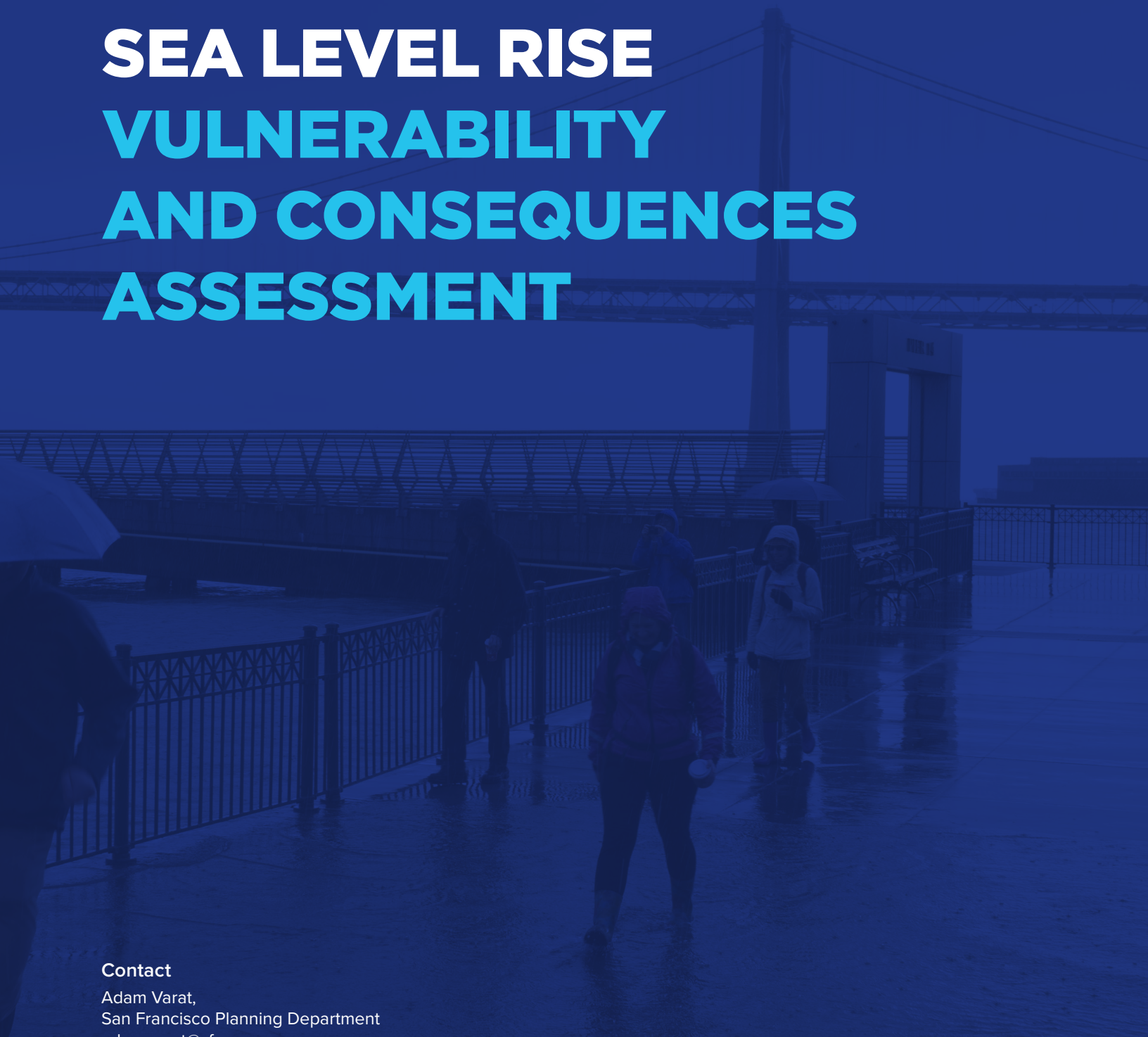
CITY AND COUNTY
OF SAN FRANCISCO

SEA LEVEL RISE VULNERABILITY AND CONSEQUENCES ASSESSMENT

FINAL REPORT FEBRUARY 2020

CITY AND COUNTY
OF SAN FRANCISCO

SEA LEVEL RISE VULNERABILITY AND CONSEQUENCES ASSESSMENT



Contact
Adam Varat,
San Francisco Planning Department
adam.varat@sfgov.org
https://sfplanning.org/sea-level-rise-action-plan

February 2020

TABLE OF CONTENTS

TABLE OF CONTENTS

SEA LEVEL RISE VULNERABILITY AND CONSEQUENCES ASSESSMENT

EXECUTIVE SUMMARY

CITY AND COUNTY OF SAN FRANCISCO

The earth and its inhabitants are facing a climate emergency. Global heating creates extreme hazards that cause significant harm to people, homes, infrastructure, and the environment. In California, we are already facing many climate-related impacts: prolonged drought, extreme heat, massive wildfires, hazardous air quality, flooding, and severe weather.

As the earth heats, polar and glacial ice is melting much faster than predicted,[1] causing sea levels to rise worldwide and reducing the earth's defenses against further warming. Combined with new, more severe weather patterns like coastal storms, sea level rise (SLR) presents a daunting challenge for waterfront cities such as San Francisco.

San Francisco already experiences flooding and erosion in our low-lying coastal areas during times of high tides and severe weather. As the century progresses, sea levels will continue to rise, and flooding and related hazards will become more frequent and intense, affecting ever-greater areas of the City.

This Sea Level Rise Vulnerability and Consequence Assessment (Assessment) describes the vulnerability of public buildings and infrastructure to SLR and coastal flooding and the consequences of SLR-related flooding on people, the economy, and the environment. The Assessment will be used to inform how the City develops, prioritizes, invests, and implements adaptation strategies to enhance San Francisco's resilience to SLR and coastal flooding.

Approximately four square miles of San Francisco (not including Treasure Island or San Francisco International Airport [SFO]) are located within the City's Sea Level Rise Vulnerability Zone.[2] This area could be flooded by a 100-year coastal flood event[3] coupled with 66 inches[4] of SLR, an upper-range scenario by end of century. These low-lying areas are home to approximately 37,200 residents, approximately 17,100 businesses, approximately 167,300 jobs, new development, and a host of vital infrastructure. This infrastructure includes roadways, water and wastewater pipelines, power infrastructure, emergency services, transit lines, parks and open spaces, the Port of San Francisco (Port), and SFO.[5]

1 A recent study found that Arctic permafrost is thawing decades earlier than predicted: https://www.theguardian.com/environment/2019/jun/18/arctic-permafrost-canada-science-climate-crisis

2 The Sea Level Rise Vulnerability Zone equates to 108 inches (66 inches of SLR plus 42 inches of tidal and storm surge).

3 A 100-year event means there is a 1 percent annual chance of the flood event happening in any given year.

4 66 inches of SLR represents the upper-bound SLR projection for the end of the century (i.e., 2100) associated with the best available science (National Research Council, 2012) when the SLR Vulnerability Zone was adopted by the City in 2014. In 2017, three new reports were released that increased the upper-bound projections (USGCRP, 2017; Rising Seas, 2017; Sweet et al., 2017); however, a revised and expanded SLR Vulnerability Zone has not been adopted at this time.

5 San Francisco International Airport (SFO) is located south of the main City of San Francisco, within San Mateo County and directly adjacent to San Francisco Bay. However, SFO is part of the jurisdiction of the City and County of San Francisco.

Figure E.1 Sea Level Rise Vulnerability Zone

Sea Level Rise Vulnerability Zone

0 0.5 1.0 2.0
Miles

N

PLANNING FOR SEA LEVEL RISE

San Francisco has been considering SLR in its planning for many years. The City first approved SLR Capital Planning Guidance in 2014, which it updated in 2015 and 2019 (SLR checklist only).[6]

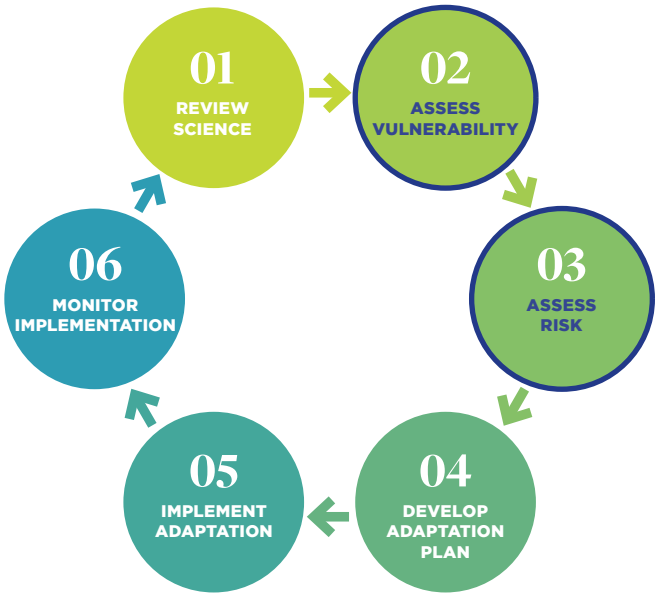
In March 2015, then-Mayor Ed Lee assembled the Sea Level Rise Coordinating Committee in response to the immediate and long-term threats from SLR and coastal flooding. The SLR Committee was tasked with developing a comprehensive understanding of the threat of SLR to San Francisco and to create a decisive plan of action.

The SLR Committee created the Sea Level Rise Action Plan, released in March 2016. The Action Plan called on City departments to work together to understand the impacts of rising sea levels and to develop strategies to protect our shoreline, critical public assets and infrastructure, and public and private lands and structures from current and future coastal and SLR flooding.

The vision of the 2016 Sea Level Rise Action Plan Vision is:

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, the natural environment, and quality of life for all.

Figure E.2 Sea Level Rise Action Plan Framework



This report, the *SLR Vulnerability and Consequences Assessment (Assessment)*, represents steps 2 and 3 in the process outlined in the SLR Action Plan: Assess Vulnerability and Assess Risk. These two steps have been combined into this Assessment.

The Assessment evaluates publicly owned infrastructure within the SLR Vulnerability Zone, identifies the infrastructure's vulnerability, and describes the consequences for people, the economy, and the environment. This information will inform capital planning, project design, and policy decisions for decision makers, City agencies, and public stakeholders so the City (in collaboration with San Francisco's communities) can develop, prioritize, and implement appropriate adaptation strategies to build San Francisco's resilience to SLR.

6 http://onesanfrancisco.org/sea-level-rise-guidance/

SEA LEVEL RISE EXPOSURE

The CPC Guidance and the 2016 Sea Level Rise Action Plan relied on the best available science at the time – the National Research Council's (NRC's) 2012 Report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future*[7] to define a SLR Vulnerability Zone. This zone equates to 108 inches (66 inches of SLR plus 42 inches of tidal and storm surge),8 an upper-range scenario for the end of the century (Figure E.1).

Within the SLR Vulnerability Zone, the Assessment studied 10 scenarios within that range from 12 to 108 inches (Table E.1) to understand at what points infrastructure assets become vulnerable to intermittent or permanent flooding from SLR and tidal and storm surge.

Table E.2 calculates the number of homes, businesses, streets, and open spaces located within the SLR Vulnerability Zone if no action is taken to protect these areas.

The Assessment is based on best current available science. As climate science evolves, the City may need to assess higher water levels in the future and develop adaptation plans accordingly.

Table E.1
Sea Level Rise Scenario (Inches above MHHW)

Mapping Scenario	Reference Water Level
Scenario 1	MHHW + 12"
Scenario 2	MHHW + 24"
Scenario 3	MHHW + 36"
Scenario 4	MHHW + 48"
Scenario 5	MHHW + 52"
Scenario 6	MHHW + 66"
Scenario 7	MHHW + 77"
Scenario 8	MHHW + 84"
Scenario 9	MHHW + 96"
Scenario 10	MHHW + 108"

MHHW = Mean Higher High Water
" = inches

Table E.2 SLR Exposure

	Scenario 5	Scenario 6	Scenario 8	Scenario 10
Residents [9]	6,500	21,500	28,600	37,200
Businesses [10]	1,500	7,300	12,800	17,100
Jobs [11]	10,800	48,500	116.225	167,250
Streets [12]	18.5 miles	50 miles	71.1 miles	96.4 miles
Parks (Port and Parks and Rec) [13]	31 acres	55 acres	65 acres	74 acres

7 National Research Council. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future. Prepared by the Committee on Sea Level Rise in California, Oregon, and Washington, Board on Earth Sciences and Resources, Ocean Studies Board, and the Division on Earth and Life Studies.

8 In response to updated national and regional reports, the State of California released updated Sea Level Rise Guidance (State Guidance) in 2018. This data results in an expanded area that is vulnerable to SLR. The additional area is not studied in this report.

9 2010 Census by block group

10 Business counts by Census Tract (2017 Dun & Bradstreet data set)

11 Job counts by Census Tract (2017 Dun & Bradstreet data set)

12 City and County of San Francisco Department of Public Works/Bureau of Street Use and Mapping (2018 San Francisco Basemap Street Centerlines data set)

13 DCP Open Space, DCP Trail Layer (2018 San Francisco data set)

SECTOR CHAPTERS

The Assessment identifies City-owned infrastructure within the SLR Vulnerability Zone by sector (Transportation, Water, Wastewater, Power, Public Safety, Open Space, and Port), describes each asset's vulnerability (sensitivity to flooding and capacity to adapt), and identifies consequences for people, the economy, and the environment. The project team collected and mapped information from agencies that own, operate, and maintain the buildings and infrastructure assets, and held in-depth meetings with key staff to determine how the asset would be affected by flooding. Based on this information, each asset was given a vulnerability rating.

Next, the Assessment describes the impact of each asset category (Figure E.2) if it were impaired or non-functional due to intermittent or permanent flooding, and describes the consequences on people, the economy, and the environment. The consequence assessment is high-level and is not a detailed multi-hazard risk assessment. More detailed assessments may be required at the project-level to support the implementation of adaptation strategies.

The sector-based vulnerability and consequence information forms the basis of the Sector Chapters (Chapters 5-11). See Figure E.3.

Figure E.3 Sector Asset Categories

Chapter 5. **TRANSPORTATION**	• Roadways • Bridges • Local and Regional Transit	• Bicycle and Pedestrian Facilities • Operations & Maintenance Facilities
Chapter 6. **WATER**	• Regional Water Distribution • Local Potable Water	
Chapter 7. **WASTEWATER**	• Treatment Plants • Pump Stations	• Buried Sewers • Combined Sewer Structures
Chapter 8. **POWER**	• Substations and Transformers • Streetlights	• PG&E facilities
Chapter 9. **PUBLIC SAFETY**	• Fire Department • Emergency Firefighting Water System	• Law Enforcement • Contaminated Lands
Chapter 10. **OPEN SPACE**	• Parks • Playgrounds • Recreational Areas	• Marinas • Trails
Chapter 11. **PORT FACILITIES**	• Piers • Seawall Lots	• Port Buildings • Rail Right-of-Way

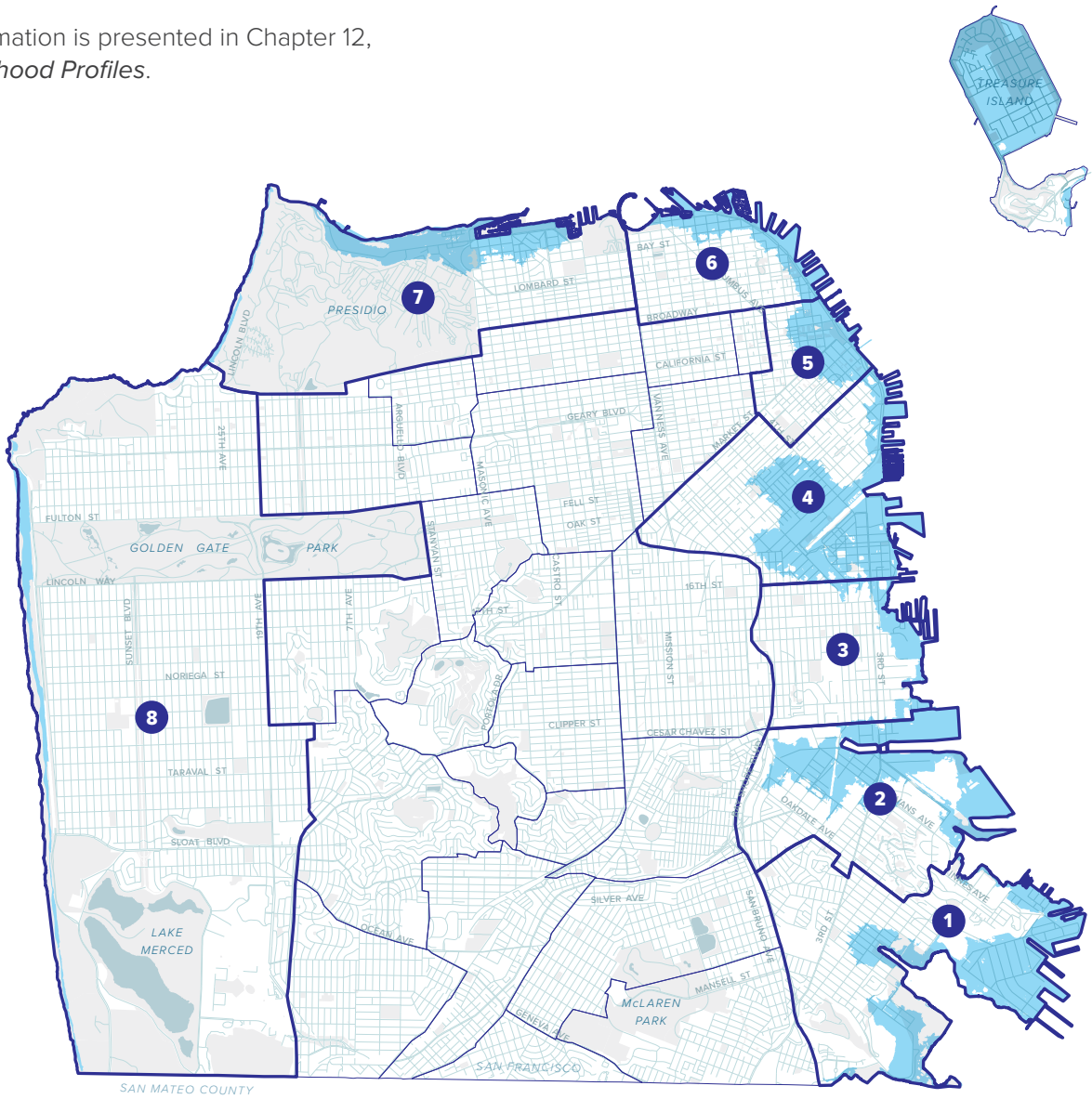
NEIGHBORHOOD PROFILES

For each shoreline neighborhood (Bay and Ocean) in San Francisco (Figure E.4), the Assessment includes a series of Neighborhood Profiles that describe potential consequences at the neighborhood scale. The Neighborhood Profiles consider how the different infrastructure sector categories would impact each other (the cascading consequences) at the neighborhood scale and how these interactions would affect the daily lives and well-being of people living and working in these neighborhoods, with a focus on how SLR impacts vulnerable populations.

This information is presented in Chapter 12, *Neighborhood Profiles*.

Figure E.4
Shoreline Neighborhoods

1. Bayview South / Hunters Point
2. Bayview North / Islais Creek
3. Potrero Hill / Central Waterfront
4. South of Market / Mission Bay
5. Financial District
6. North Beach / Fisherman's Wharf
7. Marina and Presidio
8. Westside / Ocean Beach



KEY FINDINGS

This section highlights key overall findings from the Assessment. Some of these findings are specific to one sector. Others are general and impact multiple sectors or suggest areas for further study. These findings reflect current conditions; the City is actively studying, planning for, and starting to address many of these issues.

Combined Precipitation and Coastal Flooding Risk

Although the assessment focuses on SLR, concern about the risk of combined precipitation and coastal flooding was raised throughout the process. How this combined risk will impact the City over time as sea levels rise and precipitation patterns change is not fully understood. The San Francisco Public Utilities Commission, with support from the Port of San Francisco and the Oakland International Airport, is leading a study to better understand changes in future precipitation intensity and frequency (see Chapter 4, Summary 5 for more information) to help better quantify this risk. Areas with precipitation flood risk, coastal flood risk, and drainage issues will be among the first and most severely affected neighborhoods in the City. Strategies to address flooding in these areas will need to keep coastal flooding out while allowing or improving drainage so that solutions to one type of flood risk do not exacerbate other types of flooding.

Portions of Mission Bay and Islais Creek are vulnerable today to flooding from both precipitation and coastal overtopping because they are at the downstream end of large watersheds, adjacent to the Bay, and historically these areas were tidal creeks and marshes (Figure E.5). Their current elevations are low and rain from the large upstream watersheds collects in these basins causing temporary flooding. This flooding typically occurs when Bay water levels are elevated due to storm-surge conditions concurrently with heavy rainfall. The temporary flooding subsides as the tides fall and drainage capacity is restored. Over time with higher SLR projections, the discharge outfalls will become submerged more frequently, preventing the outfalls from maintaining their function as currently designed, resulting in potential flooding that occurs more often across a wider area of the City.

Joint Impacts of Contamination and Liquefaction in Bay Fill Areas

Along San Francisco's Bay shoreline, historical fill (filling in former wetlands and areas of the Bay to create new land) and military and industrial land uses mean many neighborhoods are at risk of flooding, soil liquefaction and settlement during earthquakes, and environmental contamination. These concurrent hazards may exacerbate one another, such as when contaminated materials are mobilized during a flood event or when rising groundwater expands liquefaction areas. These physical hazards have potential public health and safety consequences. Neighborhoods like Bayview and Hunters Point, where many of these factors exist, already experience disproportionate contamination burdens among other health disparities.

Many sites undergoing remediation have plans for new housing development. Effective remediation and reuse of these sites will need to account for future flooding and groundwater changes due to SLR. Modeling and monitoring are required to fully understand interactions between sea level, groundwater, contamination, and soil stability.

Figure E.5 Historic Creeks and Sea Level Rise Vulnerability Zone

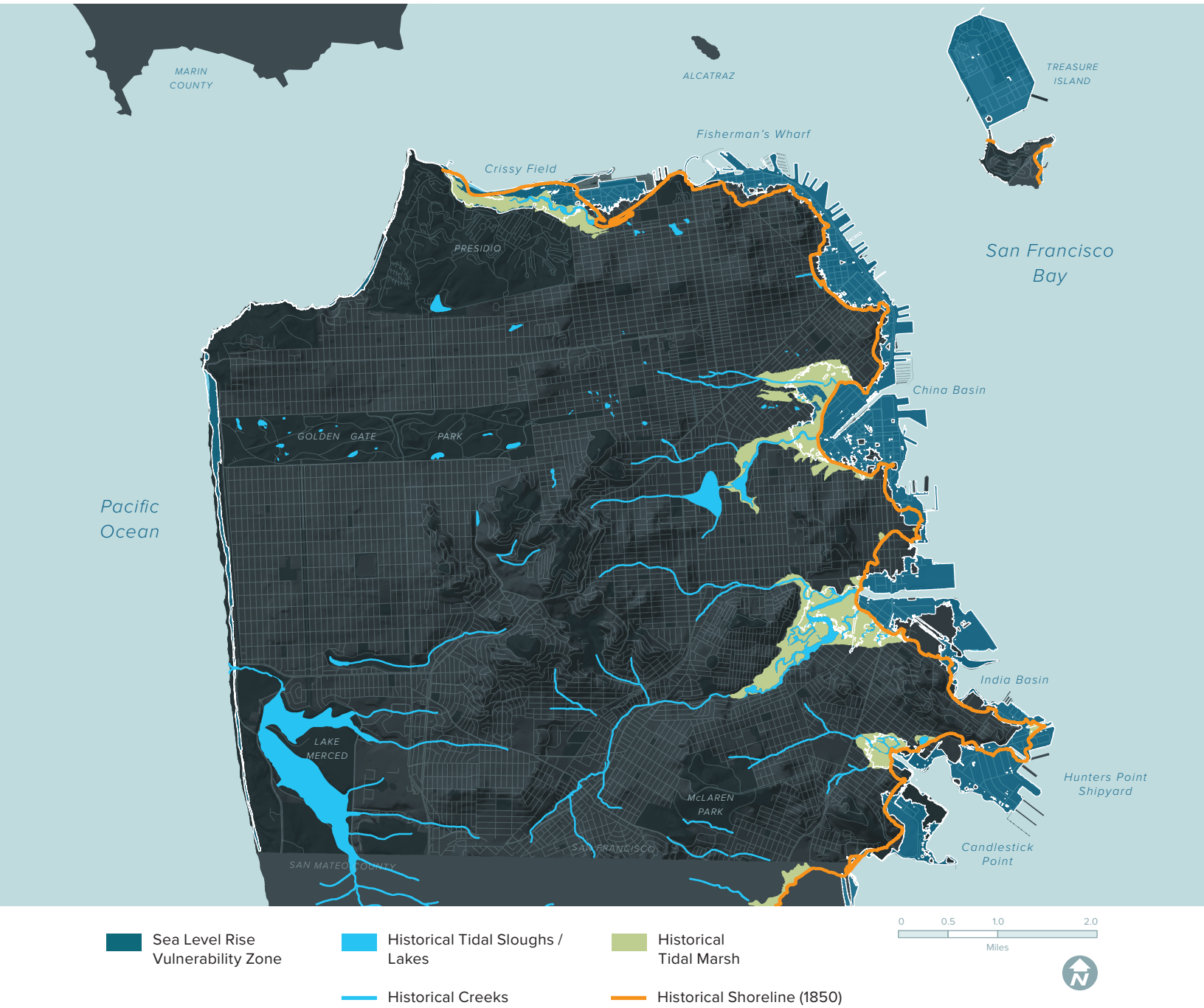


Photo E.1 Mission Rock Development

Source: Perkins&Will

Risks and Requirements for New Development in Waterfront Neighborhoods

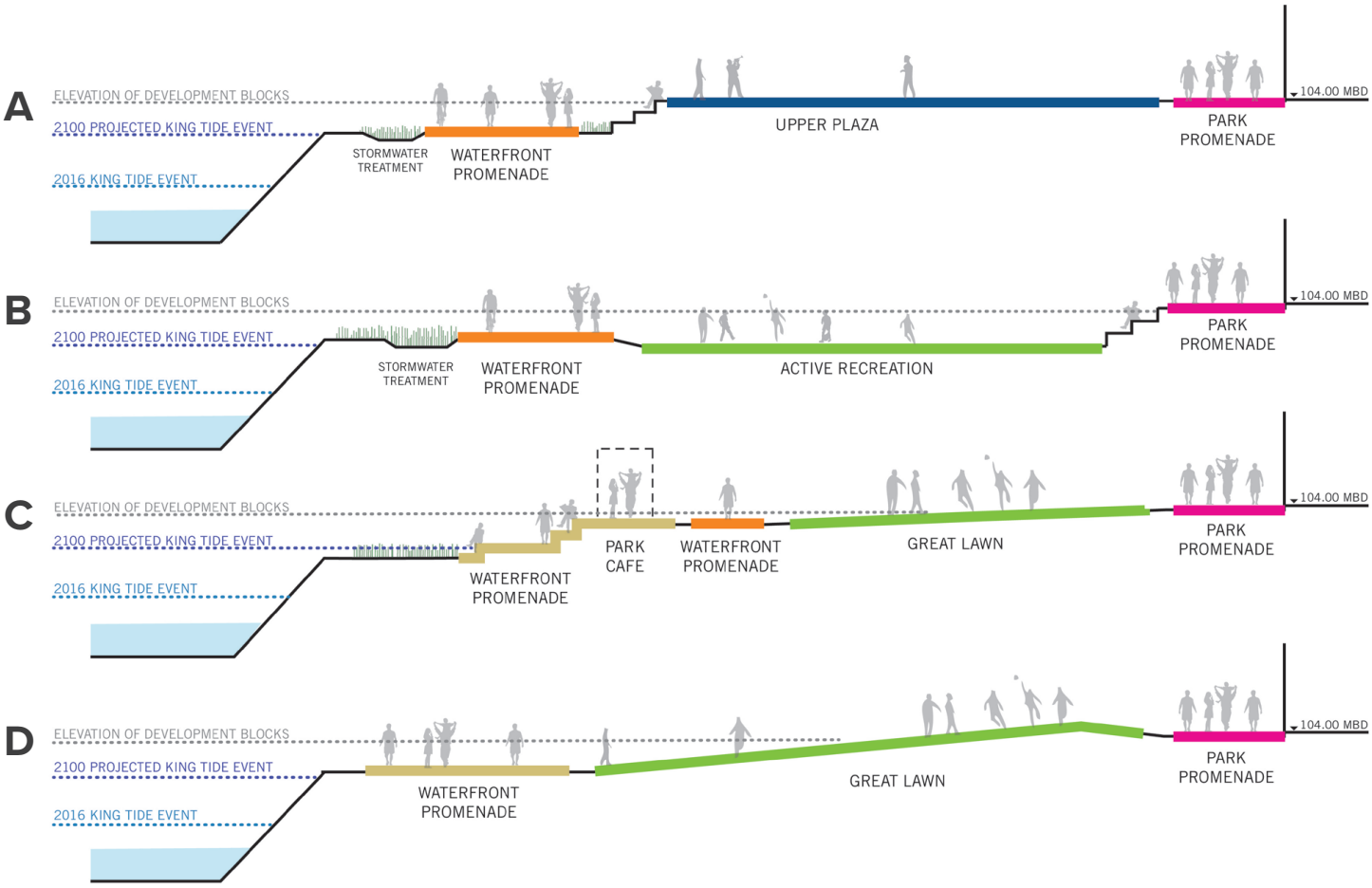
Many of San Francisco's large developable areas are along the southeastern shoreline in areas that are vulnerable to SLR. Many of these shoreline areas have planned or approved development plans. These shoreline developments would revitalize former military and industrial areas, providing significant amounts of new housing and job space. However, their location makes them potentially vulnerable to future flooding and SLR impacts (Figure E.7).

Current development plans account for expected SLR and identify adaptation measures like elevating building pads and designing open spaces to accommodate flooding. These strategies require developments to commit to a future water level elevation. If sea levels rise faster or higher than anticipated, these neighborhoods will need to pursue additional measures (Figure E.6).

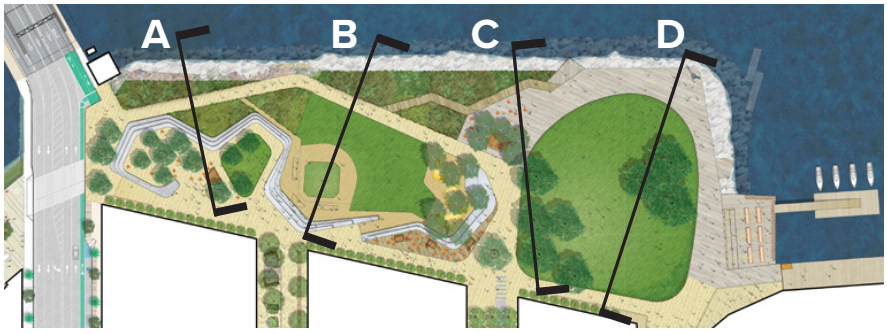
This effect is exacerbated by the long lead time for development approvals and construction. For example, the Treasure Island Redevelopment Authority secured its project approvals in 2011-2015 but buildout will not be complete until after 2035 and the housing and commercial buildings will persist past 2100. SLR science will continue to evolve and more protective measures may be necessary.

In addition to physical flood risks, these sites rely on existing transportation and utility networks that are not fully resilient to SLR and coastal flooding (Figure E.8). A residential and commercial development that becomes an island during flood events will still suffer from these impacts even if its own buildings stay dry. Site-specific adaptation strategies cannot fully protect the function and value of these new developments. They will need to engage in community adaptation planning to protect whole neighborhoods and the City.

Figure E.6 Mission Rock Development Elevations



This diagram illustrates the relationship of Mission Rock program areas to each other and to key sea level rise (SLR) elevations. The finish grade elevations will be based on 2100 king tide elevations (SLR + storm surge).



Source: Mission Rock Design Controls 2017

Photo E.2 Heron's Head Park

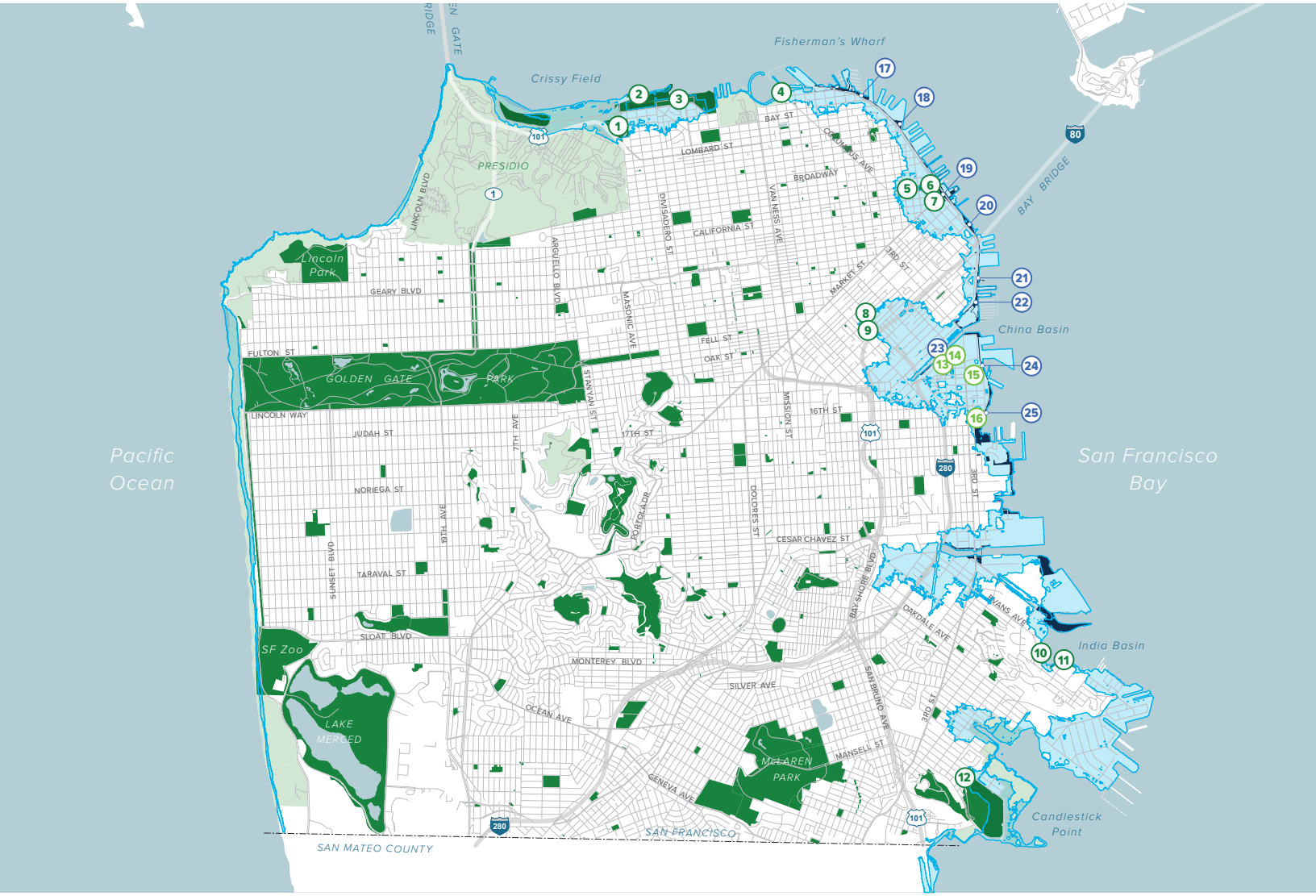
Source: Ed Brownson (CC BY-NC-ND 2.0)

Loss of Shoreline Open Space Through Flooding and Adaptation Efforts

Shoreline parks and open space add to San Francisco's quality of life and generate economic activity through tourism. Public access to the shoreline has been expanded and improved through the removal of the Embarcadero Freeway and shoreline redevelopment, but SLR may damage and eventually destroy these recreational facilities. Ocean Beach, Crissy Field, Marina Green, Fort Mason, Aquatic Park, the Embarcadero Promenade, and Heron's Head Park are iconic San Francisco destinations that are vulnerable to current flooding and future SLR impacts. Shoreline open space provides unique recreation such as swimming, small boat access, and wildlife viewing that cannot be replaced at other City open spaces.

In addition to publicly owned recreation sites, many shoreline developments have identified shoreline open spaces as part of their adaptation strategies. This approach may protect buildings and infrastructure, but the open space will narrow and eventually disappear. These shrinking open spaces will limit recreation opportunities for residents and workers in those developments and for the City as a whole. This effect would be most severe in the Central and Southeastern Waterfront areas where private developments have agreed to provide extensive open space for a rapidly growing population as part of their development agreements.

Figure E.7 Shoreline Open Space at Risk



RECREATION & PARKS

1. Palace of Fine Arts
2. San Francisco Marina Small Craft Harbor
3. Marina Green
4. Dolphin Club/South End Rowing Club
5. Maritime Plaza
6. Sue Bierman Park
7. Embarcadero Plaza
8. Gene Friend Recreation Center
9. Victoria Manalo Draves Park
10. India Basin Shoreline Park
11. India Basin Natural Areas
12. Gilman Playground

OCII

13. Mission Bay Dog Park
14. Mission Bay Kids' Park
15. Mission Bay Commons Park
16. Mission Bay Parks 23 & 24

PORT OF SAN FRANCISCO

17. Public Park (near Pear 39)
18. Pier 27 (Cruise Ship Terminal)
19. Harry Bridges Plaza
20. Rincon Park
21. Brannan Street Wharf
22. South Beach Park
23. Mission Creek Park
24. Pier 52 Boat Launch
25. Agua Vista Park
16. Mission Bay Parks 23 & 24

Photo E.3 Embarcadero Station

Source: Travel Nevada (CC BY-NC-ND 2.0)

Local and Regional Transportation Impacts

San Francisco relies on local and regional transportation infrastructure to bring workers and tourists into the City and to connect San Francisco with the rest of the Bay Area. Caltrain, the Bay Area Rapid Transit (BART), and freeways are vulnerable to current and future flooding within and beyond San Francisco's boundaries and they will not function well in the future without local and regional action. For example, the Embarcadero BART and Muni station is vulnerable to near-term flood impacts. Even if San Francisco implements adaptation measures for the Embarcadero station, the station cannot function if the Transbay Tube is out of service or BART is unable to adapt other vulnerable stations. Similarly, flooding on U.S. Highway 101 in San Mateo County has severe impacts for SFO, although the flooding is outside of San Francisco's jurisdiction.

In addition to planning for current infrastructure, the Bay Area is planning and implementing major transportation investments like High Speed Rail, a potential second Bay BART crossing, and ferry network extensions. These projects will need to consider SLR and coastal flooding in their designs and coordinate with San Francisco shoreline projects like the Embarcadero Seawall Program. San Francisco cannot plan and implement effective regional transportation adaptation alone and will need to work with state, regional, and federal partners to protect and enhance transportation networks.

CONSIDERATIONS FOR SEA LEVEL RISE ADAPTATION PLANNING

As the City advances adaptation planning efforts, we have identified key considerations to guide adaptation planning and ensure that adaptation strategies are effective, efficient, equitable, and environmentally appropriate.

Successful adaptation planning should:

- Begin with robust community engagement to ensure strategies will meet local needs and build public and political support for action
- Prioritize and include vulnerable neighborhoods that already bear disproportionate environmental contamination burdens and will be most impacted by future flooding
- Include natural solutions where possible to improve the City's environment and provide open space recreation opportunities
- Create a decision-making framework for when and where to implement facility-specific floodproofing versus neighborhood-scale shoreline strategies
- Identify strategies that could be implemented by multiple actors, including individual agencies, private landowners, and the City as a whole
- Adopt adaptation policies for private development and public investment in addition to implementing physical strategies
- Identify potential funding sources and identify and empower appropriate lead agencies for adaptation projects that cross agency jurisdictions
- Balance uncertainty in long-term climate projections with the need for urgent action
- Integrate SLR and coastal flooding programs with other City resilience efforts

NEXT STEPS

San Francisco's efforts to adapt to SLR, coastal flooding, and other climate impacts will continue for decades. Major adaptation projects that involve significant changes to the City's shoreline infrastructure will take many years to plan, fund, and build. Some areas of the City are already affected by coastal flooding and require near-term solutions. Other areas may be affected within 10 years, while others may not be affected for decades.

The City is currently developing several plans, policies, and projects that help adapt the City to SLR, including:

1. **Updated SLR Capital Planning Guidance.** The City adopted Sea Level Rise Capital Planning Guidance in 2014 for infrastructure projects of $5 million or more. The SLR checklist (a portion of the guidance) was recently revised to reflect updated State SLR projections.

2. The **Hazards and Climate Resilience Plan** assesses Citywide vulnerability to a variety of climate and other hazards, such as earthquakes, heat, poor air quality, drought, and SLR, and develops strategies to mitigate risk and make the City more resilient to these hazards.

3. **Ocean Beach Master Plan implementation** involves multiple projects that will carry out improvements to Ocean Beach and the Great Highway to protect critical infrastructure such as the Westside Pump Station, reduce beach and cliffside erosion, and add recreational opportunities such as a new multi-use trail.

4. The **Embarcadero Seawall Program** is a Citywide effort, led by the Port, to seismically strengthen the Embarcadero Seawall and to address current and future flood and SLR risk due to climate change.

5. The **U.S. Army Corps of Engineers/Port Flood Study** will study flood risk along San Francisco's Bayside shoreline from Aquatic Park to Heron's Head Park, identify areas that are vulnerable to shoreline flooding, and develop strategies to reduce current and future flood risk.

6. The **Islais Creek Adaptation Strategy** will develop a long-range vision for the Islais Creek basin, with an emphasis on securing the area's critical transportation facilities.

7. The **SFO Shoreline Protection Project** will address potential flood risks resulting from both 100-year storm and SLR out to 2085 at SFO.

All nine counties that surround San Francisco Bay are vulnerable to SLR and coastal flooding and are engaged in assessing SLR vulnerabilities and risks or moving forward with SLR adaptation efforts. The City is participating in and coordinating with several regional efforts, including San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) Program, The Bay Area Climate Adaptation Network (BayCAN), and the San Francisco Bay Regional Coastal Hazards Adaptation Resiliency Group (CHARG).

In addition, new planned developments and open spaces along the City's shoreline are being designed to adapt to SLR and provide funding for future SLR adaptation measures. See Chapter 13, *A Changing Shoreline*.

The plans and projects listed above are described in Chapter 14, *Next Steps*.

CONCLUSION

As the City continues to study, plan for, and address SLR impacts, we are considering climate resilience comprehensively – both how we continue the City's efforts to mitigate climate emissions and how we adapt our City to become more resilient to climate impacts, considering not only SLR but other climate-related hazards such as extreme precipitation, drought, poor air quality, extreme heat, and wildfire.

Next steps to adapt San Francisco to a changing climate include capital planning, code updates for new construction and renovations, and policy, funding, legislation, and governance strategies to implement climate policies and actions.

We are facing a climate emergency. San Francisco is one actor on a global scale. We can be a leader in working to address the climate crisis and adapt our City to the coming impacts of climate change to improve the lives of people who live and work in San Francisco.

This Assessment provides essential information to help us understand our vulnerabilities to SLR and coastal flooding. It lays the groundwork for the City to work with communities to develop strategies to adapt San Francisco to SLR.

Photo by Sergio Ruiz

CONTRIBUTORS

This report represents a collaborative effort among multiple City Departments, staff, and consultants. The information in this report was developed through working sessions with relevant agency staff to compile, understand, and describe asset-specific information, such as maps, asset descriptions, and asset vulnerabilities. Workshops were held with each asset-owning department to better characterize asset-specific vulnerabilities and consequences, and to begin the discussions of multi-sector consequences. A citywide consequences workshop was held to discuss how the sector- and asset-based vulnerabilities combine and interact with the other sectors to create cascading consequences at the neighborhood scale, including consequences to society and equity, the economy, governance, and the environment.

The SLR project team led the compilation of the asset information and vulnerability assessments, and prepared the individual report chapters with substantive involvement and review from the respective City departments. SLR Coordinating Committee members were provided with regular updates, and they provided feedback on the methodology, report outline, presentation of findings, and reviewed relevant chapters and complete drafts as the work progressed. This report represents the cumulative effort of all project staff and agencies to provide the best-known information about SLR vulnerabilities and consequences (with a focus on city-owned assets) in San Francisco as of this publication.

Thank you to all who contributed!

CONTRIBUTORS

Mayor

London N. Breed

Board of Supervisors

Norman Yee, *President*
Vallie Brown
Sandra Lee Fewer
Matt Haney
Rafael Mandelman
Gordon Mar
Aaron Peskin
Hillary Ronen
Ahsha Safai
Catherine Stefani
Shamann Walton

Department Heads

Naomi Kelly, City Administrator
John Rahaim, Planning Department
Elaine Forbes, Port of San Francisco
Tom Maguire, San Francisco Municipal Transportation Agency
Harlan Kelly, San Francisco Public Utilities Commission
Mohammed Nuru, SF Public Works
Phil Ginsburg, Recreation and Parks Department
Ivor Satero, San Francisco International Airport
Debbie Raphael, SF Environment
Nadia Sesay, Office of Community Investment and Infrastructure
Joaquin Torres, Office of Economic and Workforce Development
Grant Colfax, Department of Public Health

SLR Coordinating Committee Members

Co-Chair: AnMarie Rodgers, *Director of Citywide Planning*, Planning Department
Co-Chair: Brian Strong, *Chief Resilience Officer*, Office of Resilience and Capital Planning
Tyrone Jue, Mayor's Office
Adam Varat, Alesia Hsiao, Maggie Wenger, Diana Sokolove, Paul Maltzer, Planning Department
Melissa Higbee, Office of Resilience and Capital Planning
Byron Rhett, Brad Benson, Lindy Lowe, Steven Reel, Port of San Francisco
Tim Doherty, San Francisco Municipal Transportation Agency
David Behar, Anna M. Roche, San Francisco Public Utilities Commission
John Thomas, Boris Deunert, Public Works
Brian Stokle, Recreation and Parks Department
Joe Birrer, San Francisco International Airport
Cyndy Comerford, SF Environment
Sally Oerth, Office of Community Investment and Infrastructure
Leigh Lutenski, Office of Economic and Workforce Development
Matt Wolff, Department of Public Health

Primary Authors

Adam Varat, Alesia Hsiao, Maggie Wenger, Kris May, Karen Askeland

Other Contributors

Gary Chen, *Graphic Designer,* Planning Department
Mike Webster, *GIS Analyst*, Planning Department

Consultants

Laura Harnish, Armin Munevar, Karen Askeland CH2M/Jacobs
Kris May, Yanna Badet, Abigail Mohan, Silvestrum Climate Associates

● SLR Working Group member

ACRONYMS & ABBREVIATIONS

Current to April 4, 2019

°F	degrees Fahrenheit
ABAG	Association of Bay Area Governments
AC Transit	Alameda-Contra Costa Transit
ADA	Americans with Disabilities Act
ART	Adapting to Rising Tides
AST	aboveground storage tank
BARC	Bay Area Regional Collaborative
BART	Bay Area Rapid Transit
BAWSCA	Bay Area Water Supply and Conservation Agency
BCDC	Bay Conservation and Development Commission
Caltrans	California Department of Transportation
CC	City and County
CEQA	California Environmental Quality Act
City	City of San Francisco
CMGC	construction management-general contractor
CPC	Capital Planning Committee
CSD	combined sewer discharge
DB	design-build
DTSC	California Department of Toxic Substances Control
DTX	Downtown Rail Extension
DWL	dynamic water level
EFWS	Emergency Firefighting Water System
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FUDS	formally used defense site
GGNRA	Golden Gate National Recreation Area
GHG	greenhouse gas
GIS	geographic information system
gpm	gallons per minute
I-280	Interstate 280
I-80	Interstate 80
IPCC	Intergovernmental Panel on Climate Change
JPB	Joint Powers Board
LPFH	low-pressure fire hydrant
LRV	light rail vehicle
MARAD	Maritime Administration Ready Reserve
MG	million gallons
MHHW	mean higher high water
MMT	Muni Metro Turn-back Facility
MTC	Metropolitan Transportation Commission
Muni	Municipal Railway
NCAR	National Center for Atmospheric Research
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
O&M	operations and maintenance
OCII	Office of Community Investment and Infrastructure
PAH	polynuclear aromatic hydrocarbon
PCA	Priority Conservation Area
PCB	polychlorinated biphenyl
PDA	Priority Development Area
PG&E	Pacific Gas and Electric Company
PM	particulate matter
Port	Port of San Francisco
psi	pounds per square inch
Public Works	San Francisco Department of Public Works
RPD	Recreation and Park Department
RWS	Regional Water System
SamTrans	San Mateo County Transit District
SCADA	supervisory control and data acquisition
SFCD	San Francisco City Datum
SFCTA	San Francisco County Transportation Authority
SFDPH	San Francisco Department of Public Health
SFFD	San Francisco Fire Department
SFMTA	San Francisco Municipal Transportation Agency
SFO	San Francisco International Airport
SFPUC	San Francisco Public Utilities Commission
SLR	sea level rise
SOMA	South of Market area
SPP	Shoreline Protection Program
SR 1	California State Route 1
SSIP	Sewer System Improvement Program
TNC	Transportation Network Company
UCSF	University of California, San Francisco
US 101	U.S. Highway 101
USGS	United States Geological Survey
VTA	Santa Clara Valley Transportation Authority
WETA	Water Emergency Transportation Authority

GLOSSARY

Adaptation Toolkit
A suite of physical, operational, governance, and informational adaptation strategies that can be selected individually or in combination to mitigate or reduce sea level rise impacts and risks.

Adaptive capacity
The ability of an asset or system to adjust to sea level rise (including cyclic sea level variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Climate adaptation
Adjustment or preparation of natural, built or social systems to new or changing climate conditions and climate variability which moderate harm or exploit beneficial opportunities.

Climate change
A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Climate change impacts
The effects of climate variability and extreme events on built, natural, and human systems. Potential impacts are assessed in the absence of potential adaptation measures.

Consequence
The result or effect of the climate change impacts on society, equity, the economy, and the built and natural environment. Consequences can be quantitative or qualitative.

Criteria
Definitions used to map indicators to a qualitative rating scale for sensitivity and adaptive capacity.

Economic vulnerability
Economic variables that may be affected by climate impacts such infrastructure damage, repair or replacement costs and lost revenues during periods of recovery.

Environmental vulnerability
Environmental variables that may be affected by climate impacts such as species biodiversity, water quality, and ecosystem functions.

Exposure
The nature and degree to which natural, built, or social systems are subjected to sea level rise inundation and storm surge flooding.

Exposure assessment
An evaluation of the timing and degree of temporary flooding and/or permanent inundation of an asset.

Geospatial data
Information about assets and sea level rise that can be represented by numerical values in a geographic coordinate system and shared as maps and other visualizations.

Greenhouse effect
Trapping and build-up of heat in the atmosphere (troposphere) near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

Greenhouse gases
Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

Indicators
Characteristics of specific assets, asset types, or asset categories that are used to define the degree of sensitivity and adaptive capacity.

Inundation zone
The area temporarily or permanently inundated by a specific sea level rise and storm surge scenario.

King tide
While the term 'king tide' isn't a scientific term, it is used to describe an especially high tide event when there is an alignment of the gravitational pull between sun and moon.

Permanent inundation
Permanent inundation occurs if an area is exposed to regular daily tidal inundation. Maritime facilities, natural areas, shoreline protection features, and outfalls may be exposed to permanent inundation now.

Private asset
An asset that is owned, operated, and maintained by a private entity.

Public asset
An asset that is owned, operated, and maintained by a public agency or City department.

GLOSSARY

Ratings
A scale that is used to define a broad range of quantitative information in a qualitative manner for the purpose of comparison (e.g., sensitivity, adaptive capacity, vulnerability and each risk category each have a qualitative ratings scale).

Resilience
The capacity of a system and its component parts to cope with hazardous shocks and stresses in a timely and efficient manner by responding, adapting, and transforming in ways that restore, maintain, and even improve its essential functions, structures, and identity while retaining the capacity for growth and change.

Risk
The potential for temporarily and permanently losing something of value associated with the natural, built, or social environment (i.e., consequence). Values (such as level of service, economic health, physical health, social status, governance, etc.) can be gained or lost under a range of sea level rise and storm surge impacts. Risk can also be defined as the intentional interaction with uncertainty (i.e., likelihood). Risk is often framed as likelihood × consequence.

Risk assessment
Risk assessments describe (quantitatively or qualitatively) the potential consequences of the damage that could or will occur due to sea level rise and storm surge impacts.

Risk category
An over-arching values that can be used to define a specific type of risk to the natural, built, or social environment. Risk categories can be used individually or collectively to define risk ratings.

Risk metric
A standard of measurement to quantitively or qualitatively define the degree of risk associated with each risk category.

Sea level rise
As the temperature of the earth changes, so does sea level. Temperature and sea level are linked for two main reasons:

1. Changes in the volume of water and ice on land (namely glaciers and ice sheets) can increase or decrease the volume of water in the ocean
2. As water warms, it expands slightly—an effect that is cumulative over the entire depth of the oceans.

Sea level rise projections
Model-derived estimates of local and regional rates of sea level rise based on global climate models that consider a range of future greenhouse gas emission scenarios.

Sector
A distinct collection of assets that work together to comprise one complete system (e.g., water supply, wastewater, power, transportation).

Sensitivity
Characteristics of assets or asset systems that could lead to damage or disruption in the event of temporary flooding or permanent inundation. E.g., electronic equipment is sensitive to flooding and it more likely to be destroyed by a short-term flood event than a paved roadway that is less sensitive and may recover quickly once floodwater recede.

Social vulnerability
Characteristics of individuals and households that affect their ability to prepare for, respond to, and recover from a disaster.

Storm surge
The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The height of a storm surge event is the difference between the observed sea level and the sea level that is expected based on regular tidal variations.

Temporary flooding
Temporary flooding caused by storm events or extreme tides is generally short in duration (hours to days) but can have long lasting consequences.

Vulnerability
The degree to which an asset someone or something is susceptible to, or unable to cope with, a hazard. Vulnerability is a function of exposure, sensitivity, and adaptive capacity.

Vulnerability assessment
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.

Photo by Sergio Ruiz