CITY AND COUNTY
OF SAN FRANCISCO

EXECUTIVE SUMMARY

SAN FRANCISCO SEA LEVEL RISE ACTION PLAN

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

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, along with the Executive Directive, 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.

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
- Eunejune Kim, Port of San Francisco
- Sally Oerth, Office of Community Investment and Infrastructure
- Tom Hui, Department of Building Inspection
- Patrick Otellini, City Administrator's Office
- Brian Strong, Capital Planning

OTHER CONTRIBUTORS:

- Diana Sokolove (Project Manager), Lisa Fisher, San Francisco Planning Department
- Micah Hilt, City Administrator's Office
- Michael Carlin, Anna Roche, Stefani Harrison, San Francisco Public Utilities Commission
- Brad Benson, Diane Oshima, Uday Prasad, David Beaupre, Port of San Francisco
- Leigh Lutenski, Michael Martin, Office of Economic and Workforce Development
- Timothy Doherty, Craig Rafael, San Francisco Municipal Transportation Agency
- Boris Deunert, Iqbalbhai Dhapa, Rahul Shah, San Francisco Public Works Department
- Carolyn Jayin, Ronald Tom, Department of Building Inspection
- Rosalyn Yu, San Francisco International Airport

CONSULTANTS:

- Claire Bonham-Carter, Kris May, Rebecca Verity, AECOM (photo source, unless otherwise credited)
- Laura Harnish, Armin Munevar, CH2M
- Risk Management Solutions (RMS)

SUPPORTED IN PART BY:

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INTRODUCTION

Proactive, thoughtful adaptation planning will help San Francisco minimize risks and meet the challenges posed by rising seas.

San Francisco is committed to planning for and adapting to the anticipated and unavoidable impacts of climate change (sea level rise (SLR) inundating 6% of the city by end-of-century) in an innovative manner that boosts the local economy while reducing greenhouse gas emissions. A strategic focus on the immediate and long-term threats of SLR and associated coastal flooding led to the City's 2014 "Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco" (CPC Guidance). In 2015, Mayor Lee established the SLR Coordinating Committee with representatives from major City 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 and a key element in San Francisco's comprehensive SLR Resiliency Program (see below). Strategic partnerships and collaborations with local and regional stakeholders will be essential for successful adaptation planning and implementation.

VISION

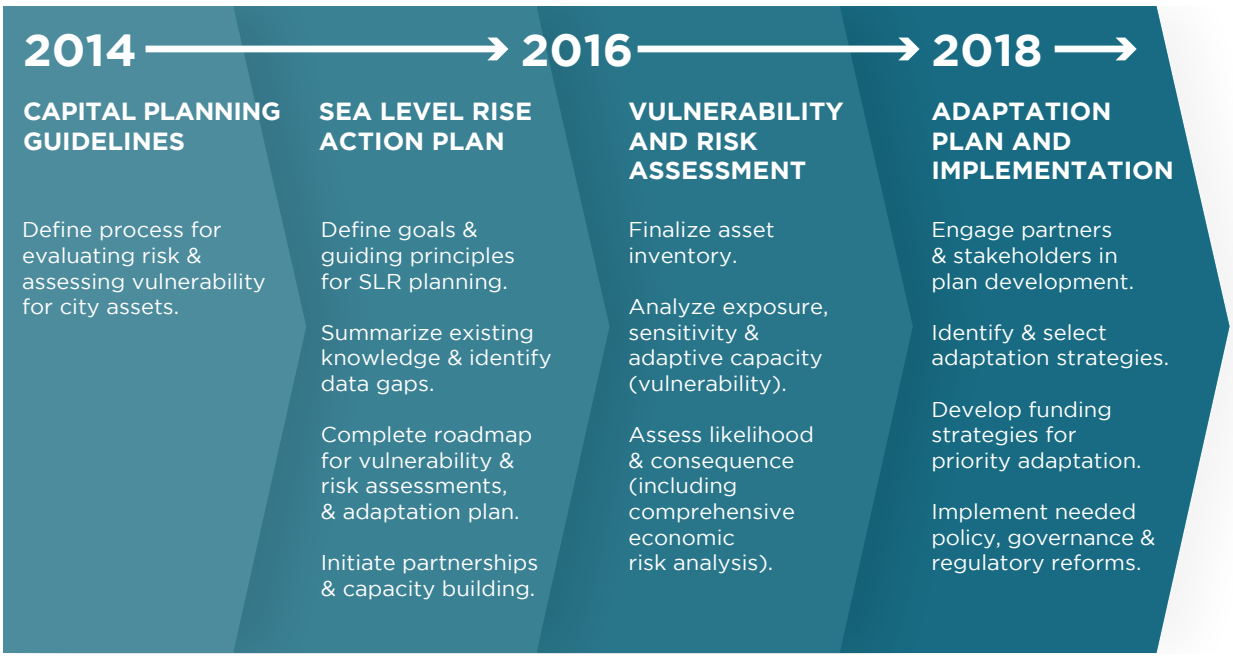
Make San Francisco a more resilient city in the face of immediate and long-term threats of sea level rise to the Bayshore and Pacific Coast, by taking measures to protect and enhance public and private assets, natural resources, and the quality of life for all.

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

SAN FRANCISCO SEA LEVEL RISE RESILIENCY PROGRAM



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
- Foster transparency and openness through dependable and actionable information
- Promote regional collaboration
- Promote an understanding of shared responsibilities (public, private, community)
- Foster innovative, interdisciplinary design approaches and solutions
- Monitor evolving climate science and adapt approaches accordingly
- Develop rigorous metrics and track progress for reducing vulnerability, risk, and impacts

ADAPTATION FRAMEWORK

Adaptation planning and implementation typically follows a cyclical, six-step process (see diagram below). 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 2016–2018, 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. Projections and adaptation strategies identified as most appropriate for San Francisco today will be revisited and revised over time as science and information evolves.

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 help inform the prioritization of assets for adaptation planning.

STEP 4: DEVELOP ADAPTATION PLAN

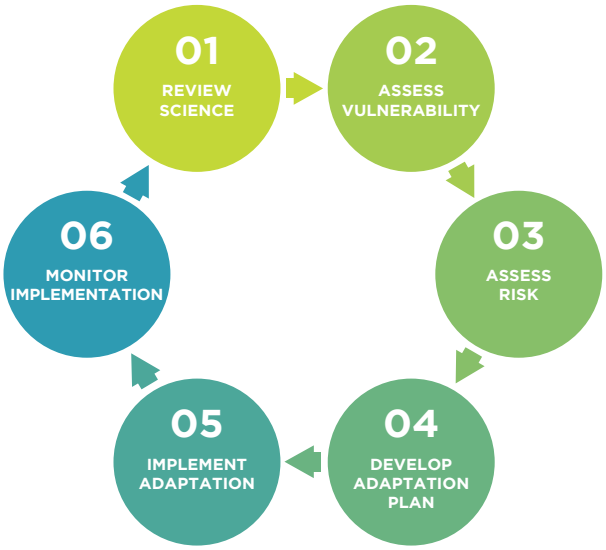
Once assets have been prioritized for adaptation, comprehensive planning evaluates the best strategies to reduce vulnerability and risk. Good planning will engage those who may be affected by or responsible for the impacts of SLR. The process will encourage and integrate innovative, interdisciplinary design thinking and solutions for adaptation.

STEP 5: IMPLEMENT ADAPTATION

Current adaptation implementation in San Francisco will continue 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

Ongoing monitoring is critical. It highlights which actions are most effective, any unintended consequences, and new data that may change direction or inspire additional strategies. Effective adaptation planning include monitoring types and timeframes, thresholds, reporting requirements, and identification of responsible parties.



THE SCIENCE OF SEA LEVEL RISE

In the last century, sea levels have risen eight inches around the San Francisco Bay and Pacific Coast. By end-of-century, they are most likely to rise an additional 36 inches. Keeping up to date with SLR science advances over time is vital to developing appropriate and implementable adaptation.

CURRENT/ FUTURE IMPACTS

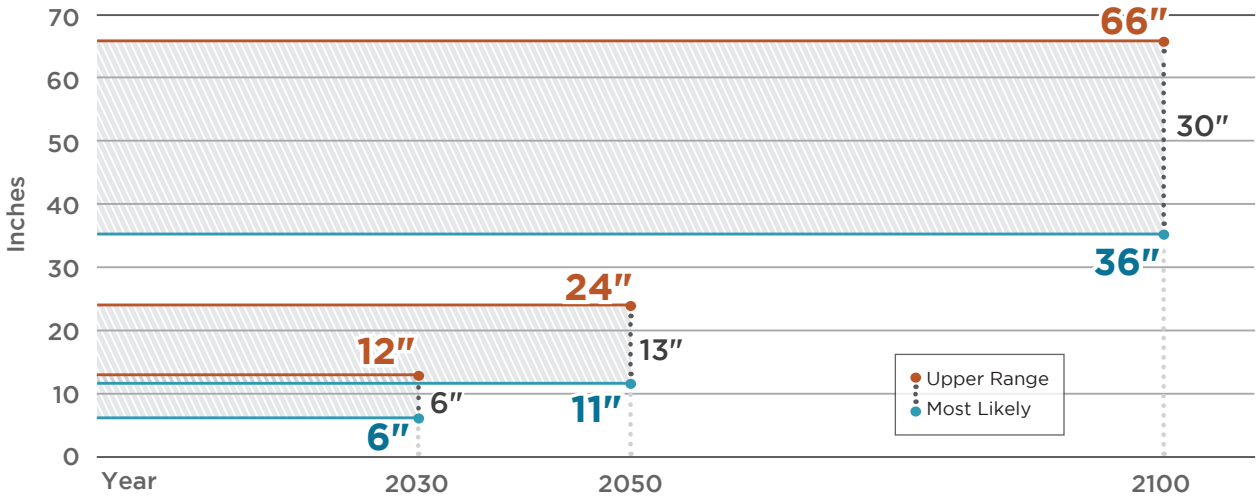
Rising Bay and coastal water levels are already affecting San Francisco with periodic coastal flooding of low-lying shorelines, increased shoreline erosion, and salt water impacts to its wastewater treatment systems. Over the coming decades, SLR-related impacts will increase in frequency and extent, and more areas will experience periodic coastal and/ or urban flooding. Shorelines built on Bayfill and at risk of subsidence may have intensified flooding risks, and higher groundwater levels may increase liquefaction during earthquakes. Without action, a variety of coastal hazards will increase as seas rise, including:

- Temporary coastal flooding from extreme tides. Damaged infrastructure, impacted sewage system, and road closures
- Urban flooding (rainfall runoff). Service disruptions and Bay sewage discharge
- Shoreline erosion. Impaired roadways and reduced recreation and natural areas
- Regular King Tide flooding (typically 12 inches higher than average daily high tide). Significant and more frequent closures on the Embarcadero
- Daily tidal inundation. Permanent inundation on 6% of San Francisco by end-of-century
- Weather and weather cycles. Potential for more frequent and intense storms

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 therefore includes shoreline areas that could be exposed to 66 inches of permanent SLR inundation with temporary flooding from a 100-year 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.

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: SLR projections do not include extreme tides or coastal storms, which could add up to 42 inches of temporary flooding, for a total of 108 inches above today's average high tide.

Legend

Sea Level Rise Vulnerability Zone

0 3,400 6,800 Feet

North

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.

DESIGNING FOR RISING SEAS: INNOVATIVE SLR ADAPTATION

The complex and evolving nature of climate change-related impacts demand innovative 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, but many parts of the existing built environment along the Bayshore and Pacific Coast remain vulnerable.

DESIGN THINKING APPLIED TO SLR CHALLENGES

In 2016, 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 (RBD), a multi-stage planning and design competition launched in 2013 in response to the physical and structural damage caused by Superstorm Sandy. RBD selected 10 of the 148 teams from around the globe to take on specific projects throughout the New York region. The process engaged 535 organizations, 141 neighborhoods and cities, 181 government agencies, and 64 community events. RBD is a model for robust inclusivity that has inspired new collaborative methods for disaster planning and responses.

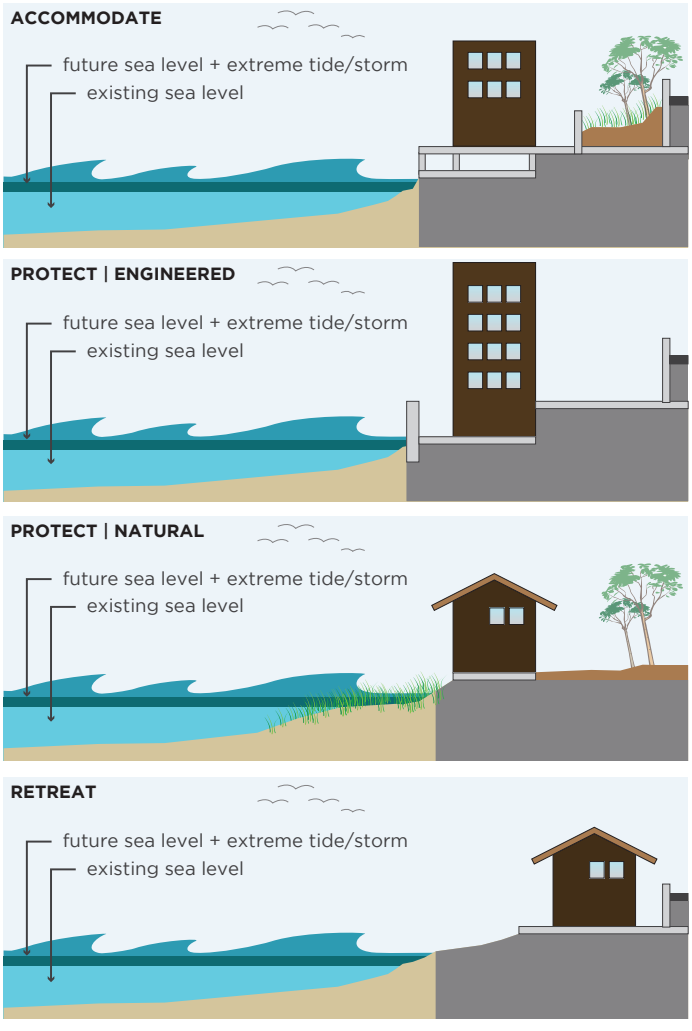
Proposal for Lower Manhattan from the BIG team

ADAPTATION STRATEGY DEVELOPMENT

For San Francisco, thoughtful adaptation efforts will likely focus on governance related strategies (e.g., zoning, design standards, maintenance procedures) and innovative physical strategies (e.g., green infrastructure, structure elevations, and flood barriers). Solutions may be implemented at multiple scales and timeframes, and in combination in order to optimize performance and efficiency.

In general, SLR adaptation requires one or a combination of three options: **accommodate** (raise or waterproof assets in place), **protect** (create natural or engineered barriers, such as wetlands or levees), or **retreat** (relocate sensitive assets to low-risk areas and/or transition high-risk areas to lower-risk uses).

INTERVENTION OPTIONS

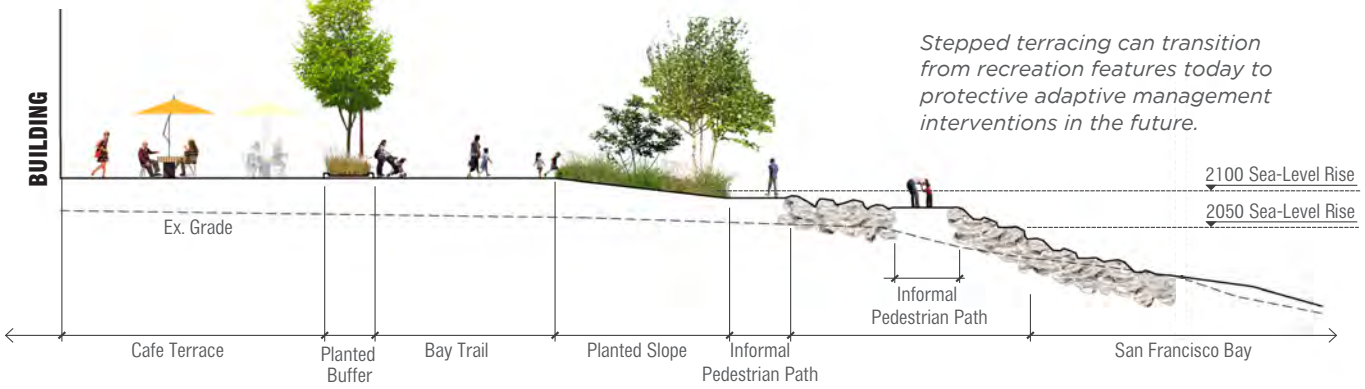


PIER 70: CRANE COVE PARK AND PIER 70 WATERFRONT PARK, BAYSHORE

Crane Cove Park. 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.

Pier 70 images courtesy of 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.

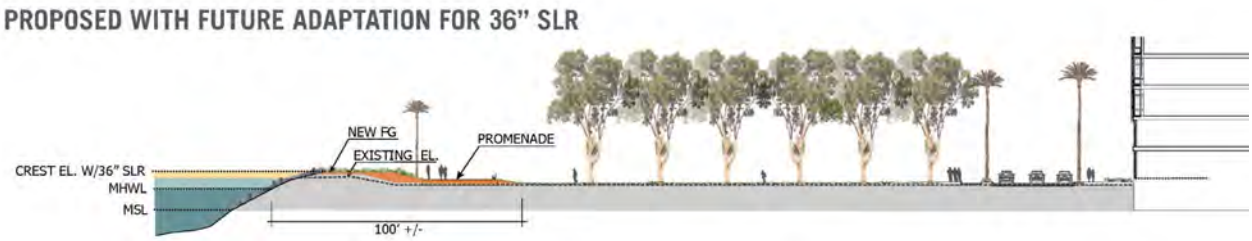
INDIA BASIN WATERFRONT

The waterfront design includes living shoreline strategies to create an adaptive and resilient Bayshore with a 100-year horizon. Natural coastal processes inform shoreline protection devices, such as wave attenuation, habitat creation, and upland habitat migration. Potential bioengineered devices include expanded tidal marshes, dunes, floating islands, terraced wetlands, artificial reefs, and eel grass beds. Together, these strategies could provide triple bottom line benefits, including a robust set of ecosystem services, to the area.

Image courtesy of Build Inc. and Bionic

TREASURE ISLAND: ADAPTIVE MANAGEMENT FOR SEA LEVEL RISE, BAYSHORE

This 450-acre development will transform a former military base into a model community of sustainable living. Plans for development of the low lying Treasure Island include both initial adaptation strategies and flexible longer-term adaptive management to address rising seas. From the outset, the project will develop elevated grades to protect all buildings and streets from SLR. Development will be set back from the water's edge to support future perimeter SLR adaptation projects. The waterfront open spaces will be designed with graduated elevations that allow for adaptive recreation and habitat areas over time. The project will also direct that Special Taxes collected via new Community Facilities Districts pay for future SLR adaptation. To accommodate rising seas beyond mid-century projections, Treasure Island includes a SLR monitoring program plus periodic flood risk assessments. 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.



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

OCEAN BEACH MASTER PLAN: SHORELINE PROTECTION, PACIFIC COAST

The three main options of shoreline protection (accommodate, protect, and retreat) are currently being incorporated into SLR planning along the Pacific Coast. The Ocean Beach Master Plan (an iterative planning process that included robust stakeholder and community engagement) recommends eventual retreat and rerouting along some discreet portions of the Great Highway, while protecting the critical Lake Merced Wastewater Tunnel with new layers of physical protection. It also recommends improving natural protective infrastructure (dunes and vegetative habitat) and replacing roads and parking lots with open space, bicycle, and pedestrian paths.

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

REGULATORY FRAMEWORK

The complex nature of land ownership and governance around coastal protection in San Francisco underscores the essential need for collaborative approaches to 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. Building partnerships with these stakeholders will 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 among coastal cities, and will continue to work with State and federal partners to develop effective, protective, and equitable SLR solutions.

LAND OWNERSHIP IN THE SLR VULNERABILITY ZONE

San Francisco's SLR Vulnerability Zone is comprised of public land owners, such as local, State, and federal agencies, as well as private residential and commercial properties in various stages of development. Public land owners around San Francisco's coasts include:

- **Federal Properties**
  - Golden Gate National Recreation Area
  - The Presidio Trust
  - U.S. Department of the Navy
- **State Property**
  - California Department of Parks and Recreation
- **San Francisco Properties**
  - Port of San Francisco
  - San Francisco Recreation and Parks Department (SFRPD)
  - San Francisco Public Utilities Commission
  - San Francisco Public Works (SFPW)
  - San Francisco Municipal Transportation Agency (SFMTA)
  - San Francisco Department of Real Estate
  - San Francisco Fire Department
  - Office of Community Investment and Infrastructure (OCII)
  - San Francisco International Airport (SFO)

REGULATORY JURISDICTIONS

Public policy around climate change, flood risk, and SLR is evolving rapidly at all levels of governance, and 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 other authorizations may be needed for shoreline protection or coastal development.

Federal

Executive Order 13690 (2015) directs Federal agencies to incorporate SLR considerations into decision making and operations. Coastal or SLR-related projects may need authorization from the following agencies:

- U.S. Army Corps of Engineers (USACE)
- Federal Emergency Management Agency (FEMA)
- U.S. Fish and Wildlife Service and National Marine and Fisheries Service

State

The Office of the Governor passed Executive Orders directing State agencies to issue climate change guidance and SLR, such as:

- California Coastal Commission (jurisdiction over Pacific Coast development)
- Bay Conservation and Development Commission (jurisdiction over Bayside development)
- San Francisco Bay Regional Water Quality Control Board (RWQCB)
- California State Lands Commission (jurisdiction over development and access to submerged and tidal lands)
- The California Department of Fish and Wildlife (CDFW)

San Francisco

Coastal or SLR-related projects may need authorization from the following agencies:

- San Francisco Planning Department
- San Francisco Capital Planning Committee
- Office of Community Investment and Infrastructure (OCII)
- Port of SF

ENGAGEMENT AND COORDINATION

San Francisco is committed to engaging the public in SLR planning, as well as fostering communication and cooperation between City Departments and neighboring jurisdictions. SLR and resiliency thinking will be coordinated and integrated into subsequent planning and implementation processes as standard practice.

LOCAL COMMUNITY ENGAGEMENT

San Francisco will coordinate and leverage existing community engagement opportunities (see map below) to increase the understanding of potential SLR effects on homes and local businesses. As needed, additional SLR-specific outreach will be added during the Citywide Adaptation Plan process.

REGIONAL ACTIVITY & COORDINATION

SLR is a regional issue that necessitates regional commitment. San Francisco will continue to convene and collaborate with its neighbors to ensure the Bay Area develops successful and cooperative solutions to living with SLR. Currently, there are over a dozen efforts ongoing with more in development.

ONGOING CITYWIDE PUBLIC OUTREACH EFFORTS

VULNERABILITY AND RISK ASSESSMENTS

San Francisco needs to conduct detailed vulnerability and risk assessments to plan effectively for SLR adaptation.

Vulnerability assessments reveal likely impacts to an asset (or set of assets) from temporary flooding or permanent inundation from coastal waters. Impacts 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 services
- Economic and financial consequences. Workforce disruptions, loss of real estate, and/or impacts to tourism or other significant industries

EXISTING ASSESSMENTS

Significant vulnerability and some risk (likelihood and consequence) information has been collected for the following assets:

- Port of SF property and assets
- SFO property and assets
- SFPUC water and wastewater utilities
- Shoreline protection (natural & engineered)
- Vulnerable populations
- Public health facilities
- Proposed or approved development projects along San Francisco's Bayshore

FUTURE ASSESSMENTS

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

THE COST OF INACTION

Estimating expected losses in public and private property value informs decisions about balancing costs of post-disaster relief with those of up-front adaptation.

The scale of total risk to public and private property value in San Francisco due to SLR is considerable. This December 2015 estimate assumes no special adaptation actions have occurred and considers upper-range risk due to Bayside SLR of 66 inches, both with and without the impacts of a 100-year extreme tide (up to 42 inches). The study produces a 'do-nothing' estimate of property permanently lost to SLR, summarized in the table below, expressed in today's dollars of property replacement value, and does not take into account planned or anticipated adaptation efforts (e.g., SFO flood control projects).

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*

Source: Risk Management Solutions study, December 2015, considering no special adaptation actions have occurred.
*Figures are rounded figures for the purposes of this report.

SEA LEVEL RISE PRIORITY ACTIONS [2016–2018]

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.

01 REVIEW SCIENCE

Review climate science and pursue sea level rise research priorities

Monitor SLR projection updates and regional, national, and international best practices, and secure funding for further research to inform adaptation strategies

06 MONITOR IMPLEMENTATION

Coordinate monitoring and tracking of storm events

Track current El Niño conditions (similar to 6" to 12" of SLR), such as flooding extent, pathways and depths of inundation, in order to evaluate and plan future responses and systems

05 IMPLEMENT ADAPTATION

Monitor and investigate backflow prevention installations

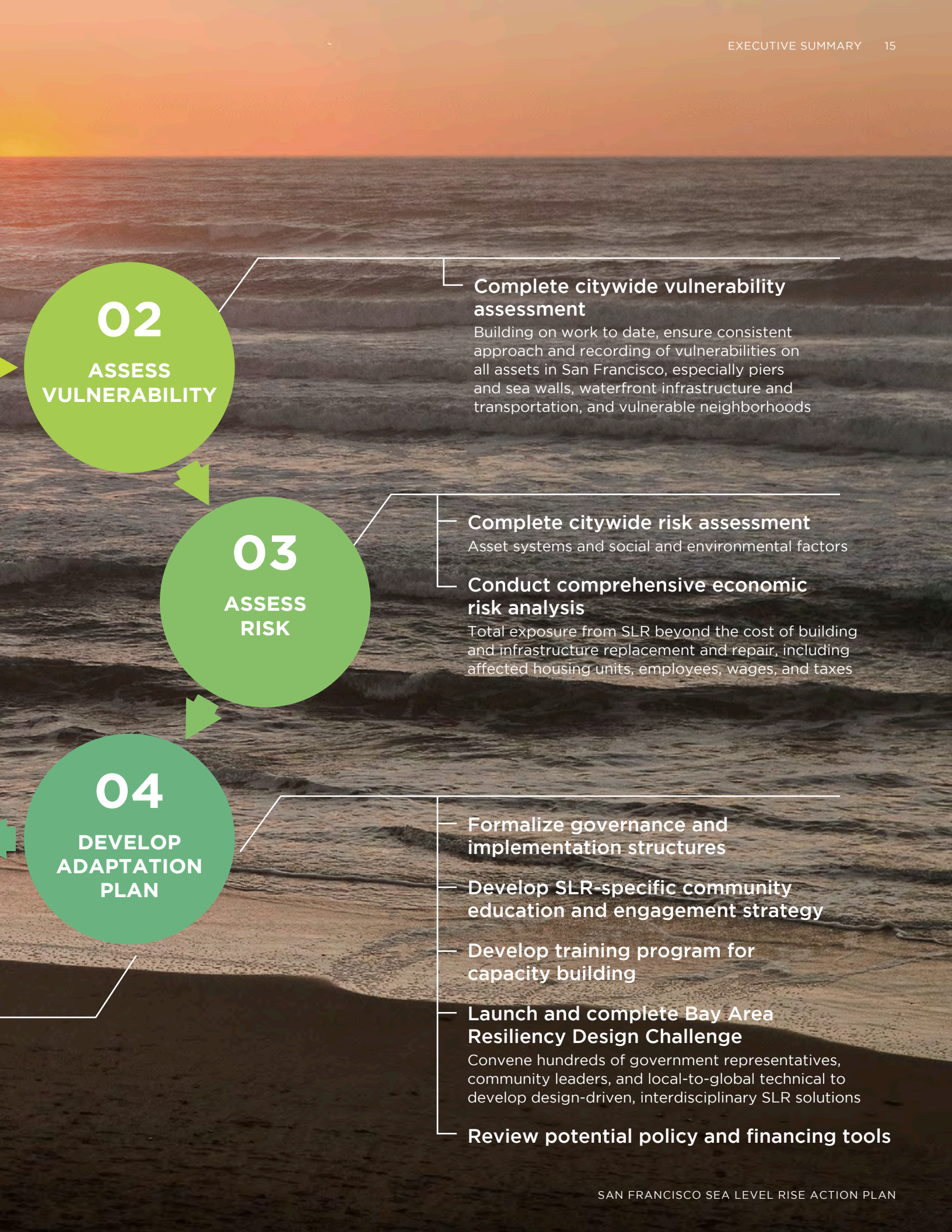
Develop interim and long-term airport shoreline protection

Including seawalls, flood/tidal gates, pump stations, levee and embankment stabilization, pavement overlay, and power enhancements

Complete comprehensive citywide SLR Adaptation Plan

Identify and select new policies, as well as individual asset, neighborhood or district scale physical strategies, depending on identified risk

Develop near-term adaptation plans for high-risk shoreline assets and geographic areas



02 ASSESS VULNERABILITY

Complete citywide vulnerability assessment

Building on work to date, ensure consistent approach and recording of vulnerabilities on all assets in San Francisco, especially piers and sea walls, waterfront infrastructure and transportation, and vulnerable neighborhoods

03 ASSESS RISK

Complete citywide risk assessment

Asset systems and social and environmental factors

Conduct comprehensive economic risk analysis

Total exposure from SLR beyond the cost of building and infrastructure replacement and repair, including affected housing units, employees, wages, and taxes

04 DEVELOP ADAPTATION PLAN

Formalize governance and implementation structures

Develop SLR-specific community education and engagement strategy

Develop training program for capacity building

Launch and complete Bay Area Resiliency Design Challenge

Convene hundreds of government representatives, community leaders, and local-to-global technical to develop design-driven, interdisciplinary SLR solutions

Review potential policy and financing tools

SLR PRIORITY ACTIONS SUMMARY [2016–2018]