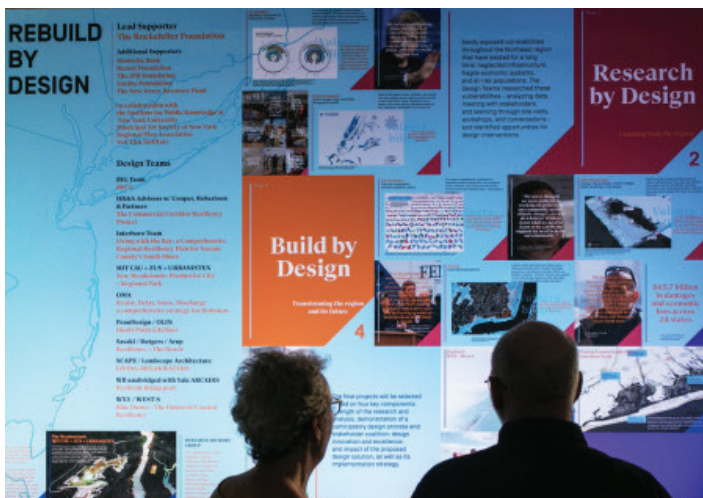
Proposal for Lower Manhattan from the BIG team

ADAPTATION STRATEGY DEVELOPMENT

Thoughtful, interdisciplinary approaches to adaptation planning enhance resilience performance and efficiency. For San Francisco, adaptation efforts will likely focus on governance related strategies (such as updating zoning, design standards, and maintenance procedures) and physical strategies (such as green infrastructure, elevating structures, and flood barriers). Potential strategies may be implemented at multiple scales and time frames, and likely in combination; i.e., a policy or zoning change may be needed in order to facilitate construction of a flood protection feature.

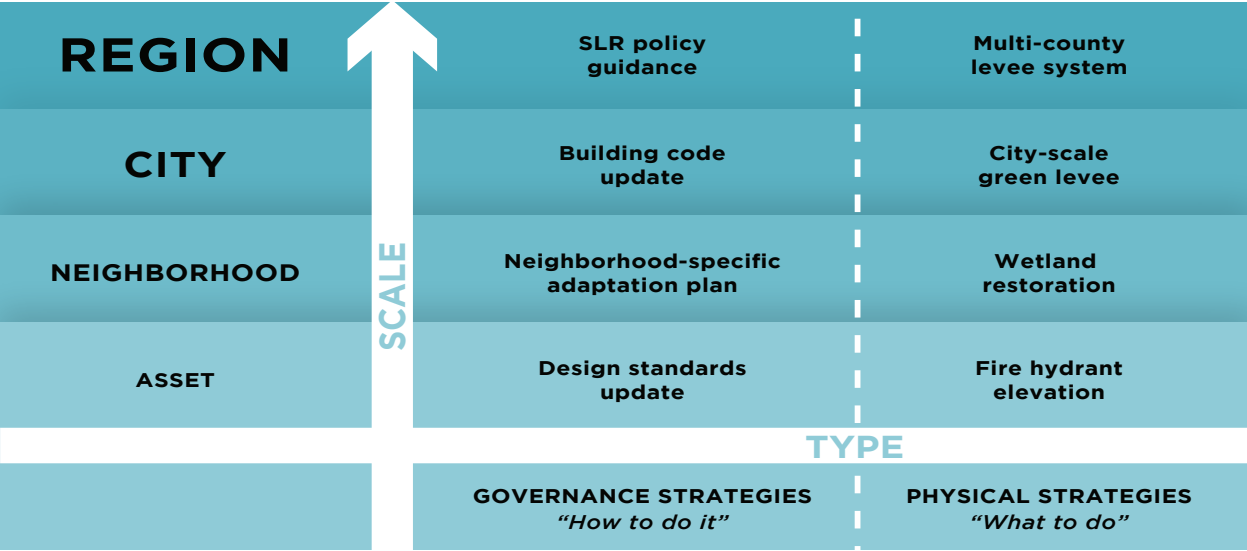
ADAPTATION OPTIONS

Whether achieved through a governance change or a physical intervention, SLR adaptation generally requires one or a combination of three options: **accommodate**, **protect** (natural or engineered), or **retreat**:



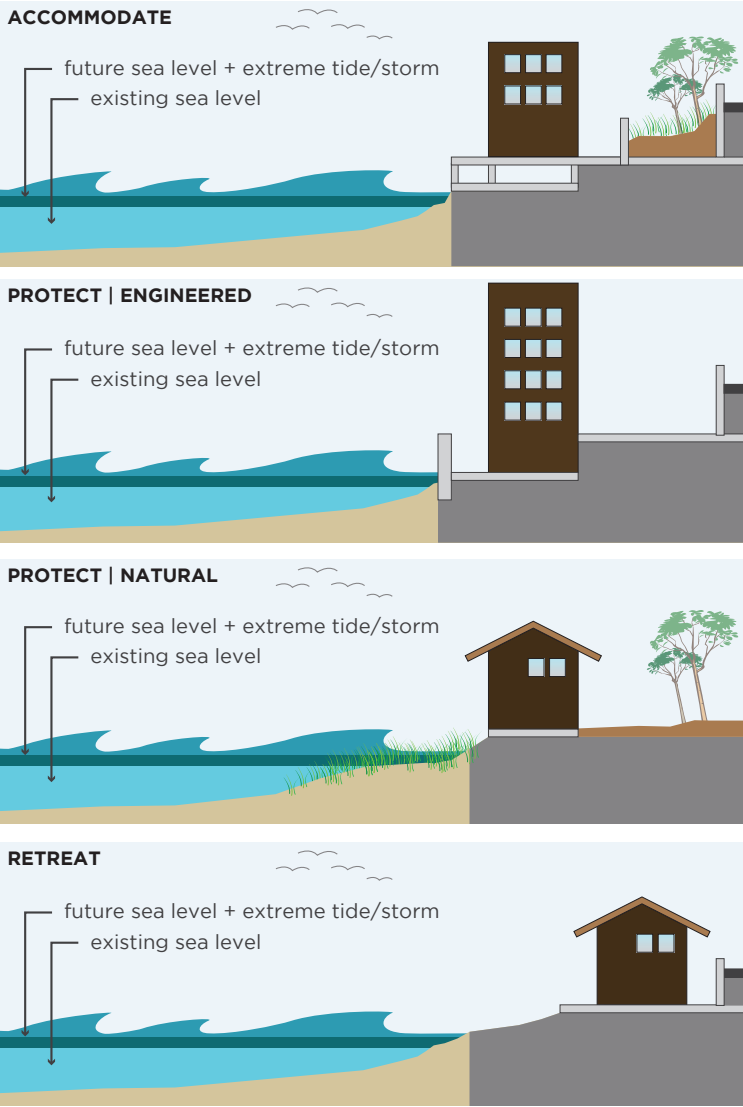
Rebuild by Design, public engagement materials.

EXAMPLE GOVERNANCE AND PHYSICAL STRATEGY OPTIONS AT DIFFERENT SCALES



- **Accommodate** facilitates remaining in areas at risk for flooding, for at least some time period, by raising or waterproofing individual assets such as fire hydrants, or the livable portions of buildings. Recent innovations have been introduced in the area of flood-resilient buildings, which allow lower levels to be flooded without permanent structural damage.
- **Protect** involves temporary or permanent flood barriers (natural or engineered solutions) to keep an asset in place. These may be installed at any scale, from a self-rising flood barrier for a building, to restoration of a wetland around a neighborhood shoreline, to regional scale levees that could stretch for miles.
- **Retreat** relocates sensitive assets, such as homes, schools, and lifeline infrastructure from at-risk areas. Such areas may still host low-risk uses (e.g., recreation or natural habitat). For an urban area like San Francisco, retreat is expected along less developed shorelines (e.g., southern reaches of Ocean Beach) or when other options have been exhausted.

INTERVENTION OPTIONS

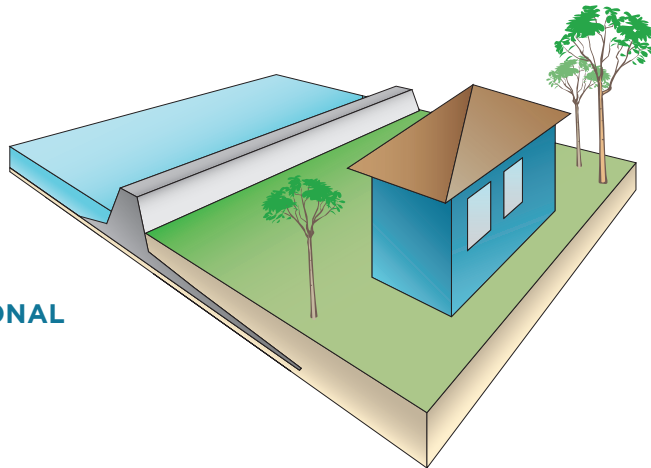


TYPES OF LEVEES

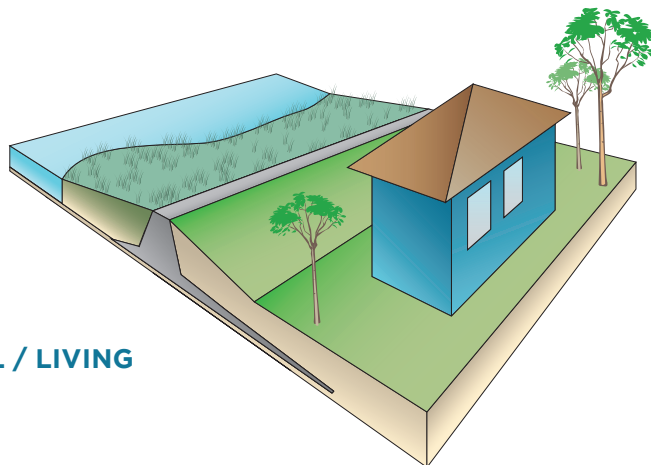
Levees are an option for larger-scale flood protection. Levees can be constructed in multiple ways and with multiple types of materials. They can also be designed with extra strength and width for near-term protection that allows for later additions to height.

- **Traditional levees** are minimally vegetated. They are often topped by roads and trails, but not by buildings.
- **Natural or living levees** are built with additional width to allow for natural habitat that transitions from upland to wetlands to submerged habitat. Additional beneficial uses may include park and open space, wildlife habitat, and/or stormwater treatment.
- **Buildable levees** are designed to be used as developable spaces. The concept is similar to the early fill of Bay waters (such as the Embarcadero area), but designed and built to withstand earthquakes and rising seas. The final levee would be several feet higher in elevation than current Bayfront property, but would allow similar uses. Such levees are larger and costlier than traditional levees, and currently face significant regulatory hurdles in the U.S. although they are common in some European countries, such as the Netherlands.

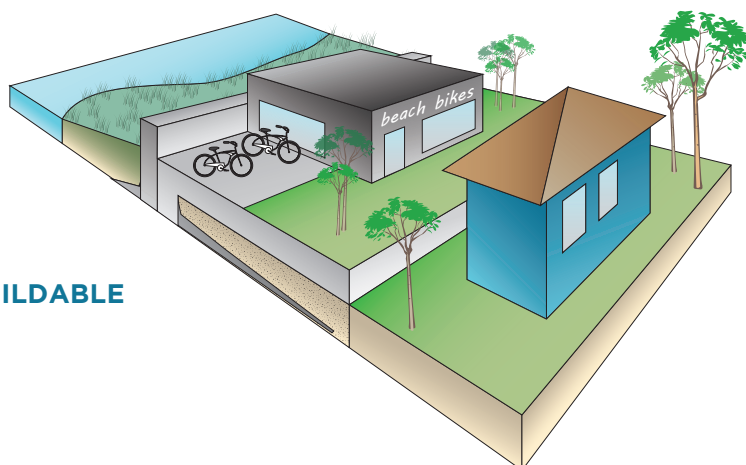
TRADITIONAL



NATURAL / LIVING



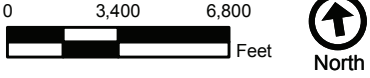
BUILDABLE





Legend

— Sea Level Rise Vulnerability Zone



NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's average high tide.

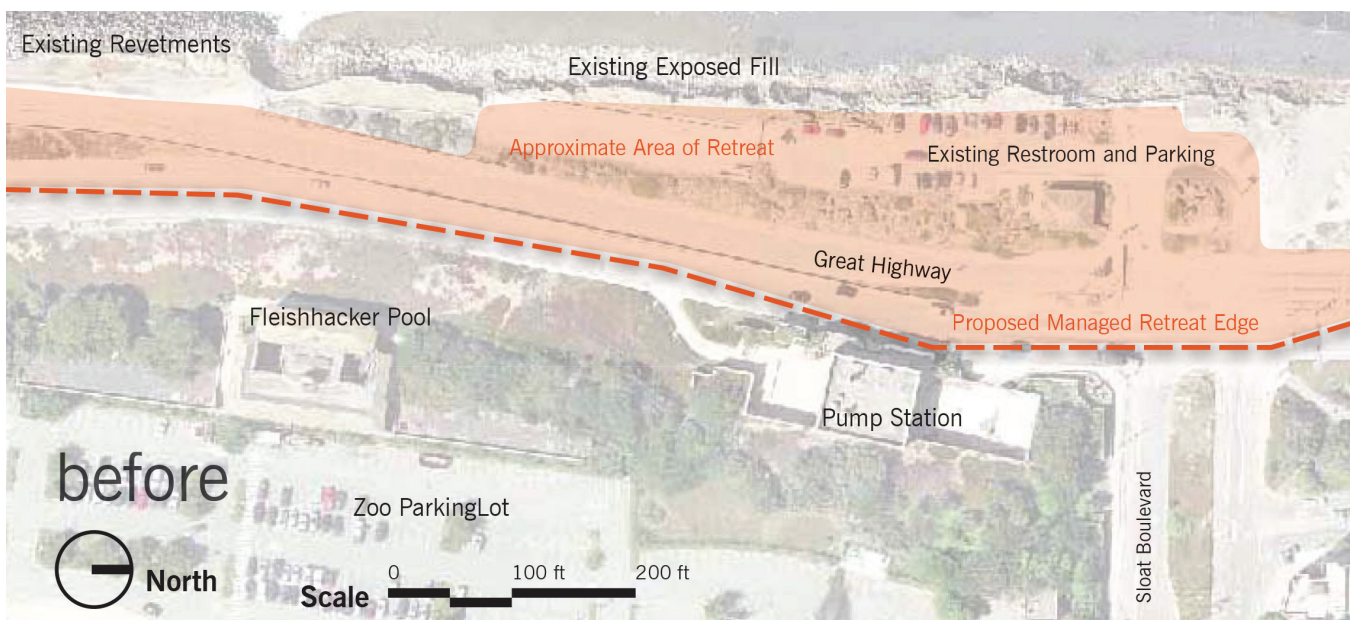
Map Disclaimer: The inundation maps and the associated analyses are intended as planning level tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The maps do not represent the exact location of flooding. The maps relied on a 1-m digital elevation model created from LiDAR data collected in 2010 and 2011. Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures narrower than the 1-m horizontal map scale may not be fully represented. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or Open Coast. For more context about the maps and analyses, including a description of the data and methods used, please see the Climate Stressors and Impacts Report: Bayside Sea Level Rise Inundation Mapping Technical Memorandum, March 2014 and FEMA Open California Coast Sea Level Rise Pilot Study, San Francisco County, 2015.

OCEAN BEACH MASTER PLAN: ACCOMMODATE, PROTECT, AND RETREAT

San Francisco, Pacific Coast

All three options of shoreline protection are currently being incorporated into SLR planning in San Francisco. For example, the Ocean Beach Master Plan (an iterative planning process that included robust stakeholder and community engagement) recommends eventual retreat for portions of the Great Highway and rerouting the Highway behind the zoo, while protecting the critical Lake Merced Wastewater Tunnel

with new layers of physical protection. It also recommends accommodating SLR by improving natural infrastructure, dunes and vegetation, and replacing roads and parking lots with open space, bicycle, and pedestrian paths. These areas may eventually be lost to shoreline retreat, but will provide recreation opportunities, shoreline connectivity, wave strength reduction, and habitat values in the interim.



South of Sloat Existing Conditions, Ocean Beach Master Plan.



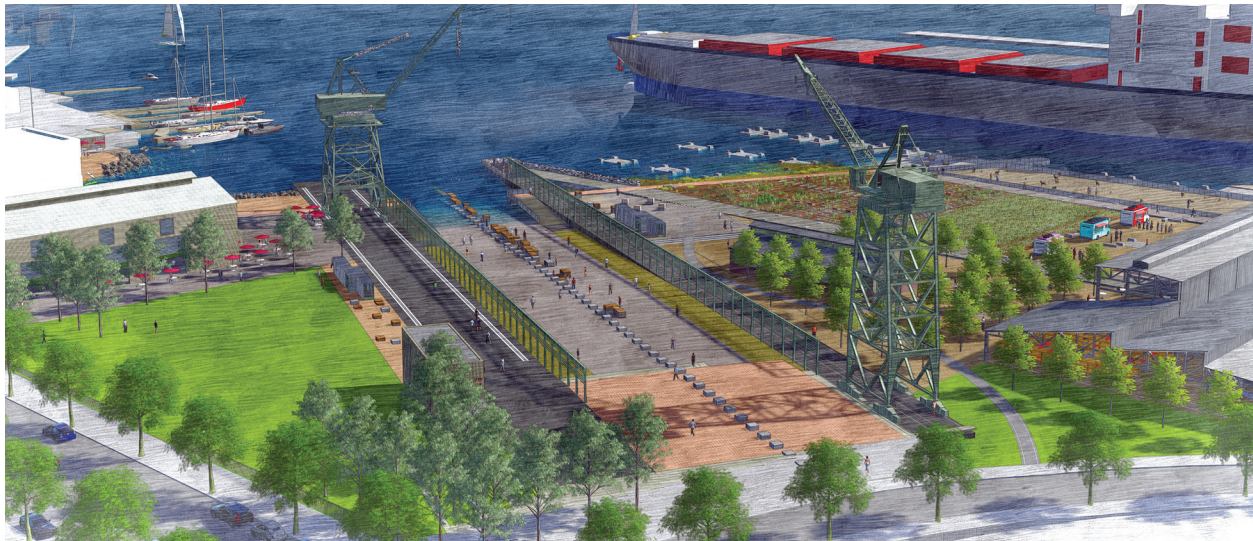
South of Sloat Multi-Stage Coastal Protection by 2050, Ocean Beach Master Plan. *Images courtesy of SPUR*

PIER 70: CRANE COVE PARK AND PIER 70 WATERFRONT PARK

San Francisco, Central Bayshore

Crane Cove Public Park, Port of SF

The design accommodates end-of-century SLR by reconstructing major portions of the shoreline for flexible recreation and habitat uses, as well as strategic site grading to allow the Bay to reclaim portions of the site. The sloped historic slipway is inherently adaptive to varying tides and the northern shoreline improvements protect key street infrastructure.



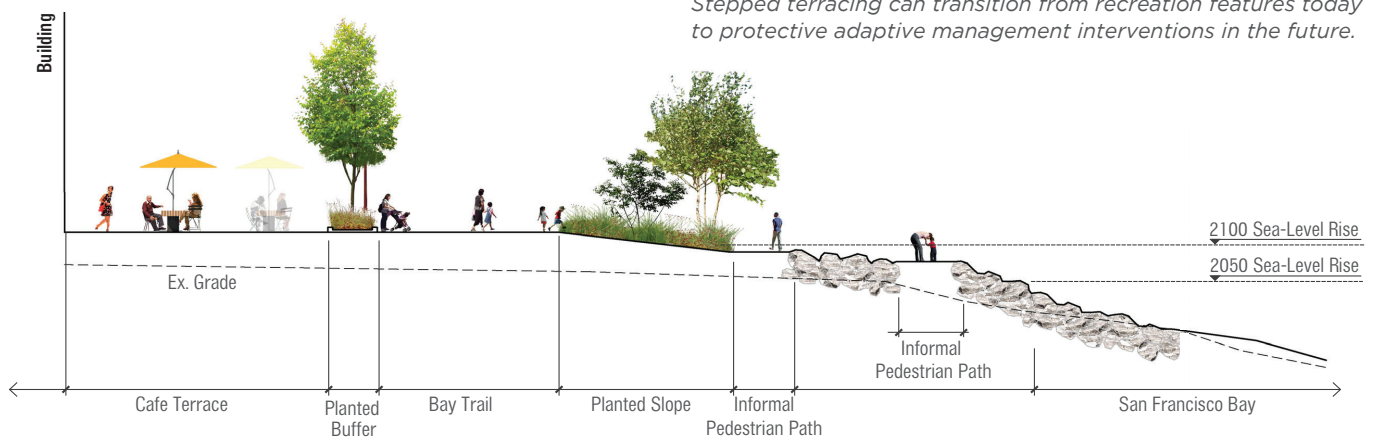
Images courtesy of the Port of San Francisco, Forest City, AECOM, and JCFO

Pier 70 Special Use District (SUD)

The SUD's innovative waterfront planning provides safe and practicable public enjoyment of the Bayshore while accommodating potential future SLR conditions. The design incorporates a variety of tiered treatments, responding to specific site conditions. Based on the principles of 'living with the Bay' and 'managed retreat' a shoreline zone allows for creative adaptation to SLR rather than over-engineering spaces now.



Stepped terracing can transition from recreation features today to protective adaptive management interventions in the future.



TREASURE ISLAND: ADAPTIVE MANAGEMENT FOR SEA LEVEL RISE

San Francisco, Bayshore

This 450-acre development will transform a former military base into a community designed as a model of sustainable living. Plans for development of the low lying Treasure Island include both initial strategies and flexible longer-term adaptive strategies to address rising seas.

Initial Development Actions

- Develop elevated grades to accommodate SLR over a 70-year horizon. All buildings and streets will be 36 inches above current 100-yr coastal flood elevations, with finished floors 42 inches above that level.
- Build perimeter protection and interior drainage improvements for a 35-year horizon, designed to accommodate future sea level elevation increases.
- Provide development setbacks that support future perimeter SLR adaptation projects.
- Provide adaptive habitat areas.

- Implement the identified Financing Plan for funding future SLR adaptation. It directs that Special Taxes collected via new Community Facilities Districts pay for future SLR adaptation.

Adaptation Strategy for Improvements Beyond Mid-Century Levels

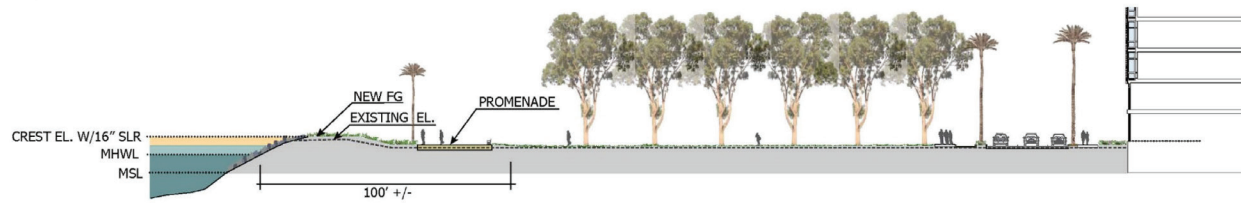
- A SLR monitoring program will include SLR observations, perimeter elevation and topographic surveys (to quantify settlement), plus periodic flood risk assessments.
- Trigger mechanisms have been identified and include consultation with relevant agencies.
- Response actions include additional perimeter levees or flood walls, storm water pumps, and natural shoreline areas (tidal wetlands and cobblestone beaches) designed to limit wave damage and provide public shoreline access.



Treasure Island Redevelopment Plan

TREASURE ISLAND ADAPTIVE MANAGEMENT STRATEGIES: CITYSIDE

PROPOSED WITH 16" SLR

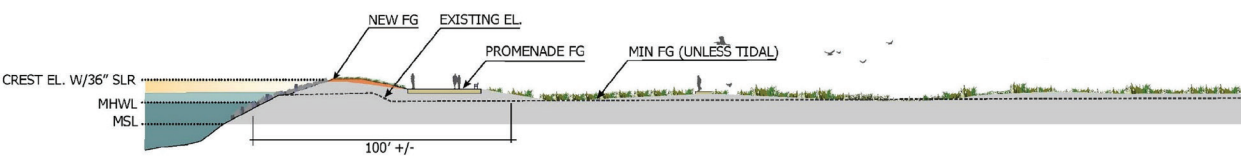


PROPOSED WITH FUTURE ADAPTATION FOR 36" SLR

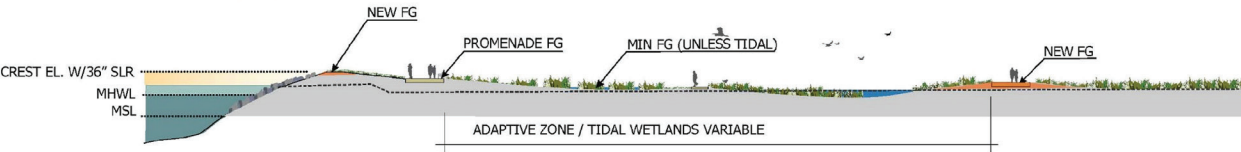


TREASURE ISLAND ADAPTIVE MANAGEMENT STRATEGIES: NORTHERN SHORELINE

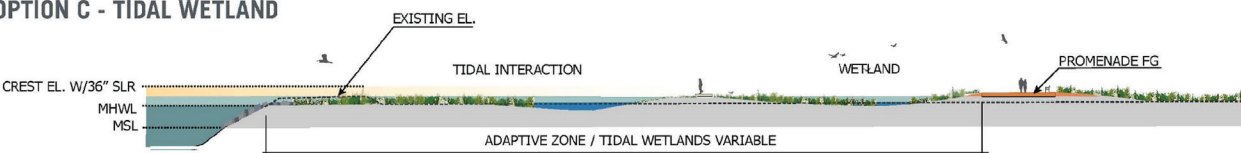
OPTION A - PROTECTED EDGE WITH CENTRAL GRASSLAND



OPTION B - CENTRAL MARSH



OPTION C - TIDAL WETLAND



KEY

SLR: Sea Level Rise
MHWL: Mean High Water Line
MSL: Mean Sea Level

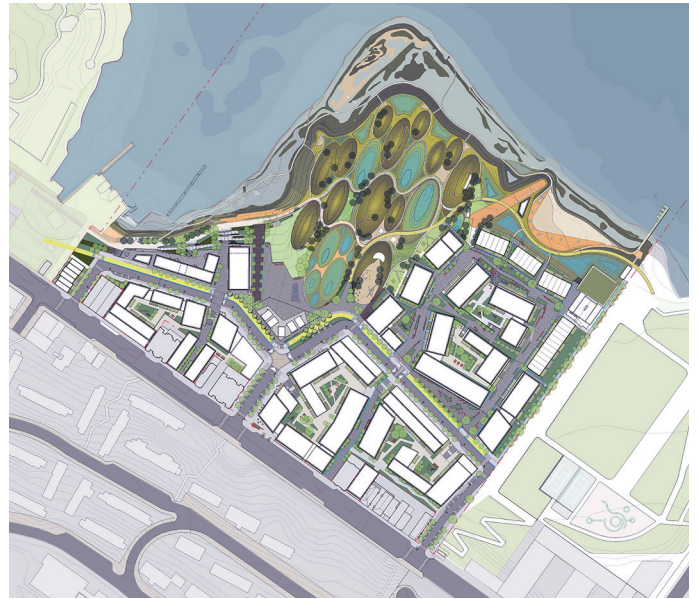
Images courtesy of the Treasure Island Community Development Sea Level Rise Risk Assessment and Adaptive Management Plan

INDIA BASIN WATERFRONT

San Francisco, Southern Bayshore

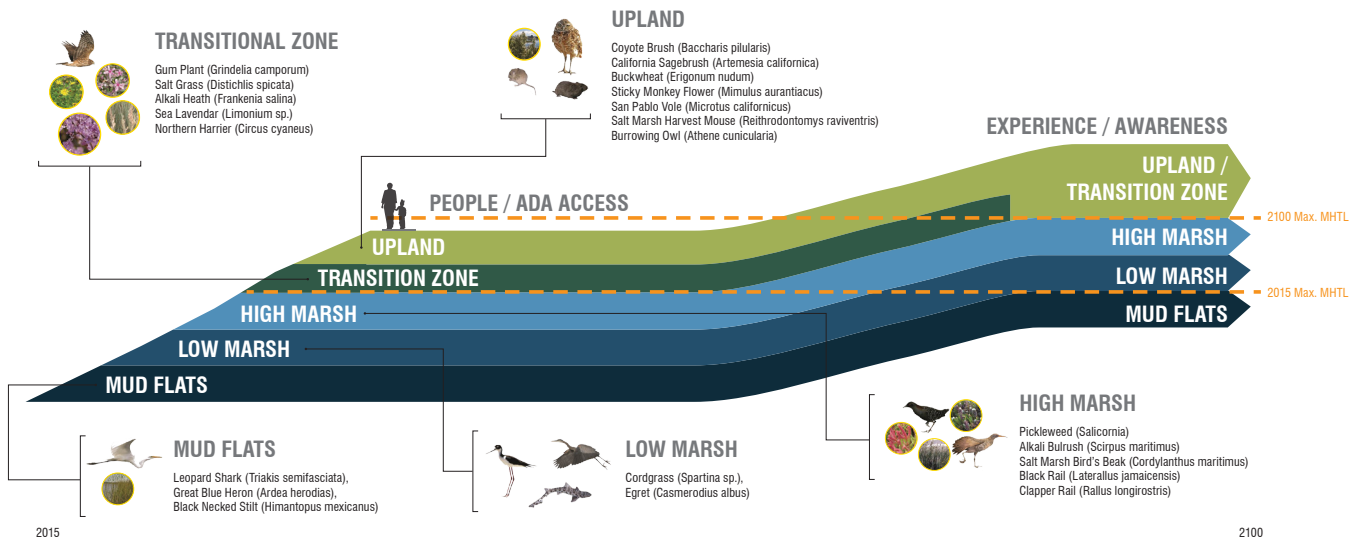
In the face of rising tides, the India Basin Waterfront design is analyzing living shoreline strategies to create an adaptive and resilient Bayshore with a 100-year horizon. Natural coastal processes have been measured to inform a suite of shoreline protection devices, such as wave attenuation, habitat creation, and upland habitat migration. Bioengineered devices being studied include expanded tidal marshes, dunes, floating islands, terraced wetlands, artificial reefs, and eel grass beds. The design for the India Basin Open Space

and 700 Innes “Big Green” incorporates terraced wetlands into the existing banks to promote upland habitat migration as seas rise over time. This strategy will also augment habitat loss occurring elsewhere in the basin. At the basin-scale, a 1+ mile continuous waterfront band is envisioned to facilitate living shoreline strategies and establish habitat continuity along its entire length. Combined, these strategies could provide triple bottom line benefits, including a robust set of ecosystem services, to the area.



A continuous ecological band connects shoreline open spaces from India Basin and surrounding waterfront parks. The site plan (and section below) integrate adaptive management strategies to address sea level rise and coastal flooding over time.

Images courtesy of Build Inc. and Bionic



SHORELINE PROTECTION AT SAN FRANCISCO INTERNATIONAL AIRPORT

San Francisco, Southernmost Bayshore

San Francisco International Airport (SFO) has done much work to protect the airfield from flooding. Major portions of SFO's eight-mile long shoreline are being protected by seawalls, berms, and sheet piles. However, there are gaps of various lengths along the shoreline that may allow water to enter the airfield. These gaps include segments at U.S. Coast Guard, Mel Leong Treatment Plant, the north and south boundaries, and drainage outfall locations. Recognizing the flood risks, the Airport is launching a new Shoreline Protection Program to address these deficiencies and to protect the Airport from extreme tide and storm flooding risks as well as long term flooding risks from SLR.



Top: Concrete Seawall along Runway 19L, Middle: Sheet piles along Runway 1R, Bottom: Berm Protection at the end of Runway 19

SELF-RISING FLOOD WALLS

City of New York, New York and City of Houston, Texas

Self-rising flood walls are permanent protective barriers installed underground. In dry conditions they are unnoticeable and allow full access. In a flood event they are passively lifted by the rising flood waters to prevent flood inundation. They may be sized to protect long waterfronts, roads, buildings, or single doorways.

When the Susquehanna River flooded in June 2006, the Lourdes hospital, New York suffered crippling losses. Floodwaters spilled into hospital facilities, resulting in \$20 million in damages, paralyzing hospital operations for two weeks, and forcing evacuation of hundreds of patients. In a similar event in 2001, Tropical Storm Allison dropped over 15 inches of rain in three hours in Houston, Texas, causing severe flood damage to many critical facilities, including the Texas Medical Center.

In response, both hospital facilities are now protected by self-rising flood walls. Designed to blend in with the medical campus architecture, the gates are concealed beneath



the ground until automatically activated during a flood.

Self-rising flood walls are also part of the International Boundary and Water Commission Levee Flood Control project, where custom roadway floodgates extend levees across highways along the Rio Grande in Texas and New Mexico.



Top: Self-Rising Flood Walls *Image courtesy of FloodBreak Automatic Floodgates*

Bottom: Flood gates protecting Lourdes Hospital, NY

4

REGULATORY FRAMEWORK



San Francisco Bayfront, Financial District

The complex nature of land ownership and governance around coastal protection in San Francisco underscores the essential need for collaboration in order to achieve successful SLR adaptation planning.

Projects addressing SLR will need to coordinate with multiple property owners and jurisdictional agencies, and comply with regulations at local, State, and federal levels. Landowners and jurisdictional agencies are critical stakeholders who must be included as the challenge of SLR is addressed; building partnerships with these stakeholders will be necessary to identify and enact cost-effective solutions at both local and regional scales.

Public policy around climate change, flood risk, and SLR is evolving rapidly. San Francisco is at the forefront of policy and project development among coastal cities, and will continue to work with State and federal partners towards the development of effective, protective, and equitable SLR solutions.

LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE

Land in the SLR Vulnerability Zone is comprised of both public and private properties. Public land owners include local, State, and federal agencies, such as the Port of San Francisco and the Golden Gate National Recreation Area (GGNRA). Private ownership includes both residential and commercial properties in various stages of development and redevelopment.



Port property on the Central waterfront, near Pier 70
Image ©Shae Rocco



Top: Ocean Beach, part of GGNRA
Bottom: SFPUC combined sewage discharge outfall



Legend

— Sea Level Rise Vulnerability Zone

Jurisdiction

Port of San Francisco
 Recreation & Park (SFRPD)
 Fire (SFFD)
 Public Works (SFPDW)

Golden Gate National
 Recreation Area (GGNRA)
 Municipal Transportation
 Agency (SFMTA)

Public Utilities Commission (SFPUC)
 Other City Owned
 SF Unified School District

DRAFT: Land ownership under transition for some parcels.

0 3,400 6,800 Feet



Map Disclaimer: The inundation maps and the associated analyses are intended as planning level tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The maps do not represent the exact location of flooding. The maps relied on a 1-m digital elevation model created from LiDAR data collected in 2010 and 2011. Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures narrower than the 1-m horizontal map scale may not be fully represented. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or Open Coast. For more context about the maps and analyses, including a description of the data and methods used, please see the Climate Stressors and Impacts Report: Bayside Sea Level Rise Inundation Mapping Technical Memorandum, March 2014 and FEMA Open California Coast Sea Level Rise Pilot Study, San Francisco County, 2015.

Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC PROPERTY IN THE SLR VULNERABILITY ZONE

FEDERAL PROPERTIES

- **Golden Gate National Recreation Area (GGNRA)**, part of the National Park Service (NPS), occupies a significant area of land along the Pacific Coast.
- **The Presidio Trust** is a federal agency that administers resources of the Presidio, a public park site within the GGNRA, in partnership with the NPS.
- **U.S. Department of the Navy (Navy)** retains ownership of parts of the former Treasure Island and Hunters Point Shipyard Naval Bases during environmental remediation. These sites will be transferred to San Francisco (Treasure Island) and the Office of Community Investment and Infrastructure (OCII, Hunters Point Shipyard) after remediation is complete.

STATE PROPERTY

- **California Department of Parks and Recreation (State Parks)** owns and operates the Candlestick Point State Recreation Area in southeast San Francisco.

SAN FRANCISCO PROPERTIES

- **Port of San Francisco** is responsible for 7.5 miles of waterfront, including over 550 ground, commercial, retail, office, industrial, and maritime industrial leases, and landmarks such as Fisherman's Wharf, PIER 39, the Ferry Building, and AT&T Park.
- **San Francisco Recreation and Parks Department (SFRPD)** is responsible for recreational facilities, parks, and open space.
- **San Francisco Public Utilities Commission (SFPUC)** is responsible for sewage and stormwater infrastructure, treatment plants, pump stations, force mains, and combined sewage discharge points.
- **San Francisco Public Works (SFPW)** is responsible for infrastructure, public right of way (including roadways), and facilities throughout San Francisco.

- **San Francisco Municipal Transportation Agency (SFMTA)** is responsible for San Francisco's transportation network, including light rail vehicles, cable cars, buses, and other transit vehicles, and the San Francisco traffic control system.
- **San Francisco Department of Real Estate** manages the new Public Safety Building, the Medical Examiner's Office at 1 Newhall, and various other properties within the SLR Vulnerability Zone.
- **San Francisco Fire Department** owns Fire Station 35 (the fire boat station at Pier 22), the Fire headquarters building at 2nd and Townsend, and fire suppression infrastructure, such as hydrants and pump stations, throughout San Francisco.
- **Office of Community Investment and Infrastructure (OCII)**, under the 2004 Conveyance Agreement between the former Redevelopment Agency (now OCII) and the Navy, 492 acres of Bayfront property at Hunters Point Shipyard will transfer from the Navy to OCII in phases over the next five to seven years for redevelopment.
- **San Francisco International Airport (SFO)** occupies approximately 5,171 acres of land with approximately eight miles of shoreline.



Port of SF land in the SLR Vulnerability Zone

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—NORTHERN BAYSHORE THROUGH END-OF-CENTURY WITHOUT ANY ADAPTATION MEASURES OR ACTIONS



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.
See Appendix for complete set of San Francisco SLR Vulnerability Zone maps and public land ownership information.

REGULATORY JURISDICTION AND KEY POLICIES

Public policy around climate change, flood risk, and sea level rise is evolving rapidly at all levels of governance, as summarized below. In addition, multiple local, State, and federal agencies have (often overlapping) regulatory jurisdiction within San Francisco's SLR Vulnerability Zone. Depending on the project type and location, permits, certificates and/or other authorizations for coastal development or shoreline protection will often be needed from the agencies described below.

FEDERAL

The primary federal regulation pertinent to SLR is Executive Order 13690 passed by the Office of the President on January 31, 2015. The Executive Order directs Federal agencies to incorporate SLR considerations into decision making and operations. Agencies such as the Federal Aviation Administration and the Federal Transit Administration will enforce these requirements when administering grants and permits. Federal agencies with flood prevention or recovery responsibilities, including the U. S. Army Corps of Engineers (USACE) and FEMA, have adopted or are considering policies related to risk reduction around SLR. At time of writing, Executive Order 13690 provides the most stringent federal standards for coastal flood protection. Coastal or SLR-related projects may need authorization from the following agencies:

- **U.S. Army Corps of Engineers** issues permits and authorizations for various environmental impacts and supports levee certification decisions for the National Flood Insurance Program (NFIP) administered by FEMA.
- **Federal Emergency Management Agency** issues FIRMs and administers the NFIP. San Francisco is a new participant in FEMA's National Flood Insurance Program, and received Preliminary FIRMs from FEMA in November 2015, which are expected to become effective in mid-2017. San Francisco is also participating in FEMA's West Coast Sea Level Rise Pilot Study.
- **The U.S. Fish and Wildlife Service and National Marine and Fisheries Service** have regulatory jurisdiction over impacts to species protected under the Federal Endangered Species Act.

STATE

In recent years, the Office of the Governor passed Executive Orders directing State agencies to issue climate change guidance. Coastal development primarily falls under the jurisdiction of the California Coastal Commission (CCC) on the Pacific Coast and the Bay Conservation and Development Commission (BCDC) on the Bayside. The California State Lands Commission has jurisdiction over development and access to submerged and tidal lands, and oversees the activities of legislative grantees like the Port of San Francisco. The following State agencies have developed guidance and policies related to SLR:

- **California Coastal Commission** shares planning, regulatory, and permitting responsibilities over development within San Francisco's Coastal Zone from Fort Funston in the south to Lands End in the north. It issued Draft SLR Policy Guidance (2015) that specifies how to address SLR through Local Coastal Program (LCP) certifications and updates, and Coastal Development Permits.
- **Bay Conservation and Development Commission** has regulatory jurisdiction over existing and proposed land use changes and structures within 100 feet (inland) from the Bayshore's mean high water elevation. SLR vulnerability and risk assessments are required when planning shoreline areas or designing larger shoreline projects within BCDC's jurisdiction. Risk assessments must be based on the best available estimates of future SLR. New projects on Bayfill, likely to be affected by future SLR and storm surge activity during the life of the project, must meet additional requirements, and as feasible, integrate hard shoreline protection structures with natural features that enhance the Bay ecosystem (e.g., include marsh and/or upland vegetation).

- **The San Francisco Bay Regional Water Quality Control Board (RWQCB)** regulates discharges to surface water (rivers, ocean, bays, etc.) and groundwater, including stormwater discharges. SLR may affect existing RWQCB jurisdictional areas, such as site design measures for stormwater management.
- **The California State Lands Commission (CSLC)** has jurisdiction over tidelands and submerged lands along the entire coast, and within three nautical miles offshore from the ordinary high water mark. CSLC requires SLR planning by Legislative Trust Grantees, such as the Port of SF, and requires grantees with average annual gross public trust revenues over \$250,000 to prepare and submit a SLR plan to the CSLC no later than July 1, 2019.
- **The California Department of Fish and Wildlife (CDFW)** has regulatory jurisdiction over impacts to species protected under the California Endangered Species Act. CDFW has been active in promoting climate planning and evaluating potential climate impacts to California wildlife and its habitats.



San Francisco City Hall, where SLR policies are adopted



Current vision for Hunters Point Shipyard/Candlestick Point, led by OCII

SAN FRANCISCO

The City and County of San Francisco has begun the process of adjusting a variety of policies to address SLR. A floodplain management ordinance was adopted in 2008, the CPC Guidance was issued in 2014, and the LCP is being updated. Coastal or SLR-related projects may need authorization from the following agencies:

- **San Francisco Planning Department** plans for and guides growth and development under the direction of the City Planning Commission. It oversees compliance with San Francisco's General Plan and Planning Code.
- **San Francisco Capital Planning Committee (CPC)** oversees compliance with capital expenditures. The CPC requires that new construction, capital improvement, and maintenance projects receiving capital planning funds use the CPC Guidance to address SLR vulnerabilities, risk, and adaptation.
- **Office of Community Investment and Infrastructure** has land use, development, and design approval authority for several major, approved development projects (Mission Bay, Hunters Point Shipyard/Candlestick Point, and Transbay). OCII is the successor agency to the San Francisco Redevelopment Agency.
- **Port of SF**, under the direction of the Port Commission, has broad regulatory authority over trust lands granted pursuant to the Burton Act. The Port has its own building code and oversees the permitting of new construction and rehabilitation projects in its jurisdiction.

5

ENGAGEMENT

AND

COORDINATION

San Francisco is committed to providing ample opportunities for public participation in sea level rise (SLR) planning, as well as fostering communication and coordination between City Departments and neighboring jurisdictions. Through the development of this Action Plan, subsequent planning phases, and implementation, SLR and resiliency thinking will become integrated into San Francisco's planning, development, and public engagement processes as standard practice.

COMMUNITY ENGAGEMENT

Given the complexity and importance of SLR and waterfront planning to the residents and businesses in San Francisco, community engagement is critical to adaptation planning, funding, and implementation. A robust engagement effort includes outreach and education as well as community feedback opportunities.

San Francisco will coordinate and leverage existing citywide and local community engagement opportunities to increase the public's understanding of the potential effects of SLR on their homes and local businesses. As needed, additional SLR-specific outreach will be added during the Citywide Adaptation Plan process.

CITYWIDE OUTREACH

Office of Resilience and Recovery

2014-ONGOING

Office of the City Administrator

The San Francisco Office of Resilience and Recovery is an interdepartmental effort with a focus to create a comprehensive resilience strategy for San Francisco. The Office of Resilience and Recovery is developing a plan for connecting new and existing governmental (and non-governmental) programs with one another and to the community, with the goal of creating a more adaptable, equitably thriving, and resilient city. A year-long outreach effort will begin in 2016 and take place in all San Francisco neighborhoods.

Sewer System Improvement Program

2011-ONGOING

SFPUC

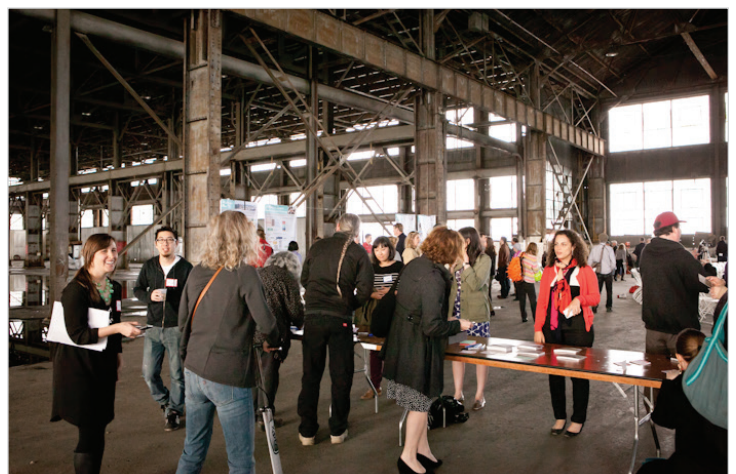
SFPUC, through the Sewer System Improvement Program (SSIP), is implementing a multi-billion dollar, 20-year citywide program to upgrade aging sewer infrastructure and ensure a reliable and seismically safe sewer system for generations to come. Climate change challenges are considered and addressed throughout the program. SFPUC offers the public numerous ways to be informed or engaged in the program through their "Get Involved" outreach efforts, including: plant tours, bike and walking tours, public meetings, and surveys. Over 5,000 community members have provided input on their preferences for stormwater management technologies and projects within their neighborhoods and communities. The SFPUC will offer similar opportunities for input and engagement as SLR adaptation projects are developed.

NOTE: For information on citywide outreach for the **Bay Area Resiliency Design Challenge** and **Plan Bay Area Update**, please see *Regional Activity and Coordination* further in this section.

ONGOING CITYWIDE PUBLIC OUTREACH EFFORTS



Ocean Beach Master Plan public meeting



Pier 70 SUD public outreach workshop

BAYSHORE OUTREACH

Waterfront Land Use Plan Update

FALL 2015 THROUGH 2018

The Port

The Waterfront Land Use Plan (Waterfront Plan) describes land use policies for the seven and a half miles of piers, shoreline, and nearby lands managed by the Port of San Francisco.

The Waterfront Plan update process will address aging historic finger piers, SLR challenges, seismic repair of San Francisco's seawall, and waterfront improvements for public and maritime industries.

A Waterfront Plan Working Group of stakeholders from San Francisco and the Bay Area are publicly discussing these issues.

The Port has also created technical Advisory Groups to provide more focused input and feedback opportunities.

Collaboration on San Bruno and Colma Creeks

2014-2016

SFO, San Mateo County, California State Coastal Conservancy

Immediately north of SFO, San Bruno and Colma Creeks drain into the San Francisco Bay. Residential neighborhoods in this area have been subject to severe flooding. A SLR vulnerability assessment and adaptation plan is being developed which will address coastal and rainfall flood risks to neighborhoods, habitat for threatened and endangered species, and public infrastructure.

Central and Southern Waterfront Regeneration Projects

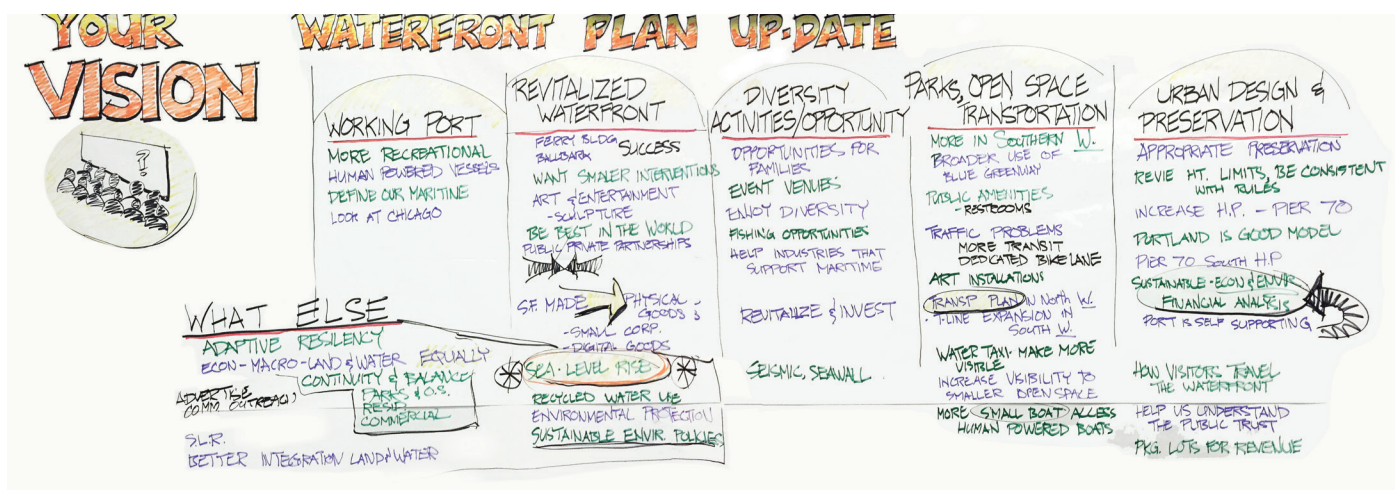
ONGOING

OEWD, Port of SF, SF Planning, OCII

Multiple residential, commercial, and open space development projects are being planned along the central and southern Bayshore. Many of the sites will be linked together by new sections of the multi-use Blue Greenway trail. Each project is incorporating SLR adaptation strategies and design considerations in its master plan. To help coordinate these large parallel processes, and glean the best overall set of development outcomes and neighborhood/city benefits, OEWD has convened the inter-agency Southern Bayfront Coordinating Committee.

Each project has its own public outreach process, many of which feed into the overarching Central Waterfront Advisory Group's process. Proposed redevelopment sites include the following:

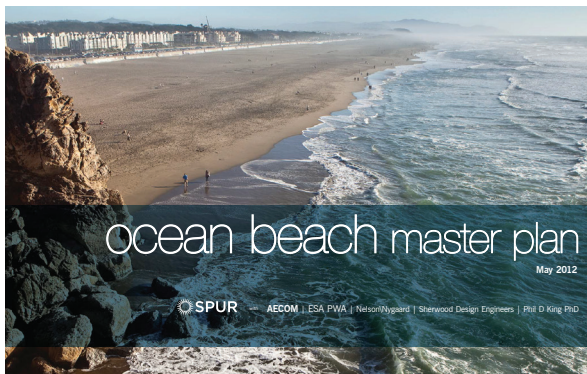
- **Mission Bay Development.** Plans include a new University of California San Francisco hospital and research center; biotech office space; residential; almost 50 acres of open space and parks; and local retail.
- **Mission Rock Development.** The San Francisco Giants plan to transform Parking Lot A, south of AT&T Park along Mission Creek, into a 28-acre development with residential, retail, and public open space.
- **Pier 70 Development.** This 70-acre site adjacent to the Dogpatch neighborhood includes large, active ship repair and three



Feedback captured at the Waterfront Land Use Plan Overview public meeting

proposed redevelopment sites: Crane Cove Public Park, a historic core for retail and PDR uses (Orton), and a waterfront site for mixed-use (Pier 70 Special Use District).

- **NRG Development.** This national energy company is planning a mixed-use development for the 23-acre site directly south of Pier 70, previously operated as the Potrero Power Plant.
- **India Basin Development.** Plans for this 27-acre site include a mixed-use development with residential, retail, school uses, and a 12-acre public park.
- **Hunters Point Shipyard Development.** Plans for this 492-acre area south of India Basin include residential, retail, commercial office/research and development space, an arts complex, community facilities, and 220 acres of open space.
- **Candlestick Point Development.** Plans for this mixed-use development east of the Bayview neighborhood include residential and retail uses, a performing arts venue, a hotel, community facilities, and 160 acres of open space.



Ocean Beach Master Plan public workshop

PACIFIC COAST OUTREACH

Ocean Beach Master Plan Implementation: Coastal Management Framework

2011-ONGOING
SFPUC

The SFPUC's Coastal Management Framework builds on the 2012 Ocean Beach Master Plan's (OBMP) recommendations for the area south of Sloat Boulevard where erosion hazards are chronic, threatening critical wastewater infrastructure. The framework will develop short- and long-term coastal protection, and a multi-objective management strategy to protect infrastructure and promote environmental stewardship. Opportunities for public participation are ongoing throughout this process.

Ocean Beach Master Plan Implementation: Transportation Improvements

2014-ONGOING
SFPW, SFRPD

As part of the OBMP implementation, SPUR, SFPW, and SFRPD are collaborating to improve circulation, access, landscape, and recreational opportunities at Ocean Beach. Plans include narrowing the Great Highway south of Sloat Boulevard, eventually rerouting it away from the coast from Sloat Boulevard to Highway 35. This process will include continued public engagement.

Local Coastal Program Amendment

FALL 2015 THROUGH FALL 2017
SF Planning

The LCP is being amended to incorporate actionable erosion and SLR policies from the OBMP into San Francisco's regulatory framework. This effort will include a robust public engagement program as well as close coordination with the Mayor's SLR Coordinating Committee and multiple agencies. A Community Advisory Group will provide input, and lead public workshops and informational hearings before the Planning Commission and Board of Supervisors.

REGIONAL ACTIVITY AND COORDINATION

Recognition of the regional nature of SLR is reflected in the number of regional collaborative programs that have been established over the past decade. The importance of these regional efforts and San Francisco's participation in them cannot be overstated, and San Francisco is committed to continued collaboration to ensure that the Bay Area as a whole develops successful solutions to living with SLR. A selection of key regional SLR initiatives relevant to San Francisco is outlined below.

Bay Area Resiliency Design Challenge

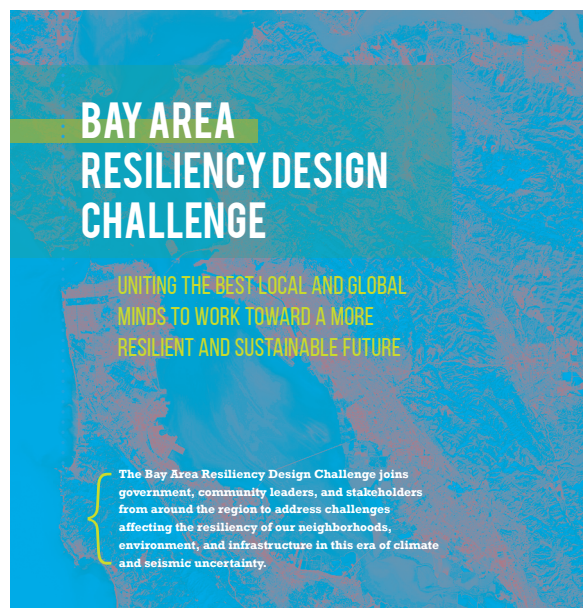
City and County of San Francisco, City of Oakland, City of Berkeley, City of San Jose, Santa Clara County, San Mateo County, Marin County, BCDC, SPUR, CCC, San Francisco Estuary Institute, and Climate Readiness Institute

The Bay Area Resiliency Design Challenge will bring together hundreds of government representatives, community leaders, and technical experts from San Francisco, the Bay Area, and around the globe to address SLR and seismic vulnerability challenges that affect the Bay. The most extensive open forum for dialogue and collaboration that the region has ever initiated around the topics of SLR and resiliency, the Design Challenge will co-develop implementable, collaborative solutions for the region. It will create for opportunities to enliven the public's imagination around waterfront planning and change public perception and awareness of the synergies between land, water, and infrastructure.

Coastal Hazards Adaptation Resiliency Group (CHARG)

Many Bay Area cities, all nine Bay Area counties, and regional, State, and federal agencies

In mid-2014, a working group of over 100 engineers, planners, scientists, and policy makers from across all levels of government in the nine Bay Area counties launched CHARG—the San Francisco Bay Region Coastal Hazards Adaptation Resiliency Group, with a vision to “collaborate across all levels of government



Bay Area Resiliency Design Challenge brochure

and align resources to implement integrated, multi-benefit coastal hazards solutions to mitigate risk and improve and protect quality of life and property along the San Francisco Bay.” CHARG provides a forum for ongoing discussions to develop and implement regional flood protection solutions to SLR and extreme tides. San Francisco serves on the CHARG Steering Committee and is active in the group in multiple capacities.

Adapting to Rising Tides

BCDC with many collaborating agencies

Adapting to Rising Tides (ART) is a collaborative planning effort to help San Francisco Bay communities and natural ecosystems adapt to SLR and storm-event flooding. ART has engaged local, regional, State, and federal agencies and organizations, as well as non-profit and private associations. Initiated in 2010, ART originally included the development, implementation, and refinement of a robust SLR and extreme tide vulnerability and risk assessment framework, and development of adaptation options across a range of sectors. Elements of the ART framework products and tools are in use by many San Francisco departments for their SLR resiliency efforts.



Rockefeller 100 Resilient Cities Challenge

City and County of San Francisco, City of Berkeley, City of Oakland, Association of Bay Area Governments (ABAG)

In December 2013, the Rockefeller Foundation announced that three Bay Area cities (Berkeley, Oakland, and San Francisco) were winners in the 100 Resilient Cities (100RC) Challenge. Since mid-2014, under the guidance of a Chief Resilience Officer, each city has been working individually and collaboratively to develop resiliency strategies for climate impacts, earthquakes, and other social resilience issues, each with its own stakeholder engagement program. Each city will publish a Resilience Strategy in 2016 to help guide the work of the cities going forward to address a multitude of resilience efforts in a holistic and cross-disciplinary way. In addition, the Association of Bay Area Governments is being supported by 100RC to act as a regional resilience coordination hub.

Bay Area Ecosystems Climate Change Consortium

Steering committee includes leaders from the CCC, BCDC, United States Geological Survey (USGS), and several conservation based NGOs

The Bay Area Ecosystems Climate Change Consortium (BAECCC) is managed by a Steering Committee of regional leaders who bring together natural resource managers, scientists, and natural resource and wildlife agencies to collaborate, understand, and reduce the negative impacts of climate change on Bay Area ecosystems. BAECCC convenes regular meetings and workshops to inspire research and disseminate information on the nexus of climate change, wildlife and open space conservation methodology, climate policy, and promote nature-based solutions to climate issues, including SLR.

While San Francisco is not currently an official BAECCC partner, it recognizes BAECCC as a knowledgeable stakeholder around natural resource planning, particularly on the Pacific coast.

Bay Area Regional Collaborative

ABAG, Bay Area Air Quality Management District, BCDC, Metropolitan Transportation Commission (MTC)

Previously known as the Bay Area Joint Policy Committee, in 2015 this group changed its name to the Bay Area Regional Collaborative (BARC) and refined its mission to a single focus: planning and policy coordination around climate change. All four member agencies have an interest in proactive climate change planning, and jurisdictional overlap between the four agencies is best served through collaboration.

Climate Readiness Institute

University of California, Berkeley, in partnership with the University of California, Davis, Stanford University, Lawrence Berkeley National Laboratory, BARC

The mission of the Climate Readiness Institute (CRI) is to develop the climate science, adaptation strategies, and mitigation tools needed to ensure a resilient, low-carbon Bay Area and beyond. CRI brings together academics and practitioners to identify critical information gaps and policy challenges related to climate change, and conduct scientific analyses of current and proposed adaptation strategies (as well as assess new mitigation strategies for reducing greenhouse gas emissions). San Francisco will play an active role in the CRI, particularly participating in the Flooding Working Group.

Plan Bay Area—Update

MTC and ABAG; 9 counties and transportation agencies

Plan Bay Area is a long-range integrated transportation and land-use/housing strategy for the Bay Area (through 2040). The Plan includes the region's Sustainable Communities Strategy and the 2040 Regional Transportation Plan. The Plan's EIR considered 24 inches of SLR inundation to identify



Erosion at the southern reaches of Ocean Beach

the number of residents, employees, and percentage of Priority Development Areas and transportation projects that could be exposed to this level of inundation. Potential adaptation strategies were identified. The update to Plan Bay Area started in 2015 and will again consider SLR and extreme tide impacts. The update is due to be finished in 2017. San Francisco will be an active participant in this update. Local officials, as well as environmental, social justice, faith-based, public-health, and business leaders are participating through a Regional Advisory Working Group.

Our Coast, Our Future

USGS, Point Blue Conservation Science, Coravai, Gulf of the Farallones National Marine Sanctuaries

Our Coast, Our Future (OCOF) is a collaborative, user-driven project focused on providing San Francisco Bay Area coastal resource and land use managers and planners with locally relevant online maps and tools to help understand, visualize, and anticipate vulnerabilities to SLR and extreme tides within the Bay and on the Pacific Coast from Half Moon Bay to Bodega Bay. San Francisco may leverage OCOF as a tool, when more detailed or tailored data is not available, and/or promote it to businesses and other organizations as a valuable, publicly-available SLR mapping tool.

San Mateo County Sea Level Rise Vulnerability Assessment

San Mateo County, SFO, all cities in San Mateo County, CCC

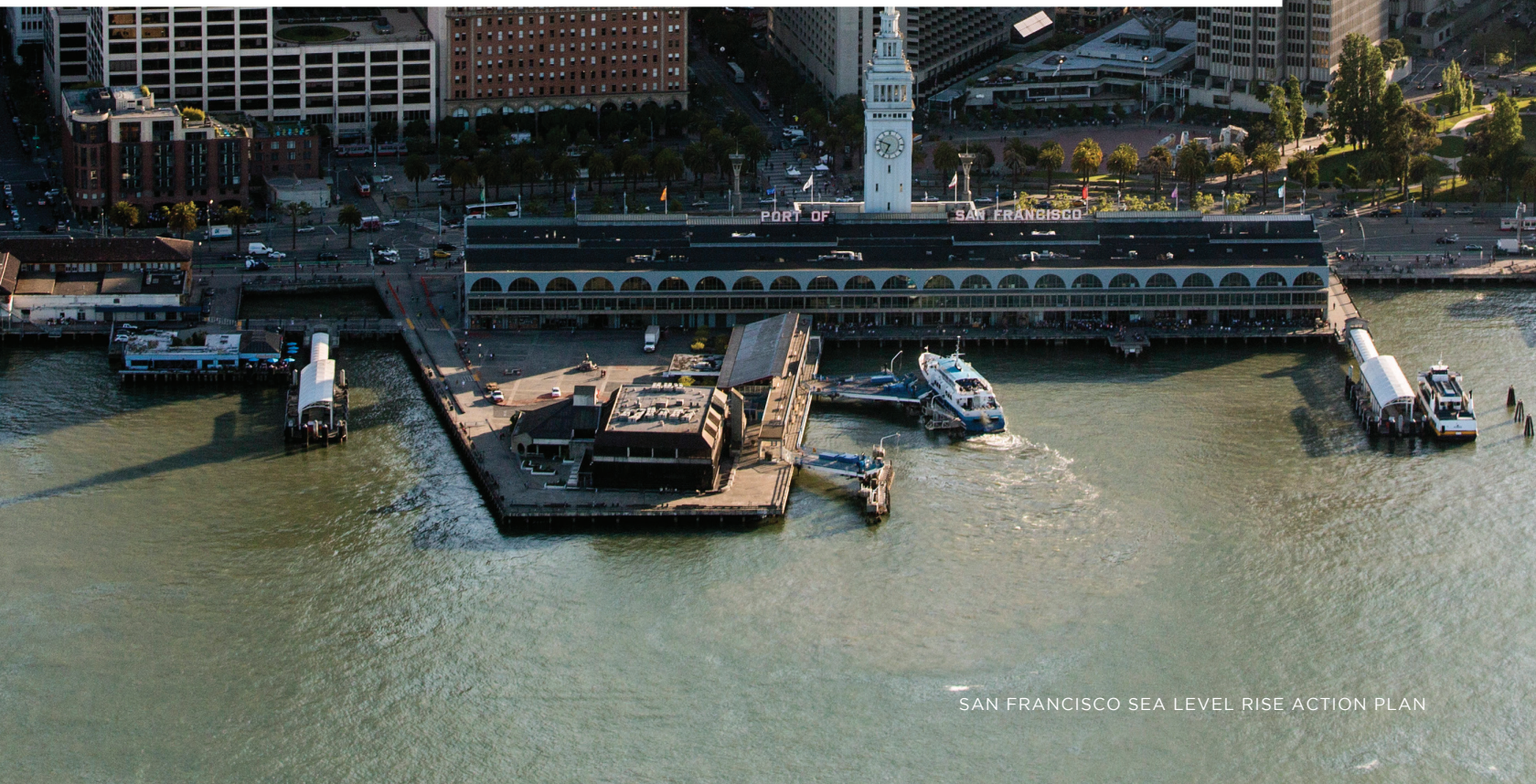
The County of San Mateo, in partnership with the CCC, is overseeing an effort to identify vulnerable assets on the Bay and Pacific sides of San Mateo County, determine impacts, recommend adaptation measures, and improve flooding and SLR mapping. The assessment is being developed through an inclusive process with participation from San Mateo County cities and relevant agencies, businesses, organizations, and community groups.

Bay Area Resilient Communities Initiative Bay Localize

The aim of the Bay Area Resilient Communities Initiative (RCI) is to create a model of resilience planning led by the communities most impacted by climate change and natural disasters for the benefit of all residents. The RCI is a coalition of community organizations throughout the nine-county Bay Area with experience in improving the quality of life in the region. In San Francisco, the Mission and Excelsior-based People Organizing to Demand Environmental and Economic Rights (PODER) worked alongside RCI to map local-scale climate vulnerability in 2012.

6

VULNERABILITY AND RISK ASSESSMENTS



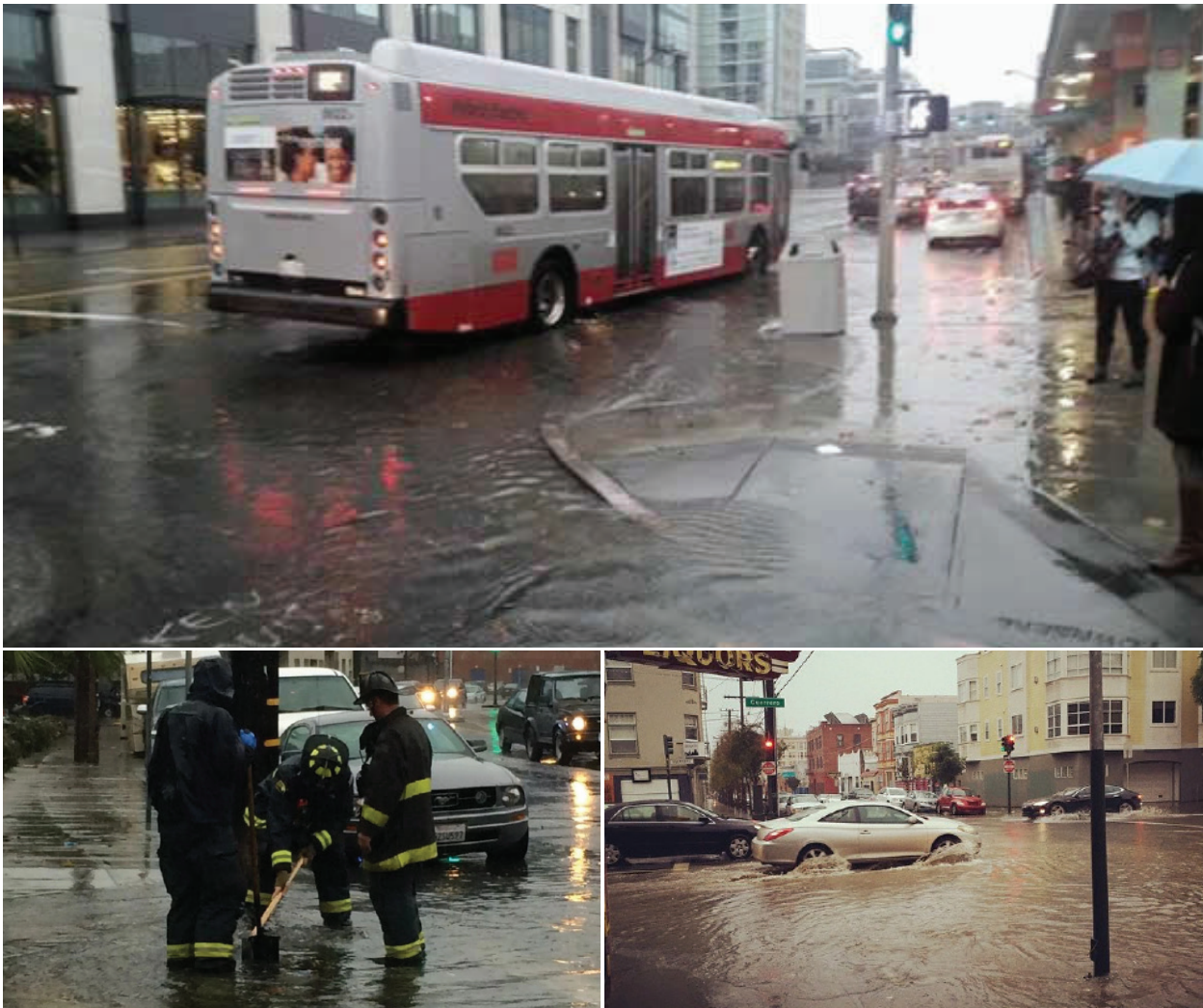
Effective and successful adaptation planning requires a detailed understanding of San Francisco's vulnerability to, and risks from, SLR.

COMPONENTS OF VULNERABILITY AND RISK ASSESSMENTS

Vulnerability assessments describe the impacts that would be incurred by an asset or set of assets by temporary flooding or permanent inundation from coastal waters. This may include erosion, physical damage or functional disruption to structures or systems from temporary coastal floods, and/or land and asset loss through permanent inundation.

Risk assessments describe (quantitatively or qualitatively) the potential consequences of the damage that could or will occur due to asset failure. The scale and focus of risk estimates vary greatly. Types of consequences considered in a risk estimate may include:

- **Critical service consequences.** Temporary or permanent disruptions to power, communications, water and wastewater services, medical facilities, and/or lifeline transportation services
- **Social consequences.** Impacts to public health and safety, general displacement and homelessness, and social services
- **Economic and financial consequences.** Workforce disruptions, loss of real estate, and/or impacts to tourism or other significant industries



Urban flooding (December 2014 storms) interrupted transportation and other services in San Francisco's downtown and Mission District *Image Credit ABC News, KQED, and contributor @DLeesf, Your Take*

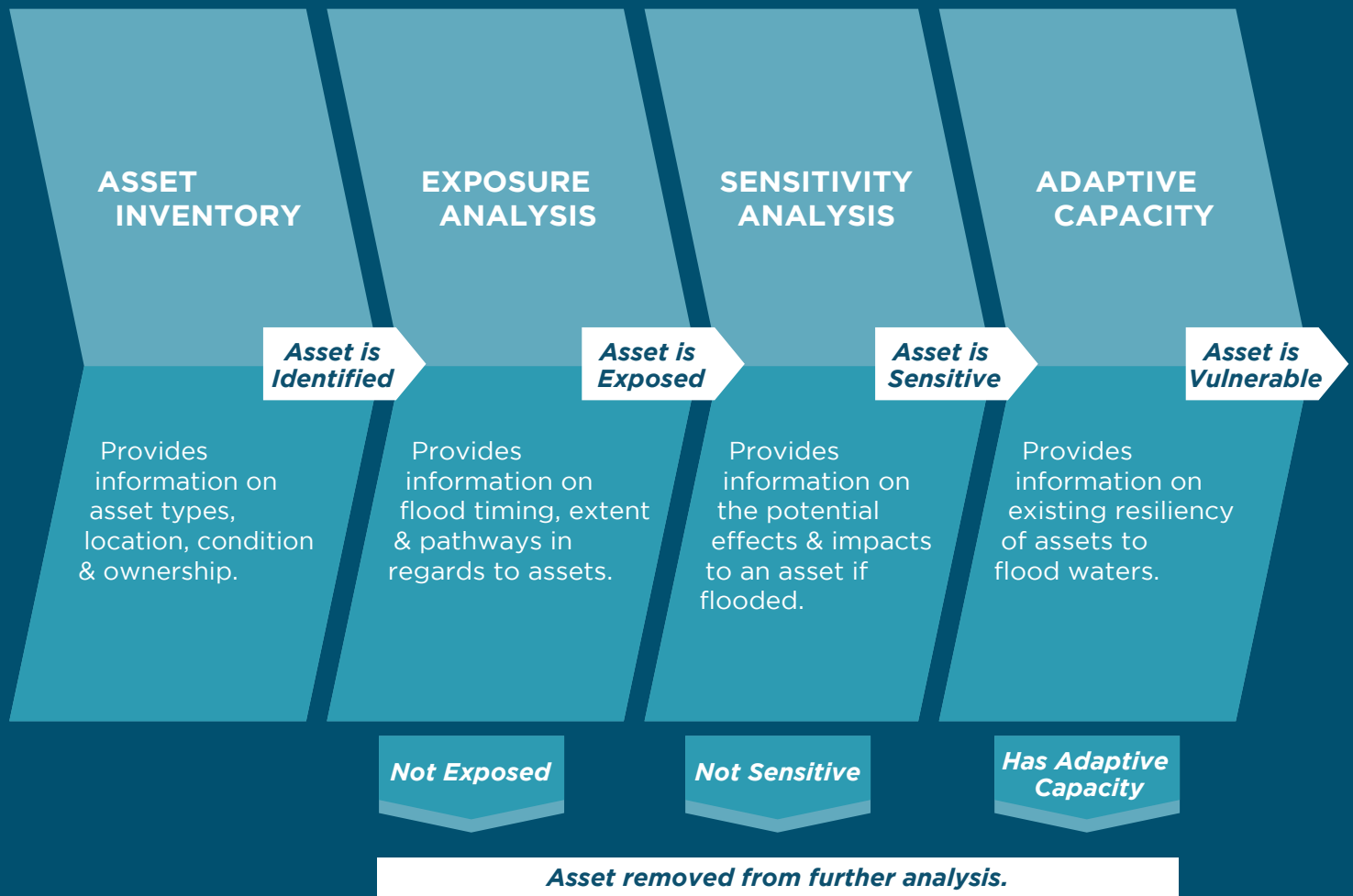
VULNERABILITY ASSESSMENT PROCESS

Vulnerability assessments follow a standardized step-by-step approach:

1. **Asset Inventory:** Provides information on the types, location, and condition of assets
2. **Exposure Analysis:** Provides information on flood timing and pathways
3. **Sensitivity Analysis:** Provides information on the effects to an asset if flooded
4. **Adaptive Capacity:** Provides information on existing resiliency to flood waters

This analytic approach has been recommended by the CPC Guidance for use by all San Francisco Departments with property and/or assets within the SLR Vulnerability Zone, including but not limited to buildings, transportation, utility infrastructure, parks and open spaces, et al. Assets identified as vulnerable in this process should move forward to a risk analysis.

STAGES OF A VULNERABILITY ASSESSMENT



EXISTING VULNERABILITY ASSESSMENTS

Significant vulnerability data has been collected for the following types of assets:

- Port of SF property and assets
- SFO property and assets
- SFPUC water and wastewater utilities
- Shoreline protection (natural features and engineered structures)
- Vulnerable populations
- Public health facilities

More information is needed for:

- Buildings and properties
- Solid and hazardous waste
- Energy
- Ground transportation
- Parks, recreation, open space, and natural ecosystems
- Communications
- Community facilities

Existing Vulnerability Assessments in San Francisco to Date

Name and Type of Study, Date, Lead	Assets	Extent
San Francisco Public Utilities Commission (SFPUC)		
Sewer System Improvement Program Climate Adaptation Study [2013–ongoing] <i>SLR: 12, 24, 36, 48, 52, 66 inches + 100-year extreme tides</i>	Wastewater and stormwater systems	San Francisco
Coastal Protection Measures & Management Strategy for South Ocean Beach, Coastal Management Framework [2014–2015], with SPUR, GGNRA, and U.S. Army Corp of Engineers (USCAE) <i>SLR: 14 inches</i>	Buildings, open space, transportation, wastewater, and stormwater systems	Pacific Coast
Port of San Francisco		
Sea Level Rise and Adaptation Study [2012] <i>SLR: 15, 55 inches + 100-year extreme tides</i>	Piers, buildings, transportation	Port Property
Blue Greenway Southern Waterfront Open Space System Area-wide Plan [2010] with San Francisco Public Works (SFPW), Bureau of Landscape Architecture <i>SLR: 15 inches</i>	Open space	Port Property
Northern Waterfront Seawall Study [2014–ongoing] <i>SLR: unknown</i>	Shoreline protection systems	Port Property
Mission Creek Draft Sea Level Rise Adaptation Study [2015], with BCDC, Delta Alliance <i>SLR: 11, 36 inches + 100-year extreme tides</i>	Piers, buildings, transportation	Properties surrounding Mission Creek
San Francisco International Airport (SFO)		
SFO Shoreline Protection Feasibility Study [2015] <i>SLR: 12, 24, 36 inches + 100-year extreme tides</i>	All airport facilities, shoreline protection systems, transportation	SFO

Existing Vulnerability Assessments in San Francisco to Date *(continued)*

Name and Type of Study, Date, Lead	Assets	Extent
San Francisco Department of Public Health (DPH)		
DPH Climate and Health Profile [2014] <i>SLR: 7, 15 inches + 100-year extreme tides</i>	Public health	San Francisco
Climate and Health. Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding & Extreme Storms [2015] <i>SLR: 77 inches + urban/watershed flooding</i>	Public health	San Francisco
SPUR		
Ocean Beach Master Plan [2012], with multiple asset owner agency partners, such as SFPUC, Golden Gate National Recreation Area, SFPW, SF Planning, San Francisco Recreation and Parks Department, San Francisco Zoological Society, etc. <i>SLR: 14, 55 inches + 100-year extreme tides</i>	Buildings, open space, transportation, wastewater, and stormwater systems	Pacific Coast
Federal Emergency Management Agency (FEMA)		
FEMA San Francisco SLR Pilot Study [2013-ongoing] <i>SLR: 12, 24, 36, 66 inches + 100-year extreme tides</i>	Open space, shoreline protection systems	Pacific Coast
San Francisco Department of Emergency Management (SFDEM)		
Hazard Mitigation Plan [2014] with 20 other San Francisco departments <i>SLR: 55 inches</i>	Sample list of natural and structural coastal assets from Ocean Beach, Marina, Embarcadero, and Treasure Island areas	San Francisco
San Francisco Office of the City Administrator		
Office of Resilience and Recovery SLR Exposure Assessment [2014-ongoing] <i>SLR: 66 inches + 100-year extreme tides</i>	Buildings, transportation, hazardous waste	SLR Vulnerability Zone
San Francisco Capital Planning Committee (CPC)		
Implementation of CPC Guidance [2014-ongoing] <i>SLR: 12-66 inches + 100-year extreme tides</i>	Infrastructure maintenance and improvement projects from the 10-year Capital Plan	SLR Vulnerability Zone

EXISTING RISK ASSESSMENTS

Risk assessments include evaluations of the probability (or likelihood) that impacts would occur and the consequence of these impacts. A combination of high likelihood and high consequence equates high risk. High-risk assets should be prioritized for adaptation

planning. The majority of publicly funded SLR-related projects conducted to date include only vulnerability assessments. However, the projects below have also assessed risk, and/or included adaptation planning.

Vulnerability Assessments with Additional Risk or Adaptation Components

Risk or Adaptation Included	Details
SFPUC	
Sewer System Improvement Program Climate Adaptation Study [2013–ongoing]	Assessing risk qualitatively as a function of the potential timing and scale of consequence from individual asset failure. Includes adaptation strategies.
Coastal Protection Measures & Management Strategy for South Ocean Beach, Coastal Management Framework [2014–2015], with SPUR	As part of the Ocean Beach Master Plan: Coastal Management Framework, this effort is developing short- and long-term coastal protection strategies, south of Sloat Boulevard, where erosion hazards are chronic and jeopardize critical San Francisco wastewater infrastructure.
Port of San Francisco	
Sea Level Rise and Adaptation Study [2012]	Concept-level adaptation strategies for 15 and 55 inches of SLR.
Northern Waterfront Seawall Study [2014–ongoing]	Considers SLR adaptation in seawall plan.
Mission Creek Draft Sea Level Rise Adaptation Study [2015]	Qualitative risk assessment identifying broader consequences or major assets going out of service; includes conceptual development and prioritization of adaptation strategies.
San Francisco International Airport	
SFO Shoreline Protection Feasibility Study [2015]	Assessed risk qualitatively as a function of impact types to shoreline components; includes adaptation strategies.
SPUR, SFPUC	
Ocean Beach Master Plan [2012]	Includes conceptual risk assessment and planning level adaptation strategies.
SFDEM	
Hazard Mitigation Plan (2014)	Included brief qualitative descriptions of flood risks, such as economic losses through the closure of businesses and government facilities, disruption of communications and utility services (e.g., water/wastewater), and emergency response expenditures.

VULNERABILITY ASSESSMENTS FOR MAJOR DEVELOPMENT

Several proposed or approved private and public-private development projects along San Francisco's Bay shores have conducted elements of SLR vulnerability and/or risk assessments as an essential part of the master planning process, including but not limited to:

- Pier 70 Crane Cove Park and Waterfront Site Development (SUD)
- Mission Rock/Lot 337 Development
- Hunters Point Shipyard Development
- Candlestick Point Development
- India Basin Development
- Treasure Island Development

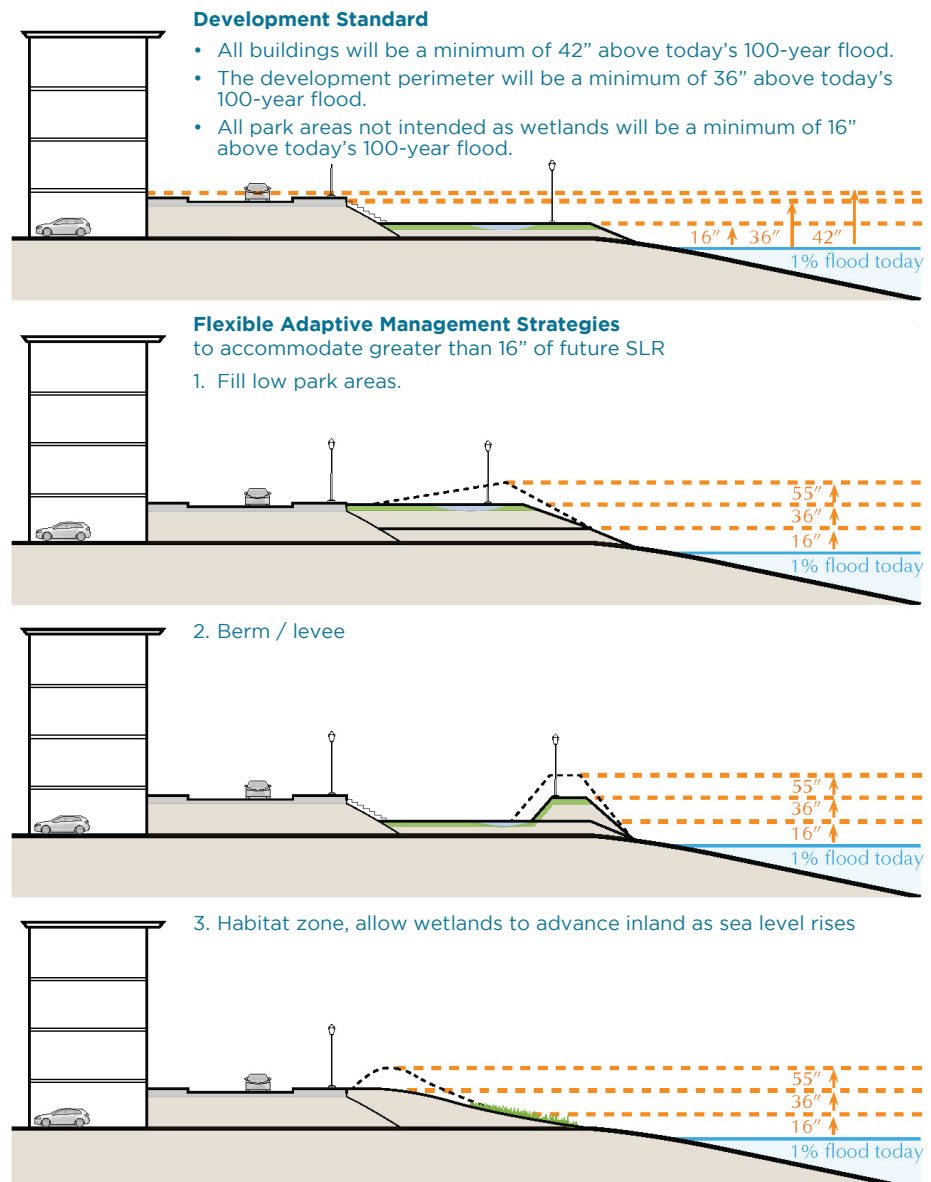
As introduced in *Section 3 Climate Design*, projects typically address SLR and coastal flooding risks by incorporating adaptive management strategies (e.g., setbacks, natural and engineered flood protection systems, and tiered site elevations) into waterfront development and open space design.

As these projects occur with public partnerships, SLR analysis and adaptation strategies are reviewed by entities such as the Port of SF, OEWD, OCII, SF Planning, and BCDC, depending on the project type and location.

ANALYSIS-DRIVEN ADAPTATION MANAGEMENT STRATEGY OPTIONS

The vulnerability analysis conducted for the Hunters Point Shipyard/Candlestick Point redevelopment identified the need for multiple types of adaptation management, which could occur over time. The SLR adaptation strategies include increased site elevations, engineered berms and armoring, and natural protection, such as tidal wetlands.

Image courtesy of the Parks, Open Space, and Habitat Concept Plan: Candlestick Point and Hunters Point Shipyard Phase II, OCII, 2010



THE COST OF INACTION

Sea Level Rise will severely affect public and private property in San Francisco. Estimating the expected loss in property value over time provides a way to make informed decisions about how to balance the cost of post-disaster relief with the cost of up-front adaptation.

Given the current understanding of SLR potential, San Francisco needs to identify the best course of action to prepare for the future. The decision-making process requires balancing risks and costs. This section answers the question: If no special actions are taken to

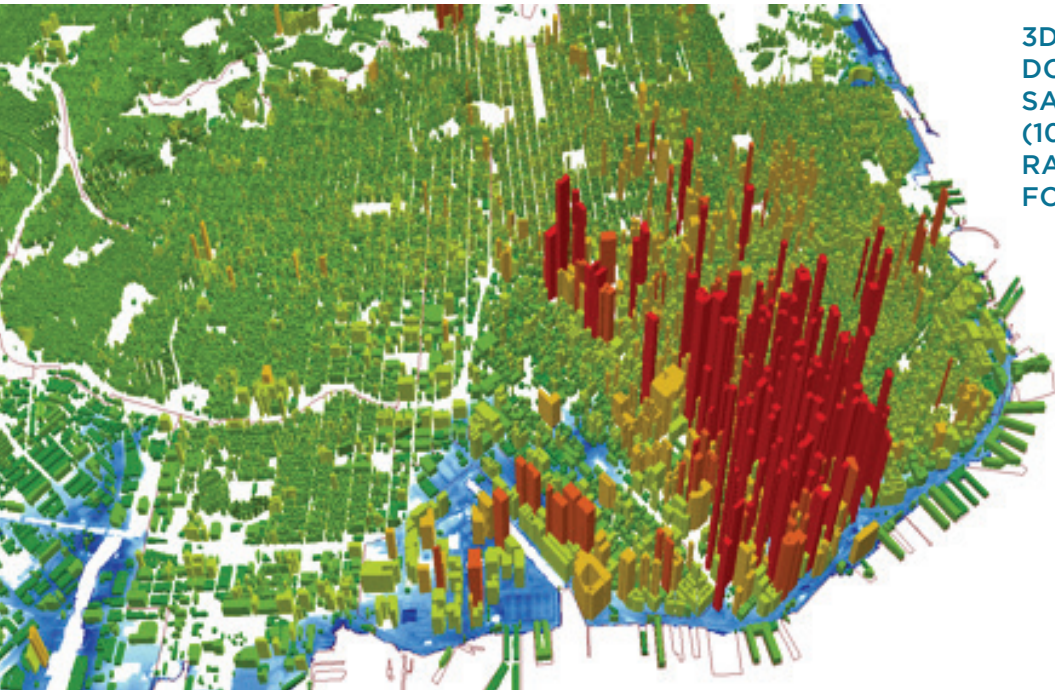
prepare for SLR, what would be the financial impact on public and private property?

Working with Risk Management Solutions (RMS), a Bay Area based risk-modeling firm, the SLR Coordinating Committee estimated the total property value at risk in San Francisco. This estimate considers risk due to Bayside SLR at the upper-range, 66-inch level, both with and without the impacts of a 100-year extreme tide (i.e., up to 108 inches), and produces a ‘do-nothing’ / ‘no action’ estimate of property permanently lost to SLR. This number illuminates the scale of the challenge SLR presents, and an estimation of the total value of assets in the public and private sector that are exposed. This value is expressed in today’s dollars of property replacement value and does not take into account any planned or anticipated adaptation efforts (i.e., approved flood control projects at SFO).

Property Value at Risk in San Francisco, Summary

	Private Property	Public Property	Total Property Value Exposed
66” SLR	\$20 Billion	\$35 Billion	\$55 Billion*
108” (66” SLR + 100-year extreme tide)	\$39 Billion	\$37 Billion	\$77 Billion*

*Figures are rounded figures for the purposes of this report.



3D VIEW OF DOWNTOWN SAN FRANCISCO (108-INCH, UPPER-RANGE INUNDATION FOOTPRINT)

TECHNICAL BACKGROUND

When discussing flooding in this context, it is important to distinguish between permanent flooding that will occur due to SLR and temporary flooding that will occur as a result of extreme tide events. The permanent inundation of a building will render its entire value completely unusable, while temporary flooding will cause damage that can potentially be repaired, and will likely be far lower than the full value of the building. For this study, it is assumed that property located within the upper-range, 66-inch scenario will be permanently lost if nothing is done to protect against SLR; property within the 108-inch scenario includes these properties plus those that will be at risk to some level of flooding under a 100-year extreme tide.

Private Property Data

RMS used a proprietary, industry-standard valuation model and property data to create a building-by-building exposure dataset

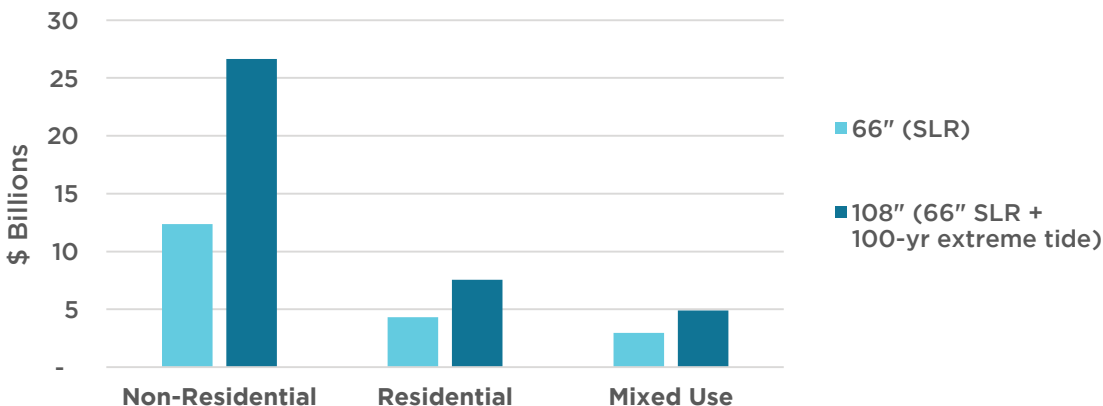
for privately owned properties (i.e., private property) within the SLR Vulnerability Zone. This dataset was then overlaid onto the inundation footprints shown in Section 2. This dataset is used as the basis of an analysis of the value of the exposed private property.

In addition to the replacement cost, private property data contains information used for catastrophe risk modeling, such as the occupancy type, number of stories, construction type, and year built. This information allows a more granular view of the type of properties in San Francisco that will be affected by SLR. Viewing total exposure in each scenario broken down by the property's primary use, for example, reveals that the majority of vulnerable buildings currently contain commercial or industrial uses. Further, when the 100-year extreme tide is added to permanent SLR flooding conditions, a significant amount of additional property will be at risk, almost doubling the exposure value.

Private Property Value at Risk in San Francisco

	EXPOSURE VALUE		BUILDING COUNT	
	66 inches (SLR)	108 inches (66" SLR + 100-yr extreme tide)	66 inches (SLR)	108 inches (66" SLR + 100-yr extreme tide)
Commercial/Industrial	\$12.4B	\$26.7B	678	1,422
Residential	\$4.3B	\$7.6B	396	1,049
Mixed Use	\$3.0B	\$4.9B	86	135
TOTAL	\$20B	\$39B	1,160	2,606

Replacement Value of Exposed Privately Owned Buildings by Occupancy



Public Sector Assets Data

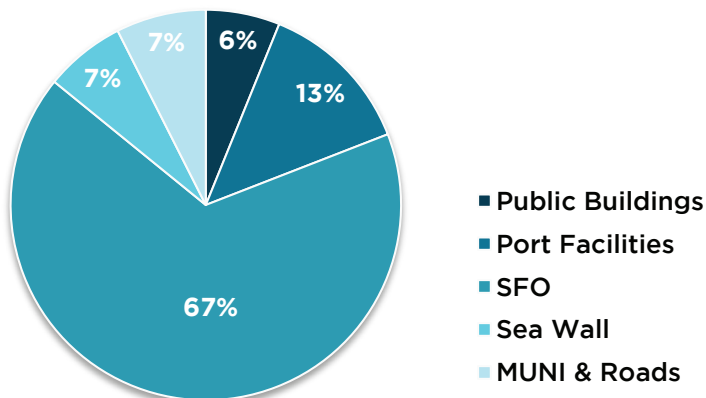
Public building data was derived by combining building information from the RMS exposure dataset with value information provided by San Francisco. Information about impacted infrastructure, certain Port of San

Francisco facilities, and the San Francisco Airport was provided based on independent asset analyses carried out by San Francisco, and exposure estimates were provided for each asset, as well as each asset category and each scenario.

Public Sector Asset Value at Risk in San Francisco

	66" (SLR)	108" (66" SLR + 100-yr extreme tide)
Public Buildings	\$1.5B	\$2.3B
Port Building Facilities	\$4.5B	\$4.9B
San Francisco Airport	\$25B	\$25B
Northern Sea Wall	\$2.5B	\$2.5B
MUNI and Streets	\$1.8B	\$2.8B
TOTAL	\$35B	\$37B

Public Property Types at Risk under 108" (66" SLR + 100-year Extreme Tide)



COMPREHENSIVE ECONOMIC RISK ANALYSIS NEXT STEPS

The SLR Coordinating Committee will continue to develop a deeper understanding of the economic risk of SLR, extreme tides and coastal flooding, over and above the cost of building and infrastructure replacement and repair. This might include the number of affected housing units, employees, wages, and payroll/property taxes.

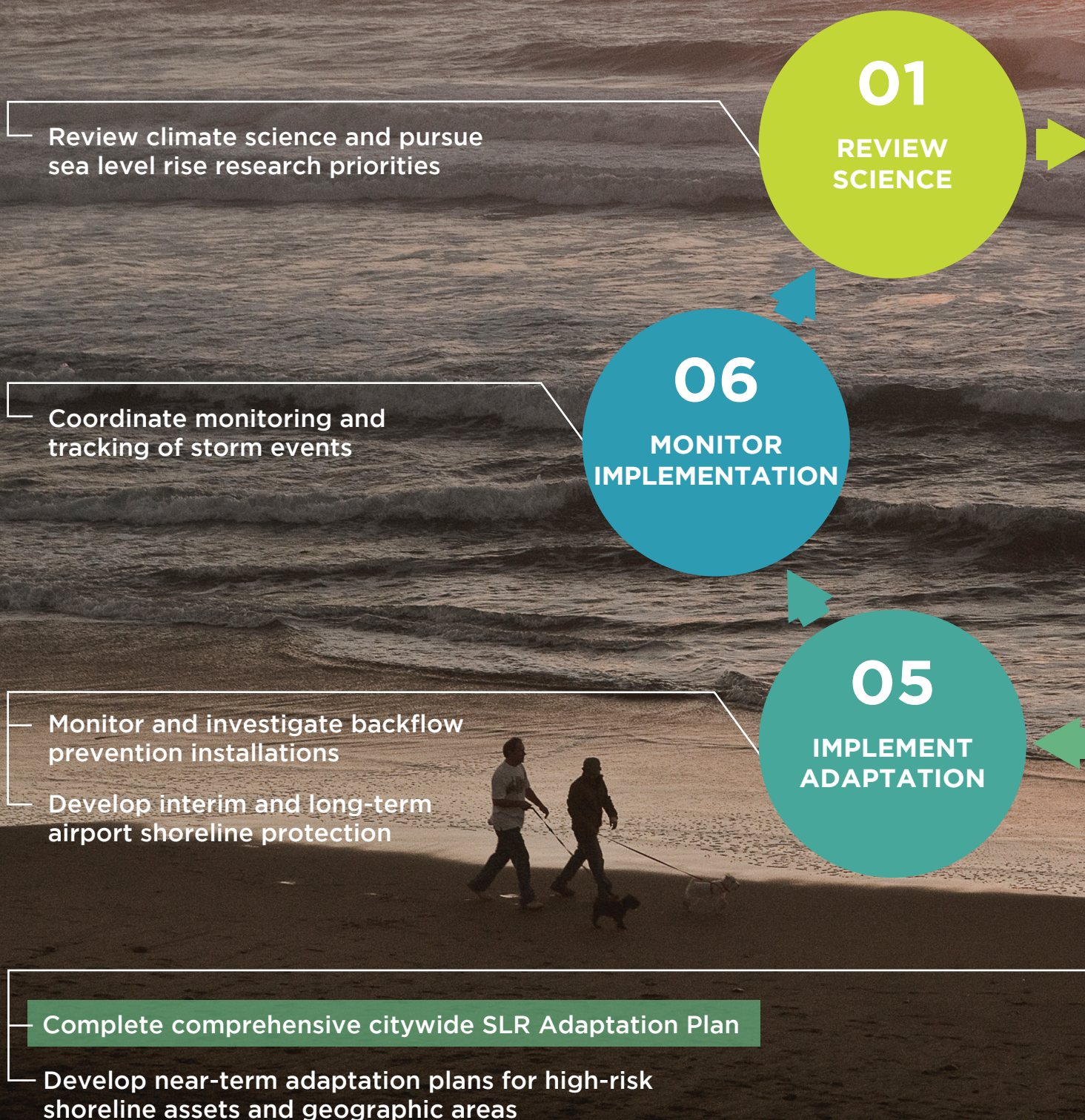
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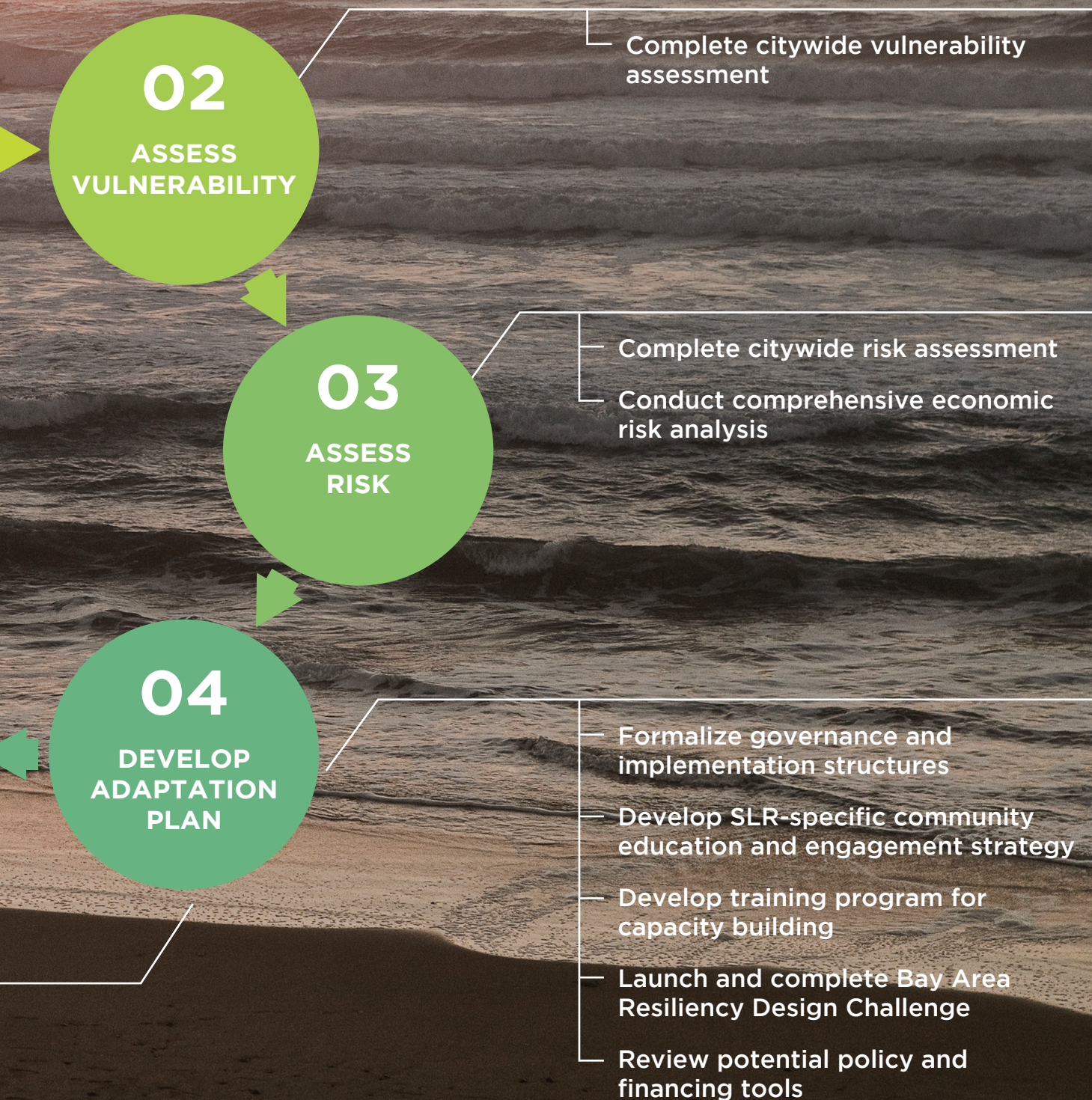
NEXT STEPS



SEA LEVEL RISE PRIORITY ACTIONS [2016–2019]

San Francisco has identified the following critical next steps and actions toward adapting to sea level rise and becoming a more resilient city. The envisioned tasks align to the cyclical nature of the adaptation process, as explained in the Introduction.





SEA LEVEL RISE PRIORITY ACTIONS [2016–2018]

The following immediate next steps have been confirmed and prioritized by the SLR Coordinating Committee for San Francisco's Resiliency Program.

GOVERNANCE AND ORGANIZATION

FORMALIZE GOVERNANCE AND IMPLEMENTATION STRUCTURES

IMMEDIATE AND ONGOING

Lead: SLR Coordinating Committee

The SLR Coordinating Committee will continue to be the driving force behind the implementation of this SLR Action Plan, the future development of the Citywide Adaptation Plan, and San Francisco's collaboration with the region. The SLR Technical Committee will also continue to track updates in SLR science and oversee implementation of the CPC Guidance. In addition, two new bodies will be set up to support next steps. A public-private advisory committee will review the development

and implementation of the Citywide Adaptation Plan. The committee will include representatives from City departments, local businesses, advocacy groups, community representatives, and other important stakeholders such as SPUR, BCDC, and FEMA. An Interdepartmental Working Group, reporting to the SLR Coordinating Committee, will track new developments, monitor City departments' responses to flooding, seek grant opportunities, and provide other recommendations for the Adaptation Plan.

SAN FRANCISCO'S RESILIENCY PROGRAM ORGANIZATION CHART



CLIMATE SCIENCE REVIEW

REVIEW SCIENCE AND PURSUE SEA LEVEL RISE RESEARCH PRIORITIES

IMMEDIATE AND ONGOING

Lead: SFPUC

San Francisco will continue to monitor SLR projection updates and regional, national, and international best practices, and pursue grant funding for further research to inform adaptation strategies. These priorities identified to date will require partnerships, collaboration, and funding.

Understand future storm intensity due to climate change: The effect of climate change on precipitation in San Francisco is not fully understood, and considerable variability exists between models. Currently, average annual precipitation totals are not projected to change significantly, but by mid-century, the Bay Area is expected to see the same average rainfall occur in less frequent but larger storms, with potential for larger urban floods. Longer and drier droughts are also predicted. Increased research, modelling, and monitoring will help clarify San Francisco's changing storm intensities.

Model interactions between rainfall, SLR, storm surge (coastal flooding), and urban/stormwater flooding: When rainfall exceeds San Francisco's combined wastewater system capacity, it is discharged to the Bay or Pacific Ocean, and/or causes temporary flooding. SLR and coastal flooding will further impede the gravity-fed flow of stormwater into the Bay. This complex modelling exercise will require specific expertise and collaboration with groups, such as the Computational Research Division at the Lawrence Berkeley National Laboratory. This analysis (currently unfunded) may take two to four years, but should provide actionable information that can help enhance resilience to climate change.



Stormwater Flooding in San Francisco Financial District
Image Courtesy of Flickr CC User "Frédéric Poirot"

Understand groundwater infiltration:

Groundwater elevation and salinity data collected throughout San Francisco will help establish a baseline for quantifying the impacts of SLR on future groundwater elevation and salinity. Groundwater is already impacting buried infrastructure, and existing baseline data is inadequate for understanding vulnerability and risks posed by current condition or future changes. This is also a priority research topic for CHARG.

Understand the liquefaction and

SLR interface: Large areas of San Francisco's shoreline were built on Bay fill (prior to the 1960s with limited engineering controls) and therefore susceptible to liquefaction during a seismic event. Groundwater plays a significant role in seismic vulnerability as soil saturation increases liquefaction risk. As seas rise, groundwater is expected to rise concurrently, increasing seismic vulnerability. Increased research on these interactions will guide engineering design so that SLR adaptation projects are resilient to seismic damage.

Understand vertical land motion in combination with SLR:

Understanding vertical land motion in San Francisco is important as it could reduce or increase relative SLR. Ongoing studies by UC Berkeley (among others) indicate that areas of the city on fill are subsiding rapidly, at a rate of two millimeters per year. Although it is unknown if there is an equilibrium subsidence rate for all development on fill, if subsidence is projected out at a linear rate to 2100, this could result in three to four feet of subsidence in addition to three to five feet of SLR. (Note that the subsidence rate is not as fast for non-fill areas.) Monitoring vertical land motion will be important to inform adaptation planning.

VULNERABILITY AND RISK ASSESSMENT

COMPLETE CITYWIDE VULNERABILITY AND RISK ASSESSMENTS

BY SPRING 2018

Lead: SF Planning, Public Works, all City departments that own property and/or assets in the SLR Vulnerability Zone

Several SLR vulnerability assessments have already been conducted within San Francisco for different asset sectors and projects (see Section 6, *Vulnerability and Risk Assessments* for details). As a priority, outstanding vulnerability assessments will be completed for additional asset types, such as ground transportation and buildings and properties. The City Administrator's Office, which has been leading collection of geocoded data on assets citywide, along with SF Planning, will help to coordinate efforts to ensure a consistent approach to recording vulnerabilities. The methodology (or a simplified version) used for the CPC guidance should be followed as described in Section 3.

There are a number of assets and communities likely to be particularly vulnerable to SLR, and special attention will be given to them as part of the assessment process, including:

- Finger piers and seawall (Port of SF)
- Existing seawall (SFO)
- Transportation system near the Embarcadero Station and vehicle storage/maintenance facilities along the waterfront (SFMTA)
- Stormwater system and discharges and Auxiliary Water Supply System (SFPUC)
- Some residential neighborhoods with a concentration of vulnerable populations (DPH, City Administrator's office)

Seeded by the information collected and created as part of the assessments, a centralized geocoded data management system with an online interface for SLR data (and eventually all climate change stressor data) will be created. This will allow agencies

to easily access and leverage existing data, identify and address data gaps, and manage data to support future analyses. Such a database would facilitate efficient collaboration and decision-making around adaptation planning and implementation.

As a priority, an outstanding citywide risk assessment will be completed, building on those already conducted within San Francisco. It will assess risk to San Francisco asset systems and social and environmental factors, as relevant to the assets under consideration. The City Administrator's Office and SF Planning will help to coordinate efforts. Risk data will be entered with vulnerability data in a centralized data management system.

CONDUCT COMPREHENSIVE ECONOMIC RISK ANALYSIS

BY SPRING 2018

Lead: Capital Planning Committee, OEWD, City Administrator's Office

This analysis will develop a deeper understanding of the economic risk of SLR, storm surge, and coastal flooding. Findings will lead to a richer and expanded understanding of the total exposure San Francisco faces from SLR over and above the cost of building and infrastructure replacement and repair. This might include the number of affected housing units, employees, wages, and payroll/property taxes.



King Tide on the Embarcadero
Image Courtesy of Flickr CC User "Tofu"

ADAPTATION PLANNING

DEVELOP SEA LEVEL RISE-SPECIFIC COMMUNITY EDUCATION AND ENGAGEMENT STRATEGY

BY FALL 2017

Lead: SF Planning, OEWD

In the near-term, information about SLR will be incorporated into the multiple planning processes already underway along the San Francisco shoreline. SF Planning will work with appropriate agencies and partners to make sure these opportunities are widely publicized and coordinated. Once the Citywide Adaptation Plan is initiated, a public engagement strategy will be developed to gather public input on potential policies and physical interventions. The San Francisco SLR Action Plan website will be used to publicize all public engagement opportunities to residents, businesses, and regional partners, as well as communicate findings from the adaptation planning process.

DEVELOP TRAINING PROGRAM FOR CAPACITY BUILDING

BY SUMMER 2017

Lead: SF Planning, OEWD, SFPUC

In addition to the public education and participation opportunities already mentioned, an engagement and training program will be developed for both capacity building within City departments and for local developers to facilitate understanding of San Francisco's approach to SLR.

LAUNCH AND COMPLETE THE BAY AREA RESILIENCY DESIGN CHALLENGE

BY SUMMER 2018

Lead: SF Planning

The Bay Area Resiliency Design Challenge aims to bring together hundreds of government representatives, community leaders, and technical experts from San Francisco, the Bay Area, and around the globe to address SLR and resiliency challenges that affect the Bay. As the most extensive, open forum for dialogue and collaboration

the area has ever convened around SLR and resiliency, the design challenge will co-create implementable solutions for the region. It will facilitate multiple and varied opportunities to spark the public's imagination around waterfront planning and change perceptions toward the synergies between land, water, and infrastructure. Ideas developed for the San Francisco shoreline as part of the competition will feed into the Adaptation Plan development process.

REVIEW POTENTIAL POLICY AND FINANCING TOOLS

BY SUMMER 2018

Lead: SF Planning, OEWD, OCII

To prepare for the Citywide Adaptation Plan process, potential policy and financing tools will be researched and reviewed that could provide clear guidance and funding for new public and private sector projects. This understanding will facilitate quicker decision making during the Adaptation Plan development. These tools may include:

- A San Francisco policy to exceed current minimum flood management requirements
- Adjusted building codes and subdivision regulations in the SLR Vulnerability Zone
- Monitoring, maintenance, and upgrade programs for shoreline protection infrastructure
- Identification/creation of cost-sharing contracting mechanisms to facilitate inter-agency collaboration on SLR-related actions
- Innovative insurance solutions at the State and federal levels, and in partnership with the private sector
- Public benefit negotiations with waterfront master plan developers structured to include contributions to current and future shoreline adaptation strategies through their infrastructure designs and financing plans
- Expansion of CPC Guidance from only projects requiring capital funding to all projects requiring San Francisco action, including permits or approvals

INITIAL ADAPTATION IMPLEMENTATION

DEVELOP INTERIM AIRPORT SHORELINE PROTECTION

2016–2020

San Francisco International Airport (SFO)

This initial project will provide system wide protection against 100-year floods and partial SLR protection by constructing various engineered shoreline improvements that meet FEMA's certification standards. These would include seawalls, flood/tidal gates, pump stations, levee and embankment stabilization, pavement overlay, and power enhancements. A segment of SFO's shoreline is federal land, owned by the US Coast Guard. Proactive collaboration with a federal agency will be necessary to complete a functional shoreline system. SFO has completed a Fiscal Feasibility Report for this project, which has been approved by the Board of Supervisors, and is proceeding with environmental documents for construction permitting.

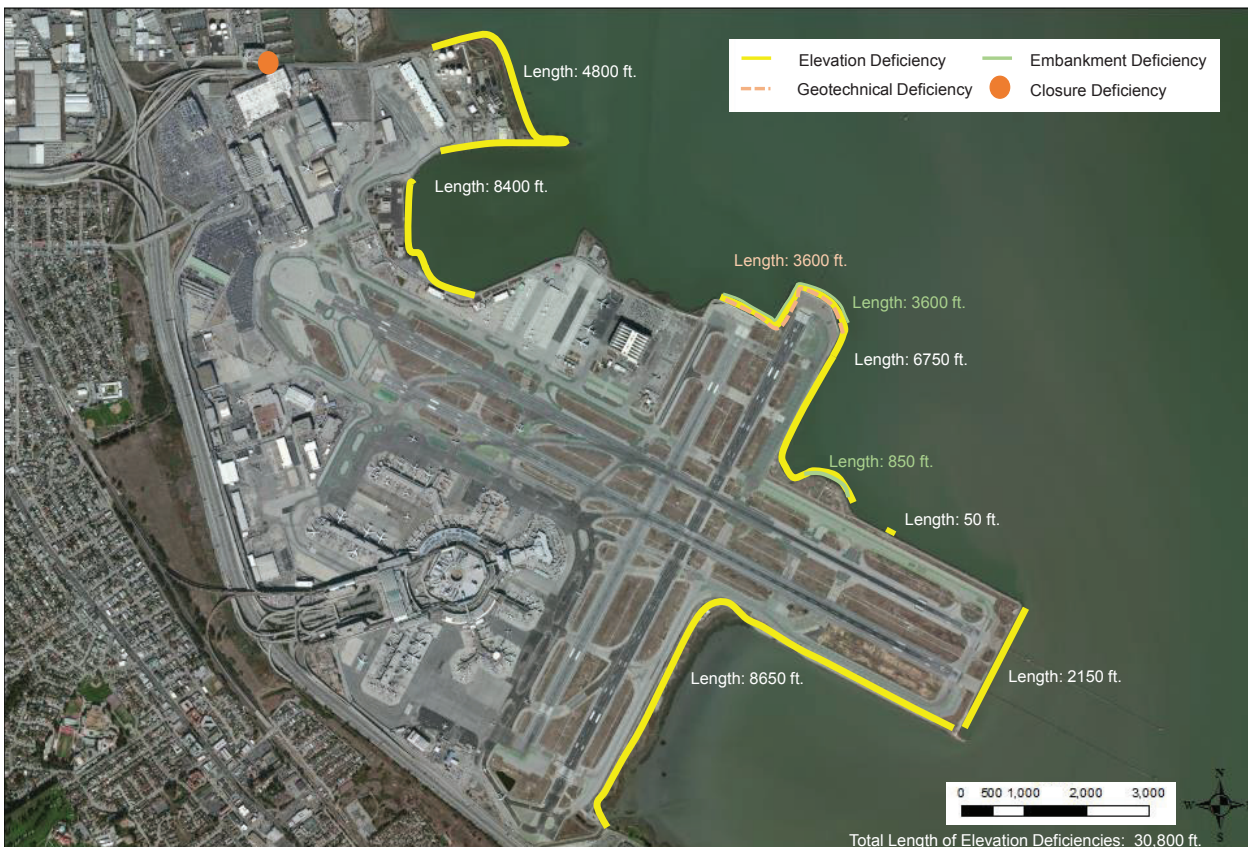
MONITOR AND INVESTIGATE BACKFLOW PREVENTION INSTALLATIONS AT COMBINED SEWER DISCHARGE STRUCTURES

ONGOING

SFPUC

An early SLR risk to San Francisco is the potential for seawater to overtop into low-elevation fixed weirs in Combined Sewer Discharge (CSD) outfall structures, ultimately entering wastewater treatment facilities and posing a risk of upsetting the wastewater treatment process due to increased salinity. In 2014, SFPUC installed its first backflow prevention device at the Baker Street CSD outfall structure. Additional installations are anticipated for other at-risk CSDs. Monitoring the Baker Street installation's performance during dry and rainy seasons for rejecting salinity and allowing CSDs to flow out during wet weather discharge events will

SFO CURRENT FLOOD PROTECTION SYSTEM DEFICIENCIES



Map courtesy of SFO

help inform the need for, and design of, backflow prevention on future CSD outfall structures. Enhanced wet-season monitoring to characterize the impact of higher tides associated with El Niño will also help future CSD backflow prevention projects.

DEVELOP LONG-TERM AIRPORT SHORELINE PROTECTION

2016–2025
SFO

Building on interim projects, long-term efforts would provide a greater focus on SLR protection by constructing adaptive shoreline seawalls with robust foundations to accommodate SLR over time and cut off seepage infiltration. Existing seawalls were built to prevent land erosion, not impacts from extreme weather events or SLR. Therefore, in addition to replacing and upgrading existing seawalls, this project will also replace sheet piles, construct new in-bay wave breaks or seawalls as needed to accommodate FAA height restrictions, and install flood protection equipment such as mechanical water barriers, flood/ tidal gates, and storm drain pump stations. In May 2015, SFO sent a Letter of Intent to the USACE to sponsor a federal General Investigation Feasibility Study on flood mitigation at SFO. Pending federal appropriations, SFO anticipates the Study to begin in Spring of 2016.

IMPLEMENTATION MONITORING

COORDINATE MONITORING AND TRACKING OF STORM EVENTS

IMMEDIATE AND ONGOING

Port of SF, Public Works, SFPUC, SFMTA

The increased depth and frequency of flooding expected due to El Niño elevated tide levels (possibly combined with large storms) will be similar to that expected after six to 12 inches of SLR. Key City departments have established systems to track and prepare for storm events. In addition, monitoring impacts (flooding extent, pathways and depths of inundation), successes, and lessons learned from storm and tide-related flooding, particularly during the 2015–2016 El Niño, will provide invaluable data for the future.

Planning responses and systems for current flooding events will ensure SLR planning and monitoring of impacts is adequately incorporated into all levels of government. In particular, developing a coordinated strategy for tracking the response to, and costs of, flooding events will inform accurate cost/benefit analyses of potential risk reduction strategies and “economic risk analysis” studies. Photographs of high-water levels and flooding impacts will be powerful communication and outreach tools. Pro-active engagement in the California King Tides Project, which encourages citizens to take photos of extreme high tides along the shoreline, will help collect such material.



Intersection flooding in the Mission District, Dec. 2014. *Image courtesy of Andrew Dudley / Hoodline*

SEA LEVEL RISE PRIORITY ACTIONS [2018–2019]

All the steps outlined in the previous section *Priority Actions 2016–2017* will prepare San Francisco for the development of a Citywide SLR Adaptation Plan, as well as geographically specific adaptation plans for especially high-risk assets along the shoreline.

ADAPTATION PLANNING

COMPLETE COMPREHENSIVE CITYWIDE SLR ADAPTATION PLAN

BY FALL 2019

Lead: SF Planning, Public Works, all City departments that own property and/or assets in the SLR Vulnerability Zone

The immediate next steps will provide valuable information for the successful development of the Adaptation Plan, the most important input being the completion of the citywide vulnerability and risk assessments.

The Adaptation Plan will identify and select potential new policies, as well as individual asset, neighborhood or district scale physical strategies, depending on identified risks. It is likely that feasibility studies and cost-benefit analyses will be required to identify the most appropriate physical interventions. This plan will consider and support existing geo-specific SLR planning efforts, such as the OBMP and LCP amendment planning along the Pacific Coast, plans in development for the Port, the airport, and proposed development along the Bay waterfront.



San Francisco from the Bay

Following the preliminary first step to expand and finalize the approach and methodology for the Adaptation Plan, the likely scope of work for its development would likely include these steps:

- **Analysis:** Coordinate data from completed vulnerability and risk assessments to identify and prioritize adaptation needs.
- **Strategy Development:** Identify strategy alternatives appropriate to minimize identified risks and provide, where possible, co-benefits. Strategies will include policy mechanisms, asset management changes as well as physical interventions. Strategy descriptions should include identification of responsible parties, funding mechanisms (if needed) and mechanisms to promote inter-agency and regional coordination.
- **Public Engagement:** Develop a comprehensive engagement program that includes regular review by the Private-Public Advisory Committee, as well as opportunities for wider public consultation.
- **Strategy Selection:** Develop evaluation criteria for selecting and prioritizing strategies for most vulnerable and at risk assets, incorporating a triple bottom line approach of social, financial, and environmental criteria. Carry out both quantitative and qualitative feasibility studies and stakeholder engagement to select/prioritize strategies.

ADAPTATION PLANNING, CONTINUED

- **Implementation:** Develop funding strategies for selected/prioritized strategies and a timeframe for implementation. There are likely to be short term and long term strategies within the Adaptation Plan. Develop a collaborative process across City departments and with other bodies and organizations for implementing projects across sectors and city boundaries.
- **Monitoring:** Identify the processes to measure and evaluate performance of the strategies and regular scientific review and update.

DEVELOP NEAR-TERM ADAPTATION PLANS FOR HIGHER-RISK SHORELINE ASSETS AND GEOGRAPHIC AREAS

BY FALL 2019

Lead: Port of SF, SFO, Public Works, OCII

As soon as the most high risk shoreline assets (and potentially areas) have been identified, specific plans for these assets will be fast tracked so that immediate opportunities for intervention are not lost. Some of these geo-specific plans are already ongoing, such

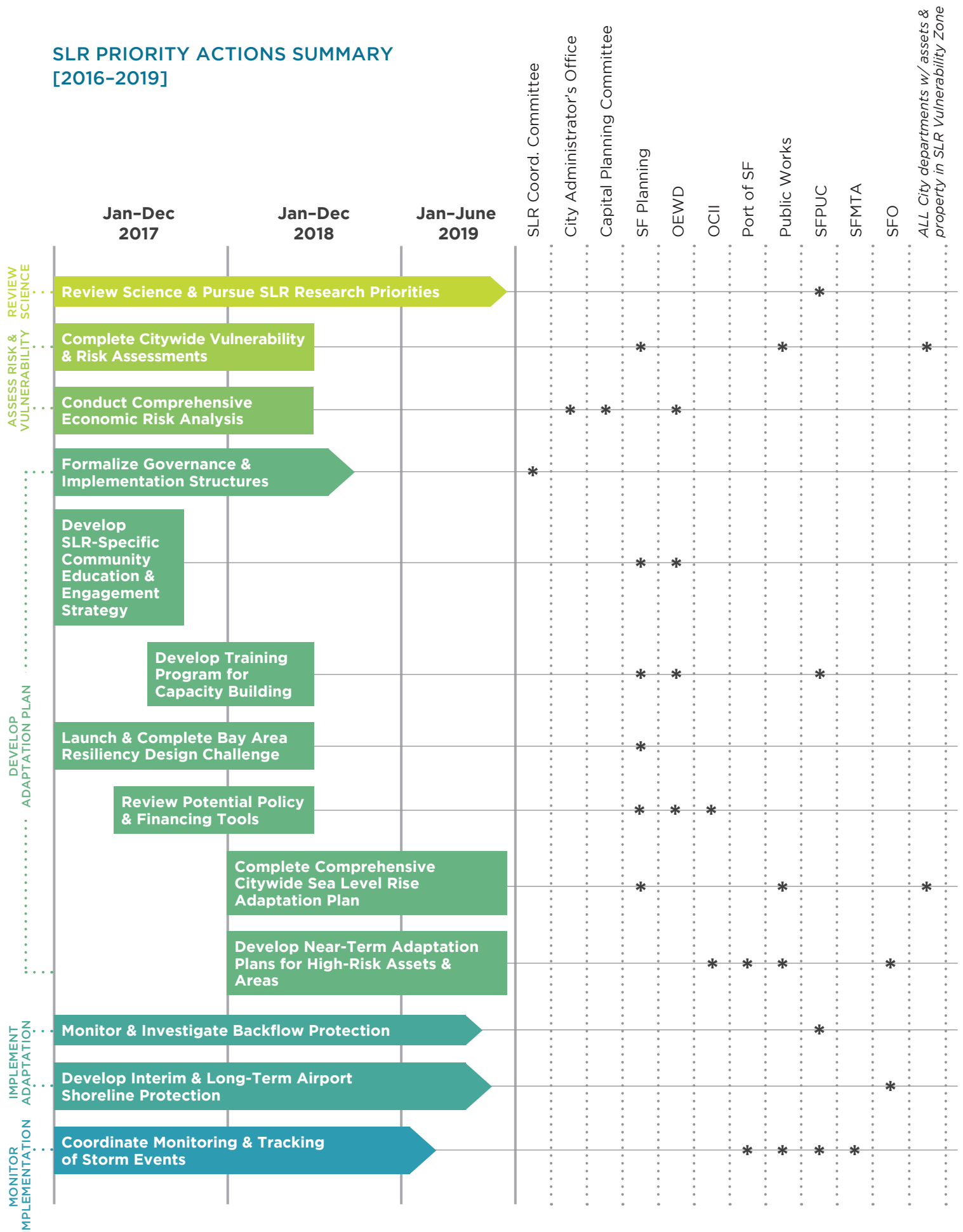
as those for Ocean Beach and SFO. It is likely that these plans will identify strategies for specific at-risk assets at a greater level of detail than the citywide San Francisco SLR Adaptation Plan. Each plan will consider the existing diversity and character of the area, and will involve local community engagement. As identified in the previous section under Complete Citywide Vulnerability and Risk Assessments, there are a number of assets that are likely to be identified as high risk, and for which these fast track strategies may be developed, including:

- Finger piers and seawall [Port of SF]
- Existing seawall [SFO]
- Transportation system near the Embarcadero MUNI/BART station and vehicle storage/maintenance facilities along the waterfront (Bayshore) [SFMTA]
- Storm water system and discharges; Auxiliary Water Supply System [SFPUC]
- Some residential neighborhoods with a concentration of vulnerable populations [DPH, City Administrator's Office]



Agua Vista Park, looking south towards Mission Rock and Pier 70

SLR PRIORITY ACTIONS SUMMARY [2016-2019]



APPENDIX

3. Climate Design

ACKNOWLEDGEMENTS

SLR COORDINATING COMMITTEE MEMBERS:

- Co-Chair: Gil Kelley, Director of Citywide Planning, San Francisco Planning Department
- Co-Chair: Fuad Sweiss, City Engineer & Deputy Director, San Francisco Public Works Department
- Roger Kim, Mayor's Office
- Ivar Satero, San Francisco International Airport
- David Behar, Kathryn How, San Francisco Public Utilities Commission
- Tom Maguire, San Francisco Municipal Transportation Agency
- Ken Rich, Office of Economic and Workforce Development
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- Laura Harnish, Armin Munevar, CH2M
- Risk Management Solutions (RMS)

SUPPORTED IN PART BY:

- 100 Resilient Cities



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AECOM



ch2m

LIST OF ACRONYMS

100RC	100 Resilient Cities—a Rockefeller Initiative
ABAG	Association of Bay Area Governments
ART	Adapting to Rising Tides
BAECCC	Bay Area Ecosystems Climate Change Consortium
BARC	Bay Area Regional Collaborative
BCDC	San Francisco Bay Conservation and Development Commission
CCC	California Coastal Commission
CDFW	The California Department of Fish and Wildlife
CHARG	San Francisco Bay Region Coastal Hazards Adaptation Resiliency Group
CPC	San Francisco Capital Planning Committee
CPC Guidance	Capital Planning Committee Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and Risk to Support Adaptation
CRI	Climate Readiness Institute
CSD	Combined sewage discharge
CSLC	California State Lands Commission
DPH	San Francisco Department of Public Health
FEMA	The Federal Emergency Management Agency
FIRMs	(National) Flood Insurance Rate Maps
GGNRA	Golden Gate National Recreation Area
GHG	Greenhouse gas
LCP	Local Coastal Program
MHHW	Mean Higher High Water
MTC	Metropolitan Transportation Commission
Navy	U.S. Department of the Navy
NFIP	National Flood Insurance Program
OBMP	Ocean Beach Master Plan
OCII	Office of Community Investment and Infrastructure

OCOF	Our Coast, Our Future
OEWD	Office of Economic and Workforce Development
RCI	Bay Area Resilient Communities Initiative
RWQCB	The San Francisco Bay Regional Water Quality Control Board
SF Planning	San Francisco Planning Department
SFDEM	San Francisco Department of Emergency Management
SFPW	San Francisco Public Works Department
SFMTA	San Francisco Municipal Transportation Agency
SFO	San Francisco International Airport
SFPUC	San Francisco Public Utilities Commission
SFRPD	San Francisco Recreation and Parks Department
SLR	Sea level Rise
SSIP	Sewer System Improvement Program
State Parks	California Department of Parks and Recreation
Port of SF	The Port of San Francisco
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
Waterfront Plan	The Waterfront Land Use Plan

REFERENCES

¹ San Francisco Capital Planning Committee, Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and Risk to Support Adaptation. Prepared by the City and County of San Francisco Sea Level Rise Committee for the San Francisco Capital Planning Committee. September 22, 2014

² DHI, Regional Coastal Hazard Modeling Study for North and Central Bay. Prepared for FEMA. September 2011.

³ Federal Emergency Management Agency, San Francisco Bay Area Coastal Study. California Coastal Analysis and Mapping Project. October 2013.

⁴ SFPUC, Climate Science Data Inventory and Technical Memorandum. February 2014.

⁵ SFPUC, Climate Stressors & Impacts: Shoreline Assessment Technical Memorandum. October 2014.

⁶ SFPUC, Climate Stressors & Impacts: Westside Sea Level Rise Mapping Technical Memorandum. June 2014.

⁷ SFPUC, Climate Stressors & Impacts: Bayside Sea Level Rise Mapping Technical Memorandum. March 2015.

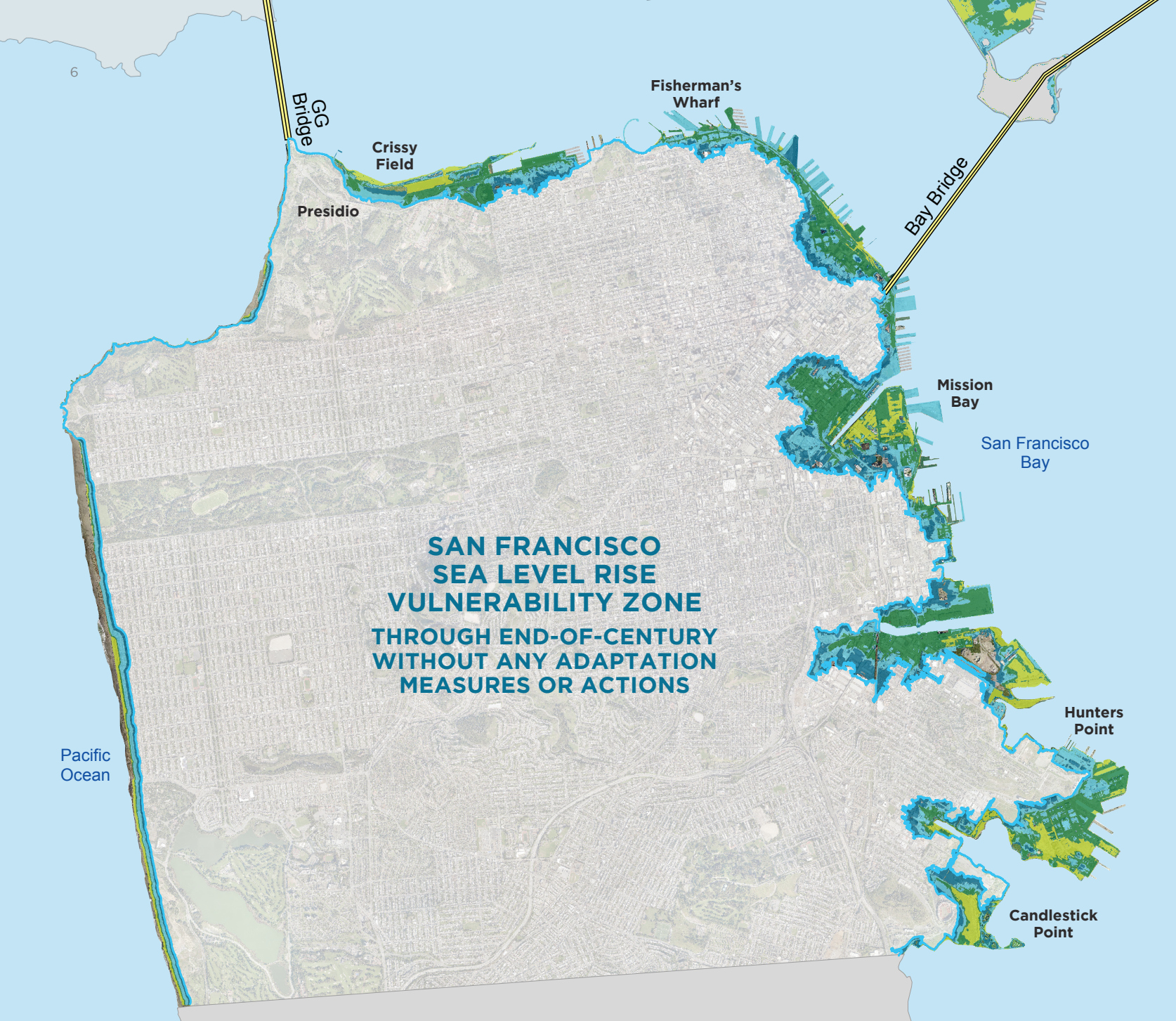
⁸ Knowles, N., Potential Inundation Due to Rising Sea Levels in the San Francisco Bay Region. San Francisco Estuary and Watershed Science, 8(1). 2010.

⁹ URS/AGS, Sea Level Rise and Adaptation Study. Prepared for the Port of San Francisco. June 29, 2012.

¹⁰ Baker, AECOM, Intermediate Data Submittal #4. Draft Floodplain Mapping. San Francisco County, California. California Coastal Analysis and Mapping Project/Open Pacific Coast Study. Submitted to FEMA Region IX. July 2014.

¹¹ Baker, AECOM, Sea Level Rise Pilot Study: Future Conditions Analysis and Mapping for San Francisco County, California. 2015, in review.

¹² SFPUC, Ocean Beach Master Plan: Coastal Management Framework. April 2015.



Legend

— Sea Level Rise Vulnerability Zone

Coastal Flood Levels

12" SLR + 100 year storm 36" SLR + 100 year storm
24" SLR + 100 year storm 66" SLR + 100 year storm

NOTE: Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's average high tide.

0 3,400 6,800
Feet



Map Disclaimer: The inundation maps and the associated analyses are intended as planning level tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The maps do not represent the exact location of flooding. The maps relied on a 1-m digital elevation model created from LiDAR data collected in 2010 and 2011. Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures narrower than the 1-m horizontal map scale may not be fully represented. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or Open Coast. For more context about the maps and analyses, including a description of the data and methods used, please see the Climate Stressors and Impacts Report: Bayside Sea Level Rise Inundation Mapping Technical Memorandum, March 2014 and FEMA Open California Coast Sea Level Rise Pilot Study, San Francisco County, 2015.

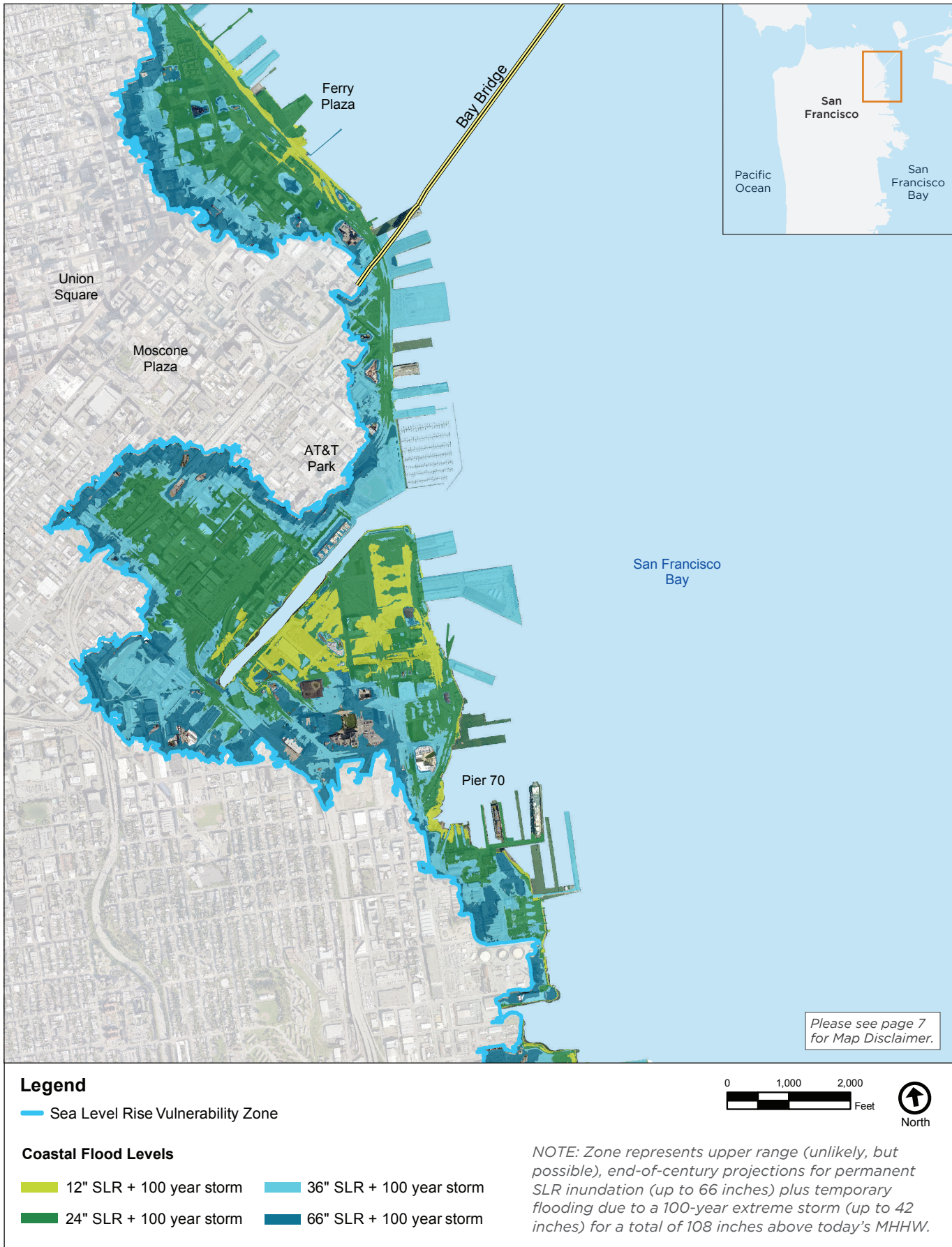
Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

SLR VULNERABILITY ZONE—NORTHERN BAYSHORE, WITHOUT ADAPTATION



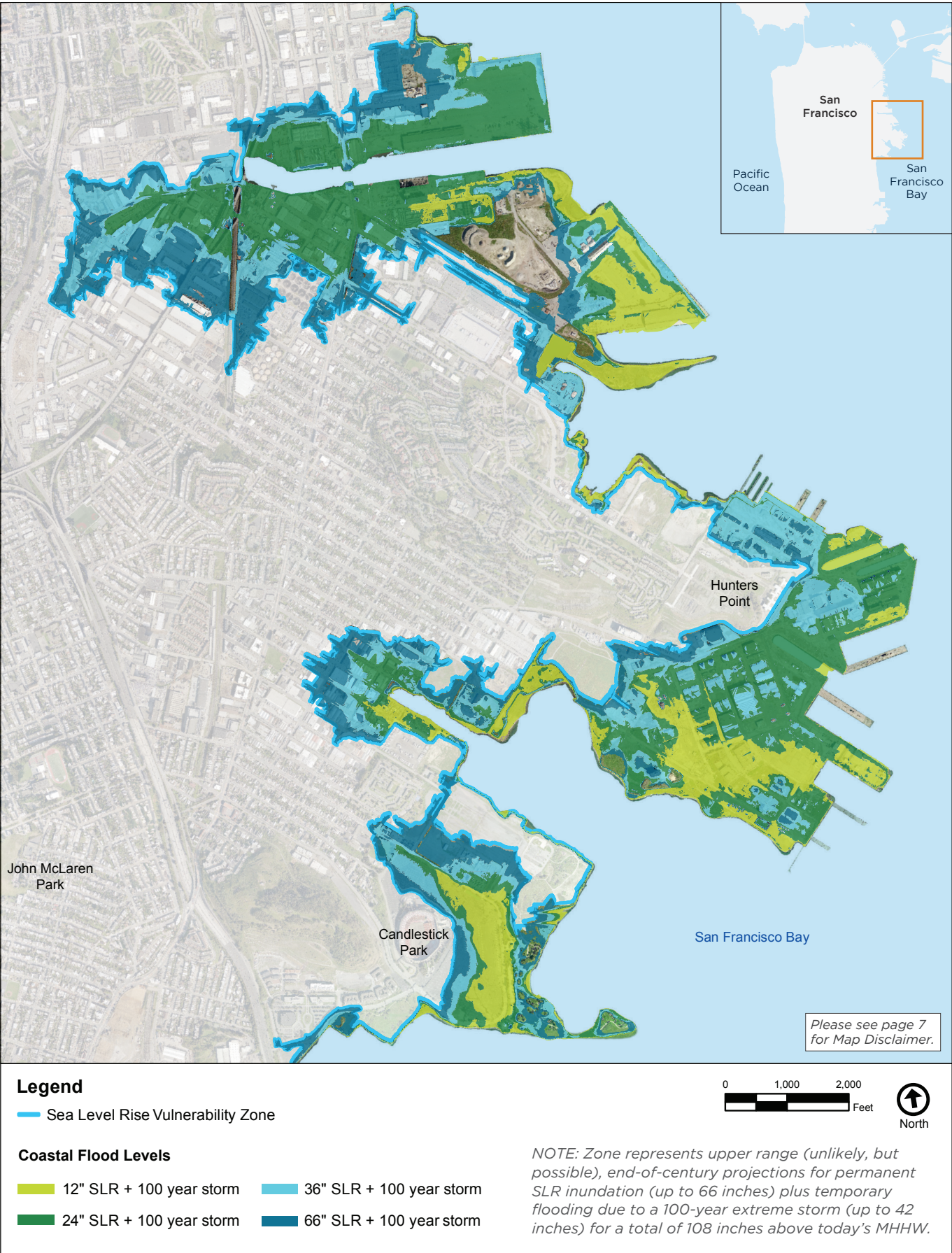
Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

SLR VULNERABILITY ZONE—DOWNTOWN TO CENTRAL BAYSHORE, WITHOUT ADAPTATION



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

SLR VULNERABILITY ZONE—SOUTHERN BAYSHORE, WITHOUT ADAPTATION



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

SLR VULNERABILITY ZONE—SAN FRANCISCO AIRPORT SHORELINE, WITHOUT ADAPTATION



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015.

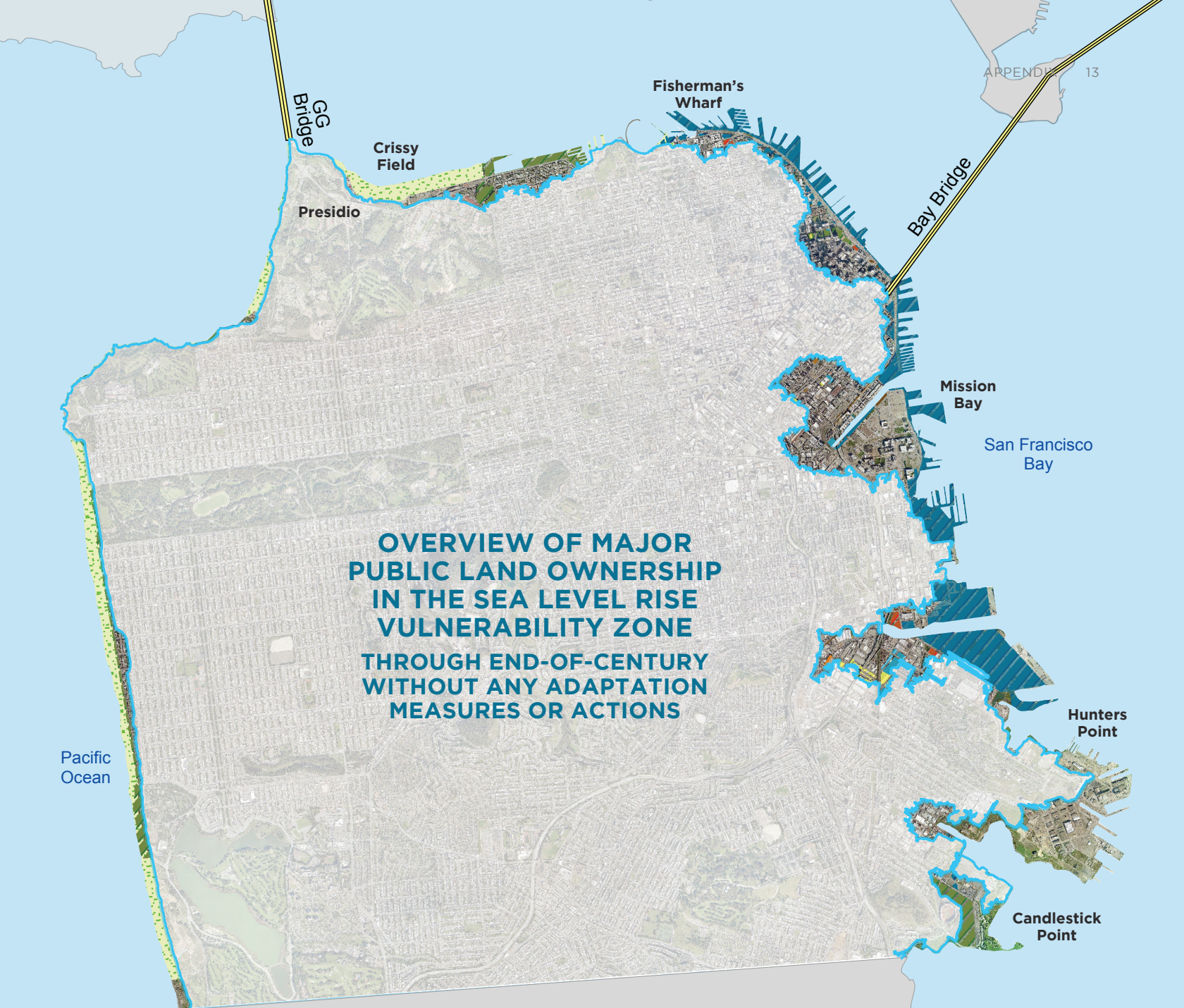
SLR VULNERABILITY ZONE—NORTHERN PACIFIC COAST, WITHOUT ADAPTATION



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

SLR VULNERABILITY ZONE—SOUTHERN PACIFIC COAST, WITHOUT ADAPTATION





Legend

— Sea Level Rise Vulnerability Zone

Jurisdiction

Port of San Francisco
 Recreation & Park (SFRPD)
 Fire (SFFD)
 Public Works (SFPDW)

Golden Gate National
 Recreation Area (GGNRA)
 Municipal Transportation
 Agency (SFMTA)

Public Utilities Commission (SFPUC)
 Other City Owned
 SF Unified School District

DRAFT: Land ownership under transition for some parcels.

0 3,400 6,800 Feet



NOTE: SLR Vulnerability Zone represents upper range (unlikely, but possible), end-of-century projections for permanent SLR inundation (up to 66 inches) plus temporary flooding due to a 100-year extreme storm (up to 42 inches) for a total of 108 inches above today's MHHW.

Map Disclaimer: The inundation maps and the associated analyses are intended as planning level tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The maps do not represent the exact location of flooding. The maps relied on a 1-m digital elevation model created from LiDAR data collected in 2010 and 2011. Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures narrower than the 1-m horizontal map scale may not be fully represented. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or Open Coast. For more context about the maps and analyses, including a description of the data and methods used, please see the Climate Stressors and Impacts Report: Bayside Sea Level Rise Inundation Mapping Technical Memorandum, March 2014 and FEMA Open California Coast Sea Level Rise Pilot Study, San Francisco County, 2015.

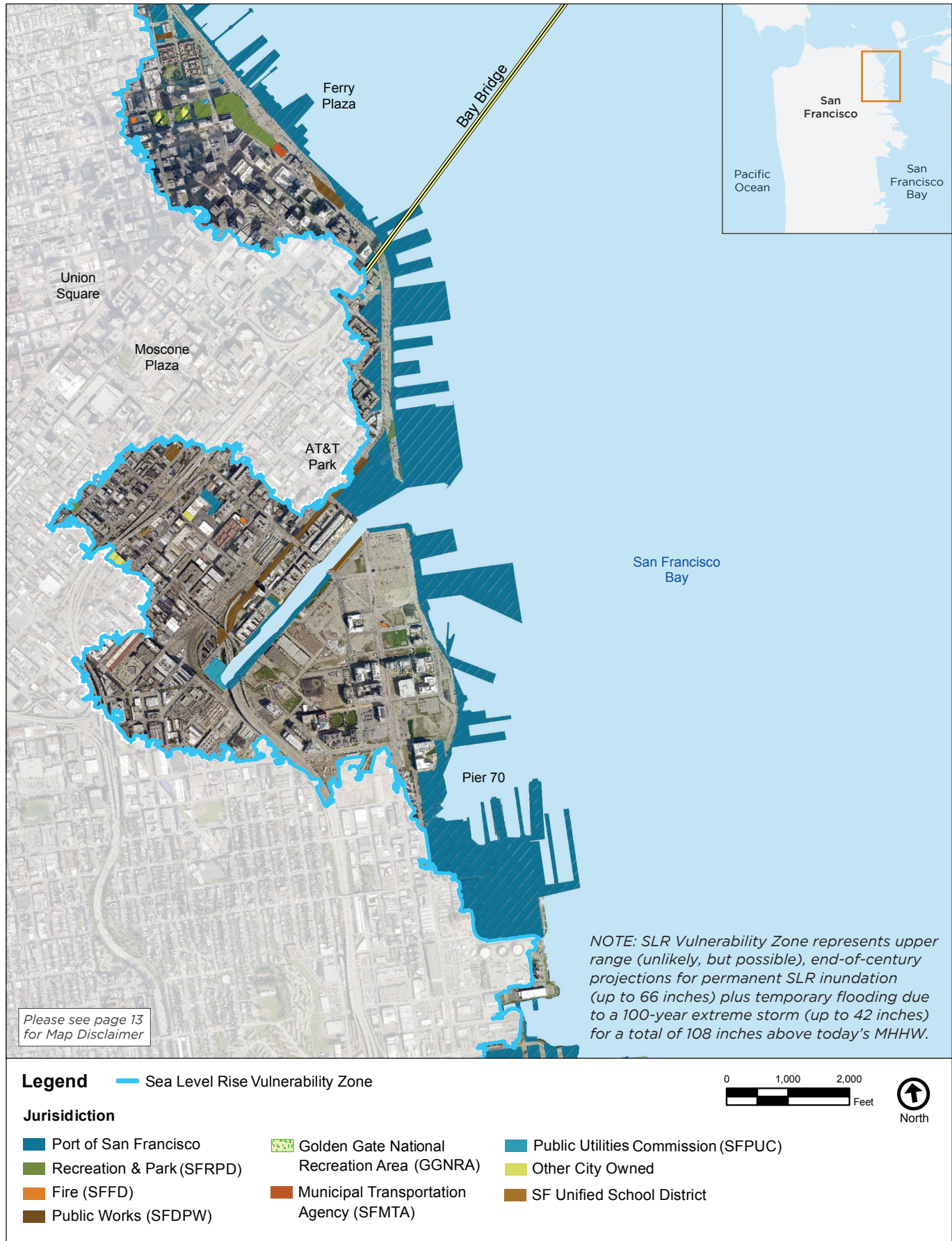
Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—NORTHERN BAYSHORE



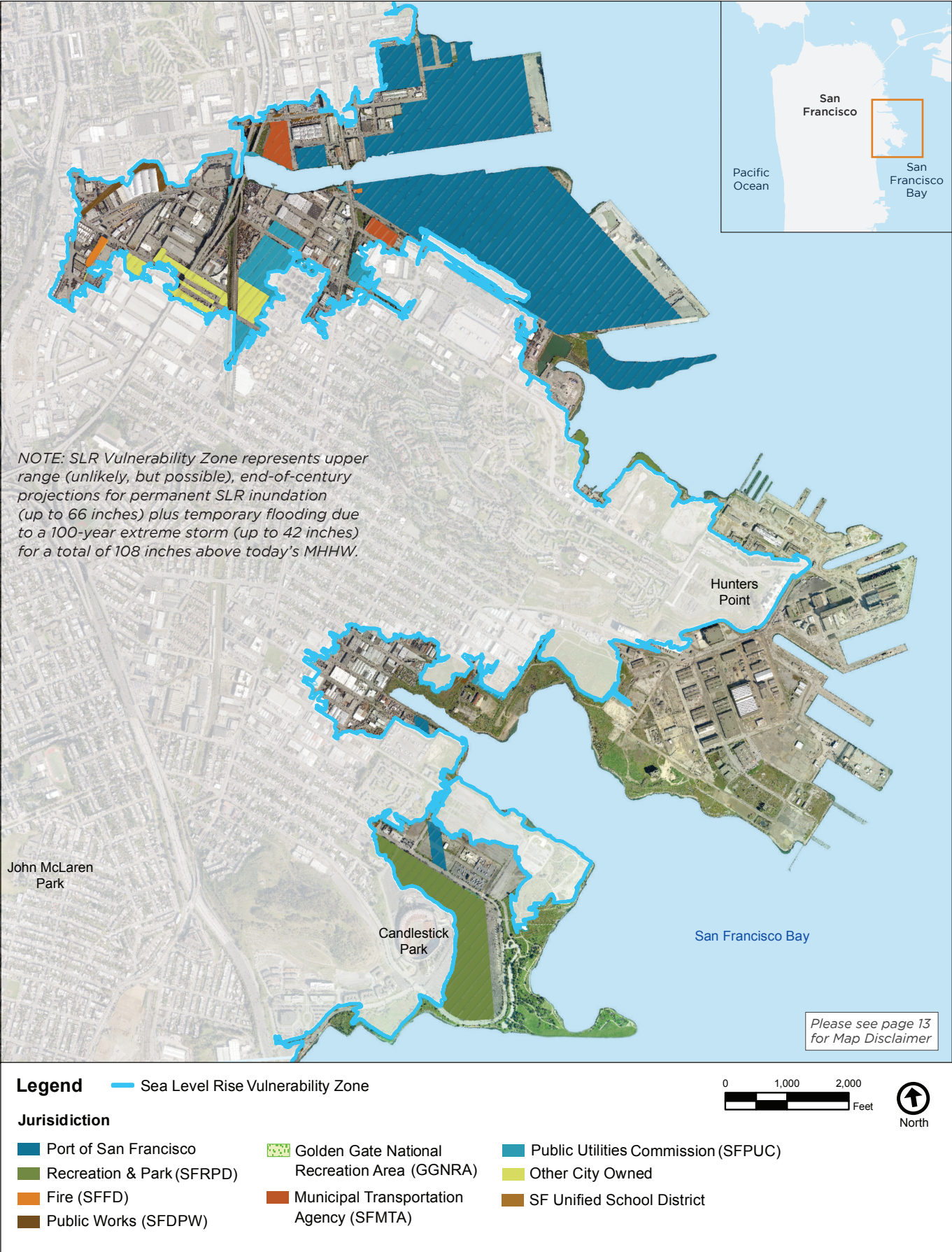
Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—DOWNTOWN TO CENTRAL BAYSHORE



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—SOUTHERN BAYSHORE



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—NORTHERN PACIFIC COAST



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.

PUBLIC LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE—SOUTHERN PACIFIC COAST



Data Source: Bayside—SFPUC SSIP Inundation Mapping, 2015. Westside—FEMA Sea Level Rise Pilot Study, 2015.





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